

Founded in 1852
by Sidney Davy Miller

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July 1, 2025

Ms. Lisa Felice
Executive Secretary
Michigan Public Service Commission
7109 W. Saginaw Hwy.
Lansing, MI 48917

Re: Upper Peninsula Power Company
2026-2027 EWR Plan
Case No. U-21684

Dear Ms. Felice:

Enclosed for electronic filing in the above-captioned matter please find Upper Peninsula Power Company's Application and the Direct Testimony and Exhibits of Andrew McNeally and Nicole E. Bell. Also included for filing is my Appearance.

Should you have any questions or concerns, please kindly advise.

Very truly yours,

Miller, Canfield, Paddock and Stone, P.L.C.

By: _____
Sherri A. Wellman

SAW:ehk
Enclosures
cc w/enc: Andrew McNeally (amcneally@upppo.com)
Nicole Bell (nbell@upppo.com)
Eric Stocking (estocking@upppo.com)

STATE OF MICHIGAN

BEFORE THE MICHIGAN PUBLIC SERVICE COMMISSION

* * * * *

In the matter, on the Commission’s own motion,)	
regarding the regulatory reviews, revisions,)	
determinations, and/or approvals necessary for)	Case No. U-21684
UPPER PENINSULA POWER COMPANY to)	
fully comply with Public Act 295 of 2008, as)	
amended.)	

APPLICATION

Upper Peninsula Power Company (“UPPCO” or the “Company”) requests approval of the Michigan Public Service Commission (“MPSC” or the “Commission”) of its 4-year Energy Waste Reduction (“EWR”) plan and related surcharges. Further, as part of this filing, UPPCO will address its Energy Optimization Plan (“EOP”), which encompasses the Company’s EWR plan, Efficient Electrification Measures Plan (“EFEL”), and Transportation Electrification (“TE”) plan. In support thereof, the Company respectfully represents as follows:

1. UPPCO is a Michigan corporation, with principal offices located at Marquette, Michigan, and is engaged as a public utility in the generation, purchase, distribution, and sale of electric energy in its service territory in the Upper Peninsula of Michigan. UPPCO serves certain cities, villages, and townships located in the counties of Alger, Baraga, Delta, Houghton, Iron, Keweenaw, Marquette, Menominee, Ontonagon, and Schoolcraft.

2. Section 71 of 2008 PA 295, as amended, requires UPPCO to file an EWR plan with the Commission. On November 7, 2024, the Commission issued an order in Case No. U-21679 *et al*, directing UPPCO to make its EWR plan filing in Case No. U-21684 by July 1, 2025.

3. Section 71 of 2008 PA 295, as amended, requires that an EWR plan: (a) proposes a set of EWR programs that include offerings for each customer class, (b) specifies necessary funding levels, (c) describes how EWR program costs will be recovered, (d) ensures that, to the extent feasible, charges collected from a particular rate class are spent on EWR programs for that rate class, (e) demonstrates that the proposed EWR programs and funding are sufficient to ensure achievement of the applicable standards, (f) specifies megawatt hours of electricity used in the calculation of incremental energy savings will be based on the average number of megawatt hours of electricity sold by the provider annually during the previous 3 years to retail customers in this state, (g) demonstrates that the EWR programs, excluding program offerings to low-income residential customers, will be cost-effective, (h) provides for the practical and effective administration of the proposed EWR programs, and (i) includes a process for obtaining an independent expert evaluation of the actual EWR programs to verify the incremental energy savings from each EWR program.

4. Consistent with the foregoing statutory requirements, UPPCO is sponsoring a EWR plan as set forth in the testimony and exhibits of Andrew McNeally and Nicole Bell. Specifically, the testimony/exhibits will, among other things, (i) provide a regulatory and policy overview of UPPCO's proposed EWR plan (including its EOP, EFEL and TE), and (ii) sponsor the Company's EWR surcharges for the EWR plan period. The Company's direct case will also (i) describe the development of the EWR plan cost-effectiveness modeling for UPPCO's EWR plan to comply with the statutory requirements of Public Act 342, (ii) provide the cost benefit results demonstrating that the energy efficiency portfolio is cost-effective using the Utility System Resource Cost Test ("UCT") (excluding the low-income customers), (iii) address the continuation of the Financial Incentive Mechanism, and (iv) request authority to create a regulatory asset to

record EFEL plan expenses, which the Company proposes to recover in a future proceeding before the Commission.

5. UPPCO's testimony and exhibits demonstrate that the EWR plan is reasonable, prudent, and consistent with applicable statutory requirements.

6. UPPCO also requests the approval of surcharges designed to recover the costs of its proposed EWR plan from its customer classes.

WHEREFORE, Upper Peninsula Power Company respectfully requests that this Commission:

- A. Find and determine that as part of the Company's EOP its EWR plan, as set forth in the supporting testimony and exhibits, is reasonable and prudent, and that it meets all of the statutory requirements;
- B. Authorize the Company, beginning January 1, 2026, to implement the revised EWR surcharges as set forth in the supporting testimony and exhibits;
- C. Authorize the continuation of the Company's Financial Incentive Mechanism;
- D. Authorize the creation of a regulatory asset to record EFEL plan expenses; and
- E. Grant such other and further relief and authorizations as may be lawful and proper.

Respectfully submitted,

UPPER PENINSULA POWER COMPANY

Dated: July 1, 2025

By: _____
One of Its Attorney
Sherri A. Wellman (P38989)
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STATE OF MICHIGAN

BEFORE THE MICHIGAN PUBLIC SERVICE COMMISSION

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UPPER PENINSULA POWER COMPANY to)
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DIRECT TESTIMONY AND EXHIBITS

OF ANDREW MCNEALLY

ON BEHALF OF UPPER PENINSULA POWER COMPANY

July 1, 2025

DIRECT TESTIMONY AND EXHIBITS

OF ANDREW MCNEALLY

1 Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

2 A. My name is Andrew McNeally and my business address is 1002 Harbor Hills Drive, Marquette,
3 Michigan 49855.

4

5 Q. BY WHOM ARE YOU EMPLOYED AND IN WHAT CAPACITY?

6 A. I am employed by Upper Peninsula Power Company (“UPPCO” or the “Company”) as the
7 Manager of Energy Services.

8

9 Q. BRIEFLY DESCRIBE YOUR EDUCATIONAL BACKGROUND AND EMPLOYMENT
10 HISTORY.

11 A. I earned my Bachelor of Science in Surveying Engineering degree from the University of Maine
12 at Orono in 1993, which included a year-long exchange at the University of Melbourne, Victoria,
13 Australia in 1992. Within the regulated electric utility industry, I began my professional career at
14 Maine Public Service Company, as a Customer Service Representative in 2005. Beginning in
15 2006, I was the sole Energy Management Auditor and primarily responsible for residential and
16 small commercial energy conservation auditing and education, training of energy auditing field
17 service personnel, and responding to customer and Maine Public Utilities Commission (“MPUC”)
18 requests. I had transitioned to a Rate and Regulatory Analyst responsible for load settlement,
19 transmission reservations, large customer billing, and governmental agency reporting to the
20 MPUC, Northern Maine Independent System Administrator (“NMISA”), Federal Energy
21 Regulatory Commission (“FERC”) and North American Electric Reliability Corporation
22 (“NERC”) in 2009. By 2012, Maine Public Service Company had been acquired by Bangor
23 Hydro Electric Company, becoming a newly formed regulated transmission and distribution
24 utility in Maine, called Emera Maine. At the newly formed Emera Maine, I assumed the role of
25 Senior Rate Analyst, and was responsible for the annual and triennial Federal transmission rate

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1 filings, the transmission Open Access Same-time Information System (“OASIS”), management of
2 the transmission interconnection queue, and providing specific project analytical support for ISO-
3 NE PTO-AC Rates Working Group. In addition, I assisted with the development of the Emera
4 Maine’s heat pump pilot program and electric vehicle assessment. In 2015, I joined Birch Point
5 Software as a Business Analyst where I was responsible for developing custom solutions and web
6 service applications, and maintaining and building enterprise software applications. In late 2016,
7 I joined UPPCO as a Business Analyst, facilitating budgeting, load settlement, and sales and
8 revenue forecasting. In October 2017, I assumed the role of Energy Efficiency Program
9 Administrator for UPPCO, and became directly responsible for administration, contractor
10 management and monitoring of UPPCO’s EWR Program. In February 2019, I was invited to join
11 the Steering Committee of the restart of the Michigan Public Service Commission’s (“MPSC” or
12 the “Commission”) Energy Waste Reduction (“EWR”) Low-Income Workgroup. In March 2022,
13 I was invited to co-lead the MPSC’s Low Income Energy Policy (LIEP) Board to fulfill the goals
14 of the Energy Affordability & Accessibility Collaborative (EAAC). As co-lead, I help guide
15 strategies for low-income Michiganders. In November 2022, I was promoted to Manager of
16 Energy Solution. I continue to ensure the success of UPPCO’s Energy Efficiency and
17 Electrification Program by (i) managing the relationship and progress of the Company’s
18 implementing contractors, (ii) conducting regular meetings, (iii) reviewing and approving plan
19 and program modifications, (iv) managing marketing campaigns , (v) improving energy
20 solutions, and (vi) building out the Company’s electrification strategies. I continue to actively
21 participate on local, state, and regional subcommittees to promote and guide sustainable energy
22 efficiency, electrification, and low-income programming.

23
24 Q. HAVE YOU PREVIOUSLY TESTIFIED IN ANY REGULATORY PROCEEDINGS?

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1 A. Yes. I have provided testimony in several cases before the Commission, on behalf of UPPCO
2 including Case Nos. U-18265, U-20032, U-20350 U-20368, U-20376, U-20706, U-20869, U-
3 20879, U-21209, U-21316, U-21325, U-21561, U-21675, and U-21809.

4
5 Q. PLEASE IDENTIFY AND DESCRIBE THE EXHIBITS IN SUPPORT OF YOUR
6 TESTIMONY?

7 A. Yes, I am sponsoring the following exhibits:

- 8 • Exhibit A-1 (AHM-1) – Energy Optimization Plan 2026-2029
- 9 • Exhibit A-2 (AHM-2) – EWR Energy Savings and Budget Summary
- 10 • Exhibit A-3 (AHM-3) – EWR Cost-Effectiveness Testing
- 11 • Exhibit A-4 (AHM-4) – EWR FIM Performance Incentive
- 12 • Exhibit A-5 (AHM-5) – EWR Revenue Requirement

13
14 Q. WHY IS UPPCO FILING THIS ENERGY OPTIMIZATION PLAN?

15 A. Pursuant to 2008 PA 295, as amended by 2016 PA 342 and 2023 PA 229 (collectively “PA 295,
16 as amended”), UPPCO is making this filing to request approval of its 2026-2029 Energy
17 Optimization (“EO”) Plan. Commission approval of this EO Plan includes authority for
18 implementation of and cost recover of an EWR Plan to comply with PA 295, as amended, and
19 authority to implement a voluntary Efficient Electrification Measures Plan (“EFEL”) with
20 deferred cost recovery.

21
22 Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY?

23 A. The purpose of my testimony is to present UPPCO’s EO Plan for the 2026 through 2029 plan
24 years.

25

DIRECT TESTIMONY AND EXHIBITS

OF ANDREW MCNEALLY

1 Q. HOW IS YOUR TESTIMONY ORGANIZED?

2 A. My testimony is organized into the following sections:

3 I) EO Plan Overview

4 II) EWR Plan

5 a) EWR Statutory Compliance

6 b) EWR Plan Description

7 c) EWR Program Budget

8 III) EFEL Plan

9 IV) Energy Efficiency and Electrification Summary

10

11 **I. EO PLAN OVERVIEW**

12

13 Q. PLEASE DESCRIBE UPPCO'S 2026 – 2029 EO PLAN?

14 A. UPPCO is submitting and proposing a self-administered EO Plan for 2026 through 2029 plan
15 years consisting of the required EWR Plan and voluntary EFEL Plan. In the EWR Plan section,
16 my testimony will highlight the programs, statutory incremental energy savings goals, UPPCO's
17 achievement targets, and Financial Incentive Mechanism ("FIM") to help customers reduce
18 energy waste. The EFEL Plan section will discuss the programs and validation which include
19 both greenhouse gas emissions reduction ("GHG") and health and safety.

20

21 Q. WHY VOLUNTARILY SUBMIT AN EFFICIENT ELECTRIFICATION MEASURES PLAN?

22 A. Simply put; efficient electrification is the right thing to do. Creating an efficient electrification
23 measures plan that provides safety and health benefits, reduces total energy consumption, reduces
24 greenhouse gas emissions, or provides annual energy cost savings to customers aligns very well

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1 with UPPCO’s mission, vision, and values which guide our daily decisions and speaks clearly to
2 being responsible, leading, and stewards.

MISSION
To keep the lights on by investing responsibly in safety, reliability, and people.

VISION
To lead the UP to a clean, connected, and sustainable future, where serving our communities remains at the center of what we do.

VALUES

- SAFETY:** The safety of our employees, customers, and communities is non-negotiable.
- RESPECT:** We seek to understand our differences and foster an environment where all people feel valued.
- INTEGRITY:** We stand by our commitments and do what is right.
- EXCELLENCE:** We challenge ourselves to deliver superior performance by meeting high standards.
- STEWARDSHIP:** We provide responsible management of our communities and environment.

3

4

5 Q. HOW DID UPPCO DESIGN THIS FIRST EO PLAN?

6 A. UPPCO knew that creating an Energy Optimization Plan would be a challenge and began
7 working with a consultant in the second half of 2024. The initial foci of this work was building
8 electrification and transportation electrification, then incorporation of energy efficiency planning
9 so that all three pieces work seamlessly together. Our EO Plan, presented as Exhibit A-1(AHM-
10 1), contains the results and recommendations of our consultant’s research, analysis, and design
11 for energy efficiency (EWR Plan) and building electrification (EFEL Plan) while transportation
12 electrification (“TE”)(TE Plan) is presented separately in compliance with the MPSC’s
13 instructions and filing requirements.

14

15 Q. WHY DID THE COMPANY TAKE A HOLISTIC APPROACH TO THE EO PLAN DESIGN?

16 A. The most significant benefit of looking at energy efficiency and electrification as a whole is
17 customer experience. Yes, EWR, EFEL, and TE programs can live in their own silos, but the
18 overlap between saving energy, health and safety, and reducing greenhouse gas emissions is

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1 significant and intertwined. Thus, creating an umbrella program, energy efficiency and
2 electrification, to provide a single point of contact for customers looking for information,
3 education, opportunities, and solutions is anticipated to lead to higher customer participation and
4 satisfaction, and deeper energy savings.

5
6 **II EWR PLAN**

7
8 Q. PLEASE DESCRIBE UPPCO's 2026-2029 EWR PLAN?

9 A. As part of our EO Plan, UPPCO is proposing a self-administered EWR Plan for the 2026 through
10 2029 plan years that achieves, at minimum, the statutory incremental energy savings equivalent
11 of 1.5% of total retail electricity sales in megawatt hours with UPPCO's achievement targets for
12 energy savings being 2.0% for 2026 and 2027 and 2.17% for 2028 and 2029. The proposed EWR
13 Plan is in direct alignment with UPPCO's Integrated Resource Plan ("IRP") in MPSC Case No.
14 U-21809.

15
16 Q. WHAT ARE SOME KEY HIGHLIGHTS OF UPPCO's 2026-2029 EWR PLAN?

17 A. The proposed EWR Plan builds upon previous and current program offerings for residential and
18 business customers to deliver customer service, cost-effective programming, and energy savings
19 while shifting toward deep energy retrofits. The Company's residential programs continue to
20 focus on a holistic approach with income eligible and market rate offerings. UPPCO's residential
21 income eligible program is increasing its spending range target to 25% to 29% of total EWR Plan
22 budget to align with Act 295, as amended, after reaching the 25% low income spend threshold in
23 2024. The low income programming also includes a health and safety component with a target
24 spend of 1% of the total plan budget. UPPCO's residential market rate program will continue to
25 offer and strengthen core programs to deliver energy-efficiency and environmental benefits.

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1 UPPCO is expanding the multi-family program, for both income eligible and market rate
2 customers, to address the energy-efficiency savings potential throughout a building or complex
3 by including weatherization and high efficiency heat pump space heating and cooling systems for
4 residential customers that historically have limited opportunity to participate in energy waste
5 reduction programs due to the predominance of low-income and tenant-landlord relationship
6 issues. Another opportunity UPPCO is pursuing for energy-efficiency and environmental
7 stewardship is the residential new construction program promoting electrification via high
8 efficiency building shell construction, ENERGY STAR® products, and cold-climate heat pump
9 systems. For business customers, the small business finance program is being continued to
10 enable customers the opportunity to participate in a low-interest finance program for installation
11 of energy waste reduction measures. UPPCO's pilot program will continue our work with
12 indigenous tribes while adding measured savings, residential infiltration, and emerging
13 technology within the residential, commercial and industrial sectors. The Company's education
14 program will continue our long-term education campaign with outreach to schools and seniors, as
15 well as participation in the Michigan Heat Pump Collaborative. Finally, the EWR Plan includes
16 a new workforce development program that will be a fusion of education and skill building
17 focused on trades and careers that support energy efficiency and electrification. The proposed
18 2026-2029 EWR Plan focuses on assisting our most vulnerable customers address energy usage,
19 promotion and installation of measures that reduce energy usage, provide a portfolio average
20 measure life greater than 8 years, and provide immediate and long-term savings for all customers
21 while benefitting the environment.

22
23 Q. WHAT IS UPPCO'S RECENT EXPERIENCE WITH ENERGY EFFICIENCY?

24 A. Since January 1, 2018, UPPCO has self-administered EWR in order to customize a program that
25 will better meet its customers' energy efficiency needs by focusing on customer satisfaction, cost-

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1 effectiveness and energy savings, in that order. UPPCO has achieved and exceeded the statutory
2 first energy savings at a lower overall cost than originally budgeted, as evidenced in EWR
3 Reconciliation Case Nos. U-20368, U-20706, U-20869, U-21209, U-21316, U-21561, and U-
4 21675.

5

6 **EWR Statutory Compliance**

7

8 Q. PURSUANT TO STATUTORY REQUIRMENTS LISTED IN PA 295, AS AMENDED ,
9 PLEASE SUMMARIZE HOW UPPCO’S PROPOSED EWR PLAN MEETS THESE
10 REQUIREMENTS?

11 A. PA 295, as amended, Sec.71(3) states that an energy waste reduction plan shall do all of the
12 following:

13 a) “Propose a set of energy waste reduction programs that include offerings for each customer
14 class, including low-income residential. The commission shall allow a provider flexibility to
15 tailor the relative amount of effort devoted to each customer class based on the specific
16 characteristics of the provider's service territory.”

17 • UPPCO is compliant. UPPCO’s proposed EWR plan includes programs for residential
18 and business customer classes, as well as low income single and multi-family residential
19 customers, and is for the 4-year period of 2026 through 2029. Please reference Exhibit
20 A-1 (AHM-1) Energy Optimization Plan 2026-2029.

21 b) “Specify necessary funding levels.”

22 • UPPCO is compliant. UPPCO identifies the costs necessary to deliver its EWR Plan for
23 the 2026 through 2029 plan years. Please reference Exhibit A-2 (AHM-2), Line 38 for
24 total EWR program costs by year.

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- 1 c) “Describe how energy waste reduction program costs will be recovered as provided in section
2 89(2).”
- 3 • UPPCO is compliant. UPPCO proposes revenue surcharges to recover the necessary
4 costs to deliver its EWR Plan for the 2026 through 2029 plan years with volumetric rates
5 for residential customers, and per-meter charges for all other metered customers. As
6 evidenced in Exhibit A-10 (NEB-5) Rate Design – Surcharges & Self-Direct Surcharges.
- 7 d) “Ensure, to the extent feasible, that charges collected from a particular customer rate class are
8 spent on energy waste reduction programs that benefit that rate class.”
- 9 • UPPCO is compliant. UPPCO’s proposed revenue surcharges align benefits within rate
10 category (residential and business), and within rate classes, to the extent feasible.
- 11 e) “Demonstrate that the proposed energy waste reduction programs and funding are sufficient
12 to ensure the achievement of applicable energy waste reduction standards.”
- 13 • UPPCO is compliant. UPPCO’s proposed EWR Plan is cost-effective using the Utility
14 System Resource Cost Test (“UCT”) excluding program offerings to low-income
15 residential customers with a UCT score of 2.75 as evidenced in Exhibit A-3 (AHM-3)
16 Cost-Effectiveness Testing.
- 17 f) “Specify whether the number of megawatt hours of electricity [...] used in the calculation of
18 incremental energy savings under section 77 will be weather-normalized or based on the
19 average number of megawatt hours of electricity [...] sold by the provider annually during
20 the previous 3 years to retail customers in this state. Once the plan is approved by the
21 commission, this option shall not be changed.”
- 22 • UPPCO is compliant. UPPCO calculated the incremental energy savings based on the
23 average number of megawatt hours (“MWh”) of electricity sold during the previous 3
24 years. As evidenced in Exhibit A-6 (NEB-1) Rate Class Sales, Energy Savings Goals and
25 Targets on Line 31, the statutory incremental savings goal is 10,760 MWh and UPPCO’s

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1 incremental savings target is 13,672 MWh at 2.0% and 14,661 MWh at 2.17%, based on
2 the average of the previous 3 years of retail sales. UPPCO notes that our election of
3 using the previous 3 years is consistent with historical filings, but contrary to section
4 77(1) which states "... shall collectively achieve incremental energy savings equivalent
5 to 1.5% of total retail electricity sales in megawatt hours **in the preceding year ...**"
6 (emphasis added)

7 g) "Demonstrate that the provider's energy waste reduction programs, excluding program
8 offerings to low-income residential customers, will collectively be cost-effective."

- 9 • UPPCO is compliant. UPPCO's proposed EWR Plan is collectively cost-effective using
10 the UCT, excluding program offerings to low-income residential customers. As
11 evidenced in Exhibit A-3 (AHM-3) Cost-Effectiveness Testing, the EWR Plan excluding
12 program offerings to low-income achieves a UCT score of 2.75.

13 h) "Provide for the practical and effective administration of the proposed energy waste reduction
14 programs. The commission shall allow providers flexibility in designing their energy waste
15 reduction programs and administrative approach, including the flexibility to determine the
16 relative amount of effort to be devoted to each customer class based on the specific
17 characteristics of the provider's service territory. A provider's energy waste reduction
18 programs or any part thereof, may be administered, at the provider's option, by the provider,
19 alone or jointly with other providers, by a state agency, or by an appropriate experienced
20 nonprofit organization selected after a competitive bid process."

- 21 • UPPCO is compliant. UPPCO maintains a full-time Manager of Energy Solutions, an
22 Energy Efficiency Program Specialist, and Contact Center Representative III for
23 administration, contractor management and monitoring, plan and program monitoring,
24 and customer relations. Please reference Exhibit A-2 (AHM-2) Energy Savings and
25 Budget Summary for residential and business administration, respectively.

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1 i) “Include a process for obtaining an independent expert evaluation of the actual energy waste
2 reduction programs to verify the incremental energy savings from each energy waste
3 reduction program for purposes of section 77. All evaluations are subject to public review and
4 commission oversight.”

5 • UPPCO is compliant. UPPCO’s proposed EWR Plan includes independent expert
6 evaluation of the actual programs to verify the incremental gross energy savings, as well
7 as net annual savings and net lifetime savings. Please reference Exhibit A-2 (AHM-2)
8 Energy Savings and Budget Summary for residential and business evaluation,
9 respectively.

10 j) PA 295, as amended, Sec.71(6) states “Beginning January 1, 2025, an electricity provider
11 shall file its energy waste reduction plan as part of a customer energy optimization plan. A
12 customer energy optimization plan shall include an energy waste reduction plan and may
13 include an efficient electrification measures plan.

14 • UPPCO is compliant. UPPCO’s proposed EWR Plan is being filed as part of an Energy
15 Optimization Plan after January 1, 2025, and in alignment with the Commission’s Order
16 of February 8, 2024, in Case No. U-21567.

17
18 Q. PLEASE DESCRIBE HOW UPPCO BUILT A PLAN THAT ALIGNS RATE CLASS
19 CHARGES WITH BENEFITS, TO THE EXTENT POSSIBLE.

20 A. To align charges and benefits, UPPCO reviewed the energy sales and revenues at the residential
21 and business sector levels rolled up from the 3-year averages by rate class in Exhibits A-6 (NEB-
22 1) and A-7 (NEB-2). This review demonstrates that the residential sector consumes 35.2% of
23 UPPCO’s annual energy sales and delivers 53.8% of UPPCO’s annual revenues while the
24 business sector consumes 64.8% of annual energy sales and delivers 46.2% of annual revenues.
25 These values define a combined range for both energy savings and charges by sector. In

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1 UPPCO's 2026-2029 EWR Plan, the residential sector delivers 45% of First-year Energy Savings
2 and 53% Lifetime Energy Savings with 51% of EWR Plan charges while the business sector
3 delivers 55% of First-year Energy Savings and 47% Lifetime Energy Savings with 49% of EWR
4 Plan charges.

5
6 Q. DOES UPPCO'S EWR PLAN INCLUDE PLAN ELEMENTS THAT THE COMMISSION
7 SHOULD CONSIDER WHEN REVIEWING THE PLAN REQUIREMENTS?

8 A. Yes. UPPCO's EWR Plan includes the following elements which are identified as Plan
9 Requirements or Plan Elements in Order U-15800 Attachment E, but not included in PA 295, as
10 amended, Sec.71(3) above:

11 a) "Allow for the coordination of energy [waste reduction] programs and services with those of
12 other utilities, agencies and the Commission-administered program."

- 13 • UPPCO is compliant. UPPCO's proposed EWR Plan includes the ability and flexibility
14 to coordinate and partner with other utilities, their implantation contractors, community
15 action agencies, and community-based organizations.

16 b) "Utilities may designate up to five percent of the energy [waste reduction] budget for pilot
17 programs, future energy optimization program development or to assess emerging
18 technologies."

- 19 • UPPCO is compliant. UPPCO's proposed EWR Plan includes a Pilot Program to
20 develop small scale offerings testing new technologies, segmentations, outreach methods,
21 and education to increase EWR participation and energy savings. UPPCO is requesting
22 Commission approval to increase Pilot Program spend to enable funding of a Measured
23 Savings Pilot by 2% for the 2026 and 2027 plan years.

24 c) "Up to three percent of the energy [waste reduction] budget may be used for the cost of
25 energy optimization education programs.

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- UPPCO is compliant. UPPCO’s proposed EWR Plan includes an Education Program designed to help customers reduce energy waste and understand the benefits of energy efficiency and conservation. UPPCO is continuing its partnership with National Energy Foundation (“NEF”) and other utilities to provide the Think! Energy curriculum to 4th grade students across the Upper Peninsula. Annually, UPPCO will reach approximately 1,200 students and several hundred seniors. In addition, UPPCO continues to support the Michigan Heat Pump Collaborative alongside the other founding members, Consumers Energy, DTE, and Indiana Michigan Power.

Additional Commission findings in Order U-21567, but not included PA 295, as amended, Sec.71(3) or Order U-15800 Attachment E, include:

a) “...that investment in Workforce Development should not receive deemed savings. [...] Levels of investment in workforce development should be established as a percentage of spend and included within the provider’s EWR plan filing.”

- UPPCO is compliant. UPPCO’s proposed EWR Plan includes a workforce development program with no deemed savings attributed with investment of 2% in 2026 and 2027 plan years and 1% in 2028 and 2029 plan years.

b) “... that programs awarded deemed savings, such as pilots, education, and health and safety, should be limited. [...] The percentages of deemed savings awarded as a percentage of the legislative requirement should be established in a plan filing with savings capped at the legislative minimum savings level.

- UPPCO is compliant. UPPCO’s proposed EWR Plan includes pilots, education, and health and safety programs with defined percentages of spend and equal defined percentages of deemed savings.

Q. IS UPPCO REQUESTING APPROVAL OF INCREASED PILOT PROGRAM SPEND?

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1 A. Yes. UPPCO is proposing a pilot program that is longer-term in duration than traditional EWR
2 pilots. To ensure UPPCO may continue investing in testing new opportunities to capture energy
3 savings at consistent levels, UPPCO proposes to increase its Pilot Program spend from 5% of
4 total EWR spend to 7% of total EWR spend in 2026 and 2027 plan years. This increase will be
5 used to fund the Measured Savings Pilot. These pilot funds will be deemed to generate a
6 proportional amount of the required energy savings for the program year during which the money
7 is spent.

8

9 Q. PLEASE DESCRIBE THE MEASURED SAVINGS PILOT AND ITS IMPORTANCE?

10 A. Through the Measured Savings Pilot, UPPCO will utilize Recurve’s FLEX Platform powered by
11 OpenDSM. Built in collaboration with the Linux Foundation Energy, OpenDSM has been
12 rigorously vetted through years of stakeholder engagement and is the first and only open-source
13 M&V software approved by the U.S. Department of Energy for use in validating energy savings
14 under the Inflation Reduction Act’s Home Efficiency Rebates program. It incorporates state-of-
15 the-art daily and hourly energy models, calibrated comparison group methods, and embedded
16 weather normalization—all designed to measure energy impacts at the population level with
17 statistical confidence. These methods form the backbone of the Measured Energy Savings
18 Approach Pilot and have already been used to track over 50,000 electrification projects in the
19 nation’s largest building decarbonization initiative.

20 Importantly, this UPPCO pilot will build on and complement the Open-Source Benefit-Cost
21 Analysis (OpenBCA) Tool initiative, developed under MPSC Docket U-20898. This effort, led
22 by the MPSC in partnership with Recurve, ICF, E4TheFuture, and LBNL, is producing a
23 transparent, spreadsheet-based platform to implement Michigan’s jurisdiction-specific BCA
24 framework, grounded in the National Standard Practice Manual (NSPM). The tool is designed to

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1 be fully compliant with Commission orders and will become the standardized method for valuing
2 DER investments, including pilots and full-scale programs, beginning in 2026.

3

4 Q. HAS THE COMMISSION PROVIDED GUIDANCE ON PILOT SPEND LIMITATIONS?

5 A. Yes. The Commission found in Case No. U-18262 that “the 5% spending limitation on pilot
6 programs may be reevaluated in the context of plans or plan amendments. In other words, if a
7 provider can demonstrate that additional spending for pilot programs is reasonable, such spending
8 may be approved.” UPPCO believes the proposed pilot spend increase is a reasonable level that
9 allows UPPCO to test, evaluate, and demonstrate measured savings in Michigan while allowing
10 continuity investing in testing new opportunities to capture energy savings through its Pilot
11 Program.

12

13 Q. IS UPPCO REQUESTING APPROVAL TO CONTINUE ITS EWR FINANCIAL INCENTIVE
14 MECHANISM?

15 A. Yes. As afforded in PA 295, as amended, UPPCO requests the Commission to continue to
16 authorize a financial incentive mechanism to incentivize the utility to implement meaningful
17 programs for its customers, focused on deep energy savings and income-qualified customer
18 spend.

19

20 Q. PLEASE DESCRIBE THE EWR FINANCIAL INCENTIVE MECHANISM.

21 A. Consistent with PA 295, as amended, as well as the Order in Case No. U-20879 and U-21325, the
22 performance incentive is based on a sliding scale with three separate metrics. The first metric
23 establishes the maximum potential incentive award based on first year energy savings, with the
24 second and third metrics, lifetime energy savings and low income spend, determining the actual
25 financial award. The baseline for the first metric, first-year annual savings, is the statutory

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1 incremental energy savings equivalent per Section 77(1) and calculated in Exhibit A-6 (NEB-1)
2 Rate Class Sales, Energy Savings Goals and Targets as 10,760 MWh for 2026 through 2029
3 based on the average number of megawatt hours of electricity sold annually during the previous 3
4 years to retail customers. The baseline for the second metric, lifetime savings, is the first metric
5 target multiplied by an “average measure life” value of 8 years. Finally, the baseline for the third
6 metric, low income spend, is the percentage range of 25% to 29% of the actual EWR cost/spend,
7 an increase over UPPCO’s 2024-2025 low-income spend range of 16% to 20%. Please see
8 Exhibit A-4 (AHM-4) FIM Performance Incentive.

9
10 Q. HAS UPPCO INCLUDED THE PROJECTED FINANCIAL INCENTIVE MECHANISM IN
11 ITS PROPOSED EWR BUDGET?

12 • A. Yes, as evidenced in Exhibit A-2 (AHM-2) – Energy Savings and Budget Summary, Line
13 35.

14
15 Q. WHAT ARE THE CRITERIA FOR EWR PLAN APPROVAL PURSUANT TO PA 295, AS
16 AMENDED, AND DESCRIBE HOW UPPCO’S PLAN MEETS THESE APPROVAL
17 CRITERIA?

18 A. Per PA 295, as amended, Sec.73(2), EWR Plan approval is dependent on determination that:

19 a) “...the energy waste reduction plan meets the utility system resource cost test...”

20 • UPPCO achieves this determination. As shown in Exhibit A-3 (AHM-3) – Cost-
21 Effectiveness Testing, UPPCO’s proposed EWR Plan achieves a utility system resource cost
22 test (“UCT”) score of 2.70 (all inclusive), and 3.63 (excluding low income and financial
23 incentive mechanism).

24 b) “... is reasonable and prudent.”

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- 1 • UPPCO achieves this determination. The elements of UPPCO’s proposed EWR Plan, in
2 aggregate, reduce the future cost of service for its customers by:
- 3 i) Influencing customers’ energy consumption patterns through educational programs,
4 incentives, and installation of energy-efficient measures.
- 5 ii) Analyzing the cost and benefit of individual measures, groups of measures at the
6 program level, groups of programs at the residential and business level, and overall
7 EWR Plan levels.
- 8 iii) Targeting 2.0% of annual retail electricity sales for the 2026 and 2027 plan years and
9 2.17% of annual retail electricity sales for the 2028 and 2029 plan years in
10 accordance with UPPCO’s proposed long-range integrated resource plan as addressed
11 in Case No. U-21809.
- 12 iv) Building program budgets to deliver benefits that are equitable by rate class, to the
13 extent feasible, based on rate class revenues as shown in Exhibit A-7 (NEB-2) Rate
14 Class Revenues.
- 15 v) Expanding programs to make energy-efficiency more available, affordable, and
16 useful for customers.

17

18 **EWR Plan Description**

19

20 Q. HOW WAS UPPCO’S 2026-2029 EWR PLAN DEVELOPED?

21 A. UPPCO engaged 5Lakes Energy to assist in the development of energy efficiency and
22 electrification plans. The 5 Lakes Energy recommendations report, sponsored as Exhibit A-1
23 (AHM-1) describes the analysis and development of the overall EO Plan, and specifically
24 addresses the EWR Plan in section 4.

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1 Q. FROM A SUMMARY PROGRAM DESIGN PERSPECTIVE, HOW DOES UPPCO'S 2026-
2 2029 EWR PLAN COMPARE TO UPPCO'S PRIOR EWR PLANS?

3 A. As evidenced in Exhibit A-1 (AHM-1), the 2026-2029 EO Plan, and more specifically the EWR
4 section builds upon UPPCO's historic EWR plans and evolves with statutory changes by utilizing
5 5 Lakes Energy for analysis, modeling and design; Integral Analytics ("IA") for cost-
6 effectiveness testing; DNV Energy Insights, Inc. for independent third-party evaluation; Superior
7 Watershed Partnerships for a portion of income eligible implementation; Slipstream, Inc. for
8 research and pilot services; and National Energy Foundation for educational services. By self-
9 administering the EWR plan since 2018, UPPCO continues to identify opportunities to improve
10 incremental energy savings by focusing on the portfolio average measure life, increasing low
11 income spend, expanding multi-family programming, expanding direct install programs, and
12 expanding educational outreach.

13

14 Q. WHAT IS THE 2026-2029 EWR PLAN AND WHAT DOES IT CONTAIN?

15 A. As evidenced in Exhibit A-1 (AHM-1) Section 4, the 2026-2029 EWR Plan provides a roadmap
16 for UPPCO to deliver statutory energy savings goals, at minimum, and achieve energy savings
17 targets cost-effectively. It is important to note that even though the 2026-2029 EWR plan
18 provides direction for implementing the programs, the programs continue to be refined during the
19 development of the detailed operational plans with the implementation contractors and during
20 implementation. This is to be expected over multi-year program plans as technologies, markets,
21 and customer opportunities change.

22

23 Q. DOES THE EWR PLAN MEET THE STATUTORY SAVINGS GOALS?

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1 A. Yes. The UPPCO 2026-2029 EWR plan was developed to exceed the statutory goals of 1.5% as
2 set forth in PA 295, as amended, Sec 77(1) by targeting 2.0% for 2026 and 2027 plan years and
3 2.17% for 2028 and 2029 plan years.

4
5 Q. IS UPPCO'S 2026-2029 EWR PLAN CONSISTENT WITH THE TARGETED 2.17% EWR
6 PLAN SET IN U-21809.

7 A. Yes. UPPCO developed the plan to meet or exceed the EWR savings target of 2.0% for the 2026
8 and 2027 plan years and meet or exceed the EWR savings target of 2.17% for the 2028 and 2029
9 plan years as set forth in its IRP.

10

11 Q. HOW WAS COST-EFFECTIVENESS OF THE EWR PROGRAMS DETERMINED?

12 A. IA utilized the DSMore cost analysis tool to calculate and report cost-effectiveness for the
13 programs using the UCT as defined by PA 295, as amended. Per statute, UPPCO's programs
14 must be cost-effective utilizing UCT to receive Commission approval.

15

16 Q. PLEASE DESCRIBE THE MODELING TOOL USED BY INTEGRAL ANALYTICS?

17 A. The DSMore tool is an award-winning modeling software that is nationally recognized and used
18 in many states across the country to determine cost-effectiveness.

19

20 Q. PLEASE LIST THE COST-EFFECTIVE TESTS COMPLETED BY INTEGRAL
21 ANALYTICS?

22 A. IA tested the cost-effectiveness of UPPCO's EWR Plan in total, by residential and business
23 classes, and for each program using the following tests:

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- 1 • Utility System Resource Cost Test (“UCT”): Defined as the ratio of the net benefits of the
2 programs to the program costs incurred by the utility for the programs. For a program to be
3 cost-effective, this ratio needs to be greater than one.
- 4 • Total Resource Cost Test (“TRC”): Defined as the total avoided cost divided by the program
5 costs plus the participant’s costs. Incentives paid to the customer are in both the cost and
6 benefit sides of the equation, so they cancel each other out.
- 7 • Rate Impact Measure (“RIM”): Defined as the avoided cost benefits divided by the program
8 costs and lost revenues.
- 9 • Societal Cost Test (“SCT”): Defined as the ratio of the total avoided costs plus the
10 quantifiable benefits to society (such as saved water and reduced pollution) divided by the
11 program costs plus the participant costs.
- 12 • Participant Test: Defined as the participant’s benefits in energy savings from their bill plus
13 their incentives divided by their costs to participate.

14

15 Q. ARE NON_ENERGY BENEFITS INCLUDED IN THE COST-EFFECTIVENESS TESTS?

16 A. While the National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy
17 Resources discusses that the TRC, SCT and any other test that includes program participant
18 impacts should include participant non-energy benefits, no non-energy mechanisms or values
19 have been established in Michigan, so they are not included in the UPPCO analysis. Because
20 such non-energy benefits are not included in UPPCO’s analyses, our TRC and SCT results
21 understate the cost-effectiveness of our efficiency programs.

22

23 Q. WHAT EXHIBIT DEMONSTRATES THESE COST-EFFECTIVENESS RESULTS?

24 A. Exhibit A-3 (AHM-3) Cost-Effectiveness Testing shows the tests results of the various cost-
25 effectiveness tests performed by IA.

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Q. PLEASE IDENTIFY KEY MODELING ASSUMPTIONS USED BY INTEGRAL ANALYTICS?

A. In order for IA to perform modeling for UPPCO’s EWR Plan, a variety of inputs were utilized including:

- a) Participation rates, incentives paid, energy savings of the measure, demand savings of the measure, life of the measure, implementation costs, administrative costs, and incremental costs to the participant of the high efficiency measure.
- b) Free-ridership or Net-To-Gross (“NTG”) values. UPPCO requested IA continue to assume the current NTG values of 1.0 for low-income, and 0.90 for most other programs, consistent with the deemed values granted by the Commission.
- c) Utility information including utility rates; electric losses, escalation rates; discount rates for the utility, society and the participant based on long-term United States treasury bond yields; avoided transmission and distribution costs; and avoided ancillary charges.
- d) Historical hourly electric prices, load shapes for various customer classes, hourly energy savings from specific measures/technologies, over 30 years of weather data, and program costs.

Q. WHAT WAS THE BASIS FOR SAVINGS USED FOR THE EWR PLAN AND COST-EFFECTIVENESS TESTING?

A. Savings for the EWR Plan and cost benefit analysis are based on the Michigan Energy Measures Database (“MEMD”). The adopted 2025 MEMD is the basis for the EWR Plan.

Q. HOW WERE PROGRAM COSTS DEVELOPED FOR THE EWR PLAN AND COST BENEFIT ANALYSIS?

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1 A. Program costs for the 2026-2029 planning years are based on incentive, implementation, and
2 administrative budgets and costs. The incentive budget development relies on historic program
3 costs, adjusted for changes over time and the UPPCO territory, reviewed for reasonableness, and
4 modified based on program best practices. The implementation budget is directly from the
5 models developed during the EWR plan design process. Finally, the administrative budget was
6 compiled based on internal and external needs, services, and contracts. In total, these separate
7 budgeting processes ensure that the Energy Savings and Budget Summary is based on realistic
8 historic operational costs and realistic levels that are proven in the market.

9

10 Q. HOW DOES INTEGRAL ANALYTICS ACCOUNT FOR AVOIDED ELECTRIC BENEFITS
11 COMPUTED?

12 A. IA calculated the avoided benefits for UPPCO's analysis utilizing historic hourly price data from
13 the Midcontinent Independent System Operator ("MISO") market and hourly weather data, to
14 determine the value of the saved kWh. The savings by measure were applied at specific hours
15 over the year since prices vary by hour. These prices were weighted based on the probability of
16 weather variations over 33 years of weather history so that the full range of weather and prices
17 were properly captured. Each hour had a unique price which was then escalated over time. This
18 assured that the savings reflect the value one would expect to see in the market over time from the
19 avoided energy sales. In addition to avoided electric production and electric production adders,
20 avoided transmission and distribution costs and ancillary charges are included in the cost benefit
21 models to reflect the total benefits of the savings.

22

23 Q. WHAT ARE THE NET BENEFITS?

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1 A. As evidenced in Exhibit A-3(AHM-3) with a UCT score of 2.70, the net benefits of the programs
2 are greater than the program costs incurred by the utility program. The proposed EWR Plan has
3 net benefits of \$29,837,016 as modeled.

4
5 Q. PLEASE DESCRIBE THE COST-EFFECTIVENESS RESULTS FOR UPPCO'S 2026-2029
6 EWR PLAN?

7 A. UPPCO's EWR Plan is cost-effective with the Program Portfolio UCT score of 2.75, excluding
8 low-income programs. This means that the savings benefits are 275% greater than the program
9 cost. The cost-effective test result is 2.70 when including low income and financial incentive
10 mechanism, which means benefits are 264% greater than program cost.

11
12 Q. IS UPPCO'S 2026-2029 EWR PLAN COST-EFFECTIVE?

13 A. Yes. Based on the analysis IA performed using DSMore, UPPCO's 2026-2029 EWR plan passes
14 the cost-effectiveness test in accordance with the legislative requirements of PA 295, as amended.
15 This analysis was done in accordance with legislative guidelines and did not include low-income
16 programs.

17
18 Q. WHY EXCLUDE LOW-INCOME PROGRAMS FROM COST-EFFECTIVENESS TESTING?

19 A. Although statute excludes low-income programs from the cost-effectiveness test, UPPCO
20 believes that a low-income program that achieves a UCT score of 1.0, cost-effective, or higher,
21 results in a lower cost EWR for all customers and helps levelize the equity between surcharge
22 payment and rebate receipt across classes. This focus on cost-effectiveness has resulted in the
23 low-income program achieving an UCT score of 2.17. This feat is accomplished by selecting
24 implementors that are knowledgeable in delivering low-income programming, as well as
25 partnering with community-based organizations like Superior Watershed Partnerships ("SWP").

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1 SWP is a well-respected organization within the low-income community and delivers services
2 across the Upper Peninsula of Michigan. In aggregate, the low-income program delivery results
3 in avoided cost benefits exceeding program costs, and a UCT score of 2.17.

4

5 **EWR Program Budget**

6

7 Q. WHAT ARE THE ANNUAL PROGRAM COSTS OF UPPCO'S 2026-2029 EWR PLAN?

8 A. The proposed budgets for the EWR Plan are \$4,170,700 for 2026 and \$4,391,642 for 2027 to
9 achieve 2.0% incremental energy savings, and \$5,016,633 for 2028 and \$5,223,535 for 2029 to
10 achieve 2.17% incremental energy savings, as evidenced in Exhibit A-2 (AHM-2).

11

12 Q. HOW HAS UPPCO CALCULATED THE REVENUE REQUIREMENTS?

13 A. The EWR Plan costs are divided into four categories: (i) low-income, (ii) residential, (iii)
14 business, and (iv) portfolio to establish the revenue requirement to be allocated, as evidenced in
15 Exhibit A-5 (AHM-5). The low-income category includes all low-income programming costs
16 that are allocated across all customer classes. The residential category contains those costs
17 specific to UPPCO's residential sector and classes. The business category contains those costs
18 specific to UPPCO's small, medium and large business and industrial sectors and classes. The
19 portfolio category includes education and pilot program costs plus the performance incentive that
20 are allocated across all customer classes.

21

22 Q. HOW ARE THE EWR SURCHARGES CALCULATED?

23 Witness Bell's testimony defines the allocation factors, revenue requirement allocation and
24 surcharge calculations.

25

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1 Q. HOW DO THE PROPOSED PROGRAM COSTS IMPACT TYPICAL CUSTOMER EWR
2 SURCHARGE RATES AND AVERAGE CUSTOMER BILLS?

3 A. As evidenced in Exhibit A-10 (NEB-5) the EWR Surcharge for Residential customers will see an
4 increase of 50%, while Commercial customers, which include Small Business, Medium Business,
5 Large Business, Industrial customers, and metered lighting customers will see an increase of
6 53%.

7

8 Q. PLEASE PROVIDE A SUMMARY OF THE TYPICAL BILL IMPACTS.

9 A. The typical bill impacts for customers, based on the incremental differences between UPPCO's
10 proposed 2024 EWR Reconciliation surcharges (Case No. U-21675) and the proposed EO Plan
11 EWR surcharges, are:

12	Rate Category	Rate Class	Monthly	Yearly
13	Residential (per 500 kWh)	A-1	\$1.60	\$19.20
14	Small Business (per meter)	C-1	\$3.60	\$43.20
15	Medium Business (per meter)	P-1	\$31.60	\$379.15
16	Large Business (per meter)	CP-U	\$309.46	\$3,713.51
17	Industrial (per meter)	WP-3	\$1,939.97	\$23,279.58
18	Lighting (per meter)	SL-3	\$1.29	\$15.48

19

20 Q. PLEASE EXPLAIN THE BIGGEST DRIVERS OF WHY EWR RATES ARE INCREASING?

21 A. Proposed EWR surcharges are increasing for residential, commercial, and industrial customers by
22 50 to 53%. The primary drivers are changes to PA 295, as amended, which set higher energy
23 savings goals, minimum low income spend of 25%, added health and safety and workforce
24 development programs, and UPPCO's shift toward deep retrofits. To reach UPPCO's higher
25 energy savings targets of 2.0% and 2.17% in the 2026-2029, EWR plan higher incentives are

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1 necessary to encourage participation and installation of longer-life measures, especially for low-
2 income residential customers and small business customers to install deeper energy savings
3 measures. Additional drivers include increases in evaluation, measurement and verification costs,
4 and the financial incentive mechanism.

5
6 **III EFEL PLAN**

7
8 Q. HOW IS UPPCO ABLE TO FILE AN EFFICIENT ELECTRIFICATION MEASURES PLAN
9 AS PART OF ITS ENERGY OPTIMIZATION PLAN?

10 A. UPPCO has chosen to voluntarily include an Efficient Electrification Measures Plan (“EFEL”) as
11 allowed by PA 295, as amended, Sec.71(6) which states “Beginning January 1, 2025, an
12 electricity provider shall file its energy waste reduction plan as part of a customer energy
13 optimization plan. A customer energy optimization plan shall include an energy waste reduction
14 plan and may include an efficient electrification measures plan.”

15
16 Q. WHAT IS AN EFEL PLAN?

17 A. An EFEL Plan helps an electric provider’s customers achieve health and safety benefits within
18 the premises they occupy OR reduce energy, greenhouse gas emissions, and annual average
19 energy costs by installing specific electric appliances or equipment that displaces an end use that
20 otherwise combusts a fossil fuel without having the effect of increasing electric rates for non-
21 participating customers of the provider. The specific equipment installed is referred to as an
22 efficient electrification measure. Similar to an EWR Plan, an EFEL Plan is available to all
23 customers including income eligible, residential, commercial, and industrial customers and has
24 costs allocated to administration, implementation, and incentives. At the same time, an EFEL
25 Plan is dissimilar to an EWR Plan because the installation of each measure is individually

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1 analyzed using health and safety, energy consumption, greenhouse gas emission reduction, and
2 annual average energy cost savings criteria. Thus, an EFEL Plan has a very focused list of
3 measures available for installation.

4

5 Q. WHAT IS AN EFFICIENT ELECTRIFICATION MEASURE?

6 A. An efficient electrification measure is defined in statute at MCL 460.1005(a) with additional
7 criteria imposed on the specific equipment in MCL 460.1072(1) and further clarified in Case No.
8 U-21567 with the focus being on measures attached to or within a building versus transportation.

9

10 Q. IS THERE A DATABASE OF EFEL MEASURES?

11 A. Yes and no. Yes, in Case No. U-21567, the Commission found that the Michigan Energy
12 Measures Database, used for storing EWR Plan measures, is the most reasonable place to
13 incorporate EFEL measures and their necessary values. In addition, the Energy Optimization
14 (“EO”) Collaborative and its MEMD updating process is the most reasonable for vetting EFEL
15 measures. The 2025 MEMD has two EFEL measures approved, water heaters and clothes dryers.
16 No, as EFEL measures are a new statutory concept created by 2023 PA 229, the measure list is
17 being created as analysis is carried out. In preparing UPPCO’s EO Plan, an extensive list of
18 EFEL measures have been analyzed using UPPCO specific scenarios and documented in Exhibit
19 A-1 (AHM-1), Section 5.1 for use in our EFEL Plan.

20

21 Q. WHAT ARE THE REQUIREMENTS OF AN EFEL PLAN?

22 Per PA 295, as amended, Sec.72(1), the efficient electrification measures under and EFEL plan
23 “**shall** provide health and safety benefits to occupants of the premises **or** satisfy all of the
24 following:” [emphasis added]

25 a) “Reduce total energy consumption at the premises.”

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1 b) Reduce greenhouse gas emissions due to energy use over the life of the electrification
2 measure.

3 c) For residential and commercial customers interconnected at secondary voltage, provide
4 annual average energy cost savings.
5

6 Q. HOW WAS UPPCO'S 2026-2029 EFEL PLAN DEVELOPED?

7 A. UPPCO engaged 5 Lakes Energy to assist in the development of energy efficiency and
8 electrification plans. The 5 Lakes Energy report, Exhibit A-1 (AHM-1) describes the analysis
9 and development of the overall EO Plan and specifically addresses the EFEL Plan in Section 5.
10

11 Q. HOW WILL UPPCO IMPLEMENT THE 2026-2029 EFEL PLAN?

12 A. During development of the EO Plan and, more specifically, the EFEL Plan, UPPCO and 5 Lakes
13 Energy worked with Slipstream Group, Inc ("Slipstream"), a mission-driven nonprofit
14 organization with more than 45 years of experience dedicated to accelerating climate solutions for
15 everyone. Slipstream's participation in the review process helps ensure UPPCO's EFEL Plan
16 design and efficient electrification measure list is compatible and in alignment with the
17 implementation of this innovative energy efficiency and electrification program. UPPCO has
18 familiarity with and confidence in Slipstream's work and abilities from prior market
19 characterization studies and EWR pilots, as well as through the Michigan Heat Pump
20 Collaborative.
21

22 Q. DOES UPPCO PROPOSE A FINANCIAL INCENTIVE MECHANISM FOR THE EFEL
23 PLAN?

24 A. UPPCO believes there may be justification to request a Financial Incentive Mechanism for an
25 EFEL Plan that shows good performance and delivers special benefits. For example, special

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1 benefits may be combining extra shell efficiency improvements with the installation of a heat
2 pump, so that the heating and cooling load of the building is permanently reduced and the sizing
3 of the heat pump is reduced resulting in greater overall energy consumption reductions than the
4 energy consumption reduction calculation of A- B as defined in MCL 460.1072(2). Additional
5 examples of good performance or special benefits may include greenhouse gas emission
6 reductions, market development and transformation for efficient electrification measures, or
7 lowering of electric rates for customers that are EFEL Plan participants and non-participants
8 within a specific rate class or across rate classes. UPPCO is not proposing a Financial Incentive
9 Mechanism for the EFEL Plan in this docket but may in a future regulatory proceeding.
10

11 Q. WHAT IS THE COST OF UPPCO'S EFEL PLAN?

12 A. UPPCO'S EFEL Plan, as evidenced in Exhibit A-1 (AHM-1), provides recommendations of
13 maximum incentive amounts, as well as methodology and calculations for individual efficient
14 electrification measure incentive amounts. With customer participation levels unknown, one is
15 not able to estimate incentive amounts or administration or implementation costs.
16

17 Q. IS UPPCO ELIGIBLE TO RECOVER EFEL PLAN COSTS?

18 A. Yes, PA 295, as amended, Section 72(4) states "An electric provider may recover the costs of an
19 efficient electrification measures program."
20

21 Q. HOW DOES UPPCO PLAN TO RECOVER EFEL PLAN COSTS?

22 A. UPPCO requests that the Commission grant the Company authority to create a regulatory asset,
23 whereby the Company will record any EFEL Plan expenses, inclusive of any and all costs
24 associated with administration, implementation, and incentives. UPPCO will seek recovery of
25 the regulatory asset in a future regulatory proceeding. As a part of the regulatory proceeding, the

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1 Company will consider providing the results of one or more cost benefit test, both pre- and post-
2 plan implementation, to provide evidence that the EFEL Plan is cost effective, as recommended
3 by the Commission's November 7, 2024 Order in Case No. U-21567.

4

5 Q. PLEASE DESCRIBE THE PROGRAM FINANCING RECOMMENDATION IN EXHIBIT A-
6 1(AHM-1)

7 A. UPPCO acknowledges that directing customers to available assistance, tax credits, and financing
8 may reduce barriers to customer participation in energy efficiency and electrification programs.

9 UPPCO is continuing its Small Business Finance Program under the EWR Plan. With respect to
10 the savings-based Tariffed On-Bill Cost Program recommendation, UPPCO will address on-bill
11 financing in a future regulatory proceeding.

12

13 Q. PLEASE DESCRIBE THE LOAD MANAGEMENT TARIFF RECOMMENDATION IN
14 EXHIBIT A_1(AHM-1).

15 A. UPPCO agrees that load management and demand reduction programs should be addressed as
16 energy efficiency and electrification programming increases overtime. UPPCO plans to address
17 the load management tariff recommendation in a future regulatory proceeding.

18

19 **IV ENERGY EFFICIENCY AND ELECTRIFICATION SUMMARY**

20

21 Q. PLEASE SUMMARIZE YOUR REQUEST IN THIS PRECEEDING?

22 A. The Company requests that the Commission:

23 i. Accept its EO Plan, as included here as Exhibit A-1 (AHM-1);

24 ii. Find and determine that its EWR Plan, as part of the EO Plan, is reasonable and prudent, and
25 that it meets all the statutory requirements;

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- 1 iii. Approve its EWR Plan surcharges;
- 2 iv. Approve the requested methodology used in calculating the EWR Plan Financial Incentive
- 3 Mechanism;
- 4 v. Authorize the Company to create a regulatory asset for its EFEL Plan costs;
- 5 vi. Grant such other and further relief as is just and reasonable.

6

7 Q. DOES THIS CONCLUDE YOUR DIRECT TESTIMONY?

8 A. Yes.



Upper Peninsula Power Company

Customer Energy Optimization Plan

2026-2029

Drafted and Recommended by

5 Lakes Energy

1 EXECUTIVE SUMMARY

1.1 About UPPCO

Upper Peninsula Power Company (“UPPCO”) is the largest electric utility serving approximately 52,000 customers across 4,460 square miles of Michigan’s Upper Peninsula. UPPCO and its predecessors have excelled at providing dependable service and safe, reliable energy to its valued customers for more than 135 years. UPPCO remains committed to planning for and delivering safe, reliable electricity to meet the energy needs of Upper Peninsula homes and businesses, now and in the future.

UPPCO provides more than just supplying energy as evidenced by a successful in-house Energy Waste Reduction (“EWR”) program since 2018. UPPCO believes EWR is good for Michigan, our company, and each and every customer by providing energy saving opportunities, helping lower greenhouse gas emissions, and improving efficiency in homes and businesses. We are committed to helping our customers get the most value possible from the energy they purchase through the portfolio of EWR and electrification programs and opportunities in this Plan.

1.2 Plan Changes and Schedule

This recommended Plan is for the period January 1, 2026 through December 31, 2029.

This recommended Plan embodies several important changes from UPPCO’s previous and current plans. First and foremost, this is an Energy Optimization Plan that includes Load Management, Energy Waste Reduction, and Efficient Electrification programs and measures. UPPCO’s Transportation Electrification Plan is presented separately in compliance with the Michigan Public Service Commission’s instructions and filing requirements but follows similar principles and will appear to customers as an integrated program.

The Load Management portion incorporates UPPCO’s existing Commercial Interruptible Load but includes recommendations for Cost-Effective Rate Design to be implemented in future rate cases that will provide price signals and incentives to all customers to shape their electricity usage in ways that reduce UPPCO’s costs of service. Those same rate designs serve to make some Energy Waste Reduction measures and some Efficient Electrification measures more economically attractive to customers, in alignment with UPPCO’s cost structure. Load Management also includes recommendations to incorporate technical standards into some Energy Waste Reduction and some Efficient Electrification measures that will enable future Flexible Load Optimization programs in conjunction with the incentive effects on customers of the recommended Cost-Effective Rate Design.

The Energy Waste Reduction portion of the recommended Plan incorporates the requirements of 2023 PA 229 by maintaining a minimum of 25% of program spending on income-qualified customers, a workforce development effort, and inclusion of space-heating demand reduction measures done in conjunction with space-heating electrification measures. In general, the recommended Plan shifts UPPCO’s Energy Waste Reduction Program toward greater emphasis on costly but cost-effective measures, sometimes referred to as deep-retrofits, and away from kit distribution and other programs that provide small savings per instance. This shift will be aided by the proposed

implementation of a residential customer tariff-based on-bill cost recovery program that enables UPPCO to assist customers with the measure costs that cannot be covered by rebates within the structure of an Energy Waste Reduction program. We recommend that UPPCO continue to offer Small-Business Energy Waste Reduction measure financing through Northern Initiatives. The recommended Plan also is intended to meet the Energy Waste Reduction levels described in UPPCO's Integrated Resource Plan as presented in Case No. U-21809, beginning at 2% in 2026 and increasing to 2.17% in 2028. Transfers of excess Renewable Energy Credits to the Energy Waste Reduction program are included in the recommended Plan as a backstop to reaching the targeted incentive levels but will be exercised only to the extent that direct Energy Waste Reduction falls short of UPPCO objectives.

The Efficient Electrification portion of the recommended Plan incorporates a number of electrification measures that meet statutory tests. They are either cooking measures that provide known health and safety benefits to building occupants or commercial kitchen workers or are space heating, water heating, or laundry measures that reduce on-site energy consumption, reduce greenhouse gas emissions on a life-cycle basis, and reduce occupant energy costs. Most of these measures will apply to customers currently using propane, but many space heating and some other measures will often not be allowed because they do not provide an energy bill reduction for customers currently using natural gas. In order to ensure that other customers' bills are not increased by the Efficient Electrification measures, we recommend that recovery of Efficient Electrification program costs be deferred and amortized over several years such that UPPCO's gross margin on increased electricity sales due to the electrification measures pays for the amortized cost recovery. Customer adoption of electrification measures, which sometimes require high initial outlays, will be aided by the proposed implementation of a residential customer tariff-based on-bill cost recovery program that enables UPPCO to assist customers with the measure costs that cannot be covered by rebates within the structure of an Efficient Electrification program. We recommend that UPPCO undertake to offer Small-Business Efficient Electrification measure financing the Northern initiatives.

Industrial process Energy Waste Reduction can be cost-effective for both the customer and UPPCO, but is always custom and often takes multiple years to implement because of the need to integrate energy changes with process changes or equipment replacement. And, the savings can be large steps forward once implemented. Industrial heat electrification can be beneficial for industries that use low-temperature and medium-temperature processes, but are similarly custom and slow to implement. We recommend new collaborations by which UPPCO may achieve greater gains through industrial Energy Waste Reduction and Efficient Electrification.

1.3 Plan Organization

The recommended Plan is structured to first address certain common Program Portfolio elements and then sequentially address Load Management, Energy Waste Reduction, and Efficient Electrification.

2 PORTFOLIO MANAGEMENT RECOMMENDATIONS

2.1 Education and Awareness

UPPCO has for many years promoted Energy Waste Reduction measures to its customers. Efforts will need to be made to include new measures in future customer education efforts. In particular, an emphasis on home comfort would nicely tie together increased emphasis on improving the thermal boundary of homes and using heat pumps for heating and cooling. Similarly, education about the health and safety benefits of electric cooking is warranted as the health risks of cooking with propane or natural gas are not well known.

UPPCO customers may become frustrated trying to take advantage of UPPCO Energy Waste Reduction or Efficient Electrification offers if they call contractors who do not offer those measures or actively discourage them. UPPCO should proactively educate contractors about these measures and UPPCO's support for them. UPPCO should consider providing contractor referrals to contractors who attend educational sessions and commit to offering the measures UPPCO supports.

2.2 Program Administration

We do not recommend any specific changes to UPPCO's current practices to administer its EWR programs, but note that with the increase in emphasis on space heating demand reduction that we recommend and with increased deployment of space heating and cooling heat pumps either to reduce electricity use in electric resistance heating or in conjunction with Efficient Electrification of space heating, a larger share of the program will require sizing calculations and custom calculations of energy savings and rebates. Further, the offer of Tariffed On-Bill cost recovery described below will require the development of custom information for Owner Participation Agreements. UPPCO should prepare its implementation contractor(s) to increase these activities in line with projected participation.

There appears to be a shortage of contractors in the Upper Peninsula that include in their lines of business some of the new measures or newly emphasized measures in the recommended programs, such as air sealing, duct sealing, heat pumps, and commercial kitchen equipment. Program administration related to these measures will require active contractor management. It may be useful for UPPCO to begin supporting these measures by reaching agreements with a small number of contractors who commit to acquiring the capacity to well perform these measures in return for the volume of business that will be directed to them by UPPCO's programs. Once these measures are readily available in the market, UPPCO can broaden contractor participation.

Particularly for measures that are new to UPPCO's programs or new to the installing contractors, UPPCO should provide rigorous quality assurance. A reputation of successful measures will help promote those measures, while a reputation of failed implementations will make it difficult to gain adoption. It is therefore important that early implementations be coached and inspected to ensure success.

2.3 Tracking and Reporting

We do not recommend any specific changes to UPPCO's current practices to track and report Energy Waste Reduction program activities and accomplishments. These practices will need to be extended to Efficient Electrification, assuming that this Plan is approved.

2.4 Evaluation, Measurement, and Verification

We recommend that UPPCO initiate a pilot project to use measured savings in its Energy Waste Reduction program. This pilot will support a transition toward a data-driven, metered approach to demand flexibility, optimized energy efficiency, and efficient electrification. We also recommend that after a pilot through the end of 2027, UPPCO should transition measured savings to be a part of UPPCO's Energy Waste Reduction Plan.

A measured savings program will provide:

- analysis of historical time-interval meter data to target program offers to customers who are most likely to benefit,
- analysis of historical time-interval and weather data to forecast load shift data due to Flexible Load Management, savings from Energy Waste Reduction measures or changes in heating fuel and electricity for Efficient Electrification measures,
- post-implementation analysis of pre-measure and post-measure time-interval and weather data to measure actual effects of measures,
- integration of measured savings with measurement and verification,
- comparison of measured savings with deemed savings.

After the pilot project, the measured savings approach should be used to compare actual savings for major measures with deemed savings which should result in recognition of additional savings in UPPCO's Energy Waste Reduction reconciliation. We conservatively forecast the incremental savings that will be demonstrated through measured savings and include those savings in the Energy Waste Reduction forecasts for 2028 and 2029.

After the pilot project, the measured savings approach could support UPPCO provision of a guaranteed performance of measures funded in a Tariffed On-Bill program, discussed below.

2.5 Coordination with External Partners

UPPCO has strong Energy Waste Reduction partnerships with local Community Action Agencies, housing authorities, and others that work on housing. It also has a strong partnership with Northern Initiatives for implementing Energy Waste Reduction measures in small businesses. Those partnerships will need to be extended to Efficient Electrification.

Industrial Energy Waste Reduction and Efficient Electrification require specialized engineering knowledge and skills. UPPCO is currently largely dependent on its industrial customers to identify opportunities and obtain assessments of potential projects, which UPPCO can then support financially. We recommend that UPPCO develop a partnership

with the Michigan State University Industrial Training and Assessment Center (“MSU-ITAC”) to promote and identify industrial Energy Waste Reduction and Efficient Electrification opportunities. MSU-ITAC has US Department of Energy funding to provide energy analyses for industrial facilities and can, in some cases, provide access to implementation grants. UPPCO and MSU-ITAC would both benefit from mutual referrals and UPPCO could provide matching funds for grants that MSU-ITAC can access. MSU-ITAC has affiliated faculty at Michigan Technological University, which is within UPPCO’s service territory. We also recommend that UPPCO develop relationships with the Michigan Economic Development Corporation, US Department of Energy, and external experts regarding funding opportunities for industrial energy improvements.

2.6 Workforce Development

To deliver the recommended Energy Waste Reduction and Efficient Electrification Plans, UPPCO will need a qualified workforce with capabilities in building envelope, heat pump, and advanced efficiency measures. This section provides recommendations for bolstering UPPCO’s network of qualified and motivated trade allies, ideally with most of these program partners based in the UP.

We recommend that UPPCO devote 1% of its Energy Waste Reduction funds each year to workforce development in its territory, with an additional 1% investment in the first two years of the Plan. These funds may support contractor training in target technologies, apprenticeship programs, or other proven strategies. Specific areas of focus should include blower door testing, air sealing (including blower-door directed air sealing and aerosol air sealing), energy audits, heat pump water heaters, and equipment selection, sizing (Manual J calculation), and installation of heat pump space heating and cooling. To the extent feasible, UPPCO should target workers in or from low-income and environmental justice communities and workers formerly employed in transition-impacted industries. UPPCO should connect to and leverage existing workforce development infrastructure through dedicated agencies such as UP Michigan Works¹ and professional networks such as the Michigan Energy Workforce Development Consortium.²

As a sponsoring utility of the MI Heat Pump Collaborative,³ UPPCO understands the value of this collective effort toward building a strong base of qualified trade allies. Those who wish to install heat pumps through UPPCO’s EWR and EFEL programs should be encouraged to complete the requirements for Graduate Designation and take advantage of the Collaborative’s ongoing education and training series.

Customer dissatisfaction due to improperly sized heat pump equipment is counterproductive to achieving UPPCO’s program goals. Therefore, UPPCO’s workforce development efforts should support the requirement that participating trade allies are trained and experienced in the proper application of ASHRAE Manual J. In addition, results of these calculations should be demonstrated for every heat pump installation as part of the EM&V process.

Based on previous industry research conducted by 5 Lakes Energy, consider targeting self-identified air conditioning installers who might value cold climate air source heat pumps as a natural extension of their existing business line.

¹ <https://upmichiganworks.org>

² <https://www.careersinenergymichigan.com>

³ <https://www.miheatpumps.com>

Industrial energy workforce efforts should leverage the MSU Industrial Training and Assessment Center (ITAC). A Michigan-based program of U.S. DOE, ITAC has a dedicated presence in the UP through Michigan Technological University. Collaboration with ITAC would foster relationships with student researchers who would soon be in the job market for related work. Also, ITAC audits can lead to business opportunities for the highly skilled energy contractors who serve this sector. UPPCO is in a good position to engage these contractors by facilitating conversations between them, ITAC staff, and the industrial facilities being assessed. Other recommendations to strengthen the industrial trade ally network are to recruit and retrain experienced workers such as boiler engineers and technicians, and train process engineers in pinch analysis methods to evaluate heat and water flow savings opportunities.

Finally, many civilian employers recognize the value of hiring military veterans who bring maturity, technical skills, and a desire to serve their communities. The UP has a larger population of veterans per capita than downstate and UPPCO should be intentional about engaging this demographic to join the skilled trades in support of EWR and EFEL programming. Relevant agencies to contact include the Michigan Veterans Affairs Agency⁴ and the Upper Peninsula Commission for Area Progress.⁵ Potential pathways to engage with younger veterans are the service organizations Team Rubicon⁶ and Team RWB.⁷

2.7 Program Financing

In this Plan, we recommend action on load management, energy waste reduction, and efficient electrification. Across these programs, we recommend a consistent strategy to finance programs, with the intent of an integrated program offering customers and compliance with law and good utility practices in the administration of these programs. The strategy is to:

- help the customer apply for available assistance programs and account for that assistance in determining the rest of the financing of the measures for the customer
- where appropriate, advise the customer that there may be tax credits for the measure and account for that in determining the rest of the financing of the measures for the customer
- provide rebates to the customer or apply the rebate to direct install when appropriate, up to the full cost of the measure after third-party rebates and tax credits
- for costly measures, inform the customer of available funding, including an UPPCO tariffed on-bill cost recovery program for residential customers
- at the residential customer's option, UPPCO will invest in the measures and recover its costs through the tariffed on-bill program, as long as the projected energy bill savings exceed the tariffed on-bill charge

⁴ www.michigan.gov/mvaa

⁵ <https://www.upcap.org>

⁶ <https://teamrubiconusa.org>

⁷ <https://teamrwb.org>

- at a small commercial customer's option, subsidized business loans will be available from Northern Initiatives.
- industrial customers may be eligible for various Federal or State grants and tax credits that are targeted to economic development, energy productivity and industrial competitiveness, or climate change mitigation, for which UPPCO can provide technical support and/or matching funds.
- the customer will be responsible for any remaining costs of the measure after those listed above.

2.7.1 Third-party Rebates

At this time, the principal third-party rebate program that may be available to UPPCO customers is the MiHER program administered by the Michigan Department of Environment, Great Lakes, and Energy (EGLE). Details of this program are available on the program web pages, at <https://www.michigan.gov/egle/about/organization/materials-management/energy/rfps-loans/home-energy-rebate-programs>.

UPPCO is already partnering with the MiHER program, having been one of the two utilities participating in the “soft launch”, UPPCO is already working with EGLE to refer applicants to MiHER and to braided funds. UPPCO plans to use its measured savings pilot project to provide MiHER its first opportunity to use a measured savings approach that is authorized by the federal home energy rebates program.⁸ Measured savings provide access to these rebates at a lower savings threshold than modeled savings and provide greater rebates to the extent that the measures outperform the minimum level of performance for each rebate bracket.

We recognize that the MiHER program may change and that other programs may be developed. In representative case analyses presented later in this Plan, we assume the current MiHER program terms but the approach we recommend is robust to changing third-party offerings.

2.7.2 Load Management Cost Recovery

We are recommending that UPPCO initiate additional load management programs, beginning with changes to rate schedules that charge customer distinctly higher prices during a few peak hours and lower prices in the remaining hours throughout the year. These price signals will induce customers to reduce load at costly times and will produce corresponding bill savings for the customers and cost reductions for UPPCO. We are also recommending that UPPCO begin developing a Flexible Load Optimization program that will automate the response of certain customer devices to either static periods of higher prices or to utility “called” events. To the extent practical, UPPCO will include Flexible Load Optimization features in the technical requirements for Energy Waste Reduction and Efficient Electrification measures. All costs of implementing new rate designs and of technology support for Flexible Load Management beyond technical requirements on Energy Waste Reduction and Efficient Electrification will be proposed and recovered through rate cases.

⁸ See the description at https://www.energystar.gov/partner-resources/web_linking_policy/homes-program

2.7.3 Energy Waste Reduction Cost Recovery

UPPCO will continue to follow Energy Waste Reduction cost recovery practices consistent with past plans, recovering current year program costs through energy waste reduction surcharges on customers, subject to annual reconciliation.

2.7.4 Efficient Electrification Cost Recovery

UPPCO proposes in this Plan to offer an Efficient Electrification program. The program will offer rebates to customers for such electrification measures as heat pumps for space heating, heat pump water heaters, heat pump clothes dryers provided that those measures meet the statutory test of on-site energy savings, life-cycle reductions in greenhouse gas emissions, and net energy cost savings for the participating customers. Additionally, UPPCO will offer rebates for induction and other electric cooking equipment as occupant health and safety measures. In each instance, the amount of the rebate will be chosen such the rebate and the associated program costs will be less than the net present value of UPPCO's gross margin on the resulting electricity sales, insuring that in the long-run the program will not impose costs on non-participants but be fully recovered through incremental electricity sales. In order to ensure that non-participating customers do not initially pay costs of the Efficient Electrification program UPPCO is requesting accounting authority to defer the Efficient Electrification program and rebate costs and to amortize cost recovery of the deferred costs at a levelized annual rate that will be less than the projected incremental gross margin of the incremental electricity sales for the measure in the first and therefore all subsequent years.

2.7.5 Tariffed On-bill Residential Program

In this Plan we recommend that UPPCO implement a Tariffed On-Bill Cost Program to aid residential customer adoption of costly but cost-effective measures such as heat pump space heating and building envelope improvements. In the programs we recommend below, such measures warrant rebates from UPPCO based on utility economics but will have significant installed costs even net of rebates. Total energy bill savings to customers often provide enough savings to warrant the customer investment to cover the installed costs net of rebates, but not all customers are able or willing to make such large investments in anticipation of the resulting energy bill savings.

An on-bill re-payment program can finance most or all of the initial investment net of rebates and guarantee customer bill savings net of payments. But, when on-bill repayment programs are done as a loan to the customer, it leaves remaining challenges, such as split incentives between landlord and renter, credit-eligibility for a loan, and impact of the loan on remaining credit capacity of the customer. A Tariffed On-bill program addresses these challenges.

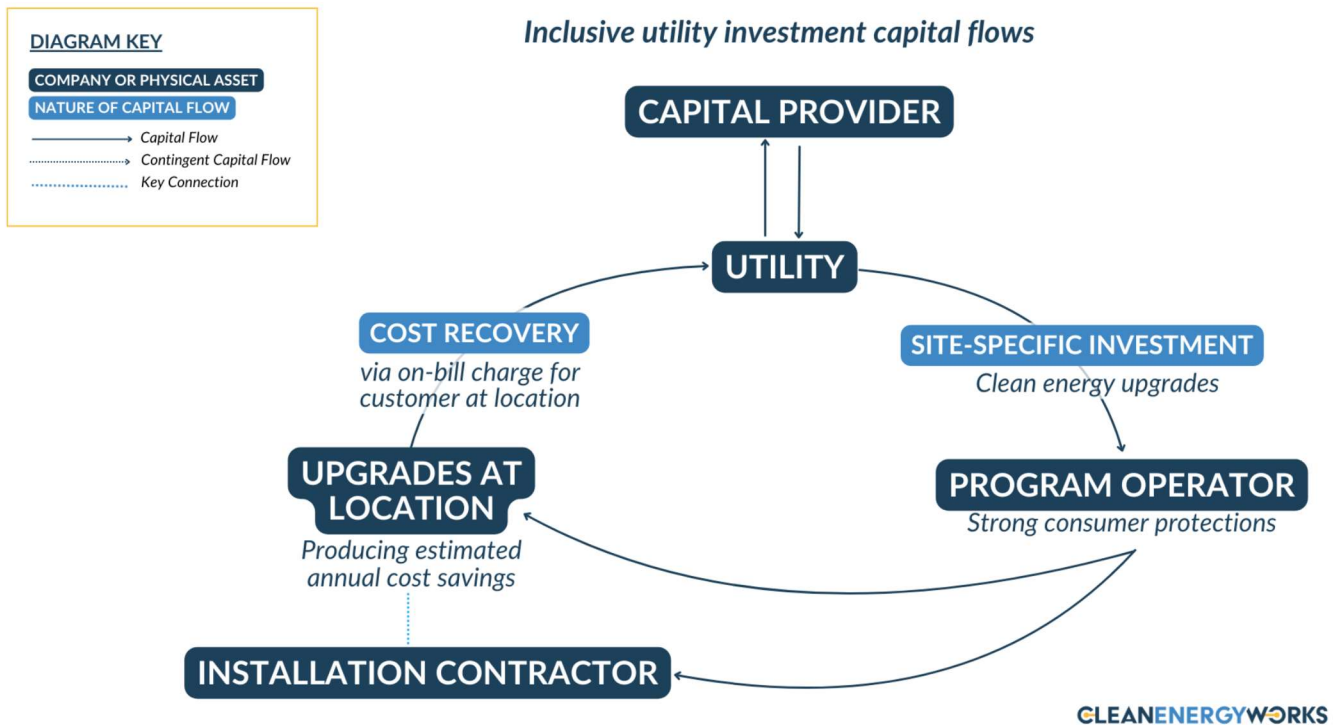
In a Tariffed On-bill program, the utility makes the investment in improvement to customer premises, books that investment as a utility asset, and then recovers that investment through a site-specific charge. While the investment is made by the utility and is not a loan to the customer, current and future customers at that location do ultimately pay for the improvement to the customer premises. Thus, the current and future customers who occupy the premise pay the full cost of the electrification or energy waste reduction measure, net of normal rebates, and there is not a

shift of costs onto other customers. A rebate capitalizes the utility’s avoided cost for an energy waste reduction measure or the utility’s gross margin on incremental electricity sales for an electrification measure. A Tariffed On-bill program capitalizes a portion of the customer’s bill savings from the measure.

A Tariffed On-Bill program can be tailored to ensure that the monthly charge to the customer for premise improvements is less than the customer’s savings, with a guarantee to that effect. For typical energy waste reduction measures that reduce electricity consumption, this can be easily done based on measured, weather-adjusted usage. For electrification measures, the savings will need to be based on modeled fuel cost savings versus incremental electricity usage, but the principle is the same. The measured savings pilot we recommend later as part of UPPCO’s Energy Waste Reduction Program will provide a sound basis for a guarantee of energy bill savings.

A Tariffed On-Bill program can increase the accessibility, acceptability, and scale of home energy upgrades. Our projections of customer adoptions of space heating electrification measures and of building envelope improvements for customers with electric resistance heat or in conjunction with heat pump installation reflect an expectation that an offer of a Tariffed On-Bill program will increase customer adoption rates.

The following diagram shows the capital flows and key actors in a Tariffed On-Bill program:



This model has been adopted by several utilities. We highlight here that the Michigan Public Service Commission approved a similar mechanism for DTE assistance in the purchase of electric school buses in Case No. U-20836.⁹ We recommend Duke Energy North Carolina’s Improve & Save program as a general model for the tariff and program

⁹ Order of November 18, 2022, p 340
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design of a Tariffed On-Bill program sponsored by a regulated investor-owned utility.¹⁰ We provide a draft tariff as Appendix A to this Plan.

To facilitate both integration of this offer with MiHER and to ensure high quality modeling as a basis for a customer offer, we recommend that UPPCO use energy modeling software that has been certified for MiHER, such as PSD's Clarity Heat Pump Toolkit¹¹.

2.7.6 Small Business Financing

For small businesses, we recommend that UPPCO continue its Small Business Financing Program and expand it to Efficient Electrification measures. The Small Business Financing program has partnered with Northern Initiatives to offer zero percent financing for qualifying customers. By providing financing, the customers can participate in the Prescriptive and Custom programs to have energy efficiency measures installed. With the advent of an Efficient Electrification program, small business financing will also be enabled to adopt electrification measures that are offered in that program. Financing will be at 0% for up to 36 months. Participants will qualify for the prescriptive and custom incentives and energy savings will be captured in those programs to ensure no double counting.

2.7.7 Industrial Energy Improvement Financing

Industrial facilities often have high capital needs and prioritize capital budgets to focus on market opportunities or process improvements with very rapid payback. Cost-effective energy waste reduction or fuel switching may be slowly adopted because of this competition for capital. The availability of grants, tax credits, and rebates can be decisive in allocating industry capital to energy improvements. UPPCO rebates can provide leverage for grants and tax credit, especially if UPPCO can be patient and make commitments one or two years in advance of the investment. Available support for industrial energy improvements is often complex to navigate and to capture and is unlikely to be mastered by someone who does this "on the side". We recommend that UPPCO's industrial account manager(s) become acquainted with and maintain a relationship with the Michigan Economic Development Corporation, US Department of Energy, and an external consultant who can help navigate industrial energy improvement finance opportunities and make connections between customers and these navigators as appropriate.

2.7.8 Project Financing Examples

The following hypothetical examples illustrate how customers can utilize UPPCO's Tariffed On-Bill program as described in Section 2.7.5 to help finance larger energy-efficiency projects. These examples also illustrate how UPPCO plans to braid together several funding buckets to support customers.

¹⁰ See <https://www.duke-energy.com/home/products/improve-and-save#:~:text=The%20agreement%20outlines%20the%20terms%20regarding%20the%20upgrades%2C,dispute%20resolution%2C%20insurance%20requirements%20and%20other%20relevant%20provisions>

¹¹ See <https://psdconsulting.com/solutions>

2.7.8.1 Comprehensive Efficiency Package

In this example, a customer with electric resistance heating and water heating upgrades these systems through the Home Performance program. The customer makes use of UPPCO EWR program rebates, federal tax credits, out-of-pocket payments, and the Tariffed On-Bill program.

Measure	Project Cost	UPPCO rebate	Tax credit	Additional down payment	Balance	On-bill annual recovery	Annual bill savings
Cold-climate Air-source Heat Pump	\$ 20,000	\$ 1,800	\$ 2,000	\$ 5,000.00	\$ 11,200	\$ 1,231.41	\$ 1,275.08
Air sealing	\$ 2,000	\$ 200	\$ 540	\$ 500	\$ 760	\$ 91.05	\$ 291.14
Heat Pump Water Heater	\$ 4,200	\$ 500	\$ -	\$ 500	\$ 3,200	\$ 456.07	\$ 493.05
Totals	\$ 26,200	\$ 2,500	\$ 2,540	\$ 6,000	\$ 15,160	\$ 1,779	\$ 2,059

Notes: Costs and rebates are for illustrative purposes and will vary based on equipment and project. Assumes use of Energy Efficient Home Improvement Credit for 30% of expenses (after UPPCO rebate). Maximum credit is \$2000 per year for qualified heat pumps and water heaters. Customer initial outlay includes tax credit + down payment. Bill savings based on MEMD kwh savings values and AH1 rate.

2.7.8.2 Space Heating Electrification

In this example, an income-qualified customer transitions from propane heating to electric heating through the Residential Efficient Electrification Program, along with building envelope improvements through the Empower program. The Residential Efficient Electrification Program is described further in Section 5. The customer makes use of MiHER rebates, UPPCO rebates (from EWR and Electrification programs), federal tax credits, and the Tariffed On-Bill program.

Measure	Project Cost	MiHER rebate	UPPCO rebate	Tax credit	Balance	On-bill annual recovery	Annual bill savings
Cold-climate Air-source Heat Pump	\$ 20,000	\$ 8,000	\$ 3,000	\$ 2,000	\$ 7,000	\$ 770	\$ 2,300
Air sealing	\$ 2,000	\$ 1,600	\$ 400		\$ -		
Duct sealing	\$ 1,500	\$ 1,500			\$ -		
Insulation - Basement wall, rim joist	\$ 3,000	\$ 1,600	\$ 1,400		\$ -		
Electrical panel and wiring	\$ 6,500	\$ 6,500			\$ -		
Totals	\$ 33,000	\$ 19,200	\$ 4,800	\$ 2,000	\$ 7,000	\$ 770	\$ 2,300

Notes: Costs and rebates are for illustrative purposes and will vary based on equipment and project. MiHER rebate subject to program approval. Assumes use of Energy Efficient Home Improvement Credit for 30% of expenses (after UPPCO and MiHER rebates). Maximum credit is \$2000 per year for qualified heat pumps. Customer initial outlay includes tax credit value. Bill savings based on modeled energy savings using ResStock load profiles and A-1 rate converting to AH-1 after project completion.

3 LOAD MANAGEMENT PROGRAMS

2008 PA 295, as amended, says that “[l]oad management’ means measures or programs that target equipment or behavior to result in decreased peak electricity demand such as by shifting demand from a peak to an off-peak period.”¹²

2008 PA 295, as amended, directs, in part, that “Subject to subsection (2), the commission shall do all of the following:

- (a) Promote load management in appropriate circumstances, including expansion of existing and establishment of new load management programs in which an electric provider may manage the operation of energy consuming device and remotely shut down air conditioning or other energy intensive systems of participating customers, demand response programs that use time of day pricing and dynamic rate pricing, and similar programs, for utility customers that have advanced metering infrastructure. Electric provider participation and customer enrollment in such programs are voluntary. However, electric providers whose rates are regulated by the commission and whose rates include the cost of advanced metering infrastructure shall offer commission-approved demand response programs. The programs may provide incentives for customer participation and shall include customer protection provisions as required by the commission. To participate in the program, a customer shall agree to remain in the program for at least 1 year.¹³

2008 PA 295, as amended, further provides that “The commission may allow a provider whose rates are regulated by the commission to recover costs for load management through base rates as part of a proceeding under section 6a of 1939 PA 3, MCL 460.6a, if the costs are reasonable and prudent and meet the utility systems resource cost test.”¹⁴ 2008 PA 295, as amended, also directs that “The commission shall allow a provider whose rates are regulated by the commission to recover the actual costs of implementing its approved energy waste reduction plan. ... Furthermore, costs for load management undertaken by an electric provider pursuant to an energy waste reduction plan are not recoverable as energy waste reduction program costs under this section, but may be recovered as described in section 95.”

UPPCO is an electric provider “whose rates are regulated by the commission and whose rates include the cost of advanced metering infrastructure” and is there obligated to offer commission-approved demand response programs, and may and can only recover the costs for load management through base rates as part of a rate case.

Because load management programs have implications for energy waste reduction and efficient electrification programs, we include recommendations regarding load management programs in our recommended 2026-2029 UPPCO Energy Optimization Plan, with the expectation that UPPCO will make proposals to implement load management programs in future rate cases. We discuss implications of the recommended load management programs in our analysis of efficient electrification and energy waste reduction programs.

¹² MCL 460.1007(f)

¹³ MCL 460.1095(1)

¹⁴ MCL 460.1095(3)

3.1 Load Management Strategy

We are aware that the commission is currently undertaking energy waste reduction, efficient electrification, and demand response potential studies pursuant to Section 6t of 2016 PA 341, as amended. But, as those studies will not be available timely for consideration in relation to UPPCO's 2026-2029 Energy Optimization Plan, we rely on the commission's 2021 Energy Waste Reduction and Demand Response Potential Study¹⁵ for guidance in formulating and recommending a load management strategy for UPPCO. As that study includes specific analyses and recommendations for Michigan's Upper Peninsula, a portion of which UPPCO serves, we focus principally on those aspects of the study.

UPPCO's load is relatively even across the year and its annual peak loads are sometimes in summer and sometimes in winter. The commission's 2021 Demand Response Potential Study results focus on summer demand response for electric demand response and do not present winter demand response results. Since costs of a year-round demand response program will likely not be materially greater than one focused on summer demand, and benefits that will accrue from winter demand response will be additive to the benefits from summer demand response, we assume that a year-round UPPCO demand response program will have greater benefits and a more favorable benefit-cost ratio than is presented in the commission's 2021 Demand Response Potential Study.

The commission's 2021 Demand Response Potential Study includes¹⁶ the following table that summarizes the study's analyses of demand response options for the Upper Peninsula:

¹⁵ Guidehouse. 2021. Michigan Demand Response Statewide Potential Study (2021-2040), available from https://www.michigan.gov/mpsc/-/media/Project/Websites/mpsc/workgroups/potential_studies_2021/MI_DR_Statewide_Potential_Study_Report_-_Final.pdf.

¹⁶ Ibid, p 9

Table ES-5. Benefit-Cost Ratio Comparisons by Scenarios of DR Options (Electric) for Upper Peninsula (Summer)

DR Option	Reference	Aggressive	Carbon Price
UCT Benefit-Cost Ratio (2021-2040)			
Real Time Pricing (RTP)	16.9	11.3	16.9
Time-Of-Use (TOU)	11.7	11.4	11.6
C&I Demand Bidding	3.8	3.1	3.8
Critical Peak Pricing (CPP)	3.0	2.9	3.0
C&I Capacity Reduction	2.7	2.4	2.7
Voltage Optimization	1.4	1.4	1.4
Bring Your Own Thermostat (BYOT)	1.3	1.1	1.3
Behavioral DR	1.1	1.1	1.1
Peak Time Rebate (PTR)	1.0	0.8	1.0
Behind the Meter (BTM) Battery Dispatch	0.7	0.5	0.7
Electric Vehicle (EV) Managed Charging	0.6	0.5	0.6
Direct Load Control-Switch (DLC)	0.5	0.4	0.5
Smart Appliances Control (Bring Your Own device)	0.2	0.2	0.2
Thermal Energy Storage (TES)	0.1	0.1	0.1

Source: Guidehouse analysis

Amongst the options presented in this table, Real-Time Pricing, Time-of-Use pricing, Critical Peak Pricing, and Peak Time Rebate all concern rate design. Peak Time Rebate has a marginal benefit-cost ratio and is essentially an alternative to Critical Peak Pricing, which has a better benefit-cost ratio. We therefore recommend including rate design in UPPCO’s load management strategy with a focus on Time-of-Use and Critical Peak Pricing.

C&I Capacity Reduction and C&I Demand Bidding target the same large and extra-large C&I customers and are essentially different transactional arrangements by which those customers reduce demand when called upon. UPPCO currently has an interruptible load program that fits within the C&I Capacity Reduction category of the commission’s 2021 Demand Response Potential Study. We therefore recommend continuing UPPCO’s interruptible load program, with considerations for improvement.

Voltage optimization entails utility control of voltage (and reactive power) in its distribution system. Voltage optimization can provide system-wide demand reduction to avoid power supply costs and capacity requirements but can also provide local distribution system benefits. Implementation of voltage optimization is done within distribution system operations. We therefore recommend that UPPCO consider voltage optimization in its next distribution system plan and, if appropriate, request commission approval in a future rate case.

The remaining demand response measures included in the commission’s 2021 Demand Response Potential Study ask customers to behaviorally or through automation reduce demand at times “called” by the utility. According to the

commission’s 2021 Demand Response Potential Study, some but not all measures of this type meet the utility resource cost test. Our view is that these measures should be orchestrated in a unified program, which we label as Flexible Load Optimization, and that individual measures should be included in such an overall program based on the utility resource cost test. The development of a Flexible Load Optimization program will be a gradual undertaking, which we recommend that UPPCO begin through a pilot program to be proposed in a future rate case.

3.2 Cost-Reflective Rate Design

UPPCO currently uses rate schedules as follows, where the number of customers and annual electricity sales are taken from UPPCO’s as-authorized Cost of Service Study in its last rate case, No U-21555:

Base Schedule	Tariff Name	Annual Average Customers	Annual Electricity Sales kWh at Meter
A-1	Residential Service – Urban and Rural	44,725	226,281,119
AH-1	Residential heating Service – U & R	2,739	22,582,841
C-1	General Service – U & R, demand <= 25kw	5,210	60,352,136
H-1	Commercial Heating Service – U & R, demand <= 25kw	202	6,036,344
P-1	Light and Power Service – U & R. 25kW < demand <=200kW	479	77,480,613
CP-U	Large C&I – CP, demand > 200kW	52	164,436,036
WP-3	Light and Power Service, demand >5000kW	5	98,721,468
RTMP	Real-Time Market Pricing	1	Not included in COSS
SL-3	Street Lighting Service, self-owned lights	71	372,335
SL-5	Street Lighting Service, Self-owned lights dusk to dawn	9	20,156
SL-6	Street Lighting Service, UPPCO lights dusk to dawn	199	1,463,179
Z-3	Dusk to Dawn Outdoor Security Lighting	1463	443,839
Total	(excluding Z-3 light count)	53,692	659,190,066

All of these rate schedules have monthly per-customer charges except SL-5, SL-6, and Z-3 that instead have pole and conductor span charges. Rate schedules P-1, CP-U, and WP-3 have demand and energy charges; all other rate schedules have energy charges but not demand charges. Demand charges are based on customer monthly maximum demand, but CP-U and WP-3 demand charges are subject to a 12-month ratchet. The RTMP customer pays actual locational marginal prices as determined by MISO in 5-minute intervals, actual MISO charges for transmission service to the RTMP’s dedicated substation, and modest administrative charges; the RTMP load is considered interruptible and does not pay capacity-related charges.

We recommend as a core load management strategy that UPPCO change the design of these rate schedules to be reflective of the cost allocators used in the cost of service study. Such rate designs will provide price signals and

incentives to customers that align with the causes of UPPCO’s costs, as determined by the commission through its approval of the cost of service study.

Higher rates at the times that drive UPPCO’s transmission charges from MISO and that determine UPPCO’s resource adequacy requirements will induce customers to reduce load at those times (mostly by shifting to lower cost times) and will thereby reduce UPPCO’s overall revenue requirements. Lower rates at other times will encourage shifts of load to those lower-cost times. The availability of lower-cost times for electricity uses such as electric vehicle charging and space heating will aid adoption of such electricity uses. Pricing that reflects UPPCO’s costs patterns will also shift the relative bill savings due to various energy waste reduction measures and thereby encourage adoption of the most cost-effective measures.

3.2.1 Seasonality of Distribution Costs

Seasonal distribution rates that reflect the joint effects of ambient temperatures and load on equipment (especially transformer) aging, hence revenue requirements, of distribution system components will encourage energy waste reduction measures that reduce summer loads and aid the efficient electrification of space heating.

Usefully, seasonal distribution rates will also reduce the bills of year-round customers and increase the bills of part-year summer and fall customers, improving on a long-standing situation in which year-round customers pay bills that generally exceed their cost of service, and part-year customers pay bills that are generally less than their cost of service.

New rate designs will need to be adopted in a rate case, in which UPPCO may change its cost of service allocators and in which costs will certainly have changed. Nonetheless, we illustrate rate designs based on our principles using the as-authorized cost of service study from UPPCO’s last rate case, No. U-21555 to clarify our recommended approach to rate design and to obtain hypothetical rate schedules that we use in some of our analyses of efficient electrification measures and energy waste reduction measures.

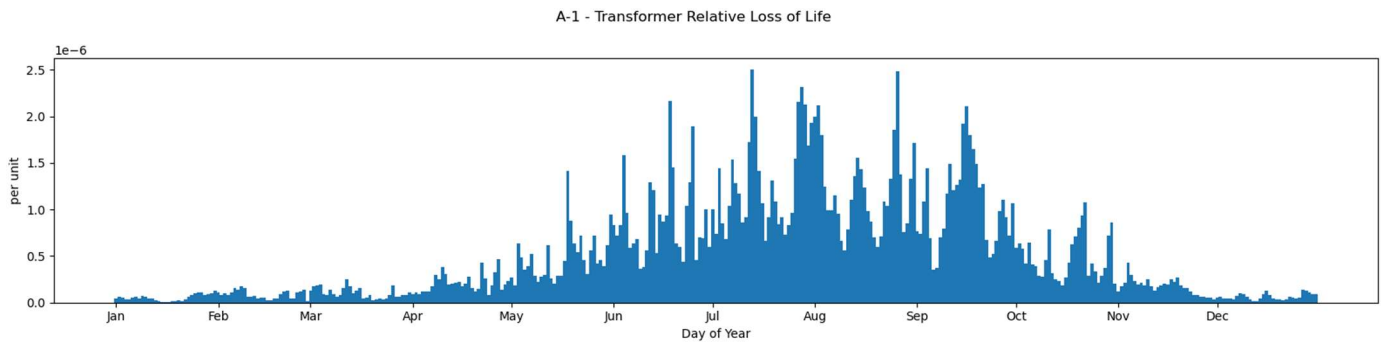
UPPCO’s heating service rate schedules, AH-1 and H-1, are seasonal with ordinary rates that match A-1 and C-1, respectively, in the months of June through September and with special rates in the months October through May

	kWh per Customer	
	A-1	AH-1
January	492	1,035
February	469	1,062
March	479	1,021
April	454	917
May	381	618
June	375	418
July	392	350
August	380	387
September	369	375
October	419	571
November	392	707
December	457	784
Annual	5,059	8,245

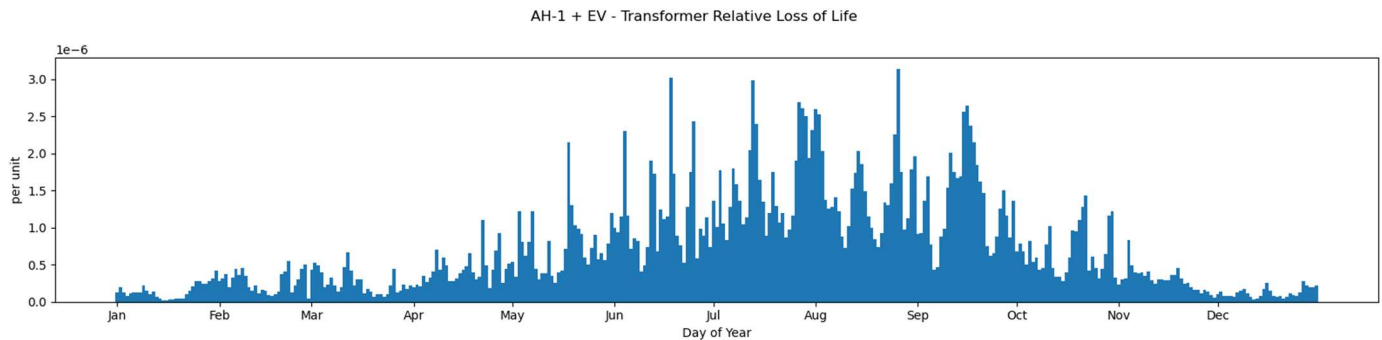
for customers that use electric heat. The following table shows monthly kWh sales at the meter, per customer, for rate schedules A-1, AH-1 based on random samples of 8760 profiles of customers from those rate schedules, normalized to the rate schedule annual average sales.

The months of June through September are similar between the two rate schedules while in the months October through May, customers in rate schedule AH-1 consume significantly more kWh, in a pattern consistent with seasonal temperatures.

Broadly, in distribution systems capacity is determined by thermal limits of system components, especially transformers.¹⁷ Thermal limits are based on thermal aging, the rate at which the component deteriorates with use. To assess the seasonality of aging in the distribution system, 5 Lakes Energy modeled aging based on the IEEE Standard C57.91-2021 Guide for Loading Mineral-Oil-Immersed Transformers, both for typical UPPCO loads and for hypothetical loading after customers adopt both electric space heating and electric vehicles. Although we modeled by residential and commercial customers, the results were very similar, so we only present residential customer transformer ageing here. The relative aging rate by day of the year for UPPCO’s common residential customers who do not have either electric space heating or an electric vehicle is as follows:



Adding both electric heat and electric vehicles leads to the following profile or relative ageing rate by day of the year:



¹⁷ Protection devices may actually be limiting but usually based on the thermal limits of transformers or conductors.

In both scenarios, most aging occurs during what we recommend as the Summer season, warranting higher rates during the Summer season than during the recommended Heating Season.

3.2.2 Pattern of Transmission Peaks

UPPCO is charged for transmission services by MISO based principally on UPPCO’s load in the hour of each month when the ATC transmission network that serves UPPCO and eastern Wisconsin experiences its peak load of the month. The following table shows the frequency that each hour of the day, in Eastern Standard Time, was the peak load in the ATC transmission network during the years 2018 through 2023. Although not shown in the table, all of these occurrences were on weekdays.

	Count of Hours in EST of ATC Monthly Peak Demand 2018-2023									
	HE 8	HE 9	HE 10	HE15	HE16	HE 17	HE 18	HE 19	HE 20	HE 22
January		4							2	
February		3	2						1	
March	2	2							1	1
April	4					1	1			
May					3	3				
June					1	5				
July				1	1	4				
August				1	3	2				
September					2	4				
October	1				1	4				
November		4							2	
December		4						2		
Annual	7	17	2	2	11	23	1	2	6	1

In the months May through October, ATC peaks occurred mostly in the hours ending 16 and 17 EST, corresponding to the periods 4pm to 6pm Eastern Daylight Time, which prevails during those months. Additional peaks and near peaks in these months occur mainly in the hour ending 15 EST, corresponding to the hour 3pm-4pm EDT. Thus, for UPPCO’s incurrence of transmission costs in the months May through October, the period 3pm to 6pm EDT accurately encompasses peak demand.

In the months November through April, ATC peaks occurred mostly in the hours ending 8 and 9 EST, and in the hours ending 19 and 20 EST, although in April the ATC peaks that were not in the morning were in late afternoon in the hours ending 17 and 18 EST. It is notable that the occurrence of ATC peaks during the hour ending 8 EST are in late March, April and October when that hour is the hour ending 9 Eastern Daylight Time. Thus, for UPPCO’s incurrence of transmission costs in the months November through April, the periods 7am-9am and 6pm-8pm prevailing time accurately encompass peak demand, with the exception of April when the afternoon peak periods occur 3pm-5pm prevailing time.

3.2.3 Pattern of Resource Adequacy Peaks

UPPCO is required to demonstrate zonal resource credits sufficient to cover its expected load and a reserve margin during MISO’s peak load hours in each of four seasons, Summer (June through August), Fall (September through November), Winter (December through February), and Spring (March through May). The method used to calculate a utility’s required resource credits is to forecast the utility’s peak load during each season with equal probabilities of actual load being less than or greater than the forecast, then multiply that load by the utility’s historical ratio of load at MISO’s peak hour to load at the utility’s peak hour. Thus, it is loads at MISO peak hours that, in the long run, determine the utility’s zonal resource credit obligation.

As part of MISO’s annual cycle of analysis to determine the resource adequacy obligations of its member load-serving entities, MISO determines accreditation for wind and solar generation based on their generation during the 8 coincident system unique-day peak hours for each of the last 3 planning years. These are listed in the Wind and Solar Capacity Credit Report,¹⁸ making that report a convenient source of identified MISO peak demand hours that are likely to determine UPPCO’s resource adequacy obligations. The following table shows the frequency that each hour of the day, in Eastern Standard Time, was the peak load in each of MISO’s resource adequacy seasons during the years 2022 through 2024. Although not shown in the table, all of these occurrences were on weekdays.

	Count of Hours in EST of MISO Seasonal Peak Demand 2022-2024										
	HE 7	HE 8	HE 9	HE 13	HE 14	HE 15	HE 16	HE 17	HE 18	HE 19	HE 20
January		7	3				1			5	
February		3	1								
March	2										
April											
May						2	11	8	1		
June						1	2				
July						1	10	1			
August						2	6	1			
September				1	1	2	17	1			
October							2				
November											
December			1						2		1
Annual	2	10	5	1	1	8	49	11	3	5	1

On the basis of this information, MISO determined that the relevant hours for solar capacity accreditation are the hours ending 15, 16, and 17 EST for Spring, Summer, and Fall (March through November) and the hours ending 8, 9, 19, and 20 EST for Winter (December through February). Had MISO considered designating hours by month rather

¹⁸ MISO’s Planning Year 2025-2026 Wind and Solar Capacity Credit Report may be found at <https://cdn.misoenergy.org/PY%2025-26%20Wind%20and%20Solar%20Capacity%20Credit%20Report684294.pdf>.

than season, they presumably would have identified the relevant hours as the hours ending 15, 16, and 17 EST for the months May through October, the hours ending 8, 9, 19, and 20 EST for the months December through March with April and November indeterminate.

3.2.4 Recommended Designation of Seasons and Peak Hours for Rate Design

Although it would be possible to design rates that are directly reflective of the seasonality of space heating load and of distribution system capacity utilization, monthly hours when UPPCO incur transmission charges, and the seasonal hours that determine UPPCO's resource adequacy obligations, the result would be complicated for customers and therefore less likely to lead to systematic response. We therefore recommend that rate design be based on seasons and peak hours that are simpler but reasonably effective in signaling high-cost times to customers.

As a general structure, we recommend using two seasons in rates, which we broadly designate as Heating Season and Summer. Distribution rates would be established by season and the hours during which rates would be elevated due to causing transmission or resource adequacy costs would be consistent within each of these seasons.

There is a seeming strain between the heating season perspective embodied in UPPCO's current heating service rate schedules as October through May, and the seasonality of transmission and resource adequacy peaks, in which May and October look more similar to the summer months of June through September. Closer examination of the underlying data suggests that using May 16 through October 15 as Summer and October 16 through May 15 as Heating Season would nearly eliminate this tension and align with the underlying patterns.

We therefore recommend that UPPCO's rate designs be constructed with Summer rates from May 16 through October 15, with peak hours identified as weekdays 3pm – 6pm Eastern Daylight Time, and with Heating Season rates from October 16 through May 15, with peak hours identified as weekdays 7am-9am and 6pm-8pm.

3.2.5 Representative Residential and Small Commercial Rate Design

To illustrate cost-reflective rate design for residential and small commercial customers we calculate alternative rate design based on UPPCO's as-approved cost-of-service study from Case No U-21555 and the same revenue responsibility per rate schedule that was implemented in that case, adjusted to the 2023 load profiles available from UPPCO's AMI data. We retain the as-approved monthly service charges. We proceed in two steps. In the first step, we calculate seasonal distribution rates. In the second step, we calculate critical peak hours rates and correspondingly reduced rates for other hours.

After careful review of the allocators used to assign costs to rate schedules in U-21555, we determined that the distribution function costs assigned based on class non-coincident peaks should be incorporated only into Summer distribution rates and that distribution function costs assigned based on load-serving entity 12 coincident peak and per customer should be incorporated into year-round distribution rates. This leads to minor differences in calculated Summer rates between rate schedule A-1 and AH-1 and between C-1 and H-1, due to minor statistical variations.

Because A-1 and AH-1 customers have similar Summer loads, are well mixed geographically and share facilities, and similarly because C-1 and H-1 customers have similar Summer loads, similar geography and facilities, we set the Summer rates equal between A-1 and AH-1 rate schedules and also between C-1 and H-1 rate schedules. We then calculate Heating Season rates to recover the balance of each rate schedule’s revenue responsibility.

Following UPPCO’s past practice we continue to use a Heating Season declining block structure for AH-1 with a first block of 500 kWh per month and for H-1 with a first block of 1000 kWh per month. We also follow UPPCO’s past practice and set equal prices for A-1 Heating Season and for the first block of AH-1 during Heating Season and set equal prices for C-1 Heating Season and for the first block of H-1 during Heating Season. We then adjust the rates for the second blocks of AH-1 and H-1 to meet revenue responsibility for these rate schedules.

The following table compares current tariff rates to the seasonal distribution rates that we would recommend based on the U-21555 cost-of-service study and continued use of a declining block structure:

Distribution Rate Block (\$ per kWh)	A-1	AH-1	C-1	H-1
Current Annual Energy Rate	0.13567	0.13567	0.16047	0.16047
Current Heating Season 2nd Block Rate	N/A	0.06783	N/A	0.08024
Proposed Summer Energy Rate	0.164372	0.164372	0.198399	0.198399
Proposed Heating Season First Block Energy Rate	0.118178	0.118178	0.138765	0.138765
Proposed Heating Season Second Block Energy Rate	N/A	0.068457	N/A	0.05943

The principal effects of this rate design strategy are to increase Summer rates and lower Heating Season first block rates. For residential customers there is little change in the Heating Season second block rate but there is a material reduction in the H-1 commercial Heating Season second block energy rate.

An alternative approach would be to discontinue the declining block structure in distribution rates but recognize that the higher energy sales to heating rate customers dilute the costs that are assigned based on customer count but are not included in fixed monthly service charges. This lowers first block Heating Season rates for electric heating customers and raises rates for sales that would have been in the second block. This change in rate design will favor heat pump customers compared to electric resistance customers, because heat pump customers do not use as much second-block power as electric resistance customers. The following table compares current tariff rates to the seasonal distribution rates that we would recommend based on the U-21555 cost of service study but with discontinued use of a declining block structure.

Distribution Rate Block (\$ per kWh)	A-1	AH-1	C-1	H-1
Current Annual Energy Rate	0.13567	0.13567	0.16047	0.16047
Current Heating Season 2nd Block Rate	N/A	0.06783	N/A	0.08024
Proposed Summer Energy Rate	0.164372	0.164372	0.198399	0.198399
Proposed Heating Season First Block Energy Rate	0.118178	0.096661	0.138765	0.08837
Proposed Heating Season Second Block Energy Rate	N/A	N/A	N/A	N/A

UPPCO’s U-21555 cost-of-service study allocates substantial production and transmission costs to rate schedules based on rate schedule class contributions to ATC transmission peaks and MISO resource adequacy. In current rate

designs for residential and small commercial customers, those costs are recovered through energy (kWh) rates that are uniform in time either annually or seasonally and consequently do not provide price signals to customers about when their use of power causes costs. We therefore construct proposed new rate designs by allocating coincident peak costs to the hours during which peaks occur, as discussed above, and allocating the remaining costs to the remaining energy. Because UPPCO’s production and transmission coincident peak cost allocators are 12CP, we do not differentiate by season. Because the relevant peaks are coincident with much larger load aggregations of which UPPCO is a small part, shifts in UPPCO load will not change the timing of those peaks and we do not consider buffering the time periods during which higher prices are applied.

Applying these principles and calculations to UPPCO’s rates based on the U-21555 cost-of-service study results in excess revenue from heating customers based on the Summer and Heating Season first block rates and quantities that match non-heating customers, even if second block rates are zero. We therefore drop the declining block rate and show a constant rate for the Heating Season non-peak hours:

Production and Transmission Rate Block (\$ per kWh)	A-1	AH-1	C-1	H-1
Current Annual Energy Rate	0.0919	0.0919	0.09568	0.09568
Current Heating Season 2nd Block Rate	N/A	0.04595	N/A	0.04784
Proposed Peak Hours Premium	0.4615513	0.46155135	0.4968606	0.4968606
Proposed Year-Round First Block Energy Rate	0.035177	0.0199787	0.0351766	0.0170419
Proposed Heating Season Second Block Energy Rate	N/A	N/A	N/A	N/A

Note that the Peak Hours Premium would be added to the underlying block rates based on usage during the peak hours. So, in this instance the A-1 rate during peak hours would be \$0.49673 per kWh.

This rate design is directly related to the cost-of-service study and only includes variable UPPCO expense in the peak period premium and therefore provides accurate price signals. However, the Peak Hours Premium is very high and the First Block rates charged at other times are very low compared to current rates, which warrants implementation caution. Further, while the peak hours that determine UPPCO’s coincident peak charges will not change as a result of any response by UPPCO customers, the projected change in resource mix in MISO is likely to change within a few years the Resource Adequacy hours that determine UPPCO’s generation capacity requirements.

We therefore evaluated an approach similar to the preceding table but in which only transmission costs are reallocated to peak hours. Although a declining block rate is technically feasible in this case, the difference between the first and second blocks is minimal, so we again drop the declining block rate and show a constant rate for the Heating Season non-peak hours:

Production and Transmission Rate Block (\$ per kWh)	A-1	AH-1	C-1	H-1
Current Annual Energy Rate	0.0919	0.0919	0.09568	0.09568
Current Heating Season 2nd Block Rate	N/A	0.04595	N/A	0.04784
Proposed Peak Hours Premium	0.17814	0.17814	0.11588	0.11588
Proposed Year-Round First Block Energy Rate	0.070007	0.055003	0.081569	0.062377
Proposed Heating Season Second Block Energy Rate	N/A	N/A	N/A	N/A

Again, the Peak Hours Premium would be added to the underlying block rates based on usage during the peak hours. So, in this instance the A-1 rate during peak hours would be \$0.27004. This level of contrast between Peak Hours and Non-Peak Hours is likely an acceptable level of change as an initial step toward a load management rate design, so we recommend it be considered in a near future rate case.

If we combine seasonal distribution rates with peak and non-peak production and transmission rates based on only allocating transmission costs to peak hours, we get the following overall rate design:

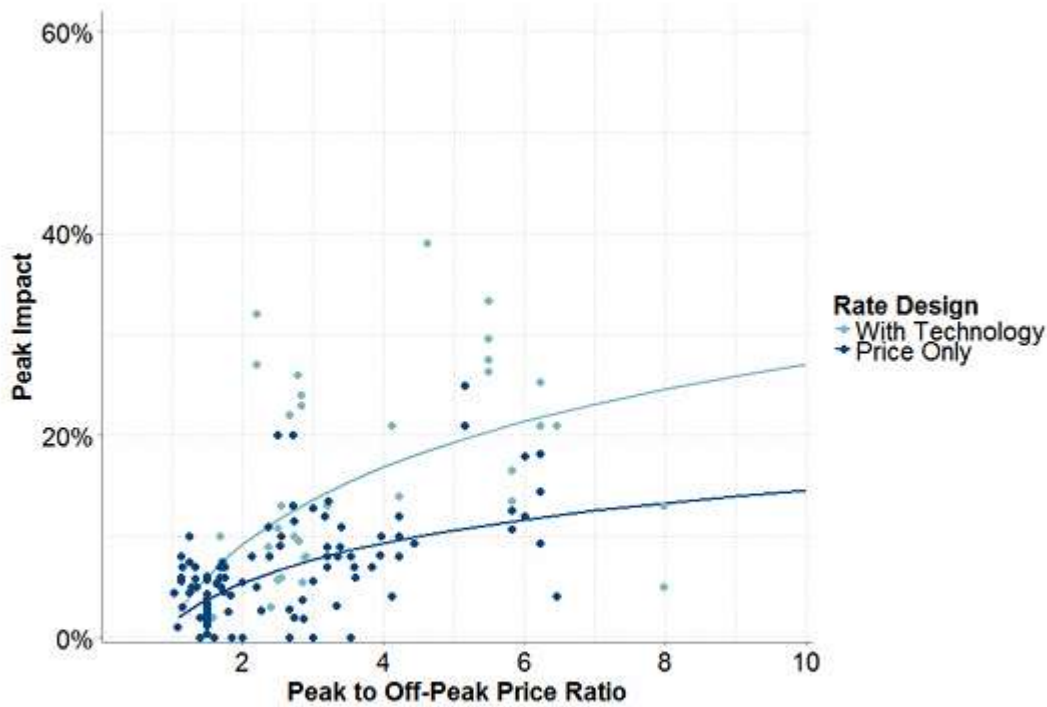
Load Management kWh Rate (\$ per kWh)	A-1	AH-1	C-1	H-1
Current Annual Energy Rate	0.22757	0.22757	0.25615	0.25615
Current Heating Season 2nd Block Rate	N/A	0.11378	N/A	0.12808
Proposed Summer Base Rate	0.23438	0.21937	0.27997	0.26078
Proposed Summer Peak Hours Rate	0.412521	0.397517	0.395847	0.3766544
Proposed Heating Season Base Rate	0.188185	0.151664	0.220334	0.150747
Proposed Heating Season Peak Hours Rate	0.366327	0.3298067	0.336213	0.266626

Actual rates developed with this approach in future rate cases will differ because the costs allocated according to peak and non-peak statistics will change.

Rate differentials in which peak hour rates for a few hours are approximately twice the rates applied during many non-peak hours have been well demonstrated to effectively shift demand away from peak hours. The following graph summarizes a large number of time-of-use pilot projects and implementations compiled by Brattle Group¹⁹:

¹⁹ Available from [A Survey of Residential Time-Of-Use \(TOU\) Rates](#)
 2026-2029 UPPCO Energy Optimization Plan

Relationship Between Price Response and Price Ratio



Sources and notes: Arcturus, a Brattle database of customer response to time-varying rates. Arcturus includes international TOU pilots (15 of 38 TOU pilots in the database).

We therefore expect that implementing these load management rate designs without supporting technology would reduce UPPCO’s coincident peak demands by the affected rate schedules by approximately 6%, while broad implementation of supporting technology would increase this to approximately 9%. A 6% reduction in residential and small commercial customer peak demands would correspond to a reduction of UPPCO’s annual peak demand by approximately 3.8 MW and a reduction of average monthly peak demand by about 3.4 MW. A 9% reduction in residential and commercial customer peak demands would correspond to a reduction of UPPCO’s annual peak demand by approximately 5.7 MW and a reduction of average monthly peak demand by about 5.1 MW.

The following table illustrates the annual savings to UPPCO per customer in the residential and small commercial customer rate schedules that would result from this load management strategy, based on the costs used in Case No. U-21555. The cost reductions would, of course, be passed through to customers as they were realized.

	A-1	AH-1	C-1	H-1
Savings from Load Management Tariff	\$ 32.43	\$ 53.29	\$ 85.00	\$ 201.04
Savings from Load Management Tariff w/Technology	\$ 48.64	\$ 79.93	\$ 127.50	\$ 301.56

If at a later time, UPPCO implements a rate design strategy that further increases the price difference between on-peak and off-peak rates, these savings will further increase. In the analysis above in which both transmission and resource adequacy 12 CP costs are recovered through peak hours prices, the Brattle Group graph suggests peak savings of 15% to 28% of current peak demand and costs with corresponding increases in savings to customers.

We discuss load management technology to be used in conjunction with the load management tariff in a later section.

3.2.6 Representative Rate Design with Demand Charges

In UPPCO's existing rate schedules that use demand charges, all of the costs that are allocated to the rate schedule in the Case No U-21555 as-approved cost-of-service study based on peak-time allocators are recovered through demand charges. In addition to the load management tariff for residential and small commercial customers discussed above, we make recommendations regarding rate schedules P-1, CP-U, and W-3 that include demand charges.

As a general rule, demand charges are less effective in signaling costs to customers than are time-of-use or dynamic rates²⁰ for two reasons. First, most costs recovered through demand charges relate to utility or grid peaks and charging those costs on customer peaks that may not be coincident with system peaks fails to signal to customers when it would be valuable to avoid load. Second, because a demand charge is based on a monthly peak, or with a ratchet an annual peak, at most times the incentive to the customer is to not have demand exceed the previous peak rather than to reduce demand at subsequent system peaks. Nonetheless, because these customers are familiar with managing demand we recommend a step forward in load management based on demand charges.

We recommend that in all three of UPPCO's rate schedules that use demand charges, demand charges for production, which encompass transmission costs and generation capacity costs, be based on demand during the seasonal peak hours identified above – 3pm to 6pm Eastern Daylight Savings Time in Summer weekdays and 7am to 9am and 6pm to 8pm Prevailing Time during Heating Season weekdays.

If monthly demand for an individual customer happens to fall within these peak hours, then the billed demand will be unchanged for that customer in that month. On the other hand, if the monthly demand for an individual customer happens to fall outside these peak hours, the demand during the peak hours will be smaller, and the billed demand will be reduced. Thus, to collect the same revenue with this reduced billed demand, demand rates will need to be larger. Based on data for a limited sample of P-1 customers, we estimate that billed demand will be approximately 14% lower if based on only peak hours compared to current practices, which will require a billed demand price approximately 16% higher than current rates to produce the same revenue. This increase in rates for billed demand will not increase average customer bills if they make no change in operations. However, the concentration of demand charges during peak hours should enable customers to plan and schedule operations so as to more effectively avoid demand during these peak hours than they are currently able to avoid monthly demand.

²⁰ Regulatory Assistance Project. 2020. Demand Charges: What Are They Good For?, available from <https://www.raponline.org/knowledge-center/demand-charges-what-are-they-good-for/>.

That avoidance will reduce UPPCO's transmission and resource adequacy costs and offset any loss of revenue through this avoidance.

Rate schedules CP-U and W-3 both use annual demand ratchets. While these ratchets provide bill predictability for both the customer and UPPCO, they significantly dull any incentive the demand charge has to avoid costs. This will be even more the case and more consequential if billed demand is based on demand during peak hours. We therefore recommend discontinuing the demand ratchets for rate schedules CP-U and W-3 as part of rate design structured for load management.

Customers in rate schedule P-1 have annual demand between 25kW and 200 kW, while customers in rate schedules CP-U and W-3 have higher demand. Since P-1 customers have peak demand that is only a modest share of substation load, and substation load is relatively synchronous with transmission and resource peak hours, we recommend also using only demand during peak hours to determine distribution billing demand. CP-U and W-3 customers may use significant distribution system capacity, so it may be appropriate to retain monthly demand in all hours as the billing demand for distribution demand charges; we leave this issue to be resolved by UPPCO in future rate cases.

There is little literature of studies of actual response to focused demand charges of the kind we recommend. However, we believe the effect will be similar to that of critical peak pricing. The Commission's 2021 Demand Response Potential Study shows demand reduction in the C&I segment, due to large and extra-large commercial and industrial customers that is approximately as large as demand reduction in the residential and small commercial classes although these classes' share of firm demand is about 40% in the Upper Peninsula.

3.3 Interruptible Load Program

UPPCO currently utilizes two separate interruptible load programs, which are reliant upon participation of UPPCO's larger industrial customers. First, the CP-I program allows participating customers to voluntarily nominate a firm demand level. In exchanges for discounted demand charges applied to participating accounts, the customers must agree to reduce their demand to their nominated firm service level when called upon for an emergency interruptible event by UPPCO, the MISO, or ATC. Additionally, the CP-I program includes provision for an "economic interruption event", whereby under specific market conditions, UPPCO may call an economic interruption event, and the customers may choose to either reduce their demand during the affected times to their firm service level, or "buy-through" and be billed directly for all costs of incremental energy and market fees that their actions caused the Company to incur. Any revenue received from an event where the CP-I participating customers "buy-through" an economic interruption event is credited against PSCR costs, thereby ensuring that nonparticipating customers are not incurring any incremental costs relating to the CP-I customer actions.

Second, UPPCO's RTMP tariff specifies that all load served under this tariff is 100% interruptible under emergency conditions as defined by UPPCO, the MISO, or ATC.

UPPCO registers both of these programs as Load-Modifying-Resources ("LMR") for the purposes of satisfying its capacity obligations at MISO. The ZRC's accredited to these programs varies from year to year, based upon observed

and anticipated load at critical time intervals, but for the purposes of the IRP modeling contained in this filing, it is assumed that the CP-I program provides approximately 15 MW (or, ZRCs) of capacity, and the RTMP program provides approximately 23 MW (or, ZRCs) of capacity. No appreciable energy-requirement related benefits exist as a result of UPPCO offering these demand response programs; the benefit is limited to the need to purchase or otherwise obtain additional capacity resources to meet the Company's total resource adequacy obligations.

These programs are sizable relative to UPPCO's overall load and are in alignment with the Commission's demand response potential study identification of highly effective demand response programs.

We do not recommend changing these programs at this time. However, if UPPCO implements our recommendations concerning rate design for rate schedules with demand charges, some degree of revision and reform of the existing CP-I program will be required. Under our recommendations, production demand charges will be based on demand during identified peak hours, which we currently identify as 7am to 9am and 6pm to 8pm prevailing Eastern time during Heating Season and 3pm to 6pm prevailing Eastern time during Summer. Thus, if a called emergency falls outside of these identified peak hours, there will be no demand charge under the regular tariff and exemption from that demand charge will be of no value. We recommend that participants in the CP-I tariff be subject to demand charges during called emergency and economic demand reduction events as well as during the static peak hours.

Additionally, we note that UPPCO's production demand charges encompass costs that include both generation capacity and transmission costs. Transmission costs are incurred by UPPCO for interruptible customers based on the demand they have during the ATC monthly peaks, regardless of whether that load is interruptible. Only generation capacity requirements are avoided by interruptible load. It would be appropriate to limit the avoided demand charges for CP-I customers to the portion of demand charges that are related to generation capacity while continuing demand charges for transmission costs on interruptible load during the static peak hours in the regular tariff. This type of change may reduce participation in the CP-I program, so it should likely be taken in conjunction with implementing load management tariffs that will serve to reduce capacity requirements.

3.4 Voltage and VAR Optimization

Voltage and VAR (reactive power) Optimization involves utility management of voltage in its distribution system in order to reduce demand at all times or at selected times. Sensors in the distribution system which can be customer meters, controlling software, line voltage regulators, and capacitor banks are integrated to accomplish this. Voltage and VAR management can provide cost-effective reduction of energy and capacity requirements in some circumstances and can be operated separately by circuit to meet local needs. Since this Plan is principally about customer programs and voltage and VAR optimization technology is primarily a distribution system function, we defer further consideration of voltage and VAR optimization to a future UPPCO distribution system plan.

3.5 Flexible Load Optimization

Above, we recommend that UPPCO adopt tariffs that provide load management price signals and incentives to customers. As noted in that analysis, significant demand shifting from on-peak to off-peak hours can be expected based on the tariff alone, presumably mostly through customer behavioral adjustments. However, additional shifting

will occur with appropriate automation. Almost all of the “technology” in the Brattle analysis of time-of-use rates was programmable or intelligent thermostats that could be programmed either to accept broader temperature ranges in specified hours or to optimize operations based on a price schedule.

The load management tariffs we recommend above are static but there can be additional value in “real-time” price signals that go beyond informing the customer that peaks usually occur on weekdays in Summer between 3pm and 6pm Eastern Daylight Time on weekdays during Heating Season between 7am and 9am and between 6pm and 9 pm and further signal customers or customer devices that particular hours on particular days will or are likely to be transmission peaks or power supply tight hours that it would be beneficial to reduce. We recommend that UPPCO begin developing a Flexible Load Optimization program that will support automated observance of time of use rates and would also support automated response to “called” events.

Expenditures that are solely for load management will need to be addressed in a rate case, but some elements of this strategy can be achieved by placing technical requirements on energy waste reduction and efficient electrification measures. In particular, we recommend that device readiness to participate in Flexible Load Optimization should in some cases be a condition for providing or rebating those devices in the energy waste reduction or efficient electrification programs.

To identify the best opportunities to automate flexible loads, we examined the end-use profiles for residential customers in UPPCO’s service territory using the ResStock profiles discussed in the Efficient Electrification section of this Plan.

Considering particularly the peak hours recommended above, we find that about 5% of residential electricity use in peak hours of both Summer and Heating Season is for appliances such as clothes washers, clothes dryers, and dishwashers that are readily scheduled to operate outside peak hours behaviorally and for which systematic automation is challenging since it depends on product features and there are generally not control add-ons or replacements available for purchase.

Approximately 27% of Summer peak hour residential electricity and about 28% of Heating Season peak hour residential electricity consumption is for cooling or heating, including both electric heat and electric fans used with fossil-fueled heat. Contributions of these weather-sensitive loads are likely significantly higher at actual transmission peak or supply tight hours. Space heating and cooling loads are susceptible to shifting without any or much effect on occupant comfort when the time period for load reduction is short. Intelligent thermostats can pre-heat or pre-cool before the targeted hours and then not initiate heating or cooling until either the end of the peak hours or when building internal temperature reaches the lower limits of comfort. Many such programmable thermostats are often also intelligent and can set back temperatures based on lack of occupancy, which typically leads to net energy savings. In order for these devices to participate in future “called” events, these thermostats would need to be able to receive communications about those events.

As heat pumps are installed through electrification programs or market activity, most such equipment comes with proprietary thermostatic controls that have varying capabilities and may not be readily incorporated into a communications-based Flexible Load Optimization program. But, most have some capability for scheduling temperature settings.

Approximately 10% of Summer peak hours residential electricity and approximately 8% of Heating Season peak hours residential electricity are currently used for water heating. Electrification programs and market development may increase this. Manual control of water heating is difficult, though behavioral avoidance of some hot water use is possible. Water heating is generally very automatically controllable for a few hours without interfering with occupant uses of hot water. Tanked hot water can meet most short-term needs without heating replacement water until after the end of the peak hours. Many new water heaters have built-in capability to schedule heating quiescence during fixed high-priced hours, and some have the ability to accept communications. Retrofit controls are available for most hot water heaters. Water heater control communications are generally compliant with an open standard protocol, ANSI/CTA-2045-A, and availability of water heaters compliant with that standard is sufficient that it can be a required feature of rebate programs. We therefore recommend inclusion of this standard as a condition of water heater rebates in both the Energy Waste Reduction and Efficient Electrification programs.

Electric vehicles are not yet abundant in UPPCO's service territory, but when present are significant electricity load and, with the exception of fast charging during highway trips, are highly manageable. At higher penetrations, some degree of management beyond driver response to time-of-use rates will become necessary. Most vehicles and chargers already provide some level of scheduling controls. At present, no specific technology intervention is needed in support of future Flexible Load Optimization.

Other residential end-uses of electricity that are prominent in UPPCO's service territory are generally not flexible without affecting customer value.

Overall, we recommend that in addition to proceeding to adopt load management tariffs, UPPCO begin requiring that space heating and cooling equipment and water heaters be programmable to minimize use of power during static, seasonal peak hours. As shown above, we expect that with load management tariffs like those we suggest, automation will accomplish additional utility savings over the load management rate schedules alone.

We further recommend that UPPCO begin promoting end-use technologies that will support future Flexible Load Optimization, specifically including intelligent communicating thermostats and water heaters compatible with ANSI/CTA-2045-A. When UPPCO is prepared to execute communications-based Flexible Load Optimization, the capability to respond to load management communications should become a condition for rebates or other assistance with space heating and cooling equipment and water heaters.

Effective Flexible Load Optimization requires both a communications infrastructure and sophisticated software. We also recommend exploring options for contracting for third-party services to manage flexible load and including a concrete proposal in a future rate case either in conjunction with or subsequent to adopting a load management tariff.

We are recommending a pilot project focused on measured savings within the Energy Waste Reduction program, below. There will be a strong synergy between that project and a Flexible Load Optimization strategy. First, the pilot project will provide processing of metering data to establish baseline usage so that changes can be measured. As part of the pilot project, that baseline analysis will also provide information to support targeted outreach for Energy Waste Reduction measures. Such targeting can also be done to promote load management measures. Further, the measured savings strategy to be developed in the pilot project and then implemented as a program measure for

Energy Waste Reduction can also be applied to participants in Flexible Load Optimization such that participant bill reductions can be based on actual individual performance. This approach should be incorporated into the recommended future Flexible Load Optimization proposal in a future rate case.

3.6 Load Management Recommendations

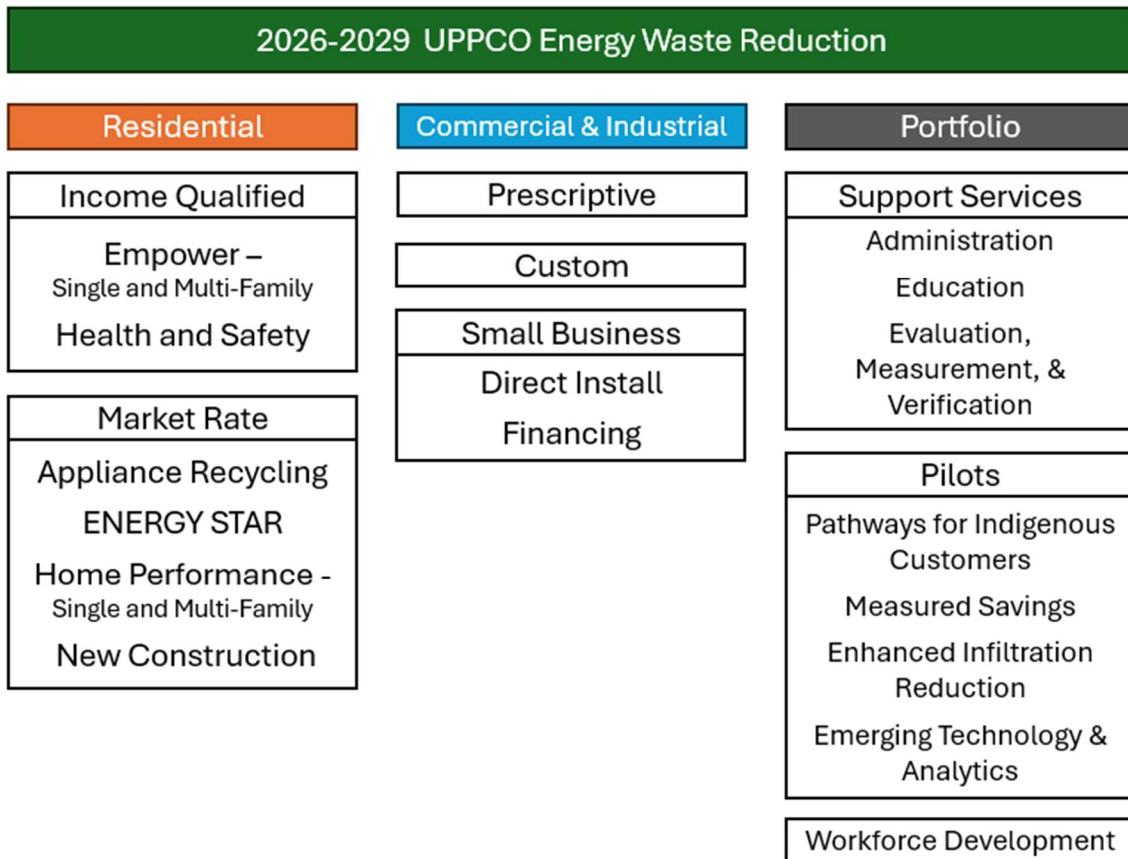
In summary of the recommendations we make to UPPCO regarding load management programs, we recommend that UPPCO:

1. Identify two seasons for rate-making purposes: Summer from May 16 through October 15, and Heating Season from October 16 through May 15.
2. Identify peak hours for rate-making and load management purposes as 3pm to 6pm prevailing Eastern time during Summer and as 7am to 9am and 6pm to 8pm prevailing Eastern time during Heating Season.
3. Adopt in a future rate case cost-reflective rate designs for residential and small commercial customers that allocate distribution peak demand costs to Summer distribution rates and other distribution costs to the entire year, which will also dilute distribution rates in Heating Season for those customers in the space heating rate schedules, and that allocate transmission costs and resource capacity costs to peak hours, thereby creating comparatively high rates during those few peak hours but lowering rates relative to past practices during the non-peak hours.
4. Modify in a future rate case the rate schedules with demand charges such that demand billing determinants, hence demand charges, for recovery of transmission and production capacity costs are determined by customer demand only during peak hours and not at other times. Interruptible customers rate provisions will need to be modified to continue addressing periods of emergency or economic “calls” that are outside of the peak hours when transmission and production capacity demand charges apply.
5. Continue to operate its current large commercial and industrial customer interruptible demand program.
6. Consider distribution system dynamic voltage and reactive power optimization in its next distribution system plan.
7. Begin requiring technical capability for Flexible Load Optimization as a condition of Energy Waste Reduction or Efficient Electrification rebates.
8. Propose a pilot project in a future rate case to begin developing the communications and control capabilities for dynamic Flexible Load Optimization.

4 ENERGY WASTE REDUCTION

The following recommendations provide a pathway for UPPCO to build upon its successful in-house Energy Waste Reduction (“EWR”) program established in 2018. In this proposed 2026-2029 EWR program, UPPCO will continue to support residential, commercial, and industrial customers with efficient appliance rebates, direct install lighting and water heating measures, and home assessments and education while helping electric heating customers adopt more efficient technologies and reduce energy loss and drafts. UPPCO will address barriers related to workforce development, health and safety, and lack of upfront capital through its offerings, and continue its tradition of innovative pilots including a measured savings program. Where possible, UPPCO will connect customers who qualify to its efficient electrification program for additional energy, cost, and emissions reduction opportunities. UPPCO will also encourage the adoption of programmable and communicating equipment so customers can maximize future load management savings opportunities.

4.1 Program Summaries



4.1.1 Residential Programs

Empower – Single Family

The Empower – Single Family program helps income qualified customers lower their energy bills by providing home weatherization assistance, installation of energy-efficient measures, and education about energy conservation and utility cost management. UPPCO provides financial assistance for home upgrades and coordinates with local weatherization providers and community nonprofit agencies to offer comprehensive services at lower administrative costs. Customers in need of services to address health and safety concerns can receive assistance through UPPCO’s dedicated low-income health and safety fund.

Empower – Multi-Family

The Empower - Multi-family program is designed to offer property owners a turn-key service to help income-qualified residents reduce in-unit energy use through the installation of various energy-saving devices. Many direct install measures are provided at no cost to the property owners and the tenants. Properties may also be eligible for incentivized comprehensive building envelope, water heating, and HVAC improvements. Customers in need of services to address health and safety concerns can receive assistance through UPPCO’s dedicated low-income health and safety fund.

Health and Safety

The Health and Safety program will help income-qualified customers with essential home repairs outside of the traditional scope of EWR programs. These may include basic roof patches, simple structural envelope remediation, asbestos removal, knob and tube wiring abandonment, and basement/foundation remediation regarding moisture infiltration. These property problems, among others, have historically been the most prevalent in preventing EWR programs from completing installations.

Appliance Recycling

The Appliance Recycling program offers an environmentally responsible recycling service that targets less-efficient secondary refrigerators, freezers, and small appliances. The program provides the dual benefits of cutting energy consumption and keeping these older appliances out of the resale market.

ENERGY STAR®

The ENERGY STAR® program provides incentives to promote the purchase of high-efficiency appliances. Customers may apply for rebates online or receive instant rebates by purchasing qualifying products.

Home Performance – Single Family

The Home Performance – Single Family program produces long-term energy savings in the residential sector by helping customers understand their energy use and emphasizing a holistic approach to making homes safe, healthy, and energy efficient. Energy Insight Assessments are offered to all residential customers, which include diagnostic testing and a visual inspection for health and safety issues. The assessment report informs the customer of the

energy savings, costs, and payback associated with the recommended improvements. The Home Performance program targets residential customers and offers financial incentives for building envelope improvements and energy-efficient heating and cooling equipment. The Home Performance – Single Family program will be enhanced by UPPCO’s offer of a tariffed on-bill repayment program that will enable customers to implement more costly but cost-effective measures.

Home Performance – Multi Family

The Home Performance - Multi-Family program offers incentives for property owners to install energy-saving equipment during retrofits of individual units and common areas. By addressing the needs of residential and commercial (common area) spaces, the program is designed to encourage comprehensive energy improvements.

New Construction

The New Construction program produces long-term energy savings by encouraging the construction of efficient electric homes that exceed the current Michigan building and energy codes. Incentives are based on the home type and level of above-code savings anticipated.

4.1.2 Commercial & Industrial Programs

Prescriptive

The Prescriptive program creates energy savings for commercial and industrial customers through the promotion of high-efficiency appliances, lighting, and common efficiency measures for pumps and compressed air systems. The program provides cash-back incentives to help cover the incremental cost to purchase high-efficiency models or pursue efficient upgrades. Customers may also be eligible for incentivized comprehensive building envelope and HVAC improvements.

Custom

The Custom program assists larger commercial and industrial customers with the analysis and selection of high-efficiency equipment or processes not covered under the prescriptive program. The program approach identifies more complex energy savings projects, provides economic analysis, and aids in the completion of the incentive application. Incentives are provided for installed measures based on project energy savings.

Small Business

Small Business programs consist of several programs targeting small commercial customers that are typically underserved by other EWR programs. These customers face unique barriers and may lack the technical and financial resources necessary to participate in EWR program offerings.

Through the Energy Insight Assessment program, customers can receive an on-site energy assessment along with limited direct installation of products. The field technicians performing the assessment discuss EWR opportunities with the business owner and install LEDs, showerheads, pipe wrap, and faucet aerators where applicable. Following

the assessment, customers receive a report listing installed measures, product recommendations, and tips on how to save more energy.

The Financing program is designed to promote larger EWR opportunities to small businesses by offering a financing option in conjunction with Northern Initiatives through an interest rate buy-down opportunity. This program offers a pathway for small business customers who would not otherwise complete a project to participate in the EWR program.

4.1.3 Portfolio Programs

Support Services

Administration provides overall management and support for UPPCO's EWR portfolio. UPPCO uses internal staff to perform implementation contractor oversight and evaluation, invoice processing and budgeting, regulatory support, and reporting. In addition, costs associated with outside services are included in administration costs.

Evaluation, measurement, and verification ("EM&V") are key elements for validating program impacts and measuring success. These activities monitor and improve program performance and verify the impact of the EWR program. Ongoing research ensures that program results are measurable, robust, and defensible, participation in programs is maximized, the portfolio is cost-effective, and customers are satisfied.

Education

Education programs support the rest of the EWR portfolio through educating customers about the benefits of energy efficiency and increasing awareness of energy-saving opportunities and UPPCO incentives. A significant component of UPPCO's education program is the Think! Energy program. This program influences students and their families to take actions that can reduce their home energy use and increase efficiency. The program provides elementary and middle school students with in-class EWR presentations and a "take-home" kit that raises awareness about how individual actions and low-cost measures reduce energy and water consumption. The program is endorsed by the Michigan Department of Education.

Pilots

UPPCO has set aside up to 5% of the EWR budget to develop small scale offerings testing new technologies, segmentations, outreach methods, and education to increase EWR participation and energy savings as set out in the EWR statute and guidelines. The intent of the pilot programs is to test new opportunities that could capture additional energy savings within the residential, commercial, and industrial sectors. Planned pilot concepts include the continuation of the Pathways for Indigenous Customers pilot, Industrial Analytics & Emerging Technology, Enhanced Infiltration Reduction, and Residential & Commercial Emerging Technology. In addition, UPPCO is requesting an additional 2% allocation to fund its Measured Savings pilot program in the first two years of the plan.

Workforce Development

A qualified and diverse workforce with capabilities in building envelope, heat pump, and advanced efficiency measures is necessary for achieving EWR goals. UPPCO will devote 1% of its EWR funds each year to workforce development in its territory, with an additional 1% investment in the first two years of the plan. Refer to section 2.6 - Workforce Development for additional details.

Renewable Energy Credits

UPPCO’s current hydroelectric assets along with planned solar projects described in U-21809 will result in renewable generation that exceeds the RPS requirement from 2026-2029. Each year, UPPCO will substitute Renewable Energy Credits (RECs) for EWR credits up to the statutory limit as needed to meet EWR target savings thresholds.

4.2 Program Details

4.2.1 Empower – Single Family

<p>Objective</p>	<p>The objective of the Empower – Single Family program is to reduce energy use of low-income customers through incentivized building envelope, HVAC, and water heating measures. The Empower program will provide energy efficient solutions, recommendations, financial assistance, and education for customers with limited incomes to assist them in reducing their energy use and managing their energy costs.</p> <p>UPPCO targets spending a minimum of 25% of its total budget on income qualified customers across all building types.</p>
<p>Target Market</p>	<p>The Empower – Single Family program is offered to any residential customer whose income is estimated to be at or below 200% of Federal Poverty Level (FPL) guidelines in a 1-4 unit building.</p> <p>Customers with electric resistance heating are eligible for additional measures including building envelope and HVAC upgrades.</p>
<p>Program Duration</p>	<p>The Empower – Single Family program is an ongoing element of the UPPCO EWR portfolio.</p>
<p>Program Description</p>	<p>The Empower – Single Family program will address the needs of individuals with household income at or below 200% of the FPL guidelines. UPPCO plans to deliver the</p>

	<p>programming through two or more implementers, community-based organizations and weatherization agencies.</p> <p>UPPCO will help qualifying customers access existing programs that can provide an energy insight assessment, self-sufficiency education, and the direct installation of efficiency measures to reduce their energy use.</p> <p>For customers with electric resistance heating, UPPCO and its implementers will propose site-specific measure packages including building envelope improvements and cold climate air-source heat pumps for significant energy and cost savings. To ensure these packages are accessible for low-income customers, UPPCO will leverage external funding sources and customers can take advantage of UPPCO’s Tariffed On-Bill Cost Program.</p> <p>Customers with propane heating are encouraged to participate in UPPCO’s residential efficient electrification program. Building envelope measures for homes participating in the electrification program are incentivized through and credited towards the EWR program.</p> <p>Households in need of health and safety improvements prior to energy efficiency work may access assistance through the Low-Income Health and Safety fund.</p>
<p><i>Eligible Measures</i></p>	<p>Eligible measures include efficient lighting, low-flow fixtures, heat pump water heaters, small appliances/electronics such as air purifiers and power strips, and additional residential energy efficiency measures in the Michigan Energy Measures Database (MEMD).</p> <p>Customers with electric resistance heating are eligible for additional measures including heat pumps, building envelope upgrades (e.g. wall insulation, ceiling insulation, basement/crawlspace insulation, infiltration reduction), and smart thermostats.</p> <p>Heat pump water heaters and heat pumps should have programmable controls so customers can take advantage of future load management savings opportunities. UPPCO and its implementers may work with contractors and customers to set up schedules and adjust equipment incentives to reflect this goal.</p>
<p><i>Implementation Strategy</i></p>	<p>UPPCO will work with one or more implementation contractors to deliver the Empower – Single Family program. UPPCO and its implementers will coordinate</p>

	<p>services with local community-based organizations, weatherization providers, the Michigan Home Energy Rebates program (MiHER), and other agencies and programs in order to provide comprehensive assistance at lower administrative costs.</p>												
<p>Marketing Strategy</p>	<p>UPPCO will closely coordinate marketing with implementation contractors, community-based organizations, Michigan Energy Assistance Program (MEAP) grantees, and weatherization agencies. Key elements of the marketing strategy may include:</p> <ul style="list-style-type: none"> • Targeted outreach media • Community presentations • UPPCO website content • UPPCO press releases and newsletters 												
<p>EM&V Requirements</p>	<p>An independent EM&V contractor will perform the evaluation of the program. Energy savings values are based on documented values from the MEMD or conversion to energy savings equivalent values. Evaluation activity will focus on verification of installation and estimates of deemed savings.</p> <p>Through UPPCO’s Measured Savings program, pre- and post-project meter data will be analyzed for a more accurate understanding of project savings. At the conclusion of the monitoring period, any difference between MEMD and measured savings will be applied in UPPCO’s annual EWR reconciliation filing.</p>												
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Savings Targets	Energy Savings (Annual NET kWh)			
	2026	2027	2028	2029
	1,471,907	1,585,707	1,467,946	1,500,817

Higher savings in 2027 are due to a higher portion of participants receiving an energy-saving kit. UPPCO will phase down kits over time as heat pump, building envelope, and water heating participation ramps up.

4.2.2 Empower - Multi-Family

Objective	<p>The objective of the Empower - Multi-Family program is to increase the energy efficiency of income-qualified multi-family buildings to save money for tenants and landlords.</p> <p>UPPCO targets spending a minimum of 25% of its total budget on income qualified customers across all building types.</p>
Target Market	<p>The Empower - Multi-Family program will assist multi-family (4+ unit) buildings with subsidized rental units housing income-qualified customers. Buildings identified as receiving subsidized rents (ex: Section 8 housing) or in areas where the population is more than 50% low-income, will be tracked through the low-income program.</p> <p>Properties with electric resistance heating are eligible for additional measures including building envelope and HVAC upgrades.</p>
Program Duration	<p>The Empower - Multi-Family program is an ongoing element of the UPPCO EWR portfolio.</p>
Program Description	<p>The multi-family market has been a difficult market to get participation in energy efficiency programs. The primary reasons are that the landlords who own the building don't pay the energy bills for the living units within the building. People living in rental properties don't have a financial incentive to improve the buildings they don't own. These tenants can improve some aspects of their energy use through more efficient lighting and appliances, low-flow fixtures, and behavioral changes.</p>

	<p>The Empower - Multi-Family program is designed to help improve the efficiency of the living units inside of multi-family buildings and to improve common areas of the building (interior and exterior). Multi-Family buildings often have two distinct areas from a utility perspective-living units that have their own meter and common areas which have a commercial meter. Basic in-unit and common area improvements will be made through a direct installation strategy. Properties will receive tailored recommendations for upgrades involving the building envelope, space heating/cooling systems, and water heating. Incentives for these measures will be available for residents and property owners, and customers can take advantage of UPPCO’s Tariffed On-Bill Cost Program. Common area savings will be captured within the Small Business Direct Install and Business Prescriptive programs to ensure that costs are allocated properly.</p> <p>Units and buildings in need of health and safety improvements prior to energy efficiency work may access assistance through the Low-Income Health and Safety fund.</p>
<p><i>Eligible Measures</i></p>	<p>Eligible measures include efficient lighting, low-flow fixtures, heat pump water heaters, small appliances/electronics such as air purifiers and power strips, and additional residential and multi-family energy efficiency measures in the Michigan Energy Measures Database (MEMD). Common Area measures may also include energy efficiency measures in the MEMD for commercial installation.</p> <p>Buildings and units with electric resistance heating are eligible for additional measures including heat pumps, building envelope upgrades (e.g. wall insulation, ceiling insulation, basement insulation, infiltration reduction), and smart thermostats.</p> <p>Heat pump water heaters and heat pumps should have programmable controls so customers can take advantage of future load management savings opportunities. UPPCO and its implementers may work with contractors and customers to set up schedules and adjust equipment incentives to reflect this goal.</p>
<p><i>Implementation Strategy</i></p>	<p>The implementation contractor will work with landlords to gain participation for that building and the tenants. Each living unit will receive direct installation of lighting and water heating measures with the consent of the tenant. The contractor will work with the landlord to install appropriate lighting and water heating measures in the common areas, coordinated through the Small Business Direct Install program. Building envelope, HVAC, and more complex water heating measures will be coordinated with the landlord and tenants as applicable. Projects will seek to minimize disruption to</p>

	<p>tenants and provide appropriate updates and education. All implementation activities will be through the implementation contractor and include low-income verification, administration, marketing, installation and tracking.</p>															
<p>Marketing Strategy</p>	<p>Marketing of the program will primarily be direct contact with landlords by program staff. Implementation staff will also make presentations to landlords and management associations where there are active associations.</p>															
<p>EM&V Requirements</p>	<p>An independent EM&V contractor will perform the evaluation of the program. Energy savings values are based on documented values from the MEMD or conversion to energy savings equivalent values. Evaluation activity will focus on verification of installation and estimates of deemed savings.</p> <p>Through UPPCO’s Measured Savings program, pre- and post-project meter data will be analyzed for a more accurate understanding of project savings. At the conclusion of the monitoring period, any difference between MEMD and measured savings will be applied in UPPCO’s annual EWR reconciliation filing.</p>															
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4.2.3 Health and Safety

Objective	The objective of the Health and Safety program is to lower EWR deferral rates thus enabling energy and cost savings for more customers, and to improve the health and safety of customers and their dwellings.
Target Market	Income-qualified customers seeking to participate in the Empower Single Family or Multi-Family programs in need of property repairs in order to implement energy measures or updates are eligible.
Program Duration	The Health and Safety program started as a pilot program in UPPCO’s 2024-2025 EWR Plan.
Program Description	<p>For some customers, home repairs and updates must be addressed before energy efficiency measures can be installed safely. These repairs are not traditionally funded by the EWR program, nor through state and federal funding provided to weatherization agencies.</p> <p>By providing funding for health and safety repairs, UPPCO’s most vulnerable low-income customers may be able to receive energy efficiency assistance from other assistance agencies and UPPCO’s EWR Plan by braiding funding and providing customers with a one-stop experience. The program also allows UPPCO a pathway to implement EWR measures in an otherwise unavailable housing stock.</p> <p>UPPCO will utilize its experience with the Low-Income Health and Safety Pilot to implement and continue to improve upon this program.</p>
Eligible Measures	Eligible repairs may include basic roof patches, simple structural envelope remediation, asbestos removal, knob and tube wiring abandonment, and basement/foundation remediation regarding moisture infiltration. Projects will be considered on a case-by-case basis and additional repairs may be eligible.
Implementation Strategy	UPPCO and its implementers will identify customers in need of health and safety-related repairs during the course of Empower program delivery, and work with contractors and other agencies as applicable to integrate these repairs into the project plan and budget.
Marketing Strategy	This program will be co-marketed with the Empower program to encourage participation by customers who may be hesitant due to property condition.

EM&V Requirements	An independent EM&V contractor will perform the evaluation of the program. Evaluation activity will focus on verification of repairs completed and subsequent EWR measures installed.															
Estimated Participation	<table border="1" style="width: 100%; text-align: center;"> <thead> <tr> <th colspan="4">Estimated Participation</th> </tr> <tr> <th>2026</th> <th>2027</th> <th>2028</th> <th>2029</th> </tr> </thead> <tbody> <tr> <td>30</td> <td>32</td> <td>37</td> <td>39</td> </tr> </tbody> </table>				Estimated Participation				2026	2027	2028	2029	30	32	37	39
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2026	2027	2028	2029													
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Estimated Budget	<table border="1" style="width: 100%; text-align: center;"> <thead> <tr> <th colspan="4">Annual Budgets</th> </tr> <tr> <th>2026</th> <th>2027</th> <th>2028</th> <th>2029</th> </tr> </thead> <tbody> <tr> <td>\$60,975</td> <td>\$64,205</td> <td>\$74,622</td> <td>\$77,559</td> </tr> </tbody> </table>				Annual Budgets				2026	2027	2028	2029	\$60,975	\$64,205	\$74,622	\$77,559
Annual Budgets																
2026	2027	2028	2029													
\$60,975	\$64,205	\$74,622	\$77,559													
Savings Targets	<table border="1" style="width: 100%; text-align: center;"> <thead> <tr> <th colspan="4">Energy Savings (Annual NET kWh)</th> </tr> <tr> <th>2026</th> <th>2027</th> <th>2028</th> <th>2029</th> </tr> </thead> <tbody> <tr> <td>215,208</td> <td>215,208</td> <td>215,208</td> <td>215,208</td> </tr> </tbody> </table>				Energy Savings (Annual NET kWh)				2026	2027	2028	2029	215,208	215,208	215,208	215,208
Energy Savings (Annual NET kWh)																
2026	2027	2028	2029													
215,208	215,208	215,208	215,208													

4.2.4 Appliance Recycling

Objective	The objective of the Appliance Recycling program is to produce cost-effective, long-term energy savings and demand reduction by removing inefficient appliances in an environmentally safe manner from the utility grid and to prevent those appliances from being resold in the used appliance market.
Target Market	All residential customers are eligible for the Appliance Recycling program. The primary target market will be customers with operable, inefficient second and third refrigerators and freezers, dehumidifiers, room air conditioners, and small refrigerators.
Program Duration	The Appliance Recycling program is an ongoing element of the EWR portfolio.

<p>Program Description</p>	<p>The Appliance Recycling program will provide opportunities and incentives for customers to remove operable, inefficient refrigerators, freezers, dehumidifiers, and room air conditioners from the utility grid in an environmentally safe manner. Older refrigerators, freezers, dehumidifiers, and room ACs can be some of the least efficient electrical appliances in the home.</p> <p>A certified recycling agency will be responsible for the recycling process of dismantling the appliances and removing oils, refrigerants, and other recyclable components.</p> <p>Barriers to replacing old and inefficient appliances with energy-efficient products include difficulty in locating recycling services, inability to deliver appliances to the drop-off location, lack of financial resources, competition for funds with other household budget items, and lack of awareness/knowledge about the benefits and costs of new energy efficiency measures. The Appliance Recycling program is designed to minimize these barriers by offering incentives, convenient scheduling of appointments, cost-free pick-up of qualifying equipment or convenient drop-off locations at special events.</p>
<p>Eligible Measures</p>	<p>Appliances included in the program are:</p> <ul style="list-style-type: none"> • Refrigerators (small and standard) • Freezers • Dehumidifiers • Room Air Conditioners <p>Eligible measures may be revised over time as needed to reflect changes in current market conditions, EM&V results, and program experience. UPPCO may pursue offering water heater and cooking range recycling if suitable partners are identified.</p>
<p>Implementation Strategy</p>	<p>UPPCO will provide Appliance Recycling program oversight. The Company will utilize an implementation contractor to provide implementation services, including the pick-up and proper disposal of the appliances in an environmentally safe manner, rebate application and incentive processing, incentive payments, education and training, community outreach, tracking, verification, and marketing.</p> <p>Customers will receive an incentive to have their old appliance recycled. Appliances</p>

	<p>will be collected via drop-off locations, drop-off events and free pick-up. Recycling Drop-Off events will be marketed and held in target communities. Pick-up service will be available for customers who cannot drop off their appliance. Room air conditioners, small refrigerators, and dehumidifiers will only be picked up with a full-size refrigerator or freezer. All qualifying appliances can be dropped off at special drop-off locations or events. Incentives may vary based on market and program responses.</p>												
<p>Marketing Strategy</p>	<p>Customer education and marketing will emphasize the savings associated with retiring old, inefficient appliances and the importance of ensuring proper disposal and recycling.</p> <p>The marketing and communications strategy will be designed to inform customers of the availability and benefits of the program and how they can participate. To control the implementation of this program and scheduling of the appliance pick-up and special events, direct marketing will be a key source of communication.</p> <p>Key elements of the marketing strategy include:</p> <ul style="list-style-type: none"> • Direct consumer marketing through the UPPCO website and newsletter. • Brochures that describe the benefits and features of the program including program contact information. The brochures will be available for various public awareness events (presentations, seminars, etc.). • Bill inserts, bill messages and email messages to targeted customers. • Special event community promotions. 												
<p>EM&V Requirements</p>	<p>An independent EM&V contractor will perform the evaluation of the program. Energy savings values are based on documented values from the MEMD. Evaluation activity will focus on verification of appliances recycled and estimates of deemed savings.</p>												
<p>Estimated Participation</p>	<table border="1"> <thead> <tr> <th colspan="4">Estimated Participation</th> </tr> <tr> <th>2026</th> <th>2027</th> <th>2028</th> <th>2029</th> </tr> </thead> <tbody> <tr> <td>900</td> <td>900</td> <td>900</td> <td>900</td> </tr> </tbody> </table>	Estimated Participation				2026	2027	2028	2029	900	900	900	900
Estimated Participation													
2026	2027	2028	2029										
900	900	900	900										

Estimated Budget	Annual Budgets			
	2026	2027	2028	2029
	\$71,240	\$72,665	\$74,118	\$75,600
Savings Targets	Energy Savings (Annual NET kWh)			
	2026	2027	2028	2029
	631,092	631,092	631,092	631,092

4.2.5 ENERGY STAR®

Objective	Produce long-term annual energy savings in the residential sector by promoting energy efficient products.
Target Market	Residential customers seeking to purchase and install high-efficiency products. Residential rental property owners and customers living in rental properties are also eligible.
Program Duration	The ENERGY STAR® program is an ongoing element of the UPPCO EWR portfolio.
Program Description	<p>The Residential ENERGY STAR® program will leverage the nationally recognized ENERGY STAR® brand, when applicable, to promote products that can reduce energy use. Energy-efficient choices can save families about a third on their energy bill without sacrificing features, style or comfort.</p> <p>Program appliance efforts will focus on retail sales of freezers, refrigerators, dishwashers, dehumidifiers, clothes washers, electric dryers, heat pump dryers, air purifiers, induction cooktops, and heat pump water heaters. The program will work through local appliance retail stores and provide incentives to customers to replace their older, inefficient equipment with high-efficiency units.</p> <p>Additional energy-saving products include power strips, exhaust fans, LED night lights, smart thermostats for electric heating customers, and low-flow fixtures.</p>

<p>Eligible Measures</p>	<p>Eligible measures may include all ENERGY STAR® measures in the MEMD.</p> <p>Measures may change over time as technology, markets and standards change. ENERGY STAR-certified technologies not in the MEMD such as all-in-one washer-heat pump dryers may also be included pending engineering review of savings and cost-effectiveness.</p> <p>In the event that ENERGY STAR products or certifications are no longer available or active, UPPCO will seek to find alternative product efficiency systems or standards to guide customers towards efficient choices. UPPCO may refer to Consortium for Energy Efficiency tiers or other systems as directed by the Commission.</p>
<p>Implementation Strategy</p>	<ul style="list-style-type: none"> • Retailer recruitment, education and outreach. The utility’s implementation contractor will utilize a field representative to facilitate the recruitment of local appliance retailers to participate in the program. • Application processing: The utility’s implementation contractor will coordinate processing of all incentives and rebate applications. • Energy Savings kits. Kits may be provided through direct community events.
<p>Marketing Strategy</p>	<p>High efficiency appliances will be marketed through local retailers. All marketing materials will carry a consumer education message emphasizing the cost of operating older, inefficient equipment and the benefits of early replacement with ENERGY STAR® qualified models (lifetime dollar savings, energy savings, lower noise, etc.). Marketing materials will leverage the ENERGY STAR® brand, which enjoys a high level of consumer recognition.</p> <p>Key elements of the marketing strategy include:</p> <ul style="list-style-type: none"> • Direct consumer marketing through the UPPCO website and newsletter • Point-of-purchase displays • Cooperative advertising with retailers
<p>EM&V Requirements</p>	<p>An independent EM&V contractor will perform the evaluation of the program. Energy savings values are based on documented values from the MEMD or conversion to</p>

	energy savings equivalent values. Evaluation activity will focus on verification of installation and estimates of deemed savings.			
Estimated Participation	Estimated Participation			
	2026	2027	2028	2029
	4,509	4,509	4,534	4,539
Estimated Budget	Annual Budgets			
	2026	2027	2028	2029
	\$129,190	\$131,774	\$160,419	\$168,934
Savings Targets	Energy Savings (Annual NET kWh)			
	2026	2027	2028	2029
	595,748	595,748	654,135	665,813

4.2.6 Home Performance – Single Family

Objective	The objective of the Home Performance – Single Family program is to produce long-term peak demand reduction and annual energy savings in the residential sector by promoting building envelope upgrades and high-efficiency HVAC and water heating equipment.
Target Market	The Home Performance – Single Family program is offered to any residential customer seeking to purchase and install new high efficiency products in a 1-4 unit building. Residential rental property owners and customers living in rental properties are eligible. Customers with electric resistance heating are eligible for additional measures including building envelope and HVAC upgrades.

Program Duration	The Home Performance – Single Family program is an ongoing element of the UPPCO EWR portfolio.
Program Description	<p>The program will focus on contractor-installed heating, cooling, and water-heating equipment. Walk-through audits will be offered and include direct install lighting and water heating measures.</p> <p>For customers with electric resistance heating, UPPCO and its implementers will propose site-specific measure packages including building envelope improvements and cold climate air-source heat pumps for significant energy and cost savings.</p> <p>In addition to utility incentives, customers will be encouraged to take advantage of additional funding opportunities such as the energy efficient home improvement tax credit and UPPCO’s Tariffed On-Bill Cost Program.</p> <p>Customers with propane heating are encouraged to participate in UPPCO’s residential efficient electrification program. Building envelope measures for homes participating in the electrification program are incentivized through and credited towards the EWR program.</p>
Eligible Measures	<p>Eligible measures include efficient lighting, low-flow fixtures, heat pump water heaters, small appliances/electronics such as air purifiers and power strips, and additional residential energy efficiency measures in the Michigan Energy Measures Database (MEMD).</p> <p>Customers with electric resistance heating are eligible for additional measures including heat pumps, building envelope upgrades (e.g. wall insulation, ceiling insulation, basement/crawlspace insulation, infiltration reduction), and smart thermostats.</p> <p>Heat pump water heaters and heat pumps should have programmable controls so customers can take advantage of future load management savings opportunities. UPPCO and its implementers may work with contractors and customers to set up schedules and adjust equipment incentives to reflect this goal.</p>
Implementation Strategy	<ul style="list-style-type: none"> • Contractor recruitment, education and outreach. The utility’s implementation contractor will utilize a field representative to facilitate the recruitment of local HVAC, plumbing, insulation, and other contractors to participate in the program.

	<ul style="list-style-type: none"> • Planning coordination with local natural gas providers. The utility’s implementation contractor will work closely with the natural gas utility to coordinate incentive levels, eligibility requirements, marketing materials, and contractor outreach. • Application processing: The utility’s implementation contractor will coordinate processing of all rebate applications. • Provide complete website presence. The program will be comprehensively outlined on the utility website. Customers and market providers will also be able to review qualifying measures and complete applications for select measures via an online portal.
<p>Marketing Strategy</p>	<p>The HVAC and water heater components of the program will be primarily marketed through local contractors, the most direct influencers of customer purchase decisions. Contractors will receive training and educational materials to share with their customers.</p> <p>All marketing materials will carry a strong consumer education message emphasizing the cost of operating older, inefficient appliances and the benefits of early replacement with ENERGY STAR® qualified models (lifetime dollar savings, energy savings, lower noise, etc.).</p> <p>Key elements of the marketing strategy include:</p> <ul style="list-style-type: none"> • Direct consumer marketing through the UPPCO website and newsletter. • Point-of-purchase displays. • Cooperative advertising with contractors.
<p>EM&V Requirements</p>	<p>An independent EM&V contractor will perform the evaluation of the program. Energy savings values are based on documented values from the MEMD or conversion to energy savings equivalent values. Evaluation activity will focus on verification of installation and estimates of deemed savings.</p> <p>Through UPPCO’s Measured Savings program, pre- and post-project meter data will be analyzed for a more accurate understanding of project savings. At the conclusion of the monitoring period, any difference between MEMD and measured savings will be applied in UPPCO’s annual EWR reconciliation filing.</p>

Estimated Participation	Estimated Participation			
	2026	2027	2028	2029
	838	883	962	997
Estimated Budget	Annual Budgets			
	2026	2027	2028	2029
	\$489,874	\$560,188	\$776,748	\$820,091
Savings Targets	Energy Savings (Annual NET kWh)			
	2026	2027	2028	2029
	1,604,952	1,607,178	2,342,848	2,303,087
<p>Higher savings in 2028 are due to a higher portion of participants receiving an energy-saving kit. UPPCO will phase down kits over time as heat pump, building envelope, and water heating participation ramps up.</p>				

4.2.7 Home Performance - Multi-Family

Objective	The objective of the Home Performance - Multi-Family program is to increase the efficiency of multi-family buildings to save money for tenants and landlords.
Target Market	<p>The Home Performance - Multi-Family program will include market rate rental units in buildings containing 4 or more units.</p> <p>Properties with electric resistance heating are eligible for additional measures including building envelope and HVAC upgrades.</p>
Program Duration	The Home Performance - Multi-Family program is an ongoing element of the UPPCO EWR portfolio.
Program Description	<p>The multi-family market has been a difficult market to get participation in energy efficiency programs. The primary reasons are that the landlords who own the building don't pay the energy bills for the living units within the building. People living in rental properties don't have a financial incentive to improve the buildings they don't own. These tenants can improve some aspects of their energy use through more efficient lighting and appliances, low-flow fixtures, and behavioral changes.</p> <p>The Home Performance - Multi-Family program is designed to help improve the efficiency of the living units inside of multi-family buildings and to improve the lighting in the common areas of the building (interior and exterior). Multi-Family buildings often have two distinct areas from a utility perspective - living units that have their own meter and common areas which have a commercial meter. Basic in-unit and common area improvements will be made through a direct install strategy. Properties will receive tailored recommendations for upgrades involving the building envelope, space heating/cooling systems, and water heating. Incentives for these measures will be available for residents and property owners, and customers can take advantage of UPPCO's Tariffed On-Bill Cost Program. Common area savings will be captured within the Small Business Direct Install and Business Prescriptive programs to ensure that costs are allocated properly.</p>
Eligible Measures	Eligible measures include efficient lighting, low-flow fixtures, heat pump water heaters, small appliances/electronics such as air purifiers and power strips, and additional residential and multi-family energy efficiency measures in the Michigan Energy

	<p>Measures Database (MEMD). Common Area measures may also include energy efficiency measures in the MEMD for commercial installation.</p> <p>Buildings and units with electric resistance heating are eligible for additional measures including heat pumps, building envelope upgrades (e.g. wall insulation, ceiling insulation, basement insulation, infiltration reduction), and smart thermostats.</p> <p>Heat pump water heaters and heat pumps should have programmable controls so customers can take advantage of future load management savings opportunities. UPPCO and its implementers may work with contractors and customers to set up schedules and adjust equipment incentives to reflect this goal.</p>
<p>Implementation Strategy</p>	<p>The implementation contractor will work with landlords to gain participation for that building and the tenants. Each living unit will receive direct installation of lighting and water heating measures with the consent of the tenant. The contractor will work with the landlord to install appropriate lighting and water heating measures in the common areas, coordinated through the Small Business Direct Install program. Building envelope, HVAC, and more complex water heating measures will be coordinated with the landlord and tenants as applicable. Projects will seek to minimize disruption to tenants and provide appropriate updates and education. All implementation activities will be through the implementation contractor and include administration, marketing, installation and tracking.</p>
<p>Marketing Strategy</p>	<p>Marketing of the program will primarily be direct contact with landlords by program staff. Implementation staff will also make presentations to landlord associations where there are active associations. Materials and information will be available for distribution and on the website.</p>
<p>EM&V Requirements</p>	<p>An independent EM&V contractor will perform the evaluation of the program. Energy savings values are based on documented values from the MEMD or conversion to energy savings equivalent values. Evaluation activity will focus on verification of installation and estimates of deemed savings.</p> <p>Through UPPCO's Measured Savings program, pre- and post-project meter data will be analyzed for a more accurate understanding of project savings. At the conclusion of the monitoring period, any difference between MEMD and measured savings will be applied in UPPCO's annual EWR reconciliation filing.</p>

Estimated Participation	Estimated Participation			
	2026	2027	2028	2029
	10	10	14	14
Estimated Budget	Annual Budgets			
	2026	2027	2028	2029
	\$11,658	\$11,891	\$16,291	\$16,616
Savings Targets	Energy Savings (Annual NET kWh)			
	2026	2027	2028	2029
	28,392	28,392	37,734	37,734

4.2.8 New Construction

Objective	Produce long-term peak demand reduction and annual energy savings in the residential sector by promoting high-efficiency home design, HVAC equipment, and appliances in new residential homes.
Target Market	Builders and Residential customers who are designing and building new homes in the UPPCO territory.
Program Duration	The New Construction program is an ongoing element of the UPPCO EWR portfolio.
Program Description	<p>New residential homes, whether single family, multi-family, or manufactured, provide an opportunity for long term energy savings based on the choice of equipment and design. By prioritizing energy efficiency during construction, savings can be realized for the life of the building and property owners can avoid costly retrofits.</p> <p>UPPCO will implement the New Construction program through special promotion of high efficiency products and HVAC measures through bundled rebates and incentives. Working with both builders and homebuyers, UPPCO will bundle and promote</p>

	<p>measures available through the MEMD. In addition, UPPCO will offer incentives for designers and builders to incorporate high efficiency into the building design using Energy Star or other reputable home rating systems to define qualifying homes and incentive levels.</p>
<p>Eligible Measures</p>	<p>Eligible measures may include all energy efficiency measures in the MEMD for residential and multi-family installations marked suitable for new construction, with a focus on the installation of high efficiency electric measures including ground source heat pumps, cold climate air source heat pumps, and heat pump water heaters.</p> <p>Heat pump water heaters and heat pumps should have programmable controls so customers can take advantage of future load management savings opportunities. UPPCO and its implementers may work with contractors and customers to set up schedules and adjust equipment incentives to reflect this goal.</p> <p>Eligible measures may be revised over time as needed to reflect changes in current market conditions, EM&V results, and program experience.</p>
<p>Implementation Strategy</p>	<p>UPPCO and the implementation contractor will promote this program to both builders and customers. Incentives may be bundled with bonuses for incorporating multiple items in the new home. Incentives will be processed through the normal rebate process.</p> <p>Where possible, UPPCO will collaborate with the Michigan State Housing Development Authority and leverage additional external funds on energy-efficient affordable homes.</p>
<p>Marketing Strategy</p>	<p>The program will be marketed through local builders, the most direct influencers of customer purchase decisions. Builders will receive training and educational materials to share with their customers.</p> <p>Key elements of the marketing strategy may include but not be limited to:</p> <ul style="list-style-type: none"> • Customer recruitment, education and outreach will occur at home shows, events and through other UPPCO marketing communications. • Builder recruitment, education and outreach will utilize a field representative for the recruitment of local builders to participate in the program.

EM&V Requirements	An independent EM&V contractor will perform the evaluation of the program. Energy savings values are based on documented values from the MEMD or conversion to energy savings equivalent values. Evaluation activity will focus on verification of installation and estimates of deemed savings.												
Estimated Participation	<table border="1"> <thead> <tr> <th colspan="4">Estimated Participation</th> </tr> <tr> <th>2026</th> <th>2027</th> <th>2028</th> <th>2029</th> </tr> </thead> <tbody> <tr> <td>16</td> <td>16</td> <td>16</td> <td>16</td> </tr> </tbody> </table>	Estimated Participation				2026	2027	2028	2029	16	16	16	16
Estimated Participation													
2026	2027	2028	2029										
16	16	16	16										
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Annual Budgets													
2026	2027	2028	2029										
\$42,472	\$43,321	\$44,188	\$45,072										
Savings Targets	<table border="1"> <thead> <tr> <th colspan="4">Energy Savings (Annual NET kWh)</th> </tr> <tr> <th>2026</th> <th>2027</th> <th>2028</th> <th>2029</th> </tr> </thead> <tbody> <tr> <td>76,104</td> <td>76,104</td> <td>76,104</td> <td>76,104</td> </tr> </tbody> </table>	Energy Savings (Annual NET kWh)				2026	2027	2028	2029	76,104	76,104	76,104	76,104
Energy Savings (Annual NET kWh)													
2026	2027	2028	2029										
76,104	76,104	76,104	76,104										

4.2.9 C&I Prescriptive

Objective	<p>There are three primary objectives for the Prescriptive program:</p> <ol style="list-style-type: none"> 1) Increase the market share of a targeted group of commercial high-efficiency technologies sold through market channels. 2) Increase the installation rate of a targeted group of high-efficiency technologies in commercial facilities by businesses that would not have done so in the absence of the program. 3) Help local businesses prosper and grow through increases in their energy efficiency and controlling their energy bill.
Target Market	All commercial and industrial customers are eligible to participate in the Prescriptive

	<p>program when they purchase qualifying equipment. The program will utilize a targeted outreach strategy to influence specific markets.</p> <ol style="list-style-type: none"> 1) Market Providers (wholesalers, distributors, engineering and architectural firms, developers, and builders) that will promote the qualifying technologies. 2) High-impact/high-need customer sectors (such as schools, municipal buildings, hospitals, food service, and hospitality). For commercial kitchens, potential target markets include smaller food service establishments with residential-style range cooking equipment and buildings without access to natural gas distribution. 3) Underserved small businesses with less than 200 kW demand.
<p>Program Duration</p>	<p>The Prescriptive program is an ongoing element of the UPPCO EWR portfolio.</p>
<p>Program Description</p>	<p>The Prescriptive program will provide incentives for the purchase and installation of specific high efficiency technologies. The program will affect the purchase and installation of high-efficiency technologies through a combination of market push and pull strategies that stimulate market demand while simultaneously increasing market provider investment in stocking and promoting them.</p> <p>The program will increase demand for efficient technologies by educating business customers about the energy and money saving benefits associated with efficient products and equipping market providers to communicate those benefits directly to their customers. To address the first-cost barrier for customers, the program will utilize financial incentives to lower the cost of purchasing qualifying technologies.</p> <p>The program will stimulate market provider investment in stocking and promoting efficient products through a targeted outreach effort. The implementation contractor will employ field representatives to proactively train and equip market providers to convey the energy and money saving benefits to customers. Further, the existence of cash-back incentives will elevate efficiency to a competitive issue that will naturally motivate market providers to stock and promote targeted products.</p>
<p>Eligible Measures</p>	<p>Eligible measures include efficient commercial kitchen and refrigeration equipment, motor and fan upgrades, ventilation, lighting and lighting controls, pumps and compressed air equipment and upgrades, equipment tune-ups and audits, heat pump water heaters, and additional energy efficiency measures in the MEMD for commercial</p>

	<p>and industrial installation, or residential measures that are used in a commercial setting. Note that eligible measures will change over time as the MEMD, markets, standards and technologies change.</p> <p>Buildings with electric resistance heating are eligible for additional measures including heat pumps, building envelope upgrades (e.g. wall insulation, roof insulation), and commercial smart thermostats.</p>
<p>Implementation Strategy</p>	<ul style="list-style-type: none"> • Outreach to market providers. The implementation contractor will inform and recruit participating market providers/trade allies. Outreach will include orientation meetings and conducting in-person visits aimed at training and equipping market providers to communicate program information to customers. Training will be provided to the market providers on new technologies and the appropriate application of those technologies. Key market providers that will be targeted include but are not limited to: <ul style="list-style-type: none"> • Lighting distributors, wholesalers, • HVAC distributors and retail contractors • Motors/compressed air vendors • Food service equipment distributors and retailers • Engineering and Architectural firms • Developers and Builders in the commercial market • Outreach to targeted customers. The program staff will personally contact energy managers and decision makers within the targeted customer sectors. They can assist business customers in determining the energy and cost savings benefits from using the prescriptive incentives for new high efficiency equipment in their operations. The UPPCO business account representatives will assist with outreach within the course of their regular contacts with business customers. • Energy Assessments. The implementation contractor will provide energy assessments to eligible customers. Energy assessments will include a walk-through analysis by the implementation contractor’s Energy Advisor and a report detailing recommended next steps and estimated energy savings. The assessments should drive customers to participate in the incentive and other UPPCO programs.

<p>Marketing Strategy</p>	<p>The C&I Prescriptive Program may employ but not be limited to the following marketing strategies:</p> <ul style="list-style-type: none">• Engage market providers/trade allies. Outreach and training will be provided for a targeted group of providers that have business motivations for promoting incentives to their customers.• Outreach to targeted customers. The implementation contractor will work closely with UPPCO to identify and conduct face-to-face meetings with key end-use customers to recruit their participation. The contractor will target decision makers within the customer’s organization including energy managers, facility managers, financial and operations managers, chief engineer and facility/property managers, maintenance supervisors, and building operators. Energy assessments will be offered to eligible customers to further encourage participation.• Outreach to key influencers. The implementation contractor’s energy advisors will generate awareness of the program through presentations and seminars with appropriate trade associations (ASHRAE, BOMA, school administrators, etc.).
<p>EM&V Requirements</p>	<p>An independent EM&V contractor will perform the evaluation of the program. Energy savings values are based on documented values from the MEMD or conversion to energy savings equivalent values. Evaluation activity will focus on verification of installation and estimates of deemed savings.</p> <p>The utility’s implementation contractor will be responsible for implementing the following types of measurement and verification activities to facilitate the third-party evaluation work:</p> <ul style="list-style-type: none">• Collect and track all participating customers, measure installations, and incentive data.• In the incentive process, verify that each product on which incentives are paid meets the prescribed efficiency standards for the incentive.• Conduct on-site inspections of 2% to 5% of equipment for which customers receive incentives to verify that products were installed and that the model and serial numbers match those provided on the incentive claim. Any inconsistencies will be researched and the resolution recorded. Market providers associated with

	<p>inconsistencies will receive follow-up inspections on projects in which they are associated.</p> <p>The implementation contractor will work with the EM&V contractor to provide necessary data to complete evaluations and assure a high verification rate.</p> <p>For projects tracked through UPPCO’s Measured Savings program, pre- and post-project meter data will be analyzed for a more accurate understanding of project savings. At the conclusion of the monitoring period, any difference between MEMD and measured savings will be applied in UPPCO’s annual EWR reconciliation filing.</p>												
Estimated Participation	<table border="1"> <thead> <tr> <th colspan="4">Estimated Participation</th> </tr> <tr> <th>2026</th> <th>2027</th> <th>2028</th> <th>2029</th> </tr> </thead> <tbody> <tr> <td>689</td> <td>699</td> <td>734</td> <td>739</td> </tr> </tbody> </table>	Estimated Participation				2026	2027	2028	2029	689	699	734	739
Estimated Participation													
2026	2027	2028	2029										
689	699	734	739										
Estimated Budget	<table border="1"> <thead> <tr> <th colspan="4">Annual Budgets</th> </tr> <tr> <th>2026</th> <th>2027</th> <th>2028</th> <th>2029</th> </tr> </thead> <tbody> <tr> <td>\$510,783</td> <td>\$522,345</td> <td>\$582,939</td> <td>\$595,485</td> </tr> </tbody> </table>	Annual Budgets				2026	2027	2028	2029	\$510,783	\$522,345	\$582,939	\$595,485
Annual Budgets													
2026	2027	2028	2029										
\$510,783	\$522,345	\$582,939	\$595,485										
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Energy Savings (Annual NET kWh)													
2026	2027	2028	2029										
2,923,133	2,929,824	3,222,822	3,229,750										

4.2.10 C&I Custom

<p>Objective</p>	<p>There are three primary objectives for the Custom program:</p> <ol style="list-style-type: none"> 1) Increase the market share of high-efficiency electric technologies sold through market channels. 2) Affect the installation of site-specific and unique energy efficiency technologies and process improvements that do not fit the parameters of the prescriptive incentive offerings by business customers that would not have done so in the absence of the program. 3) Help local businesses prosper and grow through increases in their energy efficiency and controlling their energy bill.
<p>Target Market</p>	<p>All commercial and industrial customers are eligible to participate in the Custom program when they purchase and install cost effective, energy efficiency equipment. The program will develop an outreach strategy to influence specific markets such as.</p> <ol style="list-style-type: none"> 1) Market Providers (wholesalers, distributors, engineering and architectural firms, developers, and builders) that promote qualifying technologies. 2) High-impact/high-need customers such as industrial customers and others that use unique processes or equipment that are not covered by the Prescriptive program.
<p>Program Duration</p>	<p>The Custom program is an ongoing element of the UPPCO EWR portfolio.</p>
<p>Program Description</p>	<p>The C&I Custom program helps customers and market providers identify more complex energy savings projects, analyze the economics of each project, and complete a customized incentive grant application. Over the long term, the custom solutions approach will allow the utility to develop and enhance the assistance they can provide to businesses with unique opportunities – including industrial process improvements, emerging technologies, and new facility design and/or modernization.</p> <p>To address the first-cost barrier for customers, the program will utilize financial incentives based on energy and demand savings from the cost-effective high efficiency technologies. Initial incentives will be \$0.10 per first year kWh saved for most technologies. LED lighting will be incented at \$0.08 per first year kWh saved. Incentives</p>

	<p>will change over time if needed to address market response and goal attainment.</p> <p>The program will affect the purchase and installation of unique high-efficiency technologies through a combination of market push and pull strategies that stimulate market demand while simultaneously increasing market provider investment in stocking and promoting these unique technologies. The program will increase market demand by educating business customers about the energy and money saving benefits associated with efficient products and equipping market providers to communicate those benefits directly to their customers. The implementation contractor will employ field representatives to proactively train and equip market providers to convey the energy and money saving benefits to customers.</p> <p>The Custom program will include a new construction/renovation component that will assist customers in specifying and installing unique high efficiency measures and establishing effective commissioning on the long-term performance of the building.</p>
<p>Eligible Measures</p>	<p>Unique measures, innovative technologies and new processes that cost effectively save energy are eligible for the Custom program. Savings will be based on calculated energy savings pre and post installation. Incentives will be paid only after installation and verification of the installation.</p>
<p>Implementation Strategy</p>	<ul style="list-style-type: none"> • Outreach to market providers. The implementation contractor will inform and recruit participating market providers. Outreach will include orientation meetings and conducting in-person visits aimed at training and equipping market providers to communicate program information to customers. The Contractor will ensure that providers have an updated stock of program materials. Key market providers that will be targeted include: <ul style="list-style-type: none"> • Innovative technologies and solutions from: <ul style="list-style-type: none"> ○ Lighting distributors, wholesalers, ○ HVAC distributors and retail contractors ○ Motors/compressed air vendors ○ Food service equipment distributors and retailers • Engineering and architectural firms

	<ul style="list-style-type: none"> • Developers and builders in the commercial market • Outreach to targeted customers. The program staff will personally contact energy managers and decision makers within the targeted customer sectors. They will assist business customers in determining opportunities for the Custom program for their operations. The UPPCO business account representatives will assist with outreach within the course of their regular contacts with business customers. • Energy Assessments. The implementation contractor will provide energy assessments to eligible customers. Energy assessments will include a walk-through analysis by the implementation contractor’s Energy Advisor and a report detailing the recommended next steps for installing innovative technologies or new processes.
<p>Marketing Strategy</p>	<p>The Custom program may employ but not be limited to the following marketing strategies:</p> <ul style="list-style-type: none"> • Incentives to Customers. Incentives on a per annual kWh reduced basis determined through engineering estimates reviewed by the program and the evaluator (for larger projects). • Engage market providers. Outreach and training will be provided to a targeted group of providers that have business motivations for promoting cost effective high efficiency innovative technologies or processes to their customers. • Outreach to targeted customers. The utility’s implementation contractor will work closely with UPPCO to identify and conduct face-to-face meetings with key end-use customers to recruit their participation. The contractor will target decision makers within the customer’s organization including energy managers, facility managers, financial and operations managers, chief engineer and facility/property managers, maintenance supervisors, and building operators. Energy assessments will be offered to eligible customers to further encourage participation. • Outreach to key influencers. The implementation contractor’s energy advisors will generate awareness of the program through presentations and seminars with appropriate trade associations (ASHRAE, BOMA, school administrators, etc.). • Provide website presence. The program will be comprehensively outlined on the utility website. Customers and market providers will be able to review qualifying

	<p>measures, download incentive applications and apply for incentives via an online portal.</p>												
<p>EM&V Requirements</p>	<p>An independent EM&V contractor will perform the evaluation of the program. Energy savings values are based on documented values from the MEMD or conversion to energy savings equivalent values. Evaluation activity will focus on verification of installation and estimates of deemed savings.</p> <p>The utility’s implementation contractor will be responsible for implementing the following types of measurement and verification activities to facilitate the utility’s third-party evaluation work:</p> <ul style="list-style-type: none"> • Collect and track all participating customers, measure installations, and incentive data. • Custom projects shall be considered on a case-by-case basis; product performance information will be requested from the contractor or manufacturer and efficiency will be verified by a qualified engineer. • Provide engineering support to identify and analyze the cost-effectiveness and energy saving of each project. The energy advisor will work with the customer and/or market provider to complete custom engineering calculations that assess the energy savings potential, payback horizon, project eligibility, and incentive amount. If the project is deemed eligible, the advisor will assist the customer or market provider in completing a custom incentive grant application. • Conduct on-site or virtual inspections of all installations to verify that the specified equipment has been installed and is operating as outlined in the grant application. Any inconsistencies will be researched and the resolution recorded. <p>The implementation contractor will work with the EM&V contractor to provide necessary data to complete evaluations and assure a high verification rate.</p>												
<p>Estimated Participation</p>	<table border="1"> <thead> <tr> <th colspan="4">Estimated Participation</th> </tr> <tr> <th>2026</th> <th>2027</th> <th>2028</th> <th>2029</th> </tr> </thead> <tbody> <tr> <td>7</td> <td>7</td> <td>7</td> <td>7</td> </tr> </tbody> </table>	Estimated Participation				2026	2027	2028	2029	7	7	7	7
Estimated Participation													
2026	2027	2028	2029										
7	7	7	7										

Estimated Budget	Annual Budgets			
	2026	2027	2028	2029
	\$232,000	\$236,640	\$241,373	\$246,200
Savings Targets	Energy Savings (Annual NET kWh)			
	2026	2027	2028	2029
	1,200,012	1,200,012	1,200,012	1,200,012

4.2.11 Small Business Direct Install

Objective	The primary objective of the Small Business Direct Install (SBDI) program is to install cost effective energy efficient measures in business customers’ facilities that would not install these measures without the support of the program.
Target Market	Small business customers, who have an energy demand of 25 kW or less, are eligible to participate in the SBDI program. The program will target hard-to-reach customers. This program will also work with the Empower and Home Performance Multi-Family programs in common areas of multi-family buildings to install energy efficient measures in those spaces.
Program Duration	The SBDI program is an ongoing element of the UPPCO EWR portfolio.
Program Description	UPPCO will provide energy efficiency services to its small hard-to-reach business customers to help them implement energy efficiency. This market has significant barriers to implementing energy efficiency in their businesses due to lack of time and expertise as well as the first cost of the measures. The SBDI program will provide the direct installation of energy efficiency measures during a walk-through assessment addressing those barriers. Additional incentives will be offered for larger measures to encourage installation.
Eligible Measures	Eligible measures include efficient lighting, low-flow fixtures, pre-rinse sprayers, refrigeration lighting and gaskets, and additional energy efficiency measures in the

	MEMD for commercial and industrial installation. Note that eligible measures will change over time as the MEMD, markets, standards and technologies change.												
Implementation Strategy	In coordination with other EWR programs, the implementation contractor representatives will personally contact business owners and decision makers within the targeted customer sectors. The contractor will coordinate installation of all measures and track measure installation information.												
Marketing Strategy	In coordination with other EWR programs, the SBDI program will be marketed directly to targeted small business customers based on size and location. Direct marketing outreach will occur through local meetings, direct mail and direct customer visits.												
EM&V Requirements	<p>An independent EM&V contractor will perform the evaluation of the program. Energy savings values are based on documented values from the MEMD or conversion to energy savings equivalent values. Evaluation activity will focus on verification of installation and estimates of deemed savings.</p> <p>The utility’s implementation contractor(s) will be responsible for tracking the qualifying measure installations and customer data to facilitate the utility’s third-party evaluation work:</p> <ul style="list-style-type: none"> • Collect and track all participating customers, measure installations, and incentive data. • Field or virtual verifications will occur on 10% of the installations to verify installation and correct application. <p>The implementation contractor will also work with the EM&V contractor to provide necessary data to complete evaluations and assure a high verification rate.</p>												
Estimated Participation	<table border="1" style="width: 100%; text-align: center;"> <thead> <tr> <th colspan="4">Estimated Participation</th> </tr> <tr> <th>2026</th> <th>2027</th> <th>2028</th> <th>2029</th> </tr> </thead> <tbody> <tr> <td>151</td> <td>151</td> <td>151</td> <td>151</td> </tr> </tbody> </table>	Estimated Participation				2026	2027	2028	2029	151	151	151	151
Estimated Participation													
2026	2027	2028	2029										
151	151	151	151										
Estimated Budget	<table border="1" style="width: 100%;"> <tr> <td>Annual Budgets</td> </tr> </table>	Annual Budgets											
Annual Budgets													

	2026	2027	2028	2029
	\$47,266	\$48,212	\$49,176	\$50,159
Savings Targets	Energy Savings (Annual NET kWh)			
	2026	2027	2028	2029
	349,450	349,450`	349,450	349,450

4.2.12 Small Business Financing

Objective	The objective of the Small Business Financing program is to provide a subsidized financing option for small business customers to allow them to get past the upfront cost barrier and install high efficiency measures in their facility(ies).
Target Market	The program is targeted at small business customers with energy demand less than 200 kW.
Program Duration	The Small Business Finance program has been part of UPPCO’s EWR Portfolio since 2024.
Program Description	The Small Business Financing program has partnered with Northern Initiatives to offer zero percent financing for qualifying customers. By providing financing, the customers can participate in the Prescriptive and Custom programs to have energy efficiency measures installed. Financing will be at 0% for up to 36 months. Participants will qualify for the prescriptive and custom incentives and energy savings will be captured in those programs to ensure no double counting.
Eligible Measures	All prescriptive and custom measures qualify for the program if under the financing cost maximum.
Implementation Strategy	All aspects of the program financing will be handled through Northern Initiatives. Customer recruitment and project implementation/management will occur through the

	other business programs. Energy savings will be captured through the other business programs as well.												
Marketing Strategy	Marketing will occur in conjunction with the other program efforts. Special outreach will occur to small business customers who qualify for the financing.												
EM&V Requirements	Energy savings will not be attributed to this program. Evaluation activity will focus on the effectiveness of financing in increasing participation and getting deeper measure implementation.												
Estimated Participation	Participation will be variable and dependent on funding availability.												
Estimated Budget	<table border="1"> <thead> <tr> <th colspan="4">Annual Budgets</th> </tr> <tr> <th>2026</th> <th>2027</th> <th>2028</th> <th>2029</th> </tr> </thead> <tbody> <tr> <td>\$25,000</td> <td>\$25,000</td> <td>\$25,000</td> <td>\$25,000</td> </tr> </tbody> </table>	Annual Budgets				2026	2027	2028	2029	\$25,000	\$25,000	\$25,000	\$25,000
Annual Budgets													
2026	2027	2028	2029										
\$25,000	\$25,000	\$25,000	\$25,000										
Savings Targets	Energy Savings will not be attributed to this program.												

4.2.13 Education

Objective	Influence students, families, and other customers to take actions that can reduce their home energy use and increase efficiency and raise awareness of UPPCO’s programs and rebates.
Target Market	The Education Program aims to increase awareness of energy savings opportunities and rebates across all UPPCO customers. The Think! Energy program, a major component of the Education Program, targets students in grade levels 4 and 6 in schools throughout the UPPCO service territory. UPPCO collaborates with the other utilities where service territories overlap. The program will also be expanded to include students in grades 2-3 through Think! Energy Bright Kids.
Program Duration	The Education Program is an ongoing element of the UPPCO EWR portfolio.
Program Description	<p>UPPCO will engage with community members through presentations, community events, and other means to spread awareness of energy savings opportunities and UPPCO’s energy waste reduction programs.</p> <p>Providing energy education to students can influence families’ energy use behaviors. The Think! Energy programs provide students in grades 2,3,4 and 6 with education and a “take-home” kit that raises awareness about how individual actions and low-cost measures reduce energy consumption.</p> <p>The Think! Energy program’s educational components include posters, study guides, curricula, and presentations provided to participating teachers, as well as an activity guide for students to complete with their families. Students are given a Home Energy Worksheet to fill out and return to their teacher or submit online to indicate which measures from the kit they installed.</p>
Eligible Measures	Eligible measures may include all energy efficiency measures in the MEMD for school program installation.
Implementation Strategy	<p>UPPCO staff will share information at community and school events.</p> <p>UPPCO uses an implementation contractor to deliver the Think! Energy program including:</p>

	<ul style="list-style-type: none"> • Teacher Recruitment: The implementation contractor conducts direct outreach to schools within UPPCO’s territory to promote the program and recruit participating teachers. • Student and Family Education: Through the family activity guide, students can complete educational activities with their families to learn about EWR and energy-saving behaviors. • In-Class Education: Teachers are provided with several different kinds of materials to educate students on EWR. These materials include a teacher’s guide, posters, and a presentation/curriculum that meets national and Michigan science education standards. • Teacher and School Support: The implementation contractor maintains relationships with participating teachers and schools to ensure successful program implementation, customer and teacher satisfaction, and help troubleshoot problems that arise. In addition to direct contact through email, phone, or occasional visits, the program website is available as a resource for participants. The website hosts copies of program materials and additional support elements such as energy games, safety education, and further science, technology, engineering, and math education. 												
<p>Marketing Strategy</p>	<p>Marketing of the Think! Energy program is through direct mail letters, follow-up calls, and emails sent to school districts and past participating teachers within UPPCO’s service territory.</p>												
<p>EM&V Requirements</p>	<p>An independent EM&V contractor will perform the evaluation of the program. Energy savings values are based on documented values from the MEMD or conversion to energy savings equivalent values. Evaluation activity will focus on verification of installation and estimates of deemed savings.</p>												
<p>Estimated Participation</p>	<table border="1" style="width: 100%; text-align: center;"> <tr> <td colspan="4">Estimated Participation</td> </tr> <tr> <td colspan="4">Listed participation is for Think! Energy Programs. UPPCO will reach additional participants through other engagements.</td> </tr> <tr> <td>2026</td> <td>2027</td> <td>2028</td> <td>2029</td> </tr> </table>	Estimated Participation				Listed participation is for Think! Energy Programs. UPPCO will reach additional participants through other engagements.				2026	2027	2028	2029
Estimated Participation													
Listed participation is for Think! Energy Programs. UPPCO will reach additional participants through other engagements.													
2026	2027	2028	2029										

	1,250	1,260	1,305	1,305
Estimated Budget	Annual Budgets			
	2026	2027	2028	2029
	\$91,463	\$96,308	\$111,933	\$116,339
Savings Targets	Energy Savings (Annual NET kWh)			
	Includes contributions from Think! Kits			
	2026	2027	2028	2029
	592,549	595,667	616,848	611,937

4.2.14 Pilots

Objective	The objective of the Pilots program is to enhance core programs by testing and developing new program designs, marketing strategies, technologies, and approaches to most effectively serve the energy needs of customers, and to determine the energy saving impact of emerging technologies.
Target Market	<p>All residential and business customer segments will be served by the Pilots program. The program is designed to identify and learn more about new energy efficient technologies and program strategies with the potential to capture additional energy savings.</p> <p>New program design and marketing approaches may also be tested to reach “hard-to-reach” customer segments and require testing of marketing techniques and unique partnerships for effectively delivering energy information, education, and programs.</p>
Program Duration	The Pilots program is an ongoing program for the UPPCO EWR Portfolio.
Program Description	The Pilots program is designed to enhance the effectiveness of the Energy Waste Reduction Program. The Pilot program will evolve and will be directed by the changing needs of customers and new technologies that become available.

The Energy Waste Reduction Program is designed to permit all customers to have access to program benefits. The Pilot program will help improve the effectiveness and customer reach of the Energy Waste Reduction Program.

Pathways for Indigenous Customers - UPPCO seeks to strengthen its customer relationships and broaden its program offerings to its Indigenous constituents with a focus on building trust through meaningful Tribal engagement with careful listening, feedback gathering, and documenting needs and barriers to successful energy waste reduction initiatives. This pilot extends the reach of the low-carbon energy infrastructure enhancement and development (“EIED”) grant awarded Slipstream for low carbon energy planning for Native Nations.

Enhanced Infiltration Reduction – UPPCO will work with contractors and customers to pilot advanced techniques for air sealing to achieve lower infiltration rates. These technologies may include blower-door directed air sealing, aerosol air sealing, and other methods as appropriate. Ventilation will be installed as needed for homes to maintain indoor air quality and improve occupant health and comfort. As infiltration is the largest contributing factor to residential heating load,²¹ successful envelope sealing is key to customer energy and cost savings and comfort.

Measured Savings – UPPCO’s Measured Savings program will leverage advanced metering data and algorithms to calculate project energy savings based on normalized metered energy consumption. This approach allows UPPCO, contractors, and customers to focus on true measure results rather than estimates, and motivates proper commissioning, operation, and maintenance. UPPCO and its pilot implementer will refer to established measured savings best practices including the California PUC NMEC Rulebook in developing program protocols. UPPCO plans to establish the measured savings program through a pilot program phase in 2026-2027 and include measured savings as one of its standard EM&V tools in 2028-2029. This two-year pilot period will include program development, launch, complete data collection for projects installed in 2026, data analysis, and preparation of the first measured v. estimated savings reconciliation.

Emerging Technology and Analytics –

Industrial - UPPCO seeks to deepen its engagement and services for industrial customers through providing tailored analysis and support for engineering and design services to carry out energy efficiency projects. Pinch analysis, artificial intelligence, and other tools and techniques will be used to identify efficiency opportunities. This pilot program will also support customers interested in emerging technologies such as

²¹ NREL, U.S. Building Stock Characterization Study published in July 2022
2026-2029 UPPCO Energy Optimization Plan

	<p>ultrasonic drying equipment, efficient wood chipping equipment, and energy-efficient lubricants. UPPCO and its implementor will leverage relationships with industrial customers, DOE Industrial Training and Assessment Centers such as MSU ITAC, and industrial contractors to deliver this program.</p> <p><i>Residential and Commercial</i> - UPPCO will support residential and commercial customers in adopting and testing new technologies with the potential for significant energy and demand savings. These may include commercial induction cooktops, heat pump rooftop units, smart thermal batteries, recirculating showers, advanced geothermal heat exchangers, room heat pumps, and other technologies. Projects will be evaluated for cost-effectiveness and customer incentives will be commensurate with anticipated savings.</p>												
Implementation Strategy	The Pilot program’s ideas and direction will come from feedback from current programs including customer, contractor, manufacturer research, and implementation contractor staff.												
Marketing Strategy	The technology will dictate the marketing strategy of the Pilot program, the program, or marketing approaches being tested.												
EM&V Requirements	An independent EM&V contractor will perform the evaluation of the program. Energy savings values are based on documented values from the MEMD or conversion to energy savings equivalent values. Evaluation activity will focus on verification of installation and estimates of deemed savings.												
Estimated Budget	<table border="1" style="width: 100%; text-align: center;"> <thead> <tr> <th colspan="4">Annual Budgets</th> </tr> <tr> <th>2026</th> <th>2027</th> <th>2028</th> <th>2029</th> </tr> </thead> <tbody> <tr> <td>\$213,413</td> <td>\$224,718</td> <td>\$186,555</td> <td>\$193,897</td> </tr> </tbody> </table>	Annual Budgets				2026	2027	2028	2029	\$213,413	\$224,718	\$186,555	\$193,897
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Energy Savings (Annual NET kWh)													
2026	2027	2028	2029										
753,227	753,227	538,020	538,020										

4.3 Eligible Measures

Measure eligibility is determined based on inclusion in the Michigan Energy Measures Database (MEMD), Michigan Behavior Resource Manual (BRM), and unique measures, innovative technologies and new processes that cost-effectively save energy. During the EWR Plan, measures may be added or removed based on market response, technology availability, changes to the MEMD and BRM databases, and changes in efficiency standards. Other measures may become eligible pending engineering review of cost-effectiveness analysis.

5 EFFICIENT ELECTRIFICATION

As part of its 2026-2029 plan, UPPCO seeks to increase opportunities for consumer savings, health and safety improvements, and greenhouse gas emissions reductions through introducing its efficient electrification (EFEL) program. This program is guided by Public Act 229 of 2023, as amended, and will not have the effect of increasing electric rates for customers that do not participate in the program.

Electrification measures in UPPCO’s plan must provide health and safety benefits to occupants of the premises or reduce total energy consumption at the premises, reduce greenhouse gas emissions due to energy use over the life of the measure, and provide annual average energy cost savings. Additional benefits of building electrification include increased year-round occupant comfort (through improved heating, cooling, dehumidification, air filtration, and indoor air circulation), avoided need to fill and maintain delivered fuel tanks, avoided need for heavy, inefficient window air conditioners, and increased ability for load management.

Home and commercial end uses that are candidates for electrification include space heating, water heating, clothes drying, and cooking. Industrial customers may have additional processes that are candidates for electrification.

This plan describes the process by which representative measures were identified and screened to meet statutory requirements, presents these screening results to suggest eligible measures, and makes recommendations for how UPPCO should structure and implement its new EFEL program.

5.1 Statutory Screening Tests

Public Act 229 of 2023 requires that “efficient electrification measures under the efficient electrification measures plan shall provide health and safety benefits to occupants of the premises or satisfy all of the following: (a) Reduce total energy consumption at the premises. (b) Reduce greenhouse gas emissions due to energy use over the life of the electrification measure. (c) For residential and commercial customers interconnected at secondary voltage, provide annual average energy cost savings.”

The following sections describe the various analyses which were performed to ensure that UPPCO’s EFEL program will meet these statutory requirements.

5.1.1 Efficient Electrification Candidate Measures

Public Act 235 of 2023 defines “Efficient electrification measure” as “an electric appliance or equipment installed in an existing building to electrify, in whole or in part, space heating, water heating, cooling, drying, cooking, industrial processes, or another building or industrial end use that would otherwise be served by combustion of fossil fuel on the premises and that meets best-practice standards for cost-effective energy efficiency as determined by the commission.”

Guided by this language, we compiled a comprehensive list of candidate electrification measures from sources which included the MEMD, existing building electrification programs in other jurisdictions, technical and policy reports, and

UPPCO staff. While there is good reason for UPPCO to focus the EFEL program on a limited number of measures early in the program, the candidate measure list presented in Table 5.1 was wide-ranging to ensure that any technology particularly well suited to UPPCO's service area and customer base would not be overlooked. In any case, it should serve as a valuable resource for future planning as the program evolves.

Table 5.1. Candidate Electrification Measures by Sector and End Use

Sector and End Use	Candidate Measure Category
Residential Space Heating	Central Cold Climate Air Source Heat Pump (ccASHP) with ER Backup
	Central ccASHP with Dual-Fuel Application
	Minisplit ccASHP
	Cold Climate "Micro" Heat Pump, 120V
	Central Closed Loop Ground Source Heat Pump
	Geothermal Heat Exchanger (for vertical well fields)
	Air-to-Water Heat Pump
	Air-to-Water Heat Pump with Thermal Battery
	Integrated HVAC/dehumidification/ventilation "Combi" Heat Pump System
	Packaged Terminal Heat Pump (Multi-family)
	Single-Package Vertical Heat Pump (Multi-family)
	Variable Refrigerant Flow Heat Pump System (Multi-family)
Residential Domestic Water Heating	ENERGY STAR Heat Pump Water Heater, 120V
	ENERGY STAR Heat Pump Water Heater, 240V
	ENERGY STAR Split Heat Pump Water Heater
	Central Heat Pump Water Heaters, >= 10 MBH (Multi-family)
Residential Cooking	ENERGY STAR Induction Range
	ENERGY STAR Induction Cooktop
	Portable Induction Cooktop (unavailable with ENERGY STAR)
	ENERGY STAR Electric Oven
Residential Clothes Drying	ENERGY STAR Heat Pump Clothes Dryer, 120V
	ENERGY STAR Heat Pump Clothes Dryer, 240V
	ENERGY STAR Heat Pump Laundry Set (Washer/Dryer)
	ENERGY STAR Electric Clothes Dryer
Commercial and Industrial Space Heating	Central Cold Climate Air Source Heat Pump (ccASHP) with ER Backup
	Central ccASHP with Dual-Fuel Application
	Minisplit ccASHP
	Ground Loop Heat Pump
	Water Loop Heat Pump
	Geothermal Heat Exchanger (for vertical well fields)
	Air-to-Water Heat Pump
	Commercial Packaged Heat Pumps, or Roof Top Unit (RTU)
	Packaged Terminal Heat Pump (Multi-family)
	Single-Package Vertical Heat Pump (Multi-family)
Variable Refrigerant Flow Heat Pump System	
Commercial and Industrial Domestic Water Heating	ENERGY STAR Heat Pump Water Heater, 120V
	ENERGY STAR Heat Pump Water Heater, 240V
	ENERGY STAR Split Heat Pump Water Heater
	Central Heat Pump Water Heaters, 10 to 500 MBH
Commercial and Industrial Cooking	Convection Oven
	Specialty Oven
	Combination Oven

Table 5.1. (Continued)

Sector and End Use	Candidate Measure Category
Commercial and Industrial Cooking	Convection Oven
	Specialty Oven
	Combination Oven
	Steam Cookers
	Cooks/Ranges
	Fryer
	Griddle
	Charbroiler
	Steam Jacketed Skillet/Kettle
	Pasta Cooker
	Smoker
	Proofer/Convection Oven
	Hot Food Counter
Steam Generator	
Commercial Clothes Drying	ENERGY STAR Heat Pump Clothes Dryer
	ENERGY STAR Electric Clothes Dryer
Industrial Heat: Low- and Medium-Temperature Applications	Induction Heating Equipment
	Infrared Curing Oven
	Infrared Heating Equipment
	Infrared Drying Equipment
	Ultrasonic Drying Equipment
	Heat Pump for Drying Process
Air-Source Heat Pump Electric Steam Boiler	

5.1.2 Measure Scenarios Selected for Screening

The candidate measure list was shortened to construct a manageable number of representative measure scenarios to screen for program eligibility. Here we define “measure scenario” as a measure situated within a specific customer context. Thus, it is possible for multiple scenarios to share a common measure. Early in the process we carefully evaluated the building stock in the UPPCO service area to inform the choice of measure scenarios. Results of this building characterization research are summarized in a report which draws substantially from NREL ResStock and ComStock metadata and a 2021 potential study done for UPPCO by Slipstream. This report is available as Appendix B of this plan.

Eleven weather-sensitive (WS) measure scenarios were developed to represent various combinations of building types, vintages, baseline fuels, and equipment types found in UPPCO’s service area. We assigned one of two general classes of heat pump equipment—cold climate air source heat pump and ground source heat pump—to reflect the meaningful differences between these two technologies in terms of performance and installed cost.

To develop the non-weather-sensitive (NWS) measure scenarios, we looked to existing MEMD EFEL and EWR measures. Specifically, we incorporated all 2025 measures in the electrification tab of the MEMD (16 residential water heaters and 3 residential clothes dryers). The remaining measures scenarios were based on MEMD EWR

entries for water heating (1 commercial) and cooking (1 residential and 5 commercial). Each of the 26 NWS measures were modeled with natural gas and propane baselines for a total of 52 NWS measure scenarios. Table 5.2 tallies the total number of measure scenarios by sector and measure type. In all, we developed 63 measure scenarios (47 residential and 16 commercial, or 11 WS and 52 NWS) to screen for program eligibility.

Table 5.2. UPPCO Measure Scenarios by Sector and Measure Type

Measure Type	Residential	Commercial
Space Heating (WS)	7	4
Water Heating (NWS)	32	2
Clothes Drying (NWS)	6	0
Cooking (NWS)	2	10
	47	16

We decided not to include measure scenarios from the industrial sector due to UPPCO’s relatively few industrial customers compared to other sectors, the site-specific context of most industrial facilities, and ongoing development of heat pump technologies to serve industrial heating loads. Although not evaluated at this time, as more industrial electrification measures become available, they will be evaluated and added to the measure list.

Tables 5.3 through 5.6, which are described in the following sections on eligibility screening tests, identify all 63 measure scenarios with their context-specific information.

5.1.3 On-Site Energy Savings through Electrification

Eligible measures, other than those which demonstrate occupant health and safety benefits, must demonstrate lower on-site energy use for each electrification measure scenario compared to the on-site energy use if that end use is fueled by natural gas or delivered fuel.

To screen the WS measure scenarios, we developed spreadsheet tools which convert 8760-hour baseline fuel consumption profiles to space heating demand profiles, and simulate heat pump performance to meet the same demand profiles. Cold climate air source heat pump (ccASHP) results were computed for electric resistance backup and dual-fuel installations while ground source heat pump (GSHP) results were computed for electric resistance backup only. For residential WS measure scenarios, hourly profiles for baseline natural gas consumption were obtained from Rewiring America which developed these from ResStock end use load profiles aggregated for Climate Zones 6A and 7A in Michigan (for single family detached units) and the ten counties in UPPCO’s service area (for mobile home and multifamily units). Propane heating profiles were derived from natural gas profiles using appropriate energy intensity factors for these fuels.

To simulate heat pump operation, coefficient of performance (COP) curves were modeled as a function of outdoor air temperature using data from the NEEP cold climate heat pump database for equipment with HSPF2 of 9.1. Fuel-fired baseline equipment efficiency was assumed as AFUE 84. For ccASHP scenarios, the spreadsheet tools also estimate the additional electricity needed to defrost the unit under freezing conditions.

A similar approach was used to screen commercial WS measure scenarios. Here total electricity load was set to 11,584 kWh, or the average annual usage for UPPCO customers on the C-1 tariff. Baseline natural gas profiles were

then constructed by scaling ComStock building-specific space heating load profiles by the ratio of 11,584 kWh per ComStock total electricity use for each building type.

As shown in Table 5.3, all 11 WS measure scenarios demonstrate on-site energy savings—meaning that space heating energy use prior to electrification exceeds energy used by a heat pump to meet the same demand. This modeling outcome is unsurprising because the efficiency of baseline fuel-fired heating equipment is always less than unity while heat pump COPs deliver efficiencies greater than unity. For detailed computations, see Workpapers HP Tool_WS_ASHP_v1; HP Tool_WS_ASHP_Commercial_v2; HP Tool_WS_GSHP_v1; HP Tool_WS_GSHP_Commercial_v2; ComStock Profiles_Rescaled; Climate_Zone_After 1980_Natural Gas; Climate_Zone_After 1980_Propane; Climate_Zone_Before 1980_Natural Gas; Climate_Zone_Before 1980_Propane; UPPCO_Mobile Home_Natural Gas; UPPCO_Mobile Home_Propane; UPPCO_Multi-Family_Natural Gas.

To screen the NWS measure scenarios, two different methods were used. For MEMD electrification measures listed in the 2025 electrification tab, these were assumed to meet the energy savings requirement by default. For other measures, performance parameters for baseline and proposed equipment were obtained from MEMD and other sources, then used to estimate end use annual demand figures to which proposed measure efficiencies were applied. For detailed computations, see Workpaper Energy and GHG Tool NWS.

As shown in Tables 5.4 through 5.6, all 52 NWS measure scenarios pass the screen for on-site energy savings.

Table 5.3. Annual Energy Savings and Lifetime Greenhouse Gas Emissions Reductions, Weather-Sensitive Measures

Scenario	Building Type	Vintage	Heating Fuel	Measure Life	All-Electric				Dual-Fuel				All-Electric			
					Baseline Fuel (Btu)	Proposed Electricity (kWh)	Annual Energy Savings (kWh)	Lifetime GHG Savings (MT)	Baseline Fuel (Btu)	Proposed Electricity (kWh)	Annual Energy Savings (kWh)	Lifetime GHG Savings (MT)	Baseline Fuel (Btu)	Proposed Electricity (kWh)	Annual Energy Savings (kWh)	Lifetime GHG Savings (MT)
Residential_WS1	SF Detached	Pre-1980	Natural Gas	15	139,320,917	9,850	30,983	160.0	137,539,304	9,685	30,626	158.2	139,320,917	8,120	32,713	171
Residential_WS2	SF Detached	Post-1980	Natural Gas	15	143,432,505	10,161	31,876	164.5	141,600,996	9,991	31,510	162.7	143,432,505	8,397	33,641	176
Residential_WS3	Mobile Home	All years	Natural Gas	15	117,151,147	8,283	26,052	134.5	115,645,498	8,143	25,751	133.0	117,151,147	6,857	27,478	144
Residential_WS4	Multifamily	All years	Natural Gas	15	51,749,609	3,719	11,448	59.0	51,038,938	3,652	11,306	58.3	51,749,609	3,074	12,093	63
Residential_WS5	SF Detached	Pre-1980	Propane	15	148,029,388	10,484	32,901	610.2	146,163,264	10,310	32,528	602.7	148,029,388	8,657	34,728	622
Residential_WS6	SF Detached	Post-1980	Propane	15	130,397,136	9,255	28,963	537.4	128,723,443	9,099	28,628	530.7	130,397,136	7,648	30,569	548
Residential_WS7	Mobile Home	All years	Propane	15	97,872,832	6,801	21,884	404.3	96,581,318	6,682	21,624	399.1	97,872,832	5,611	23,074	412
Commercial_WS1	Retail Strip Mall	All years	Natural Gas	15	38,447,843	3,221	8,047	40.8	37,680,295	3,142	7,901	40.1	38,447,843	2,629	8,639	45
Commercial_WS2	Retail Standalone	All years	Natural Gas	15	45,906,673	3,766	9,688	49.3	45,147,441	3,688	9,544	48.6	45,906,673	3,139	10,315	53
Commercial_WS3	Small Office	All years	Natural Gas	15	45,783,799	3,876	9,543	48.4	44,700,874	3,764	9,337	47.3	45,783,799	3,131	10,287	53
Commercial_WS4	Full Service Restaurant	All years	Natural Gas	15	37,754,044	3,105	7,960	40.5	37,193,055	3,047	7,853	40.0	37,754,044	2,582	8,483	44

Table 5.4. Annual Energy Savings and Lifetime Greenhouse Gas Emissions Reductions, Water Heating Measures

Scenario	MEMD Measure Code	Measure Description	Measure Life	Baseline Minimum Efficiency	Proposed Minimum Efficiency	Baseline Natural Gas (therms)	Baseline Propane (gallons)	Baseline Energy (kWh)	Proposed Electricity (kWh)	Annual Energy Savings (kWh)	Lifetime GHG Savings (MT)
Residential_NWS_WH1_NG	N-RE-WH-010370-E-XX-XX-XX-01	Electrification of ENERGY STAR Gas WH to ENERGY STAR HPWH (UEF >= 3.3), High Draw, Conditioned Space	10	0.86	3.30	167.9		4,869	1,269	3,600	12.5
Residential_NWS_WH2_NG	N-RE-WH-010371-E-XX-XX-XX-01	Electrification of Standard Gas WH to ENERGY STAR HPWH (UEF >= 3.3), High Draw, Conditioned Space	10	0.62	3.30	231.4		6,711	1,269	5,442	19.3
Residential_NWS_WH3_NG	N-RE-WH-010372-E-XX-XX-XX-01	Electrification of ENERGY STAR Gas WH to ENERGY STAR HPWH, (UEF >= 2.2), High Draw, Conditioned Space	10	0.86	2.20	167.9		4,869	1,903	2,966	9.7
Residential_NWS_WH4_NG	N-RE-WH-010373-E-XX-XX-XX-01	Electrification of Standard Gas WH to ENERGY STAR HPWH, (UEF >= 2.2), High Draw, Conditioned Space	10	0.62	2.20	231.4		6,711	1,903	4,807	16.5
Residential_NWS_WH5_NG	N-RE-WH-010374-E-XX-XX-XX-01	Electrification of ENERGY STAR Gas WH to ENERGY STAR HPWH (UEF >= 3.3) Medium Draw, Conditioned Space	10	0.81	3.30	101.5		2,944	722	2,221	7.7
Residential_NWS_WH6_NG	N-RE-WH-010375-E-XX-XX-XX-01	Electrification of Standard Gas WH to ENERGY STAR HPWH (UEF >= 3.3), Medium Draw, Conditioned Space	10	0.56	3.30	147.0		4,263	722	3,541	12.6
Residential_NWS_WH7_NG	N-RE-WH-010376-E-XX-XX-XX-01	Electrification of ENERGY STAR Gas WH to ENERGY STAR HPWH, (UEF >= 2.2), Medium Draw, Conditioned Space	10	0.81	2.20	101.5		2,944	1,084	1,860	6.2
Residential_NWS_WH8_NG	N-RE-WH-010377-E-XX-XX-XX-01	Electrification of Standard Gas WH to ENERGY STAR HPWH, (UEF >= 2.2), Medium Draw, Conditioned Space	10	0.56	2.20	147.0		4,263	1,083	3,180	11.1
Residential_NWS_WH9_NG	N-RE-WH-010378-E-XX-XX-XX-01	Electrification of ENERGY STAR Gas WH to ENERGY STAR HPWH (UEF >= 3.3), High Draw, Semi-Conditioned Space	10	0.86	3.30	167.9		4,869	1,269	3,600	12.5
Residential_NWS_WH10_NG	N-RE-WH-010379-E-XX-XX-XX-01	Electrification of Standard Gas WH to ENERGY STAR HPWH (UEF >= 3.3), High Draw, Semi-Conditioned Space	10	0.62	3.30	231.4		6,711	1,269	5,442	19.3
Residential_NWS_WH11_NG	N-RE-WH-010380-E-XX-XX-XX-01	Electrification of ENERGY STAR Gas WH to ENERGY STAR HPWH, (UEF >= 2.2), High Draw, Semi-Conditioned Space	10	0.86	2.20	167.9		4,869	1,903	2,966	9.7
Residential_NWS_WH12_NG	N-RE-WH-010381-E-XX-XX-XX-01	Electrification of Standard Gas WH to ENERGY STAR HPWH, (UEF >= 2.2), High Draw, Semi-Conditioned Space	10	0.62	2.20	231.4		6,711	1,903	4,807	16.5
Residential_NWS_WH13_NG	N-RE-WH-010382-E-XX-XX-XX-01	Electrification of ENERGY STAR Gas WH to ENERGY STAR HPWH (UEF >= 3.3), Medium Draw, Semi-Conditioned Space	10	0.81	3.30	101.5		2,944	722	2,221	7.7
Residential_NWS_WH14_NG	N-RE-WH-010383-E-XX-XX-XX-01	Electrification of Standard Gas WH to ENERGY STAR HPWH (UEF >= 3.3), Medium Draw, Semi-Conditioned Space	10	0.56	3.30	147.0		4,263	722	3,541	12.6
Residential_NWS_WH15_NG	N-RE-WH-010384-E-XX-XX-XX-01	Electrification of ENERGY STAR Gas WH to ENERGY STAR HPWH, (UEF >= 2.2), Medium Draw, Semi-Conditioned Space	10	0.81	2.20	101.5		2,944	1,084	1,860	6.2
Residential_NWS_WH16_NG	N-RE-WH-010385-E-XX-XX-XX-01	Electrification of Standard Gas WH to ENERGY STAR HPWH, (UEF >= 2.2), Medium Draw, Semi-Conditioned Space	10	0.56	2.20	147.0		4,263	1,083	3,180	11.1
Residential_NWS_WH1_Propane	N-RE-WH-010370-E-XX-XX-XX-01	Electrification of ENERGY STAR Gas WH to ENERGY STAR HPWH (UEF >= 3.3), High Draw, Conditioned Space	10	0.86	3.30		182.3	4,869	1,269	3,600	42.3
Residential_NWS_WH2_Propane	N-RE-WH-010371-E-XX-XX-XX-01	Electrification of Standard Gas WH to ENERGY STAR HPWH (UEF >= 3.3), High Draw, Conditioned Space	10	0.62	3.30		251.2	6,711	1,269	5,442	60.4
Residential_NWS_WH3_Propane	N-RE-WH-010372-E-XX-XX-XX-01	Electrification of ENERGY STAR Gas WH to ENERGY STAR HPWH, (UEF >= 2.2), High Draw, Conditioned Space	10	0.86	2.20		182.3	4,869	1,903	2,966	39.5
Residential_NWS_WH4_Propane	N-RE-WH-010373-E-XX-XX-XX-01	Electrification of Standard Gas WH to ENERGY STAR HPWH, (UEF >= 2.2), High Draw, Conditioned Space	10	0.62	2.20		251.2	6,711	1,903	4,807	57.6
Residential_NWS_WH5_Propane	N-RE-WH-010374-E-XX-XX-XX-01	Electrification of ENERGY STAR Gas WH to ENERGY STAR HPWH (UEF >= 3.3) Medium Draw, Conditioned Space	10	0.81	3.30		110.2	2,944	722	2,221	25.8
Residential_NWS_WH6_Propane	N-RE-WH-010375-E-XX-XX-XX-01	Electrification of Standard Gas WH to ENERGY STAR HPWH (UEF >= 3.3), Medium Draw, Conditioned Space	10	0.56	3.30		159.6	4,263	722	3,541	38.7
Residential_NWS_WH7_Propane	N-RE-WH-010376-E-XX-XX-XX-01	Electrification of ENERGY STAR Gas WH to ENERGY STAR HPWH, (UEF >= 2.2), Medium Draw, Conditioned Space	10	0.81	2.20		110.2	2,944	1,084	1,860	24.2
Residential_NWS_WH8_Propane	N-RE-WH-010377-E-XX-XX-XX-01	Electrification of Standard Gas WH to ENERGY STAR HPWH, (UEF >= 2.2), Medium Draw, Conditioned Space	10	0.56	2.20		159.6	4,263	1,083	3,180	37.1
Residential_NWS_WH9_Propane	N-RE-WH-010378-E-XX-XX-XX-01	Electrification of ENERGY STAR Gas WH to ENERGY STAR HPWH (UEF >= 3.3), High Draw, Semi-Conditioned Space	10	0.86	3.30		182.3	4,869	1,269	3,600	42.3
Residential_NWS_WH10_Propane	N-RE-WH-010379-E-XX-XX-XX-01	Electrification of Standard Gas WH to ENERGY STAR HPWH (UEF >= 3.3), High Draw, Semi-Conditioned Space	10	0.62	3.30		251.2	6,711	1,269	5,442	60.4
Residential_NWS_WH11_Propane	N-RE-WH-010380-E-XX-XX-XX-01	Electrification of ENERGY STAR Gas WH to ENERGY STAR HPWH, (UEF >= 2.2), High Draw, Semi-Conditioned Space	10	0.86	2.20		182.3	4,869	1,903	2,966	39.5
Residential_NWS_WH12_Propane	N-RE-WH-010381-E-XX-XX-XX-01	Electrification of Standard Gas WH to ENERGY STAR HPWH, (UEF >= 2.2), High Draw, Semi-Conditioned Space	10	0.62	2.20		251.2	6,711	1,903	4,807	57.6
Residential_NWS_WH13_Propane	N-RE-WH-010382-E-XX-XX-XX-01	Electrification of ENERGY STAR Gas WH to ENERGY STAR HPWH (UEF >= 3.3), Medium Draw, Semi-Conditioned Space	10	0.81	3.30		110.2	2,944	722	2,221	25.8
Residential_NWS_WH14_Propane	N-RE-WH-010383-E-XX-XX-XX-01	Electrification of Standard Gas WH to ENERGY STAR HPWH (UEF >= 3.3), Medium Draw, Semi-Conditioned Space	10	0.56	3.30		159.6	4,263	722	3,541	38.7
Residential_NWS_WH15_Propane	N-RE-WH-010384-E-XX-XX-XX-01	Electrification of ENERGY STAR Gas WH to ENERGY STAR HPWH, (UEF >= 2.2), Medium Draw, Semi-Conditioned Space	10	0.81	2.20		110.2	2,944	1,084	1,860	24.2
Residential_NWS_WH16_Propane	N-RE-WH-010385-E-XX-XX-XX-01	Electrification of Standard Gas WH to ENERGY STAR HPWH, (UEF >= 2.2), Medium Draw, Semi-Conditioned Space	10	0.56	2.20		159.6	4,263	1,083	3,180	37.1
Commercial_NWS_WH1_NG	N-CO-WH-000507-G-XX-XX-XX-03	ENERGY STAR Heat Pump Storage Water Heater, <= 55 gallons	10	0.78	3.30	677.1		19,846	4,691	15,155	52.3
Commercial_NWS_WH1_Propane	N-CO-WH-000507-G-XX-XX-XX-03	ENERGY STAR Heat Pump Storage Water Heater, <= 55 gallons	10	0.78	3.30		735.0	19,846	4,691	15,155	174.4

Table 5.5. Annual Energy Savings and Lifetime Greenhouse Gas Emissions Reductions, Clothes Drying Measures

Scenario	New Measure Code	Measure life	Base Efficiency Level	Proposed Efficiency Level	Hours of Operation	Baseline Natural Gas (therms)	Baseline Propane (gallons)	Baseline Energy (kWh)	Proposed Electricity (kWh)	Annual Energy Savings (kWh)	Lifetime GHG Savings (MT)
Residential_NWS_ClothDry1_NG	N-RE-AP-010393-E-XX-XX-XX-01	12	Gas Clothes Dryer	Standard Electric Clothes Dryer	283	23.9		699.2	546.6	152.6	0.2
Residential_NWS_ClothDry2_NG	N-RE-AP-010394-E-XX-XX-XX-01	12	Gas Clothes Dryer	Heat Pump Clothes Dryer	283	23.9		699.2	257.0	442.2	1.7
Residential_NWS_ClothDry3_NG	N-MF-AP-020314-E-XX-XX-XX-01	12	Gas Clothes Dryer	Heat Pump Clothes Dryer	517	43.6		1,277.4	386.7	890.7	3.6
Residential_NWS_ClothDry1_Propane	N-RE-AP-010393-E-XX-XX-XX-01	12	Gas Clothes Dryer	Standard Electric Clothes Dryer	283		25.9	699.2	546.6	152.6	5.4
Residential_NWS_ClothDry2_Propane	N-RE-AP-010394-E-XX-XX-XX-01	12	Gas Clothes Dryer	Heat Pump Clothes Dryer	283		25.9	699.2	257.0	442.2	7.0
Residential_NWS_ClothDry3_Propane	N-MF-AP-020314-E-XX-XX-XX-01	12	Gas Clothes Dryer	Heat Pump Clothes Dryer	517		47.3	1,277.4	386.7	890.7	13.1

Table 5.6. Annual Energy Savings and Lifetime Greenhouse Gas Emissions Reductions, Cooking Measures

Scenario	MEMD Measure Code	Measure Description	Measure Life	Baseline Minimum Efficiency	Proposed Minimum Efficiency	Baseline Natural Gas (therms)	Baseline Propane (gallons)	Baseline Energy (kWh)	Proposed Electricity (kWh)	Annual Energy Savings (kWh)	Lifetime GHG Savings (MT)
Residential_NWS_Cooking1_NG	N-RE-AP-010397-E-XX-XX-XX-01	Induction Cooktops	16	0.42	0.81	8.2		238	123	114	0.5
Residential_NWS_Cooking1_Propane	N-RE-AP-010397-E-XX-XX-XX-01	Induction Cooktops	16	0.42	0.81		8.9	238	123	114	2.9
Commercial_NWS_Cooking1_NG	N-CO-KR-000350-E-XX-XX-XX-04	ENERGY STAR Fryers	12	0.38	0.83	1,841.0		53,390	24,122	29,268	108.1
Commercial_NWS_Cooking2_NG	N-CO-KR-000354-E-XX-XX-XX-04	ENERGY STAR Convection Ovens	12	0.48	0.74	1,493.5		43,312	28,094	15,218	42.8
Commercial_NWS_Cooking3_NG	N-CO-KR-000344-G-XX-XX-XX-02	ENERGY STAR Steam Cookers 5 Pan	12	0.15	0.50	3,360.5		98,491	29,547	68,944	278.2
Commercial_NWS_Cooking4_NG	N-CO-KR-000346-G-XX-XX-XX-02	ENERGY STAR Steam Cookers 6 Pan	12	0.15	0.50	3,443.1		100,912	30,274	70,639	285.0
Commercial_NWS_Cooking5_NG	N-CO-KR-000357-G-XX-XX-XX-02	Combination Ovens	12	0.35	0.64	2,737.0		80,217	43,869	36,348	122.3
Commercial_NWS_Cooking1_Propane	N-CO-KR-000350-E-XX-XX-XX-04	ENERGY STAR Fryers	12	0.38	0.83		1,998.4	53,390	24,122	29,268	502.5
Commercial_NWS_Cooking2_Propane	N-CO-KR-000354-E-XX-XX-XX-04	ENERGY STAR Convection Ovens	12	0.48	0.74		1,621.2	43,312	28,094	15,218	362.8
Commercial_NWS_Cooking3_Propane	N-CO-KR-000344-G-XX-XX-XX-02	ENERGY STAR Steam Cookers 5 Pan	12	0.15	0.50		3,647.8	98,491	29,547	68,944	1,005.8
Commercial_NWS_Cooking4_Propane	N-CO-KR-000346-G-XX-XX-XX-02	ENERGY STAR Steam Cookers 6 Pan	12	0.15	0.50		3,737.5	100,912	30,274	70,639	1,030.5
Commercial_NWS_Cooking5_Propane	N-CO-KR-000357-G-XX-XX-XX-02	Combination Ovens	12	0.35	0.64		2,971.0	80,217	43,869	36,348	714.9

5.1.4 Life-cycle Greenhouse Gas Emissions Reduction

For each measure scenario which screened for on-site energy savings, GHG emissions reduction was assessed over the standard measure life, given the baseline fuel and the assumed GHG intensity of UPPCO's electricity supply. The basic calculation is avoided GHG emissions from eliminating fossil fuel usage, compared to the projected electricity usage adjusted for the on-site energy savings by electrifying the end use, multiplied by the emissions intensity of electricity over the measure life.

Spreadsheet tools were created to perform these calculations by applying fuel-specific emissions factors to the annual displaced fuel energy and the annual incremental electricity consumed by the new equipment over measure life. Emissions factors for CO₂, CH₄, and N₂O were obtained from the U.S. EPA GHG Factors Hub.²² For electricity emissions factors, the RFC Michigan eGRID subregion was assumed. Because first-year electricity emissions were assumed to persist over the period being analyzed, these results should be considered conservative in that the carbon intensity of the grid serving UPPCO's customers is expected to decrease given statutory requirements and UPPCO's current commitments for sourcing low-emissions power as outlined in its IRP filed earlier this year.

As presented in Tables 5.3 through 5.6, all 11 WS and all 52 NWS measure scenarios demonstrated life-cycle greenhouse gas reductions over measure life. This aligns with the observation that fuel switching is often put forward as an effective carbon reduction strategy in many jurisdictions. For detailed computations, see Workpapers GHG Tool_WS_v1; GHG Tool_WS_Commercial_v2; Energy and GHG Tool_NWS.

5.1.5 Customer Energy Bill Savings through Electrification

The final screening test for program eligibility is to assess customer energy bill savings. Unless a measure is excepted for delivering occupant health and safety benefits, the annual expense of the measure's incremental electricity must not exceed the annual baseline heating fuel expense.

To conduct this analysis, the 63 measures scenarios described in Section 5.1.2 were combined with various UPPCO tariffs to yield 171 unique measure scenario/tariff combinations. These combinations are listed in Table 5.7. For WS cases, the residential electricity tariff was moved from A-1 to AH-1 as a result of installing electric space heating equipment. Similarly, the commercial tariff was moved from C-1 to H-1. NWS measure scenarios were combined with both non-heating and heating baseline tariffs to evaluate how these impacts might influence EFEL program design decisions.

Hourly electricity and on-site fuel expenses²³ were computed using 8760-hour energy profiles and summed for the year. WS hourly energy profiles were developed using the method described earlier in Section 5.1.3. NWS profiles were constructed by applying annual fuel and electricity consumption figures to MEMD measure profile shapes for the appropriate sector and end use category.

²² US EPA GHG Factors Hub website: <https://www.epa.gov/climateleadership/ghg-emission-factors-hub>.

²³ Using SEMCO Residential and GS-1 tariffs for gas customers and an average price of \$2.343/gallon for propane customers based on U.S. EIA economic data for Michigan

All 171 measure scenario/tariff combinations were screened twice: once using UPPCO's existing A-1, AH-1, C-1, H-1, and P-1 tariffs and again using the proposed load management variants of A-1, AH-1, C-1, and H-1 discussed elsewhere in Section 3.2.5.

Results of the customer energy bill screening are presented in Tables 5.8 through 5.15 and include only those combinations which achieved bill savings or deliver occupant health and safety benefits, namely all residential and commercial cooking measures. The reason for having separate tables for low-income, moderate-income, and market rate residential customers is explained in Section 5.1.8. For detailed calculations, see Workpapers Rebate and OBR_v6; EFEL Measures List and Profiles_v8; Building_measures_calculator.py; EFEL Measures List and Profiles_v8.xlsx; Toolkit_assumptions.xlsx; Toolkit_building.py; Toolkit_project.py.

Table 5.7. Measure Scenario/Tariff Combinations Screened for Energy Bill Savings

Line	Measure Scenario	Building Type	Baseline Fuel	Measure Description (MEMD code, if applicable)	Measure Life	Pre-EFEL Tariff	Post-EFEL Tariff
1	Residential_WS1	SF Detached	Natural Gas	ccASHP (All-Electric)	15	A-1	AH-1
2	Residential_WS1	SF Detached	Natural Gas	ccASHP (Dual-Fuel)	15	A-1	AH-1
3	Residential_WS1	SF Detached	Natural Gas	GSHP (All-Electric)	15	A-1	AH-1
4	Residential_WS2	SF Detached	Natural Gas	ccASHP (All-Electric)	15	A-1	AH-1
5	Residential_WS2	SF Detached	Natural Gas	ccASHP (Dual-Fuel)	15	A-1	AH-1
6	Residential_WS2	SF Detached	Natural Gas	GSHP (All-Electric)	15	A-1	AH-1
7	Residential_WS3	Mobile Home	Natural Gas	ccASHP (All-Electric)	15	A-1	AH-1
8	Residential_WS3	Mobile Home	Natural Gas	ccASHP (Dual-Fuel)	15	A-1	AH-1
9	Residential_WS3	Mobile Home	Natural Gas	GSHP (All-Electric)	15	A-1	AH-1
10	Residential_WS4	Multifamily	Natural Gas	ccASHP (All-Electric)	15	A-1	AH-1
11	Residential_WS4	Multifamily	Natural Gas	ccASHP (Dual-Fuel)	15	A-1	AH-1
12	Residential_WS4	Multifamily	Natural Gas	GSHP (All-Electric)	15	A-1	AH-1
13	Residential_WS5	SF Detached	Propane	ccASHP (All-Electric)	15	A-1	AH-1
14	Residential_WS5	SF Detached	Propane	ccASHP (Dual-Fuel)	15	A-1	AH-1
15	Residential_WS5	SF Detached	Propane	GSHP (All-Electric)	15	A-1	AH-1
16	Residential_WS6	SF Detached	Propane	ccASHP (All-Electric)	15	A-1	AH-1
17	Residential_WS6	SF Detached	Propane	ccASHP (Dual-Fuel)	15	A-1	AH-1
18	Residential_WS6	SF Detached	Propane	GSHP (All-Electric)	15	A-1	AH-1
19	Residential_WS7	Mobile Home	Propane	ccASHP (All-Electric)	15	A-1	AH-1
20	Residential_WS7	Mobile Home	Propane	ccASHP (Dual-Fuel)	15	A-1	AH-1
21	Residential_WS7	Mobile Home	Propane	GSHP (All-Electric)	15	A-1	AH-1
22	Commercial_WS1	Retail Stripmall	Natural Gas	ccASHP (All-Electric)	15	C-1	H-1
23	Commercial_WS1	Retail Stripmall	Natural Gas	ccASHP (Dual-Fuel)	15	C-1	H-1
24	Commercial_WS1	Retail Stripmall	Natural Gas	GSHP (All-Electric)	15	C-1	H-1
25	Commercial_WS1	Retail Stripmall	Natural Gas	GSHP (All-Electric)	15	P-1	P-1
26	Commercial_WS2	Retail Standalone	Natural Gas	ccASHP (All-Electric)	15	C-1	H-1
27	Commercial_WS2	Retail Standalone	Natural Gas	ccASHP (Dual-Fuel)	15	C-1	H-1
28	Commercial_WS2	Retail Standalone	Natural Gas	GSHP (All-Electric)	15	C-1	H-1
29	Commercial_WS2	Retail Standalone	Natural Gas	GSHP (All-Electric)	15	P-1	P-1
30	Commercial_WS3	Small Office	Natural Gas	ccASHP (All-Electric)	15	C-1	H-1
31	Commercial_WS3	Small Office	Natural Gas	ccASHP (Dual-Fuel)	15	C-1	H-1
32	Commercial_WS3	Small Office	Natural Gas	GSHP (All-Electric)	15	C-1	H-1
33	Commercial_WS3	Small Office	Natural Gas	GSHP (All-Electric)	15	P-1	P-1
34	Commercial_WS4	Full Service Restaurant	Natural Gas	ccASHP (All-Electric)	15	C-1	H-1
35	Commercial_WS4	Full Service Restaurant	Natural Gas	ccASHP (Dual-Fuel)	15	C-1	H-1
36	Commercial_WS4	Full Service Restaurant	Natural Gas	GSHP (All-Electric)	15	C-1	H-1
37	Commercial_WS4	Full Service Restaurant	Natural Gas	GSHP (All-Electric)	15	P-1	P-1
38	Residential_NWS_WH1_NG	SF Detached	Natural Gas	N-RE-WH-010370-E-XX-XX-XX-XX-01	10	A-1	A-1
39	Residential_NWS_WH1_NG	SF Detached	Natural Gas	N-RE-WH-010370-E-XX-XX-XX-XX-01	10	AH-1	AH-1
40	Residential_NWS_WH1_Propane	SF Detached	Propane	N-RE-WH-010370-E-XX-XX-XX-XX-01	10	A-1	A-1
41	Residential_NWS_WH1_Propane	SF Detached	Propane	N-RE-WH-010370-E-XX-XX-XX-XX-01	10	AH-1	AH-1
42	Residential_NWS_WH2_NG	SF Detached	Natural Gas	N-RE-WH-010371-E-XX-XX-XX-XX-01	10	A-1	A-1
43	Residential_NWS_WH2_NG	SF Detached	Natural Gas	N-RE-WH-010371-E-XX-XX-XX-XX-01	10	AH-1	AH-1
44	Residential_NWS_WH2_Propane	SF Detached	Propane	N-RE-WH-010371-E-XX-XX-XX-XX-01	10	A-1	A-1
45	Residential_NWS_WH2_Propane	SF Detached	Propane	N-RE-WH-010371-E-XX-XX-XX-XX-01	10	AH-1	AH-1
46	Residential_NWS_WH3_NG	SF Detached	Natural Gas	N-RE-WH-010372-E-XX-XX-XX-XX-01	10	A-1	A-1
47	Residential_NWS_WH3_NG	SF Detached	Natural Gas	N-RE-WH-010372-E-XX-XX-XX-XX-01	10	AH-1	AH-1
48	Residential_NWS_WH3_Propane	SF Detached	Propane	N-RE-WH-010372-E-XX-XX-XX-XX-01	10	A-1	A-1
49	Residential_NWS_WH3_Propane	SF Detached	Propane	N-RE-WH-010372-E-XX-XX-XX-XX-01	10	AH-1	AH-1
50	Residential_NWS_WH4_NG	SF Detached	Natural Gas	N-RE-WH-010373-E-XX-XX-XX-XX-01	10	A-1	A-1
51	Residential_NWS_WH4_NG	SF Detached	Natural Gas	N-RE-WH-010373-E-XX-XX-XX-XX-01	10	AH-1	AH-1
52	Residential_NWS_WH4_Propane	SF Detached	Propane	N-RE-WH-010373-E-XX-XX-XX-XX-01	10	A-1	A-1
53	Residential_NWS_WH4_Propane	SF Detached	Propane	N-RE-WH-010373-E-XX-XX-XX-XX-01	10	AH-1	AH-1
54	Residential_NWS_WH5_NG	SF Detached	Natural Gas	N-RE-WH-010374-E-XX-XX-XX-XX-01	10	A-1	A-1
55	Residential_NWS_WH5_NG	SF Detached	Natural Gas	N-RE-WH-010374-E-XX-XX-XX-XX-01	10	AH-1	AH-1
56	Residential_NWS_WH5_Propane	SF Detached	Propane	N-RE-WH-010374-E-XX-XX-XX-XX-01	10	A-1	A-1
57	Residential_NWS_WH5_Propane	SF Detached	Propane	N-RE-WH-010374-E-XX-XX-XX-XX-01	10	AH-1	AH-1
58	Residential_NWS_WH6_NG	SF Detached	Natural Gas	N-RE-WH-010375-E-XX-XX-XX-XX-01	10	A-1	A-1
59	Residential_NWS_WH6_NG	SF Detached	Natural Gas	N-RE-WH-010375-E-XX-XX-XX-XX-01	10	AH-1	AH-1
60	Residential_NWS_WH6_Propane	SF Detached	Propane	N-RE-WH-010375-E-XX-XX-XX-XX-01	10	A-1	A-1
61	Residential_NWS_WH6_Propane	SF Detached	Propane	N-RE-WH-010375-E-XX-XX-XX-XX-01	10	AH-1	AH-1
62	Residential_NWS_WH7_NG	SF Detached	Natural Gas	N-RE-WH-010376-E-XX-XX-XX-XX-01	10	A-1	A-1

Table 5.7 (Continued)

Line	Measure Scenario	Building Type	Baseline Fuel	Measure Description (MEMD code, if applicable)	Measure Life	Pre-EFEL Tariff	Post-EFEL Tariff
63	Residential_NWS_WH7_NG	SF Detached	Natural Gas	N-RE-WH-010376-E-XX-XX-XX-XX-01	10	AH-1	AH-1
64	Residential_NWS_WH7_Propane	SF Detached	Propane	N-RE-WH-010376-E-XX-XX-XX-XX-01	10	A-1	A-1
65	Residential_NWS_WH7_Propane	SF Detached	Propane	N-RE-WH-010376-E-XX-XX-XX-XX-01	10	AH-1	AH-1
66	Residential_NWS_WH8_NG	SF Detached	Natural Gas	N-RE-WH-010377-E-XX-XX-XX-XX-01	10	A-1	A-1
67	Residential_NWS_WH8_NG	SF Detached	Natural Gas	N-RE-WH-010377-E-XX-XX-XX-XX-01	10	AH-1	AH-1
68	Residential_NWS_WH8_Propane	SF Detached	Propane	N-RE-WH-010377-E-XX-XX-XX-XX-01	10	A-1	A-1
69	Residential_NWS_WH8_Propane	SF Detached	Propane	N-RE-WH-010377-E-XX-XX-XX-XX-01	10	AH-1	AH-1
70	Residential_NWS_WH9_NG	SF Detached	Natural Gas	N-RE-WH-010378-E-XX-XX-XX-XX-01	10	A-1	A-1
71	Residential_NWS_WH9_NG	SF Detached	Natural Gas	N-RE-WH-010378-E-XX-XX-XX-XX-01	10	AH-1	AH-1
72	Residential_NWS_WH9_Propane	SF Detached	Propane	N-RE-WH-010378-E-XX-XX-XX-XX-01	10	A-1	A-1
73	Residential_NWS_WH9_Propane	SF Detached	Propane	N-RE-WH-010378-E-XX-XX-XX-XX-01	10	AH-1	AH-1
74	Residential_NWS_WH10_NG	SF Detached	Natural Gas	N-RE-WH-010379-E-XX-XX-XX-XX-01	10	A-1	A-1
75	Residential_NWS_WH10_NG	SF Detached	Natural Gas	N-RE-WH-010379-E-XX-XX-XX-XX-01	10	AH-1	AH-1
76	Residential_NWS_WH10_Propane	SF Detached	Propane	N-RE-WH-010379-E-XX-XX-XX-XX-01	10	A-1	A-1
77	Residential_NWS_WH10_Propane	SF Detached	Propane	N-RE-WH-010379-E-XX-XX-XX-XX-01	10	AH-1	AH-1
78	Residential_NWS_WH11_NG	SF Detached	Natural Gas	N-RE-WH-010380-E-XX-XX-XX-XX-01	10	A-1	A-1
79	Residential_NWS_WH11_NG	SF Detached	Natural Gas	N-RE-WH-010380-E-XX-XX-XX-XX-01	10	AH-1	AH-1
80	Residential_NWS_WH11_Propane	SF Detached	Propane	N-RE-WH-010380-E-XX-XX-XX-XX-01	10	A-1	A-1
81	Residential_NWS_WH11_Propane	SF Detached	Propane	N-RE-WH-010380-E-XX-XX-XX-XX-01	10	AH-1	AH-1
82	Residential_NWS_WH12_NG	SF Detached	Natural Gas	N-RE-WH-010381-E-XX-XX-XX-XX-01	10	A-1	A-1
83	Residential_NWS_WH12_NG	SF Detached	Natural Gas	N-RE-WH-010381-E-XX-XX-XX-XX-01	10	AH-1	AH-1
84	Residential_NWS_WH12_Propane	SF Detached	Propane	N-RE-WH-010381-E-XX-XX-XX-XX-01	10	A-1	A-1
85	Residential_NWS_WH12_Propane	SF Detached	Propane	N-RE-WH-010381-E-XX-XX-XX-XX-01	10	AH-1	AH-1
86	Residential_NWS_WH13_NG	SF Detached	Natural Gas	N-RE-WH-010382-E-XX-XX-XX-XX-01	10	A-1	A-1
87	Residential_NWS_WH13_NG	SF Detached	Natural Gas	N-RE-WH-010382-E-XX-XX-XX-XX-01	10	AH-1	AH-1
88	Residential_NWS_WH13_Propane	SF Detached	Propane	N-RE-WH-010382-E-XX-XX-XX-XX-01	10	A-1	A-1
89	Residential_NWS_WH13_Propane	SF Detached	Propane	N-RE-WH-010382-E-XX-XX-XX-XX-01	10	AH-1	AH-1
90	Residential_NWS_WH14_NG	SF Detached	Natural Gas	N-RE-WH-010383-E-XX-XX-XX-XX-01	10	A-1	A-1
91	Residential_NWS_WH14_NG	SF Detached	Natural Gas	N-RE-WH-010383-E-XX-XX-XX-XX-01	10	AH-1	AH-1
92	Residential_NWS_WH14_Propane	SF Detached	Propane	N-RE-WH-010383-E-XX-XX-XX-XX-01	10	A-1	A-1
93	Residential_NWS_WH14_Propane	SF Detached	Propane	N-RE-WH-010383-E-XX-XX-XX-XX-01	10	AH-1	AH-1
94	Residential_NWS_WH15_NG	SF Detached	Natural Gas	N-RE-WH-010384-E-XX-XX-XX-XX-01	10	A-1	A-1
95	Residential_NWS_WH15_NG	SF Detached	Natural Gas	N-RE-WH-010384-E-XX-XX-XX-XX-01	10	AH-1	AH-1
96	Residential_NWS_WH15_Propane	SF Detached	Propane	N-RE-WH-010384-E-XX-XX-XX-XX-01	10	A-1	A-1
97	Residential_NWS_WH15_Propane	SF Detached	Propane	N-RE-WH-010384-E-XX-XX-XX-XX-01	10	AH-1	AH-1
98	Residential_NWS_WH16_NG	SF Detached	Natural Gas	N-RE-WH-010385-E-XX-XX-XX-XX-01	10	A-1	A-1
99	Residential_NWS_WH16_NG	SF Detached	Natural Gas	N-RE-WH-010385-E-XX-XX-XX-XX-01	10	AH-1	AH-1
100	Residential_NWS_WH16_Propane	SF Detached	Propane	N-RE-WH-010385-E-XX-XX-XX-XX-01	10	A-1	A-1
101	Residential_NWS_WH16_Propane	SF Detached	Propane	N-RE-WH-010385-E-XX-XX-XX-XX-01	10	AH-1	AH-1
102	Commercial_NWS_WH1_NG	Small Office	Natural Gas	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	C-1	C-1
103	Commercial_NWS_WH1_NG	Small Office	Natural Gas	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	H-1	H-1
104	Commercial_NWS_WH1_NG	Small Office	Natural Gas	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	P-1	P-1
105	Commercial_NWS_WH1_NG	Retail Stripmall	Natural Gas	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	C-1	C-1
106	Commercial_NWS_WH1_NG	Retail Stripmall	Natural Gas	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	H-1	H-1
107	Commercial_NWS_WH1_NG	Retail Stripmall	Natural Gas	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	P-1	P-1
108	Commercial_NWS_WH1_NG	Retail Standalone	Natural Gas	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	C-1	C-1
109	Commercial_NWS_WH1_NG	Retail Standalone	Natural Gas	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	H-1	H-1
110	Commercial_NWS_WH1_NG	Retail Standalone	Natural Gas	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	P-1	P-1
111	Commercial_NWS_WH1_NG	Full Service Restaurant	Natural Gas	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	C-1	C-1
112	Commercial_NWS_WH1_NG	Full Service Restaurant	Natural Gas	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	H-1	H-1
113	Commercial_NWS_WH1_NG	Full Service Restaurant	Natural Gas	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	P-1	P-1
114	Commercial_NWS_WH1_Propane	Small Office	Propane	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	C-1	C-1
115	Commercial_NWS_WH1_Propane	Small Office	Propane	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	H-1	H-1
116	Commercial_NWS_WH1_Propane	Small Office	Propane	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	P-1	P-1
117	Commercial_NWS_WH1_Propane	Retail Stripmall	Propane	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	C-1	C-1
118	Commercial_NWS_WH1_Propane	Retail Stripmall	Propane	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	H-1	H-1
119	Commercial_NWS_WH1_Propane	Retail Stripmall	Propane	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	P-1	P-1
120	Commercial_NWS_WH1_Propane	Retail Standalone	Propane	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	C-1	C-1
121	Commercial_NWS_WH1_Propane	Retail Standalone	Propane	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	H-1	H-1
122	Commercial_NWS_WH1_Propane	Retail Standalone	Propane	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	P-1	P-1
123	Commercial_NWS_WH1_Propane	Full Service Restaurant	Propane	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	C-1	C-1
124	Commercial_NWS_WH1_Propane	Full Service Restaurant	Propane	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	H-1	H-1

Table 5.7 (Continued)

Line	Measure Scenario	Building Type	Baseline Fuel	Measure Description (MEMD code, if applicable)	Measure Life	Pre-EFEL Tariff	Post-EFEL Tariff
125	Commercial_NWS_WH1_Propane	Full Service Restaurant	Propane	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	P-1	P-1
126	Residential_NWS_ClothDry1_NG	SF Detached	Natural Gas	N-RE-AP-010393-E-XX-XX-XX-XX-01	12	A-1	A-1
127	Residential_NWS_ClothDry1_NG	SF Detached	Natural Gas	N-RE-AP-010393-E-XX-XX-XX-XX-01	12	AH-1	AH-1
128	Residential_NWS_ClothDry1_Propane	SF Detached	Propane	N-RE-AP-010393-E-XX-XX-XX-XX-01	12	A-1	A-1
129	Residential_NWS_ClothDry1_Propane	SF Detached	Propane	N-RE-AP-010393-E-XX-XX-XX-XX-01	12	AH-1	AH-1
130	Residential_NWS_ClothDry2_NG	SF Detached	Natural Gas	N-RE-AP-010394-E-XX-XX-XX-XX-01	12	A-1	A-1
131	Residential_NWS_ClothDry2_NG	SF Detached	Natural Gas	N-RE-AP-010394-E-XX-XX-XX-XX-01	12	AH-1	AH-1
132	Residential_NWS_ClothDry2_Propane	SF Detached	Propane	N-RE-AP-010394-E-XX-XX-XX-XX-01	12	A-1	A-1
133	Residential_NWS_ClothDry2_Propane	SF Detached	Propane	N-RE-AP-010394-E-XX-XX-XX-XX-01	12	AH-1	AH-1
134	Residential_NWS_ClothDry3_NG	Multifamily	Natural Gas	N-MF-AP-020314-E-XX-XX-XX-XX-01	12	A-1	A-1
135	Residential_NWS_ClothDry3_NG	Multifamily	Natural Gas	N-MF-AP-020314-E-XX-XX-XX-XX-01	12	AH-1	AH-1
136	Residential_NWS_ClothDry3_Propane	Multifamily	Propane	N-MF-AP-020314-E-XX-XX-XX-XX-01	12	A-1	A-1
137	Residential_NWS_ClothDry3_Propane	Multifamily	Propane	N-MF-AP-020314-E-XX-XX-XX-XX-01	12	AH-1	AH-1
138	Residential_NWS_Cooking1_NG	SF Detached	Natural Gas	N-RE-AP-010397-E-XX-XX-XX-XX-01	16	A-1	A-1
139	Residential_NWS_Cooking1_NG	SF Detached	Natural Gas	N-RE-AP-010397-E-XX-XX-XX-XX-01	16	AH-1	AH-1
140	Residential_NWS_Cooking1_Propane	SF Detached	Propane	N-RE-AP-010397-E-XX-XX-XX-XX-01	16	A-1	A-1
141	Residential_NWS_Cooking1_Propane	SF Detached	Propane	N-RE-AP-010397-E-XX-XX-XX-XX-01	16	AH-1	AH-1
142	Commercial_NWS_Cooking1_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000350-E-XX-XX-XX-XX-04	12	C-1	C-1
143	Commercial_NWS_Cooking1_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000350-E-XX-XX-XX-XX-04	12	H-1	H-1
144	Commercial_NWS_Cooking1_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000350-E-XX-XX-XX-XX-04	12	P-1	P-1
145	Commercial_NWS_Cooking1_Propane	Full Service Restaurant	Propane	N-CO-KR-000350-E-XX-XX-XX-XX-04	12	C-1	C-1
146	Commercial_NWS_Cooking1_Propane	Full Service Restaurant	Propane	N-CO-KR-000350-E-XX-XX-XX-XX-04	12	H-1	H-1
147	Commercial_NWS_Cooking1_Propane	Full Service Restaurant	Propane	N-CO-KR-000350-E-XX-XX-XX-XX-04	12	P-1	P-1
148	Commercial_NWS_Cooking2_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000354-E-XX-XX-XX-XX-04	12	C-1	C-1
149	Commercial_NWS_Cooking2_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000354-E-XX-XX-XX-XX-04	12	H-1	H-1
150	Commercial_NWS_Cooking2_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000354-E-XX-XX-XX-XX-04	12	P-1	P-1
151	Commercial_NWS_Cooking2_Propane	Full Service Restaurant	Propane	N-CO-KR-000354-E-XX-XX-XX-XX-04	12	C-1	C-1
152	Commercial_NWS_Cooking2_Propane	Full Service Restaurant	Propane	N-CO-KR-000354-E-XX-XX-XX-XX-04	12	H-1	H-1
153	Commercial_NWS_Cooking2_Propane	Full Service Restaurant	Propane	N-CO-KR-000354-E-XX-XX-XX-XX-04	12	P-1	P-1
154	Commercial_NWS_Cooking3_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000344-G-XX-XX-XX-XX-02	12	C-1	C-1
155	Commercial_NWS_Cooking3_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000344-G-XX-XX-XX-XX-02	12	H-1	H-1
156	Commercial_NWS_Cooking3_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000344-G-XX-XX-XX-XX-02	12	P-1	P-1
157	Commercial_NWS_Cooking3_Propane	Full Service Restaurant	Propane	N-CO-KR-000344-G-XX-XX-XX-XX-02	12	C-1	C-1
158	Commercial_NWS_Cooking3_Propane	Full Service Restaurant	Propane	N-CO-KR-000344-G-XX-XX-XX-XX-02	12	H-1	H-1
159	Commercial_NWS_Cooking3_Propane	Full Service Restaurant	Propane	N-CO-KR-000344-G-XX-XX-XX-XX-02	12	P-1	P-1
160	Commercial_NWS_Cooking4_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000346-G-XX-XX-XX-XX-02	12	C-1	C-1
161	Commercial_NWS_Cooking4_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000346-G-XX-XX-XX-XX-02	12	H-1	H-1
162	Commercial_NWS_Cooking4_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000346-G-XX-XX-XX-XX-02	12	P-1	P-1
163	Commercial_NWS_Cooking4_Propane	Full Service Restaurant	Propane	N-CO-KR-000346-G-XX-XX-XX-XX-02	12	C-1	C-1
164	Commercial_NWS_Cooking4_Propane	Full Service Restaurant	Propane	N-CO-KR-000346-G-XX-XX-XX-XX-02	12	H-1	H-1
165	Commercial_NWS_Cooking4_Propane	Full Service Restaurant	Propane	N-CO-KR-000346-G-XX-XX-XX-XX-02	12	P-1	P-1
166	Commercial_NWS_Cooking5_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000357-G-XX-XX-XX-XX-02	12	C-1	C-1
167	Commercial_NWS_Cooking5_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000357-G-XX-XX-XX-XX-02	12	H-1	H-1
168	Commercial_NWS_Cooking5_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000357-G-XX-XX-XX-XX-02	12	P-1	P-1
169	Commercial_NWS_Cooking5_Propane	Full Service Restaurant	Propane	N-CO-KR-000357-G-XX-XX-XX-XX-02	12	C-1	C-1
170	Commercial_NWS_Cooking5_Propane	Full Service Restaurant	Propane	N-CO-KR-000357-G-XX-XX-XX-XX-02	12	H-1	H-1
171	Commercial_NWS_Cooking5_Propane	Full Service Restaurant	Propane	N-CO-KR-000357-G-XX-XX-XX-XX-02	12	P-1	P-1

Table 5.8. Measures Successfully Screened for Energy Bill Savings or Health & Safety Benefits (Residential Low Income, Existing Tariff Set)

Building Type	Baseline Fuel	Measure Code	Measure Life	Tariff (Pre)	Tariff (Post)	Annual Bill Change (\$)	First Year Gross Margin (\$)	Program Budget (\$)	UPPCO Rebate (\$)	Measure Cost (\$)	MIHER Rebate (\$)	Tax Credit (\$)	Net Before UPPCO Rebate (\$)	UPPCO Rebate Applied (\$)	Net After UPPCO Rebate (\$)	Maximum TOBR (\$)	Customer Co-Pay (\$)
SF Detached	Natural Gas	GSHP (All-Electric)	15	A-1	AH-1	(57)	497	4,518	3,162	48,607	8,000	14,582	26,025	3,162	22,863	363	22,500
SF Detached	Natural Gas	GSHP (All-Electric)	15	A-1	AH-1	(65)	507	4,614	3,230	48,607	8,000	14,582	26,025	3,230	22,795	412	22,383
SF Detached	Propane	ccASHP (All-Electric)	15	A-1	AH-1	(2,579)	589	5,359	3,751	22,332	8,000	2,000	12,332	3,751	8,581	16,371	0
SF Detached	Propane	ccASHP (Dual-Fuel)	15	A-1	AH-1	(2,555)	577	5,252	3,676	22,332	8,000	2,000	12,332	3,676	8,656	16,217	0
SF Detached	Propane	GSHP (All-Electric)	15	A-1	AH-1	(2,826)	465	4,231	2,961	48,607	8,000	14,582	26,025	2,961	23,064	17,938	5,126
SF Detached	Propane	ccASHP (All-Electric)	15	A-1	AH-1	(2,339)	479	4,356	3,049	22,332	8,000	2,000	12,332	3,049	9,283	14,846	0
SF Detached	Propane	ccASHP (Dual-Fuel)	15	A-1	AH-1	(2,317)	468	4,260	2,982	22,332	8,000	2,000	12,332	2,982	9,350	14,707	0
SF Detached	Propane	GSHP (All-Electric)	15	A-1	AH-1	(2,556)	370	3,364	2,355	48,607	8,000	14,582	26,025	2,355	23,671	16,223	7,447
Mobile Home	Propane	ccASHP (All-Electric)	15	A-1	AH-1	(1,696)	397	3,609	2,527	18,823	8,000	2,000	8,823	2,527	6,296	10,764	0
Mobile Home	Propane	ccASHP (Dual-Fuel)	15	A-1	AH-1	(1,679)	389	3,536	2,475	18,823	8,000	2,000	8,823	2,475	6,347	10,657	0
Mobile Home	Propane	GSHP (All-Electric)	15	A-1	AH-1	(1,857)	316	2,874	2,012	26,712	8,000	8,014	10,698	2,012	8,687	11,786	0
SF Detached	Propane	N-RE-WH-010370-E-XX-XX-XX-01	10	A-1	A-1	(107)	172	1,208	846	3,829	1,750	2,000	79	79	0	460	0
SF Detached	Propane	N-RE-WH-010370-E-XX-XX-XX-01	10	AH-1	AH-1	(212)	109	766	536	3,829	1,750	2,000	79	79	0	915	0
SF Detached	Propane	N-RE-WH-010371-E-XX-XX-XX-01	10	A-1	A-1	(267)	172	1,208	846	3,829	1,750	2,000	79	79	0	1,149	0
SF Detached	Propane	N-RE-WH-010371-E-XX-XX-XX-01	10	AH-1	AH-1	(372)	109	766	536	3,829	1,750	2,000	79	79	0	1,604	0
SF Detached	Propane	N-RE-WH-010372-E-XX-XX-XX-01	10	AH-1	AH-1	(107)	164	1,149	804	3,829	1,750	2,000	79	79	0	463	0
SF Detached	Propane	N-RE-WH-010373-E-XX-XX-XX-01	10	A-1	A-1	(109)	258	1,812	1,268	3,829	1,750	2,000	79	79	0	469	0
SF Detached	Propane	N-RE-WH-010373-E-XX-XX-XX-01	10	AH-1	AH-1	(267)	164	1,149	804	3,829	1,750	2,000	79	79	0	1,151	0
SF Detached	Propane	N-RE-WH-010374-E-XX-XX-XX-01	10	A-1	A-1	(76)	98	688	481	3,829	1,750	2,000	79	79	0	326	0
SF Detached	Propane	N-RE-WH-010374-E-XX-XX-XX-01	10	AH-1	AH-1	(136)	62	436	305	3,829	1,750	2,000	79	79	0	585	0
SF Detached	Propane	N-RE-WH-010375-E-XX-XX-XX-01	10	A-1	A-1	(190)	98	687	481	3,829	1,750	2,000	79	79	0	820	0
SF Detached	Propane	N-RE-WH-010375-E-XX-XX-XX-01	10	AH-1	AH-1	(250)	62	436	305	3,829	1,750	2,000	79	79	0	1,079	0
SF Detached	Propane	N-RE-WH-010376-E-XX-XX-XX-01	10	AH-1	AH-1	(76)	93	654	458	3,829	1,750	2,000	79	79	0	327	0
SF Detached	Propane	N-RE-WH-010377-E-XX-XX-XX-01	10	A-1	A-1	(100)	147	1,031	722	3,829	1,750	2,000	79	79	0	433	0
SF Detached	Propane	N-RE-WH-010377-E-XX-XX-XX-01	10	AH-1	AH-1	(191)	93	654	458	3,829	1,750	2,000	79	79	0	821	0
SF Detached	Propane	N-RE-WH-010378-E-XX-XX-XX-01	10	A-1	A-1	(107)	172	1,208	846	3,829	1,750	2,000	79	79	0	460	0
SF Detached	Propane	N-RE-WH-010378-E-XX-XX-XX-01	10	AH-1	AH-1	(212)	109	766	536	3,829	1,750	2,000	79	79	0	915	0
SF Detached	Propane	N-RE-WH-010379-E-XX-XX-XX-01	10	A-1	A-1	(267)	172	1,208	846	3,829	1,750	2,000	79	79	0	1,149	0
SF Detached	Propane	N-RE-WH-010379-E-XX-XX-XX-01	10	AH-1	AH-1	(372)	109	766	536	3,829	1,750	2,000	79	79	0	1,604	0
SF Detached	Propane	N-RE-WH-010380-E-XX-XX-XX-01	10	AH-1	AH-1	(107)	164	1,149	804	3,829	1,750	2,000	79	79	0	463	0
SF Detached	Propane	N-RE-WH-010381-E-XX-XX-XX-01	10	A-1	A-1	(109)	258	1,812	1,268	3,829	1,750	2,000	79	79	0	469	0
SF Detached	Propane	N-RE-WH-010381-E-XX-XX-XX-01	10	AH-1	AH-1	(267)	164	1,149	804	3,829	1,750	2,000	79	79	0	1,151	0
SF Detached	Propane	N-RE-WH-010382-E-XX-XX-XX-01	10	A-1	A-1	(76)	98	688	481	3,829	1,750	2,000	79	79	0	326	0
SF Detached	Propane	N-RE-WH-010382-E-XX-XX-XX-01	10	AH-1	AH-1	(136)	62	436	305	3,829	1,750	2,000	79	79	0	585	0
SF Detached	Propane	N-RE-WH-010383-E-XX-XX-XX-01	10	A-1	A-1	(190)	98	687	481	3,829	1,750	2,000	79	79	0	820	0
SF Detached	Propane	N-RE-WH-010383-E-XX-XX-XX-01	10	AH-1	AH-1	(250)	62	436	305	3,829	1,750	2,000	79	79	0	1,079	0
SF Detached	Propane	N-RE-WH-010384-E-XX-XX-XX-01	10	AH-1	AH-1	(76)	93	654	458	3,829	1,750	2,000	79	79	0	327	0
SF Detached	Propane	N-RE-WH-010385-E-XX-XX-XX-01	10	A-1	A-1	(100)	147	1,031	722	3,829	1,750	2,000	79	79	0	433	0
SF Detached	Propane	N-RE-WH-010385-E-XX-XX-XX-01	10	AH-1	AH-1	(191)	93	654	458	3,829	1,750	2,000	79	79	0	821	0
SF Detached	Propane	N-RE-AP-010394-E-XX-XX-XX-01	12	AH-1	AH-1	(17)	22	178	125	1,000	840	0	160	125	35	91	0
Multifamily	Propane	N-MF-AP-020314-E-XX-XX-XX-01	12	A-1	A-1	(15)	52	416	291	1,000	840	0	160	160	0	76	0
Multifamily	Propane	N-MF-AP-020314-E-XX-XX-XX-01	12	AH-1	AH-1	(42)	36	285	200	1,000	840	0	160	160	0	221	0
SF Detached	Natural Gas	N-RE-AP-010397-E-XX-XX-XX-01	16	A-1	A-1	24	17	158	110	1,300	840	0	460	110	350	0	350
SF Detached	Natural Gas	N-RE-AP-010397-E-XX-XX-XX-01	16	AH-1	AH-1	14	11	102	71	1,300	840	0	460	71	389	0	389
SF Detached	Propane	N-RE-AP-010397-E-XX-XX-XX-01	16	A-1	A-1	10	17	157	110	1,300	840	0	460	110	350	0	350
SF Detached	Propane	N-RE-AP-010397-E-XX-XX-XX-01	16	AH-1	AH-1	0	11	102	71	1,300	840	0	460	71	389	0	389

Table 5.9. Measures Successfully Screened for Energy Bill Savings or Health & Safety Benefits (Residential Moderate Income, Existing Tariff Set)

Scenario	Building Type	Baseline Fuel	Measure Code	Measure Life	Tariff (Pre)	Tariff (Post)	Annual Bill Change (\$)	First Year Margin (\$)	Program Budget (\$)	UPPCO Rebate (\$)	Measure Cost (\$)	MIHER Rebate (\$)	Tax Credit (\$)	Net Before UPPCO Rebate (\$)	UPPCO Rebate Applied (\$)	Net After UPPCO Rebate (\$)	Maximum TOBR (\$)	Customer Co-Pay (\$)
Residential_WS1	SF Detached	Natural Gas	GSHP (All-Electric)	15	A-1	AH-1	(57)	497	4,518	3,162	48,607	4,000	14,582	30,025	3,162	26,863	363	26,500
Residential_WS2	SF Detached	Natural Gas	GSHP (All-Electric)	15	A-1	AH-1	(65)	507	4,614	3,230	48,607	4,000	14,582	30,025	3,230	26,795	412	26,383
Residential_WS5	SF Detached	Propane	ccASHP (All-Electric)	15	A-1	AH-1	(2,579)	589	5,359	3,751	22,332	4,000	2,000	16,332	3,751	12,581	16,371	0
Residential_WS5	SF Detached	Propane	ccASHP (Dual-Fuel)	15	A-1	AH-1	(2,555)	577	5,252	3,676	22,332	4,000	2,000	16,332	3,676	12,656	16,217	0
Residential_WS5	SF Detached	Propane	GSHP (All-Electric)	15	A-1	AH-1	(2,826)	465	4,231	2,961	48,607	4,000	14,582	30,025	2,961	27,064	17,938	9,126
Residential_WS6	SF Detached	Propane	ccASHP (All-Electric)	15	A-1	AH-1	(2,339)	479	4,356	3,049	22,332	4,000	2,000	16,332	3,049	13,283	14,846	0
Residential_WS6	SF Detached	Propane	ccASHP (Dual-Fuel)	15	A-1	AH-1	(2,317)	468	4,260	2,982	22,332	4,000	2,000	16,332	2,982	13,350	14,707	0
Residential_WS6	SF Detached	Propane	GSHP (All-Electric)	15	A-1	AH-1	(2,556)	370	3,364	2,355	48,607	4,000	14,582	30,025	2,355	27,671	16,223	11,447
Residential_WS7	Mobile Home	Propane	ccASHP (All-Electric)	15	A-1	AH-1	(1,696)	397	3,609	2,527	18,823	4,000	2,000	12,823	2,527	10,296	10,764	0
Residential_WS7	Mobile Home	Propane	ccASHP (Dual-Fuel)	15	A-1	AH-1	(1,679)	389	3,536	2,475	18,823	4,000	2,000	12,823	2,475	10,347	10,657	0
Residential_WS7	Mobile Home	Propane	GSHP (All-Electric)	15	A-1	AH-1	(1,857)	316	2,874	2,012	26,712	4,000	8,014	14,698	2,012	12,687	11,786	901
Residential_NWS_WH1_Propane	SF Detached	Propane	N-RE-WH-010370-E-XX-XX-XX-01	10	A-1	A-1	(107)	172	1,208	846	3,829	875	2,000	954	846	109	460	0
Residential_NWS_WH1_Propane	SF Detached	Propane	N-RE-WH-010370-E-XX-XX-XX-01	10	AH-1	AH-1	(212)	109	766	536	3,829	875	2,000	954	536	418	915	0
Residential_NWS_WH2_Propane	SF Detached	Propane	N-RE-WH-010371-E-XX-XX-XX-01	10	A-1	A-1	(267)	172	1,208	846	3,829	875	2,000	954	846	109	1,149	0
Residential_NWS_WH2_Propane	SF Detached	Propane	N-RE-WH-010371-E-XX-XX-XX-01	10	AH-1	AH-1	(372)	109	766	536	3,829	875	2,000	954	536	418	1,604	0
Residential_NWS_WH3_Propane	SF Detached	Propane	N-RE-WH-010372-E-XX-XX-XX-01	10	AH-1	AH-1	(107)	164	1,149	804	3,829	875	2,000	954	804	150	463	0
Residential_NWS_WH4_Propane	SF Detached	Propane	N-RE-WH-010373-E-XX-XX-XX-01	10	A-1	A-1	(109)	258	1,812	1,268	3,829	875	2,000	954	954	0	469	0
Residential_NWS_WH4_Propane	SF Detached	Propane	N-RE-WH-010373-E-XX-XX-XX-01	10	AH-1	AH-1	(267)	164	1,149	804	3,829	875	2,000	954	804	150	1,151	0
Residential_NWS_WH5_Propane	SF Detached	Propane	N-RE-WH-010374-E-XX-XX-XX-01	10	A-1	A-1	(76)	98	688	481	3,829	875	2,000	954	481	473	326	147
Residential_NWS_WH5_Propane	SF Detached	Propane	N-RE-WH-010374-E-XX-XX-XX-01	10	AH-1	AH-1	(136)	62	436	305	3,829	875	2,000	954	305	649	585	64
Residential_NWS_WH6_Propane	SF Detached	Propane	N-RE-WH-010375-E-XX-XX-XX-01	10	A-1	A-1	(190)	98	687	481	3,829	875	2,000	954	481	473	820	0
Residential_NWS_WH6_Propane	SF Detached	Propane	N-RE-WH-010375-E-XX-XX-XX-01	10	AH-1	AH-1	(250)	62	436	305	3,829	875	2,000	954	305	649	1,079	0
Residential_NWS_WH7_Propane	SF Detached	Propane	N-RE-WH-010376-E-XX-XX-XX-01	10	AH-1	AH-1	(76)	93	654	458	3,829	875	2,000	954	458	496	327	169
Residential_NWS_WH8_Propane	SF Detached	Propane	N-RE-WH-010377-E-XX-XX-XX-01	10	A-1	A-1	(100)	147	1,031	722	3,829	875	2,000	954	722	233	433	0
Residential_NWS_WH8_Propane	SF Detached	Propane	N-RE-WH-010377-E-XX-XX-XX-01	10	AH-1	AH-1	(191)	93	654	458	3,829	875	2,000	954	458	497	821	0
Residential_NWS_WH9_Propane	SF Detached	Propane	N-RE-WH-010378-E-XX-XX-XX-01	10	A-1	A-1	(107)	172	1,208	846	3,829	875	2,000	954	846	109	460	0
Residential_NWS_WH9_Propane	SF Detached	Propane	N-RE-WH-010378-E-XX-XX-XX-01	10	AH-1	AH-1	(212)	109	766	536	3,829	875	2,000	954	536	418	915	0
Residential_NWS_WH10_Propane	SF Detached	Propane	N-RE-WH-010379-E-XX-XX-XX-01	10	A-1	A-1	(267)	172	1,208	846	3,829	875	2,000	954	846	109	1,149	0
Residential_NWS_WH10_Propane	SF Detached	Propane	N-RE-WH-010379-E-XX-XX-XX-01	10	AH-1	AH-1	(372)	109	766	536	3,829	875	2,000	954	536	418	1,604	0
Residential_NWS_WH11_Propane	SF Detached	Propane	N-RE-WH-010380-E-XX-XX-XX-01	10	AH-1	AH-1	(107)	164	1,149	804	3,829	875	2,000	954	804	150	463	0
Residential_NWS_WH12_Propane	SF Detached	Propane	N-RE-WH-010381-E-XX-XX-XX-01	10	A-1	A-1	(109)	258	1,812	1,268	3,829	875	2,000	954	954	0	469	0
Residential_NWS_WH12_Propane	SF Detached	Propane	N-RE-WH-010381-E-XX-XX-XX-01	10	AH-1	AH-1	(267)	164	1,149	804	3,829	875	2,000	954	804	150	1,151	0
Residential_NWS_WH13_Propane	SF Detached	Propane	N-RE-WH-010382-E-XX-XX-XX-01	10	A-1	A-1	(76)	98	688	481	3,829	875	2,000	954	481	473	326	147
Residential_NWS_WH13_Propane	SF Detached	Propane	N-RE-WH-010382-E-XX-XX-XX-01	10	AH-1	AH-1	(136)	62	436	305	3,829	875	2,000	954	305	649	585	64
Residential_NWS_WH14_Propane	SF Detached	Propane	N-RE-WH-010383-E-XX-XX-XX-01	10	A-1	A-1	(190)	98	687	481	3,829	875	2,000	954	481	473	820	0
Residential_NWS_WH14_Propane	SF Detached	Propane	N-RE-WH-010383-E-XX-XX-XX-01	10	AH-1	AH-1	(250)	62	436	305	3,829	875	2,000	954	305	649	1,079	0
Residential_NWS_WH15_Propane	SF Detached	Propane	N-RE-WH-010384-E-XX-XX-XX-01	10	AH-1	AH-1	(76)	93	654	458	3,829	875	2,000	954	458	496	327	169
Residential_NWS_WH16_Propane	SF Detached	Propane	N-RE-WH-010385-E-XX-XX-XX-01	10	A-1	A-1	(100)	147	1,031	722	3,829	875	2,000	954	722	233	433	0
Residential_NWS_WH16_Propane	SF Detached	Propane	N-RE-WH-010385-E-XX-XX-XX-01	10	AH-1	AH-1	(191)	93	654	458	3,829	875	2,000	954	458	497	821	0
Residential_NWS_ClothDry2_Propane	SF Detached	Propane	N-RE-AP-010394-E-XX-XX-XX-01	12	AH-1	AH-1	(17)	22	178	125	1,000	420	0	580	125	455	91	364
Residential_NWS_ClothDry3_Propane	Multifamily	Propane	N-MF-AP-020314-E-XX-XX-XX-01	12	A-1	A-1	(15)	52	416	291	1,000	420	0	580	291	289	76	212
Residential_NWS_ClothDry3_Propane	Multifamily	Propane	N-MF-AP-020314-E-XX-XX-XX-01	12	AH-1	AH-1	(42)	36	285	200	1,000	420	0	580	200	380	221	160
Residential_NWS_Cooking1_NG	SF Detached	Natural Gas	N-RE-AP-010397-E-XX-XX-XX-01	16	A-1	A-1	24	17	158	110	1,300	420	0	880	110	770	0	770
Residential_NWS_Cooking1_NG	SF Detached	Natural Gas	N-RE-AP-010397-E-XX-XX-XX-01	16	AH-1	AH-1	14	11	102	71	1,300	420	0	880	71	809	0	809
Residential_NWS_Cooking1_Propane	SF Detached	Propane	N-RE-AP-010397-E-XX-XX-XX-01	16	A-1	A-1	10	17	157	110	1,300	420	0	880	110	770	0	770
Residential_NWS_Cooking1_Propane	SF Detached	Propane	N-RE-AP-010397-E-XX-XX-XX-01	16	AH-1	AH-1	0	11	102	71	1,300	420	0	880	71	809	0	809

Table 5.10. Measures Successfully Screened for Energy Bill Savings or Health & Safety Benefits (Residential Market Rate, Existing Tariff Set)

Scenario	Building Type	Baseline Fuel	Measure Code	Measure Life	Tariff (Pre)	Tariff (Post)	Annual Bill Change (\$)	First Year Margin (\$)	Program Budget (\$)	UPPCO Rebate (\$)	Measure Cost (\$)	MIHER Rebate (\$)	Tax Credit (\$)	Net Before UPPCO Rebate (\$)	UPPCO Rebate Applied (\$)	Net After UPPCO Rebate (\$)	Maximum TOBR (\$)	Customer Co-Pay (\$)
Residential_WS1	SF Detached	Natural Gas	GSHP (All-Electric)	15	A-1	AH-1	(57)	497	4,518	3,162	48,607	0	14,582	34,025	3,162	30,863	363	30,500
Residential_WS2	SF Detached	Natural Gas	GSHP (All-Electric)	15	A-1	AH-1	(65)	507	4,614	3,230	48,607	0	14,582	34,025	3,230	30,795	412	30,383
Residential_WS5	SF Detached	Propane	ccASHP (All-Electric)	15	A-1	AH-1	(2,579)	589	5,359	3,751	22,332	0	2,000	20,332	3,751	16,581	16,371	210
Residential_WS5	SF Detached	Propane	ccASHP (Dual-Fuel)	15	A-1	AH-1	(2,555)	577	5,252	3,676	22,332	0	2,000	20,332	3,676	16,656	16,217	439
Residential_WS5	SF Detached	Propane	GSHP (All-Electric)	15	A-1	AH-1	(2,826)	465	4,231	2,961	48,607	0	14,582	34,025	2,961	31,064	17,938	13,126
Residential_WS6	SF Detached	Propane	ccASHP (All-Electric)	15	A-1	AH-1	(2,339)	479	4,356	3,049	22,332	0	2,000	20,332	3,049	17,283	14,846	2,437
Residential_WS6	SF Detached	Propane	ccASHP (Dual-Fuel)	15	A-1	AH-1	(2,317)	468	4,260	2,982	22,332	0	2,000	20,332	2,982	17,350	14,707	2,643
Residential_WS6	SF Detached	Propane	GSHP (All-Electric)	15	A-1	AH-1	(2,556)	370	3,364	2,355	48,607	0	14,582	34,025	2,355	31,671	16,223	15,447
Residential_WS7	Mobile Home	Propane	ccASHP (All-Electric)	15	A-1	AH-1	(1,696)	397	3,609	2,527	18,823	0	2,000	16,823	2,527	14,296	10,764	3,532
Residential_WS7	Mobile Home	Propane	ccASHP (Dual-Fuel)	15	A-1	AH-1	(1,679)	389	3,536	2,475	18,823	0	2,000	16,823	2,475	14,347	10,657	3,691
Residential_WS7	Mobile Home	Propane	GSHP (All-Electric)	15	A-1	AH-1	(1,857)	316	2,874	2,012	26,712	0	8,014	18,698	2,012	16,687	11,786	4,901
Residential_NWS_WH1_Propane	SF Detached	Propane	N-RE-WH-010370-E-XX-XX-XX-XX-01	10	A-1	A-1	(107)	172	1,208	846	3,829	0	2,000	1,829	846	984	460	524
Residential_NWS_WH1_Propane	SF Detached	Propane	N-RE-WH-010370-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(212)	109	766	536	3,829	0	2,000	1,829	536	1,293	915	378
Residential_NWS_WH2_Propane	SF Detached	Propane	N-RE-WH-010371-E-XX-XX-XX-XX-01	10	A-1	A-1	(267)	172	1,208	846	3,829	0	2,000	1,829	846	984	1,149	0
Residential_NWS_WH2_Propane	SF Detached	Propane	N-RE-WH-010371-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(372)	109	766	536	3,829	0	2,000	1,829	536	1,293	1,604	0
Residential_NWS_WH3_Propane	SF Detached	Propane	N-RE-WH-010372-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(107)	164	1,149	804	3,829	0	2,000	1,829	804	1,025	463	562
Residential_NWS_WH4_Propane	SF Detached	Propane	N-RE-WH-010373-E-XX-XX-XX-XX-01	10	A-1	A-1	(109)	258	1,812	1,268	3,829	0	2,000	1,829	1,268	561	469	93
Residential_NWS_WH4_Propane	SF Detached	Propane	N-RE-WH-010373-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(267)	164	1,149	804	3,829	0	2,000	1,829	804	1,025	1,151	0
Residential_NWS_WH5_Propane	SF Detached	Propane	N-RE-WH-010374-E-XX-XX-XX-XX-01	10	A-1	A-1	(76)	98	688	481	3,829	0	2,000	1,829	481	1,348	326	1,022
Residential_NWS_WH5_Propane	SF Detached	Propane	N-RE-WH-010374-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(136)	62	436	305	3,829	0	2,000	1,829	305	1,524	585	939
Residential_NWS_WH6_Propane	SF Detached	Propane	N-RE-WH-010375-E-XX-XX-XX-XX-01	10	A-1	A-1	(190)	98	687	481	3,829	0	2,000	1,829	481	1,348	820	529
Residential_NWS_WH6_Propane	SF Detached	Propane	N-RE-WH-010375-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(250)	62	436	305	3,829	0	2,000	1,829	305	1,524	1,079	446
Residential_NWS_WH7_Propane	SF Detached	Propane	N-RE-WH-010376-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(76)	93	654	458	3,829	0	2,000	1,829	458	1,371	327	1,044
Residential_NWS_WH8_Propane	SF Detached	Propane	N-RE-WH-010377-E-XX-XX-XX-XX-01	10	A-1	A-1	(100)	147	1,031	722	3,829	0	2,000	1,829	722	1,108	433	675
Residential_NWS_WH8_Propane	SF Detached	Propane	N-RE-WH-010377-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(191)	93	654	458	3,829	0	2,000	1,829	458	1,372	821	551
Residential_NWS_WH9_Propane	SF Detached	Propane	N-RE-WH-010378-E-XX-XX-XX-XX-01	10	A-1	A-1	(107)	172	1,208	846	3,829	0	2,000	1,829	846	984	460	524
Residential_NWS_WH9_Propane	SF Detached	Propane	N-RE-WH-010378-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(212)	109	766	536	3,829	0	2,000	1,829	536	1,293	915	378
Residential_NWS_WH10_Propane	SF Detached	Propane	N-RE-WH-010379-E-XX-XX-XX-XX-01	10	A-1	A-1	(267)	172	1,208	846	3,829	0	2,000	1,829	846	984	1,149	0
Residential_NWS_WH10_Propane	SF Detached	Propane	N-RE-WH-010379-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(372)	109	766	536	3,829	0	2,000	1,829	536	1,293	1,604	0
Residential_NWS_WH11_Propane	SF Detached	Propane	N-RE-WH-010380-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(107)	164	1,149	804	3,829	0	2,000	1,829	804	1,025	463	562
Residential_NWS_WH12_Propane	SF Detached	Propane	N-RE-WH-010381-E-XX-XX-XX-XX-01	10	A-1	A-1	(109)	258	1,812	1,268	3,829	0	2,000	1,829	1,268	561	469	93
Residential_NWS_WH12_Propane	SF Detached	Propane	N-RE-WH-010381-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(267)	164	1,149	804	3,829	0	2,000	1,829	804	1,025	1,151	0
Residential_NWS_WH13_Propane	SF Detached	Propane	N-RE-WH-010382-E-XX-XX-XX-XX-01	10	A-1	A-1	(76)	98	688	481	3,829	0	2,000	1,829	481	1,348	326	1,022
Residential_NWS_WH13_Propane	SF Detached	Propane	N-RE-WH-010382-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(136)	62	436	305	3,829	0	2,000	1,829	305	1,524	585	939
Residential_NWS_WH14_Propane	SF Detached	Propane	N-RE-WH-010383-E-XX-XX-XX-XX-01	10	A-1	A-1	(190)	98	687	481	3,829	0	2,000	1,829	481	1,348	820	529
Residential_NWS_WH14_Propane	SF Detached	Propane	N-RE-WH-010383-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(250)	62	436	305	3,829	0	2,000	1,829	305	1,524	1,079	446
Residential_NWS_WH15_Propane	SF Detached	Propane	N-RE-WH-010384-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(76)	93	654	458	3,829	0	2,000	1,829	458	1,371	327	1,044
Residential_NWS_WH16_Propane	SF Detached	Propane	N-RE-WH-010385-E-XX-XX-XX-XX-01	10	A-1	A-1	(100)	147	1,031	722	3,829	0	2,000	1,829	722	1,108	433	675
Residential_NWS_WH16_Propane	SF Detached	Propane	N-RE-WH-010385-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(191)	93	654	458	3,829	0	2,000	1,829	458	1,372	821	551
Residential_NWS_ClothDry2_Propane	SF Detached	Propane	N-RE-AP-010394-E-XX-XX-XX-XX-01	12	AH-1	AH-1	(17)	22	178	125	1,000	0	0	1,000	125	875	91	784
Residential_NWS_ClothDry3_Propane	Multifamily	Propane	N-MF-AP-020314-E-XX-XX-XX-XX-01	12	A-1	A-1	(15)	52	416	291	1,000	0	0	1,000	291	709	76	632
Residential_NWS_ClothDry3_Propane	Multifamily	Propane	N-MF-AP-020314-E-XX-XX-XX-XX-01	12	AH-1	AH-1	(42)	36	285	200	1,000	0	0	1,000	200	800	221	580
Residential_NWS_Cooking1_NG	SF Detached	Natural Gas	N-RE-AP-010397-E-XX-XX-XX-XX-01	16	A-1	A-1	24	17	158	110	1,300	0	0	1,300	110	1,190	0	1,190
Residential_NWS_Cooking1_NG	SF Detached	Natural Gas	N-RE-AP-010397-E-XX-XX-XX-XX-01	16	AH-1	AH-1	14	11	102	71	1,300	0	0	1,300	71	1,229	0	1,229
Residential_NWS_Cooking1_Propane	SF Detached	Propane	N-RE-AP-010397-E-XX-XX-XX-XX-01	16	A-1	A-1	10	17	157	110	1,300	0	0	1,300	110	1,190	0	1,190
Residential_NWS_Cooking1_Propane	SF Detached	Propane	N-RE-AP-010397-E-XX-XX-XX-XX-01	16	AH-1	AH-1	0	11	102	71	1,300	0	0	1,300	71	1,229	0	1,229

Table 5.11. Measures Successfully Screened for Energy Bill Savings or Health & Safety Benefits (Residential Low Income, Proposed LM Tariff Set)

Scenario	Building Type	Baseline Fuel	Measure Code	Measure Life	Tariff (Pre)	Tariff (Post)	Annual Bill Change (\$)	First Year Gross Margin (\$)	Program Budget (\$)	UPPCO Rebate (\$)	Measure Cost (\$)	MIHER Rebate (\$)	Tax Credit (\$)	Net Before UPPCO Rebate (\$)	UPPCO Rebate Applied (\$)	Net After UPPCO Rebate (\$)	Maximum TOBR (\$)	Customer Co-Pay (\$)
Residential_WS5	SF Detached	Propane	ccASHP (All-Electric)	15	A-1	AH-1	(2,004)	896	8,148	5,703	22,332	8,000	2,000	12,332	5,703	6,629	12,720	0
Residential_WS5	SF Detached	Propane	ccASHP (Dual-Fuel)	15	A-1	AH-1	(1,991)	879	7,995	5,597	22,332	8,000	2,000	12,332	5,597	6,736	12,634	0
Residential_WS5	SF Detached	Propane	GSHP (All-Electric)	15	A-1	AH-1	(2,361)	719	6,540	4,578	48,607	8,000	14,582	26,025	4,578	21,447	14,986	6,461
Residential_WS6	SF Detached	Propane	ccASHP (All-Electric)	15	A-1	AH-1	(1,809)	767	6,974	4,882	22,332	8,000	2,000	12,332	4,882	7,450	11,480	0
Residential_WS6	SF Detached	Propane	ccASHP (Dual-Fuel)	15	A-1	AH-1	(1,797)	752	6,838	4,786	22,332	8,000	2,000	12,332	4,786	7,546	11,404	0
Residential_WS6	SF Detached	Propane	GSHP (All-Electric)	15	A-1	AH-1	(2,123)	611	5,561	3,893	48,607	8,000	14,582	26,025	3,893	22,132	13,473	8,660
Residential_WS7	Mobile Home	Propane	ccASHP (All-Electric)	15	A-1	AH-1	(1,384)	560	5,089	3,562	18,823	8,000	2,000	8,823	3,562	5,260	8,786	0
Residential_WS7	Mobile Home	Propane	ccASHP (Dual-Fuel)	15	A-1	AH-1	(1,375)	548	4,984	3,489	18,823	8,000	2,000	8,823	3,489	5,334	8,728	0
Residential_WS7	Mobile Home	Propane	GSHP (All-Electric)	15	A-1	AH-1	(1,619)	444	4,041	2,829	26,712	8,000	8,014	10,698	2,829	7,869	10,276	0
Residential_NWS_WH1_Propane	SF Detached	Propane	N-RE-WH-010370-E-XX-XX-XX-01	10	A-1	A-1	(110)	166	1,163	814	3,829	1,750	2,000	79	79	0	474	0
Residential_NWS_WH1_Propane	SF Detached	Propane	N-RE-WH-010370-E-XX-XX-XX-01	10	AH-1	AH-1	(149)	146	1,023	716	3,829	1,750	2,000	79	79	0	642	0
Residential_NWS_WH2_Propane	SF Detached	Propane	N-RE-WH-010371-E-XX-XX-XX-01	10	A-1	A-1	(270)	166	1,163	814	3,829	1,750	2,000	79	79	0	1,162	0
Residential_NWS_WH2_Propane	SF Detached	Propane	N-RE-WH-010371-E-XX-XX-XX-01	10	AH-1	AH-1	(309)	146	1,023	716	3,829	1,750	2,000	79	79	0	1,330	0
Residential_NWS_WH3_Propane	SF Detached	Propane	N-RE-WH-010372-E-XX-XX-XX-01	10	AH-1	AH-1	(12)	219	1,534	1,074	3,829	1,750	2,000	79	79	0	52	0
Residential_NWS_WH4_Propane	SF Detached	Propane	N-RE-WH-010373-E-XX-XX-XX-01	10	A-1	A-1	(113)	249	1,744	1,221	3,829	1,750	2,000	79	79	0	489	0
Residential_NWS_WH4_Propane	SF Detached	Propane	N-RE-WH-010373-E-XX-XX-XX-01	10	AH-1	AH-1	(172)	219	1,534	1,074	3,829	1,750	2,000	79	79	0	741	0
Residential_NWS_WH5_Propane	SF Detached	Propane	N-RE-WH-010374-E-XX-XX-XX-01	10	A-1	A-1	(77)	94	662	463	3,829	1,750	2,000	79	79	0	334	0
Residential_NWS_WH5_Propane	SF Detached	Propane	N-RE-WH-010374-E-XX-XX-XX-01	10	AH-1	AH-1	(100)	83	582	408	3,829	1,750	2,000	79	79	0	429	0
Residential_NWS_WH6_Propane	SF Detached	Propane	N-RE-WH-010375-E-XX-XX-XX-01	10	A-1	A-1	(192)	94	662	463	3,829	1,750	2,000	79	79	0	827	0
Residential_NWS_WH6_Propane	SF Detached	Propane	N-RE-WH-010375-E-XX-XX-XX-01	10	AH-1	AH-1	(214)	83	582	407	3,829	1,750	2,000	79	79	0	923	0
Residential_NWS_WH7_Propane	SF Detached	Propane	N-RE-WH-010376-E-XX-XX-XX-01	10	AH-1	AH-1	(22)	124	873	611	3,829	1,750	2,000	79	79	0	94	0
Residential_NWS_WH8_Propane	SF Detached	Propane	N-RE-WH-010377-E-XX-XX-XX-01	10	A-1	A-1	(103)	141	992	695	3,829	1,750	2,000	79	79	0	444	0
Residential_NWS_WH8_Propane	SF Detached	Propane	N-RE-WH-010377-E-XX-XX-XX-01	10	AH-1	AH-1	(136)	124	873	611	3,829	1,750	2,000	79	79	0	588	0
Residential_NWS_WH9_Propane	SF Detached	Propane	N-RE-WH-010378-E-XX-XX-XX-01	10	A-1	A-1	(110)	166	1,163	814	3,829	1,750	2,000	79	79	0	474	0
Residential_NWS_WH9_Propane	SF Detached	Propane	N-RE-WH-010378-E-XX-XX-XX-01	10	AH-1	AH-1	(149)	146	1,023	716	3,829	1,750	2,000	79	79	0	642	0
Residential_NWS_WH10_Propane	SF Detached	Propane	N-RE-WH-010379-E-XX-XX-XX-01	10	A-1	A-1	(270)	166	1,163	814	3,829	1,750	2,000	79	79	0	1,162	0
Residential_NWS_WH10_Propane	SF Detached	Propane	N-RE-WH-010379-E-XX-XX-XX-01	10	AH-1	AH-1	(309)	146	1,023	716	3,829	1,750	2,000	79	79	0	1,330	0
Residential_NWS_WH11_Propane	SF Detached	Propane	N-RE-WH-010380-E-XX-XX-XX-01	10	AH-1	AH-1	(12)	219	1,534	1,074	3,829	1,750	2,000	79	79	0	52	0
Residential_NWS_WH12_Propane	SF Detached	Propane	N-RE-WH-010381-E-XX-XX-XX-01	10	A-1	A-1	(113)	249	1,744	1,221	3,829	1,750	2,000	79	79	0	489	0
Residential_NWS_WH12_Propane	SF Detached	Propane	N-RE-WH-010381-E-XX-XX-XX-01	10	AH-1	AH-1	(172)	219	1,534	1,074	3,829	1,750	2,000	79	79	0	741	0
Residential_NWS_WH13_Propane	SF Detached	Propane	N-RE-WH-010382-E-XX-XX-XX-01	10	A-1	A-1	(77)	94	662	463	3,829	1,750	2,000	79	79	0	334	0
Residential_NWS_WH13_Propane	SF Detached	Propane	N-RE-WH-010382-E-XX-XX-XX-01	10	AH-1	AH-1	(100)	83	582	408	3,829	1,750	2,000	79	79	0	429	0
Residential_NWS_WH14_Propane	SF Detached	Propane	N-RE-WH-010383-E-XX-XX-XX-01	10	A-1	A-1	(192)	94	662	463	3,829	1,750	2,000	79	79	0	827	0
Residential_NWS_WH14_Propane	SF Detached	Propane	N-RE-WH-010383-E-XX-XX-XX-01	10	AH-1	AH-1	(214)	83	582	407	3,829	1,750	2,000	79	79	0	923	0
Residential_NWS_WH15_Propane	SF Detached	Propane	N-RE-WH-010384-E-XX-XX-XX-01	10	AH-1	AH-1	(22)	124	873	611	3,829	1,750	2,000	79	79	0	94	0
Residential_NWS_WH16_Propane	SF Detached	Propane	N-RE-WH-010385-E-XX-XX-XX-01	10	A-1	A-1	(103)	141	992	695	3,829	1,750	2,000	79	79	0	444	0
Residential_NWS_WH16_Propane	SF Detached	Propane	N-RE-WH-010385-E-XX-XX-XX-01	10	AH-1	AH-1	(136)	124	873	611	3,829	1,750	2,000	79	79	0	588	0
Residential_NWS_ClothDry2_Propane	SF Detached	Propane	N-RE-AP-010394-E-XX-XX-XX-01	12	AH-1	AH-1	(5)	30	237	166	1,000	840	0	160	160	0	28	0
Residential_NWS_ClothDry3_Propane	Multifamily	Propane	N-MF-AP-020314-E-XX-XX-XX-01	12	A-1	A-1	(16)	51	404	283	1,000	840	0	160	160	0	84	0
Residential_NWS_ClothDry3_Propane	Multifamily	Propane	N-MF-AP-020314-E-XX-XX-XX-01	12	AH-1	AH-1	(28)	45	357	250	1,000	840	0	160	160	0	145	0
Residential_NWS_Cooking1_NG	SF Detached	Natural Gas	N-RE-AP-010397-E-XX-XX-XX-01	16	A-1	A-1	25	16	153	107	1,300	840	0	460	107	353	0	353
Residential_NWS_Cooking1_NG	SF Detached	Natural Gas	N-RE-AP-010397-E-XX-XX-XX-01	16	AH-1	AH-1	22	14	135	95	1,300	840	0	460	95	365	0	365
Residential_NWS_Cooking1_Propane	SF Detached	Propane	N-RE-AP-010397-E-XX-XX-XX-01	16	A-1	A-1	11	16	153	107	1,300	840	0	460	107	353	0	353
Residential_NWS_Cooking1_Propane	SF Detached	Propane	N-RE-AP-010397-E-XX-XX-XX-01	16	AH-1	AH-1	7	14	135	94	1,300	840	0	460	94	366	0	366

Table 5.12. Measures Successfully Screened for Energy Bill Savings or Health & Safety Benefits (Residential Moderate Income, Proposed LM Tariff Set)

Scenario	Building Type	Baseline Fuel	Measure Code	Measure Life	Tariff (Pre)	Tariff (Post)	Annual Bill Change (\$)	First Year Gross Margin (\$)	Program Budget (\$)	UPPCO Rebate (\$)	Measure Cost (\$)	MIHER Rebate (\$)	Tax Credit (\$)	Net Before UPPCO Rebate (\$)	UPPCO Rebate Applied (\$)	Net After UPPCO Rebate (\$)	Maximum TOBR (\$)	Customer Co-Pay (\$)
Residential_WS5	SF Detached	Propane	ccASHP (All-Electric)	15	A-1	AH-1	(2,004)	896	8,148	5,703	22,332	4,000	2,000	16,332	5,703	10,629	12,720	0
Residential_WS5	SF Detached	Propane	ccASHP (Dual-Fuel)	15	A-1	AH-1	(1,991)	879	7,995	5,597	22,332	4,000	2,000	16,332	5,597	10,736	12,634	0
Residential_WS5	SF Detached	Propane	GSHP (All-Electric)	15	A-1	AH-1	(2,361)	719	6,540	4,578	48,607	4,000	14,582	30,025	4,578	25,447	14,986	10,461
Residential_WS6	SF Detached	Propane	ccASHP (All-Electric)	15	A-1	AH-1	(1,809)	767	6,974	4,882	22,332	4,000	2,000	16,332	4,882	11,450	11,480	0
Residential_WS6	SF Detached	Propane	ccASHP (Dual-Fuel)	15	A-1	AH-1	(1,797)	752	6,838	4,786	22,332	4,000	2,000	16,332	4,786	11,546	11,404	142
Residential_WS6	SF Detached	Propane	GSHP (All-Electric)	15	A-1	AH-1	(2,123)	611	5,561	3,893	48,607	4,000	14,582	30,025	3,893	26,132	13,473	12,660
Residential_WS7	Mobile Home	Propane	ccASHP (All-Electric)	15	A-1	AH-1	(1,384)	560	5,089	3,562	18,823	4,000	2,000	12,823	3,562	9,260	8,786	474
Residential_WS7	Mobile Home	Propane	ccASHP (Dual-Fuel)	15	A-1	AH-1	(1,375)	548	4,984	3,489	18,823	4,000	2,000	12,823	3,489	9,334	8,728	606
Residential_WS7	Mobile Home	Propane	GSHP (All-Electric)	15	A-1	AH-1	(1,619)	444	4,041	2,829	26,712	4,000	8,014	14,698	2,829	11,869	10,276	1,593
Residential_NWS_WH1_Propane	SF Detached	Propane	N-RE-WH-010370-E-XX-XX-XX-XX-01	10	A-1	A-1	(110)	166	1,163	814	3,829	875	2,000	954	814	141	474	0
Residential_NWS_WH1_Propane	SF Detached	Propane	N-RE-WH-010370-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(149)	146	1,023	716	3,829	875	2,000	954	716	239	642	0
Residential_NWS_WH2_Propane	SF Detached	Propane	N-RE-WH-010371-E-XX-XX-XX-XX-01	10	A-1	A-1	(270)	166	1,163	814	3,829	875	2,000	954	814	141	1,162	0
Residential_NWS_WH2_Propane	SF Detached	Propane	N-RE-WH-010371-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(309)	146	1,023	716	3,829	875	2,000	954	716	239	1,330	0
Residential_NWS_WH3_Propane	SF Detached	Propane	N-RE-WH-010372-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(12)	219	1,534	1,074	3,829	875	2,000	954	954	0	52	0
Residential_NWS_WH4_Propane	SF Detached	Propane	N-RE-WH-010373-E-XX-XX-XX-XX-01	10	A-1	A-1	(113)	249	1,744	1,221	3,829	875	2,000	954	954	0	489	0
Residential_NWS_WH4_Propane	SF Detached	Propane	N-RE-WH-010373-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(172)	219	1,534	1,074	3,829	875	2,000	954	954	0	741	0
Residential_NWS_WH5_Propane	SF Detached	Propane	N-RE-WH-010374-E-XX-XX-XX-XX-01	10	A-1	A-1	(77)	94	662	463	3,829	875	2,000	954	463	491	334	157
Residential_NWS_WH5_Propane	SF Detached	Propane	N-RE-WH-010374-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(100)	83	582	408	3,829	875	2,000	954	408	547	429	118
Residential_NWS_WH6_Propane	SF Detached	Propane	N-RE-WH-010375-E-XX-XX-XX-XX-01	10	A-1	A-1	(192)	94	662	463	3,829	875	2,000	954	463	491	827	0
Residential_NWS_WH6_Propane	SF Detached	Propane	N-RE-WH-010375-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(214)	83	582	407	3,829	875	2,000	954	407	547	923	0
Residential_NWS_WH7_Propane	SF Detached	Propane	N-RE-WH-010376-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(22)	124	873	611	3,829	875	2,000	954	611	343	94	249
Residential_NWS_WH8_Propane	SF Detached	Propane	N-RE-WH-010377-E-XX-XX-XX-XX-01	10	A-1	A-1	(103)	141	992	695	3,829	875	2,000	954	695	260	444	0
Residential_NWS_WH8_Propane	SF Detached	Propane	N-RE-WH-010377-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(136)	124	873	611	3,829	875	2,000	954	611	343	588	0
Residential_NWS_WH9_Propane	SF Detached	Propane	N-RE-WH-010378-E-XX-XX-XX-XX-01	10	A-1	A-1	(110)	166	1,163	814	3,829	875	2,000	954	814	141	474	0
Residential_NWS_WH9_Propane	SF Detached	Propane	N-RE-WH-010378-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(149)	146	1,023	716	3,829	875	2,000	954	716	239	642	0
Residential_NWS_WH10_Propane	SF Detached	Propane	N-RE-WH-010379-E-XX-XX-XX-XX-01	10	A-1	A-1	(270)	166	1,163	814	3,829	875	2,000	954	814	141	1,162	0
Residential_NWS_WH10_Propane	SF Detached	Propane	N-RE-WH-010379-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(309)	146	1,023	716	3,829	875	2,000	954	716	239	1,330	0
Residential_NWS_WH11_Propane	SF Detached	Propane	N-RE-WH-010380-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(12)	219	1,534	1,074	3,829	875	2,000	954	954	0	52	0
Residential_NWS_WH12_Propane	SF Detached	Propane	N-RE-WH-010381-E-XX-XX-XX-XX-01	10	A-1	A-1	(113)	249	1,744	1,221	3,829	875	2,000	954	954	0	489	0
Residential_NWS_WH12_Propane	SF Detached	Propane	N-RE-WH-010381-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(172)	219	1,534	1,074	3,829	875	2,000	954	954	0	741	0
Residential_NWS_WH13_Propane	SF Detached	Propane	N-RE-WH-010382-E-XX-XX-XX-XX-01	10	A-1	A-1	(77)	94	662	463	3,829	875	2,000	954	463	491	334	157
Residential_NWS_WH13_Propane	SF Detached	Propane	N-RE-WH-010382-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(100)	83	582	408	3,829	875	2,000	954	408	547	429	118
Residential_NWS_WH14_Propane	SF Detached	Propane	N-RE-WH-010383-E-XX-XX-XX-XX-01	10	A-1	A-1	(192)	94	662	463	3,829	875	2,000	954	463	491	827	0
Residential_NWS_WH14_Propane	SF Detached	Propane	N-RE-WH-010383-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(214)	83	582	407	3,829	875	2,000	954	407	547	923	0
Residential_NWS_WH15_Propane	SF Detached	Propane	N-RE-WH-010384-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(22)	124	873	611	3,829	875	2,000	954	611	343	94	249
Residential_NWS_WH16_Propane	SF Detached	Propane	N-RE-WH-010385-E-XX-XX-XX-XX-01	10	A-1	A-1	(103)	141	992	695	3,829	875	2,000	954	695	260	444	0
Residential_NWS_WH16_Propane	SF Detached	Propane	N-RE-WH-010385-E-XX-XX-XX-XX-01	10	AH-1	AH-1	(136)	124	873	611	3,829	875	2,000	954	611	343	588	0
Residential_NWS_ClothDry2_Propane	SF Detached	Propane	N-RE-AP-010394-E-XX-XX-XX-XX-01	12	AH-1	AH-1	(5)	30	237	166	1,000	420	0	580	166	414	28	385
Residential_NWS_ClothDry3_Propane	Multifamily	Propane	N-MF-AP-020314-E-XX-XX-XX-XX-01	12	A-1	A-1	(16)	51	404	283	1,000	420	0	580	283	297	84	214
Residential_NWS_ClothDry3_Propane	Multifamily	Propane	N-MF-AP-020314-E-XX-XX-XX-XX-01	12	AH-1	AH-1	(28)	45	357	250	1,000	420	0	580	250	330	145	186
Residential_NWS_Cooking1_NG	SF Detached	Natural Gas	N-RE-AP-010397-E-XX-XX-XX-XX-01	16	A-1	A-1	25	16	153	107	1,300	420	0	880	107	773	0	773
Residential_NWS_Cooking1_NG	SF Detached	Natural Gas	N-RE-AP-010397-E-XX-XX-XX-XX-01	16	AH-1	AH-1	22	14	135	95	1,300	420	0	880	95	785	0	785
Residential_NWS_Cooking1_Propane	SF Detached	Propane	N-RE-AP-010397-E-XX-XX-XX-XX-01	16	A-1	A-1	11	16	153	107	1,300	420	0	880	107	773	0	773
Residential_NWS_Cooking1_Propane	SF Detached	Propane	N-RE-AP-010397-E-XX-XX-XX-XX-01	16	AH-1	AH-1	7	14	135	94	1,300	420	0	880	94	786	0	786

Table 5.13. Measures Successfully Screened for Energy Bill Savings or Health & Safety Benefits (Residential Market Rate, Proposed LM Tariff Set)

Scenario	Building Type	Baseline Fuel	Measure Code	Measure Life	Tariff (Pre)	Tariff (Post)	Annual Bill Change (\$)	First Year Gross Margin (\$)	Program Budget (\$)	UPPCO Rebate (\$)	Measure Cost (\$)	MIHER Rebate (\$)	Tax Credit (\$)	Net Before UPPCO Rebate (\$)	UPPCO Rebate Applied (\$)	Net After UPPCO Rebate (\$)	Maximum TOBR (\$)	Customer Co-Pay (\$)
Residential_WS5	SF Detached	Propane	ccASHP (All-Electric)	15	A-1	AH-1	(2,004)	896	8,148	5,703	22,332	0	2,000	20,332	5,703	14,629	12,720	1,909
Residential_WS5	SF Detached	Propane	ccASHP (Dual-Fuel)	15	A-1	AH-1	(1,991)	879	7,995	5,597	22,332	0	2,000	20,332	5,597	14,736	12,634	2,101
Residential_WS5	SF Detached	Propane	GSHP (All-Electric)	15	A-1	AH-1	(2,361)	719	6,540	4,578	48,607	0	14,582	34,025	4,578	29,447	14,986	14,461
Residential_WS6	SF Detached	Propane	ccASHP (All-Electric)	15	A-1	AH-1	(1,809)	767	6,974	4,882	22,332	0	2,000	20,332	4,882	15,450	11,480	3,970
Residential_WS6	SF Detached	Propane	ccASHP (Dual-Fuel)	15	A-1	AH-1	(1,797)	752	6,838	4,786	22,332	0	2,000	20,332	4,786	15,546	11,404	4,142
Residential_WS6	SF Detached	Propane	GSHP (All-Electric)	15	A-1	AH-1	(2,123)	611	5,561	3,893	48,607	0	14,582	34,025	3,893	30,132	13,473	16,660
Residential_WS7	Mobile Home	Propane	ccASHP (All-Electric)	15	A-1	AH-1	(1,384)	560	5,089	3,562	18,823	0	2,000	16,823	3,562	13,260	8,786	4,474
Residential_WS7	Mobile Home	Propane	ccASHP (Dual-Fuel)	15	A-1	AH-1	(1,375)	548	4,984	3,489	18,823	0	2,000	16,823	3,489	13,334	8,728	4,606
Residential_WS7	Mobile Home	Propane	GSHP (All-Electric)	15	A-1	AH-1	(1,619)	444	4,041	2,829	26,712	0	8,014	18,698	2,829	15,869	10,276	5,593
Residential_NWS_WH1_Propane	SF Detached	Propane	N-RE-WH-010370-E-XX-XX-XX-01	10	A-1	A-1	(110)	166	1,163	814	3,829	0	2,000	1,829	814	1,016	474	542
Residential_NWS_WH1_Propane	SF Detached	Propane	N-RE-WH-010370-E-XX-XX-XX-01	10	AH-1	AH-1	(149)	146	1,023	716	3,829	0	2,000	1,829	716	1,114	642	472
Residential_NWS_WH2_Propane	SF Detached	Propane	N-RE-WH-010371-E-XX-XX-XX-01	10	A-1	A-1	(270)	166	1,163	814	3,829	0	2,000	1,829	814	1,016	1,162	0
Residential_NWS_WH2_Propane	SF Detached	Propane	N-RE-WH-010371-E-XX-XX-XX-01	10	AH-1	AH-1	(309)	146	1,023	716	3,829	0	2,000	1,829	716	1,114	1,330	0
Residential_NWS_WH3_Propane	SF Detached	Propane	N-RE-WH-010372-E-XX-XX-XX-01	10	AH-1	AH-1	(12)	219	1,534	1,074	3,829	0	2,000	1,829	1,074	756	52	704
Residential_NWS_WH4_Propane	SF Detached	Propane	N-RE-WH-010373-E-XX-XX-XX-01	10	A-1	A-1	(113)	249	1,744	1,221	3,829	0	2,000	1,829	1,221	609	489	120
Residential_NWS_WH4_Propane	SF Detached	Propane	N-RE-WH-010373-E-XX-XX-XX-01	10	AH-1	AH-1	(172)	219	1,534	1,074	3,829	0	2,000	1,829	1,074	756	741	15
Residential_NWS_WH5_Propane	SF Detached	Propane	N-RE-WH-010374-E-XX-XX-XX-01	10	A-1	A-1	(77)	94	662	463	3,829	0	2,000	1,829	463	1,366	334	1,032
Residential_NWS_WH5_Propane	SF Detached	Propane	N-RE-WH-010374-E-XX-XX-XX-01	10	AH-1	AH-1	(100)	83	582	408	3,829	0	2,000	1,829	408	1,422	429	993
Residential_NWS_WH6_Propane	SF Detached	Propane	N-RE-WH-010375-E-XX-XX-XX-01	10	A-1	A-1	(192)	94	662	463	3,829	0	2,000	1,829	463	1,366	827	539
Residential_NWS_WH6_Propane	SF Detached	Propane	N-RE-WH-010375-E-XX-XX-XX-01	10	AH-1	AH-1	(214)	83	582	407	3,829	0	2,000	1,829	407	1,422	923	499
Residential_NWS_WH7_Propane	SF Detached	Propane	N-RE-WH-010376-E-XX-XX-XX-01	10	AH-1	AH-1	(22)	124	873	611	3,829	0	2,000	1,829	611	1,218	94	1,124
Residential_NWS_WH8_Propane	SF Detached	Propane	N-RE-WH-010377-E-XX-XX-XX-01	10	A-1	A-1	(103)	141	992	695	3,829	0	2,000	1,829	695	1,135	444	691
Residential_NWS_WH8_Propane	SF Detached	Propane	N-RE-WH-010377-E-XX-XX-XX-01	10	AH-1	AH-1	(136)	124	873	611	3,829	0	2,000	1,829	611	1,218	588	631
Residential_NWS_WH9_Propane	SF Detached	Propane	N-RE-WH-010378-E-XX-XX-XX-01	10	A-1	A-1	(110)	166	1,163	814	3,829	0	2,000	1,829	814	1,016	474	542
Residential_NWS_WH9_Propane	SF Detached	Propane	N-RE-WH-010378-E-XX-XX-XX-01	10	AH-1	AH-1	(149)	146	1,023	716	3,829	0	2,000	1,829	716	1,114	642	472
Residential_NWS_WH10_Propane	SF Detached	Propane	N-RE-WH-010379-E-XX-XX-XX-01	10	A-1	A-1	(270)	166	1,163	814	3,829	0	2,000	1,829	814	1,016	1,162	0
Residential_NWS_WH10_Propane	SF Detached	Propane	N-RE-WH-010379-E-XX-XX-XX-01	10	AH-1	AH-1	(309)	146	1,023	716	3,829	0	2,000	1,829	716	1,114	1,330	0
Residential_NWS_WH11_Propane	SF Detached	Propane	N-RE-WH-010380-E-XX-XX-XX-01	10	AH-1	AH-1	(12)	219	1,534	1,074	3,829	0	2,000	1,829	1,074	756	52	704
Residential_NWS_WH12_Propane	SF Detached	Propane	N-RE-WH-010381-E-XX-XX-XX-01	10	A-1	A-1	(113)	249	1,744	1,221	3,829	0	2,000	1,829	1,221	609	489	120
Residential_NWS_WH12_Propane	SF Detached	Propane	N-RE-WH-010381-E-XX-XX-XX-01	10	AH-1	AH-1	(172)	219	1,534	1,074	3,829	0	2,000	1,829	1,074	756	741	15
Residential_NWS_WH13_Propane	SF Detached	Propane	N-RE-WH-010382-E-XX-XX-XX-01	10	A-1	A-1	(77)	94	662	463	3,829	0	2,000	1,829	463	1,366	334	1,032
Residential_NWS_WH13_Propane	SF Detached	Propane	N-RE-WH-010382-E-XX-XX-XX-01	10	AH-1	AH-1	(100)	83	582	408	3,829	0	2,000	1,829	408	1,422	429	993
Residential_NWS_WH14_Propane	SF Detached	Propane	N-RE-WH-010383-E-XX-XX-XX-01	10	A-1	A-1	(192)	94	662	463	3,829	0	2,000	1,829	463	1,366	827	539
Residential_NWS_WH14_Propane	SF Detached	Propane	N-RE-WH-010383-E-XX-XX-XX-01	10	AH-1	AH-1	(214)	83	582	407	3,829	0	2,000	1,829	407	1,422	923	499
Residential_NWS_WH15_Propane	SF Detached	Propane	N-RE-WH-010384-E-XX-XX-XX-01	10	AH-1	AH-1	(22)	124	873	611	3,829	0	2,000	1,829	611	1,218	94	1,124
Residential_NWS_WH16_Propane	SF Detached	Propane	N-RE-WH-010385-E-XX-XX-XX-01	10	A-1	A-1	(103)	141	992	695	3,829	0	2,000	1,829	695	1,135	444	691
Residential_NWS_WH16_Propane	SF Detached	Propane	N-RE-WH-010385-E-XX-XX-XX-01	10	AH-1	AH-1	(136)	124	873	611	3,829	0	2,000	1,829	611	1,218	588	631
Residential_NWS_ClothDry2_Propane	SF Detached	Propane	N-RE-AP-010394-E-XX-XX-XX-01	12	AH-1	AH-1	(5)	30	237	166	1,000	0	0	1,000	166	834	28	805
Residential_NWS_ClothDry3_Propane	Multifamily	Propane	N-MF-AP-020314-E-XX-XX-XX-01	12	A-1	A-1	(16)	51	404	283	1,000	0	0	1,000	283	717	84	634
Residential_NWS_ClothDry3_Propane	Multifamily	Propane	N-MF-AP-020314-E-XX-XX-XX-01	12	AH-1	AH-1	(28)	45	357	250	1,000	0	0	1,000	250	750	145	606
Residential_NWS_Cooking1_NG	SF Detached	Natural Gas	N-RE-AP-010397-E-XX-XX-XX-01	16	A-1	A-1	25	16	153	107	1,300	0	0	1,300	107	1,193	0	1,193
Residential_NWS_Cooking1_NG	SF Detached	Natural Gas	N-RE-AP-010397-E-XX-XX-XX-01	16	AH-1	AH-1	22	14	135	95	1,300	0	0	1,300	95	1,205	0	1,205
Residential_NWS_Cooking1_Propane	SF Detached	Propane	N-RE-AP-010397-E-XX-XX-XX-01	16	A-1	A-1	11	16	153	107	1,300	0	0	1,300	107	1,193	0	1,193
Residential_NWS_Cooking1_Propane	SF Detached	Propane	N-RE-AP-010397-E-XX-XX-XX-01	16	AH-1	AH-1	7	14	135	94	1,300	0	0	1,300	94	1,206	0	1,206

Table 5.14. Measures Successfully Screened for Energy Bill Savings or Health & Safety Benefits (Commercial, Existing Tariff Set)

Scenario	Building Type	Baseline Fuel	Measure Code	Measure Life	Tariff (Pre)	Tariff (Post)	Annual Bill Change (\$)	First Year Gross Margin (\$)	Program Budget (\$)	UPPCO Rebate (\$)	Measure Cost (\$)	MIHER Rebate (\$)	Tax Credit (\$)	Net Before UPPCO Rebate (\$)	UPPCO Rebate Applied (\$)	Net After UPPCO Rebate (\$)
Commercial_NWS_WH1_Propane	Small Office	Propane	N-CO-WH-000507-G-XX-XX-XX-03	10	C-1	C-1	(450)	753	5,282	3,697	3,829	0	0	3,829	3,697	132
Commercial_NWS_WH1_Propane	Small Office	Propane	N-CO-WH-000507-G-XX-XX-XX-03	10	H-1	H-1	(870)	489	3,434	2,404	3,829	0	0	3,829	2,404	1,426
Commercial_NWS_WH1_Propane	Small Office	Propane	N-CO-WH-000507-G-XX-XX-XX-03	10	P-1	P-1	(915)	288	2,024	1,417	3,829	0	0	3,829	1,417	2,413
Commercial_NWS_WH1_Propane	Retail Stripmall	Propane	N-CO-WH-000507-G-XX-XX-XX-03	10	C-1	C-1	(450)	753	5,282	3,697	3,829	0	0	3,829	3,697	132
Commercial_NWS_WH1_Propane	Retail Stripmall	Propane	N-CO-WH-000507-G-XX-XX-XX-03	10	H-1	H-1	(871)	489	3,431	2,401	3,829	0	0	3,829	2,401	1,428
Commercial_NWS_WH1_Propane	Retail Stripmall	Propane	N-CO-WH-000507-G-XX-XX-XX-03	10	P-1	P-1	(923)	284	1,995	1,396	3,829	0	0	3,829	1,396	2,433
Commercial_NWS_WH1_Propane	Retail Standalone	Propane	N-CO-WH-000507-G-XX-XX-XX-03	10	C-1	C-1	(450)	753	5,282	3,697	3,829	0	0	3,829	3,697	132
Commercial_NWS_WH1_Propane	Retail Standalone	Propane	N-CO-WH-000507-G-XX-XX-XX-03	10	H-1	H-1	(871)	489	3,431	2,401	3,829	0	0	3,829	2,401	1,428
Commercial_NWS_WH1_Propane	Retail Standalone	Propane	N-CO-WH-000507-G-XX-XX-XX-03	10	P-1	P-1	(916)	288	2,024	1,417	3,829	0	0	3,829	1,417	2,413
Commercial_NWS_WH1_Propane	Full Service Restaurant	Propane	N-CO-WH-000507-G-XX-XX-XX-03	10	C-1	C-1	(450)	753	5,282	3,697	3,829	0	0	3,829	3,697	132
Commercial_NWS_WH1_Propane	Full Service Restaurant	Propane	N-CO-WH-000507-G-XX-XX-XX-03	10	H-1	H-1	(871)	489	3,431	2,401	3,829	0	0	3,829	2,401	1,428
Commercial_NWS_WH1_Propane	Full Service Restaurant	Propane	N-CO-WH-000507-G-XX-XX-XX-03	10	P-1	P-1	(918)	287	2,016	1,411	3,829	0	0	3,829	1,411	2,418
Commercial_NWS_Cooking1_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000350-E-XX-XX-XX-04	12	C-1	C-1	5,284	3,871	30,709	21,496	10,925	0	0	10,925	10,925	0
Commercial_NWS_Cooking1_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000350-E-XX-XX-XX-04	12	H-1	H-1	3,421	2,704	21,452	15,016	10,925	0	0	10,925	10,925	0
Commercial_NWS_Cooking1_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000350-E-XX-XX-XX-04	12	P-1	P-1	2,812	1,442	11,443	8,010	10,925	0	0	10,925	8,010	2,915
Commercial_NWS_Cooking1_Propane	Full Service Restaurant	Propane	N-CO-KR-000350-E-XX-XX-XX-04	12	C-1	C-1	1,908	3,871	30,709	21,496	10,925	0	0	10,925	10,925	0
Commercial_NWS_Cooking1_Propane	Full Service Restaurant	Propane	N-CO-KR-000350-E-XX-XX-XX-04	12	H-1	H-1	46	2,704	21,452	15,016	10,925	0	0	10,925	10,925	0
Commercial_NWS_Cooking1_Propane	Full Service Restaurant	Propane	N-CO-KR-000350-E-XX-XX-XX-04	12	P-1	P-1	(564)	1,442	11,443	8,010	10,925	0	0	10,925	8,010	2,915
Commercial_NWS_Cooking2_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000354-E-XX-XX-XX-04	12	C-1	C-1	6,599	4,508	35,766	25,036	11,325	0	0	11,325	11,325	0
Commercial_NWS_Cooking2_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000354-E-XX-XX-XX-04	12	H-1	H-1	4,429	3,149	24,985	17,489	11,325	0	0	11,325	11,325	0
Commercial_NWS_Cooking2_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000354-E-XX-XX-XX-04	12	P-1	P-1	3,733	1,687	13,385	9,370	11,325	0	0	11,325	9,370	1,955
Commercial_NWS_Cooking2_Propane	Full Service Restaurant	Propane	N-CO-KR-000354-E-XX-XX-XX-04	12	C-1	C-1	3,860	4,508	35,766	25,036	11,325	0	0	11,325	11,325	0
Commercial_NWS_Cooking2_Propane	Full Service Restaurant	Propane	N-CO-KR-000354-E-XX-XX-XX-04	12	H-1	H-1	1,691	3,149	24,985	17,489	11,325	0	0	11,325	11,325	0
Commercial_NWS_Cooking2_Propane	Full Service Restaurant	Propane	N-CO-KR-000354-E-XX-XX-XX-04	12	P-1	P-1	995	1,687	13,385	9,370	11,325	0	0	11,325	9,370	1,955
Commercial_NWS_Cooking3_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000344-G-XX-XX-XX-02	12	C-1	C-1	5,717	4,741	37,616	26,331	14,160	0	0	14,160	14,160	0
Commercial_NWS_Cooking3_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000344-G-XX-XX-XX-02	12	H-1	H-1	3,435	3,312	26,277	18,394	14,160	0	0	14,160	14,160	0
Commercial_NWS_Cooking3_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000344-G-XX-XX-XX-02	12	P-1	P-1	2,708	1,777	14,096	9,867	14,160	0	0	14,160	9,867	4,293
Commercial_NWS_Cooking3_Propane	Full Service Restaurant	Propane	N-CO-KR-000344-G-XX-XX-XX-02	12	C-1	C-1	(534)	4,741	37,616	26,331	14,160	0	0	14,160	14,160	0
Commercial_NWS_Cooking3_Propane	Full Service Restaurant	Propane	N-CO-KR-000344-G-XX-XX-XX-02	12	H-1	H-1	(2,815)	3,312	26,277	18,394	14,160	0	0	14,160	14,160	0
Commercial_NWS_Cooking3_Propane	Full Service Restaurant	Propane	N-CO-KR-000344-G-XX-XX-XX-02	12	P-1	P-1	(3,543)	1,777	14,096	9,867	14,160	0	0	14,160	9,867	4,293
Commercial_NWS_Cooking4_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000346-G-XX-XX-XX-02	12	C-1	C-1	5,858	4,858	38,541	26,978	31,175	0	0	31,175	26,978	4,197
Commercial_NWS_Cooking4_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000346-G-XX-XX-XX-02	12	H-1	H-1	3,520	3,394	26,923	18,846	31,175	0	0	31,175	18,846	12,329
Commercial_NWS_Cooking4_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000346-G-XX-XX-XX-02	12	P-1	P-1	2,777	1,822	14,451	10,116	31,175	0	0	31,175	10,116	21,059
Commercial_NWS_Cooking4_Propane	Full Service Restaurant	Propane	N-CO-KR-000346-G-XX-XX-XX-02	12	C-1	C-1	(547)	4,858	38,541	26,978	31,175	0	0	31,175	26,978	4,197
Commercial_NWS_Cooking4_Propane	Full Service Restaurant	Propane	N-CO-KR-000346-G-XX-XX-XX-02	12	H-1	H-1	(2,885)	3,394	26,923	18,846	31,175	0	0	31,175	18,846	12,329
Commercial_NWS_Cooking4_Propane	Full Service Restaurant	Propane	N-CO-KR-000346-G-XX-XX-XX-02	12	P-1	P-1	(3,628)	1,822	14,451	10,116	31,175	0	0	31,175	10,116	21,059
Commercial_NWS_Cooking5_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000357-G-XX-XX-XX-02	12	C-1	C-1	10,027	7,040	55,848	39,093	21,225	0	0	21,225	21,225	0
Commercial_NWS_Cooking5_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000357-G-XX-XX-XX-02	12	H-1	H-1	6,639	4,918	39,013	27,309	21,225	0	0	21,225	21,225	0
Commercial_NWS_Cooking5_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000357-G-XX-XX-XX-02	12	P-1	P-1	5,603	2,661	21,108	14,775	21,225	0	0	21,225	14,775	6,450
Commercial_NWS_Cooking5_Propane	Full Service Restaurant	Propane	N-CO-KR-000357-G-XX-XX-XX-02	12	C-1	C-1	4,936	7,040	55,848	39,093	21,225	0	0	21,225	21,225	0
Commercial_NWS_Cooking5_Propane	Full Service Restaurant	Propane	N-CO-KR-000357-G-XX-XX-XX-02	12	H-1	H-1	1,548	4,918	39,013	27,309	21,225	0	0	21,225	21,225	0
Commercial_NWS_Cooking5_Propane	Full Service Restaurant	Propane	N-CO-KR-000357-G-XX-XX-XX-02	12	P-1	P-1	512	2,661	21,108	14,775	21,225	0	0	21,225	14,775	6,450

Table 5.15. Measures Successfully Screened for Energy Bill Savings or Health & Safety Benefits (Commercial, Proposed LM Tariff Set)

Scenario	Building Type	Baseline Fuel	Measure Code	Measure Life	Tariff (Pre)	Tariff (Post)	Annual Bill Change (\$)	First Year Gross Margin (%)	Program Budget (\$)	UPPCO Rebate (\$)	Measure Cost (\$)	MIHER Rebate (\$)	Tax Credit (\$)	Net Before UPPCO Rebate (\$)	UPPCO Rebate Applied (\$)	Net After UPPCO Rebate (\$)
Commercial_NWS_WH1_Propane	Small Office	Propane	N-CO-WH-000507-G-XX-XX-XX-03	10	C-1	C-1	(468)	735	5,154	3,608	3,829	0	0	3,829	3,608	222
Commercial_NWS_WH1_Propane	Small Office	Propane	N-CO-WH-000507-G-XX-XX-XX-03	10	H-1	H-1	(724)	569	3,991	2,794	3,829	0	0	3,829	2,794	1,035
Commercial_NWS_WH1_Propane	Small Office	Propane	N-CO-WH-000507-G-XX-XX-XX-03	10	P-1	P-1	(928)	282	1,977	1,384	3,829	0	0	3,829	1,384	2,445
Commercial_NWS_WH1_Propane	Retail Stripmall	Propane	N-CO-WH-000507-G-XX-XX-XX-03	10	C-1	C-1	(468)	735	5,154	3,608	3,829	0	0	3,829	3,608	222
Commercial_NWS_WH1_Propane	Retail Stripmall	Propane	N-CO-WH-000507-G-XX-XX-XX-03	10	H-1	H-1	(724)	569	3,991	2,794	3,829	0	0	3,829	2,794	1,035
Commercial_NWS_WH1_Propane	Retail Stripmall	Propane	N-CO-WH-000507-G-XX-XX-XX-03	10	P-1	P-1	(934)	279	1,958	1,371	3,829	0	0	3,829	1,371	2,459
Commercial_NWS_WH1_Propane	Retail Standalone	Propane	N-CO-WH-000507-G-XX-XX-XX-03	10	C-1	C-1	(468)	735	5,154	3,608	3,829	0	0	3,829	3,608	222
Commercial_NWS_WH1_Propane	Retail Standalone	Propane	N-CO-WH-000507-G-XX-XX-XX-03	10	H-1	H-1	(724)	569	3,991	2,794	3,829	0	0	3,829	2,794	1,035
Commercial_NWS_WH1_Propane	Retail Standalone	Propane	N-CO-WH-000507-G-XX-XX-XX-03	10	P-1	P-1	(938)	277	1,943	1,360	3,829	0	0	3,829	1,360	2,469
Commercial_NWS_WH1_Propane	Full Service Restaurant	Propane	N-CO-WH-000507-G-XX-XX-XX-03	10	C-1	C-1	(468)	735	5,154	3,608	3,829	0	0	3,829	3,608	222
Commercial_NWS_WH1_Propane	Full Service Restaurant	Propane	N-CO-WH-000507-G-XX-XX-XX-03	10	H-1	H-1	(724)	569	3,991	2,794	3,829	0	0	3,829	2,794	1,035
Commercial_NWS_WH1_Propane	Full Service Restaurant	Propane	N-CO-WH-000507-G-XX-XX-XX-03	10	P-1	P-1	(934)	279	1,957	1,370	3,829	0	0	3,829	1,370	2,460
Commercial_NWS_Cooking1_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000350-E-XX-XX-XX-04	12	C-1	C-1	5,416	3,918	31,087	21,761	10,925	0	0	10,925	10,925	0
Commercial_NWS_Cooking1_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000350-E-XX-XX-XX-04	12	H-1	H-1	4,220	3,186	25,272	17,690	10,925	0	0	10,925	10,925	0
Commercial_NWS_Cooking1_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000350-E-XX-XX-XX-04	12	P-1	P-1	2,874	1,475	11,702	8,192	10,925	0	0	10,925	8,192	2,733
Commercial_NWS_Cooking1_Propane	Full Service Restaurant	Propane	N-CO-KR-000350-E-XX-XX-XX-04	12	C-1	C-1	2,040	3,918	31,087	21,761	10,925	0	0	10,925	10,925	0
Commercial_NWS_Cooking1_Propane	Full Service Restaurant	Propane	N-CO-KR-000350-E-XX-XX-XX-04	12	H-1	H-1	845	3,186	25,272	17,690	10,925	0	0	10,925	10,925	0
Commercial_NWS_Cooking1_Propane	Full Service Restaurant	Propane	N-CO-KR-000350-E-XX-XX-XX-04	12	P-1	P-1	(501)	1,475	11,702	8,192	10,925	0	0	10,925	8,192	2,733
Commercial_NWS_Cooking2_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000354-E-XX-XX-XX-04	12	C-1	C-1	6,753	4,564	36,206	25,344	11,325	0	0	11,325	11,325	0
Commercial_NWS_Cooking2_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000354-E-XX-XX-XX-04	12	H-1	H-1	5,360	3,710	29,434	20,604	11,325	0	0	11,325	11,325	0
Commercial_NWS_Cooking2_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000354-E-XX-XX-XX-04	12	P-1	P-1	3,799	1,721	13,657	9,560	11,325	0	0	11,325	9,560	1,765
Commercial_NWS_Cooking2_Propane	Full Service Restaurant	Propane	N-CO-KR-000354-E-XX-XX-XX-04	12	C-1	C-1	4,014	4,564	36,206	25,344	11,325	0	0	11,325	11,325	0
Commercial_NWS_Cooking2_Propane	Full Service Restaurant	Propane	N-CO-KR-000354-E-XX-XX-XX-04	12	H-1	H-1	2,622	3,710	29,434	20,604	11,325	0	0	11,325	11,325	0
Commercial_NWS_Cooking2_Propane	Full Service Restaurant	Propane	N-CO-KR-000354-E-XX-XX-XX-04	12	P-1	P-1	1,061	1,721	13,657	9,560	11,325	0	0	11,325	9,560	1,765
Commercial_NWS_Cooking3_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000344-G-XX-XX-XX-02	12	C-1	C-1	5,879	4,800	38,079	26,655	14,160	0	0	14,160	14,160	0
Commercial_NWS_Cooking3_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000344-G-XX-XX-XX-02	12	H-1	H-1	4,414	3,902	30,956	21,669	14,160	0	0	14,160	14,160	0
Commercial_NWS_Cooking3_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000344-G-XX-XX-XX-02	12	P-1	P-1	2,775	1,812	14,373	10,061	14,160	0	0	14,160	10,061	4,099
Commercial_NWS_Cooking3_Propane	Full Service Restaurant	Propane	N-CO-KR-000344-G-XX-XX-XX-02	12	C-1	C-1	(372)	4,800	38,079	26,655	14,160	0	0	14,160	14,160	0
Commercial_NWS_Cooking3_Propane	Full Service Restaurant	Propane	N-CO-KR-000344-G-XX-XX-XX-02	12	H-1	H-1	(1,837)	3,902	30,956	21,669	14,160	0	0	14,160	14,160	0
Commercial_NWS_Cooking3_Propane	Full Service Restaurant	Propane	N-CO-KR-000344-G-XX-XX-XX-02	12	P-1	P-1	(3,476)	1,812	14,373	10,061	14,160	0	0	14,160	10,061	4,099
Commercial_NWS_Cooking4_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000346-G-XX-XX-XX-02	12	C-1	C-1	6,024	4,918	39,015	27,310	31,175	0	0	31,175	27,310	3,865
Commercial_NWS_Cooking4_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000346-G-XX-XX-XX-02	12	H-1	H-1	4,523	3,998	31,717	22,202	31,175	0	0	31,175	22,202	8,973
Commercial_NWS_Cooking4_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000346-G-XX-XX-XX-02	12	P-1	P-1	2,845	1,857	14,731	10,312	31,175	0	0	31,175	10,312	20,863
Commercial_NWS_Cooking4_Propane	Full Service Restaurant	Propane	N-CO-KR-000346-G-XX-XX-XX-02	12	C-1	C-1	(381)	4,918	39,015	27,310	31,175	0	0	31,175	27,310	3,865
Commercial_NWS_Cooking4_Propane	Full Service Restaurant	Propane	N-CO-KR-000346-G-XX-XX-XX-02	12	H-1	H-1	(1,882)	3,998	31,717	22,202	31,175	0	0	31,175	22,202	8,973
Commercial_NWS_Cooking4_Propane	Full Service Restaurant	Propane	N-CO-KR-000346-G-XX-XX-XX-02	12	P-1	P-1	(3,560)	1,857	14,731	10,312	31,175	0	0	31,175	10,312	20,863
Commercial_NWS_Cooking5_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000357-G-XX-XX-XX-02	12	C-1	C-1	10,267	7,126	56,535	39,574	21,225	0	0	21,225	21,225	0
Commercial_NWS_Cooking5_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000357-G-XX-XX-XX-02	12	H-1	H-1	8,093	5,793	45,960	32,172	21,225	0	0	21,225	21,225	0
Commercial_NWS_Cooking5_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000357-G-XX-XX-XX-02	12	P-1	P-1	5,683	2,702	21,438	15,007	21,225	0	0	21,225	15,007	6,218
Commercial_NWS_Cooking5_Propane	Full Service Restaurant	Propane	N-CO-KR-000357-G-XX-XX-XX-02	12	C-1	C-1	5,176	7,126	56,535	39,574	21,225	0	0	21,225	21,225	0
Commercial_NWS_Cooking5_Propane	Full Service Restaurant	Propane	N-CO-KR-000357-G-XX-XX-XX-02	12	H-1	H-1	3,001	5,793	45,960	32,172	21,225	0	0	21,225	21,225	0
Commercial_NWS_Cooking5_Propane	Full Service Restaurant	Propane	N-CO-KR-000357-G-XX-XX-XX-02	12	P-1	P-1	592	2,702	21,438	15,007	21,225	0	0	21,225	15,007	6,218

5.1.6 Avoiding Rate Impact on Non-Participating Customers

This Plan must ensure that UPPCO's EFEL program will comply with the statutory requirement that it not increase rates for non-participating customers. To do this, we computed first-year gross margin on incremental sales for each measure scenario/tariff combination. These results are presented in Tables 5.8 through 5.15. To set the allowable program budget for each measure, we derived a net present value such that levelized annual transfers from a deferred account to UPPCO's income statement equal first-year gross margin and then apply a discount rate at UPPCO's weighted average cost of capital over the measure life. The resulting value, reported for each measure combination in Tables 5.8 through 5.15, is the justifiable UPPCO expenditure that will be offset by the incremental revenue from applying the measure. This ensures that UPPCO's program expenditure for the electrification measure does not increase rates for non-participating customers.

Note that under current tariffs, some larger C-1 customers switching to H-1 could radically reduce their electricity bill given the structure of the block tariff. In this case, a customer could add electric heating and take advantage of this outcome, but UPPCO would not be able to offer a rebate due to the negative impact on other customers. This will be avoided for now by the custom calculation of maximum rebate that we recommend; it will not be a problem with our recommended load management version of rates C-1 and H-1.

We recommend that UPPCO's maximum rebate incentive for an eligible measure be set initially at 70% of maximum program cost for that measure, leaving the remaining funds for program administration and education. These rebate amounts are shown in Tables 5.8 through 5.15. The mechanism by which UPPCO will recover EFEL program costs is explained in Section 2.7.4. Further recommendations on how to structure and apply EFEL measure rebates are discussed in Section 5.2.

For detailed calculations behind the gross margin, program budget, and UPPCO rebate figures reported in Tables 5.8 through 5.15, see Workpapers Rebate and OBR_v6; EFEL Measures List and Profiles_v8; Building_measures_calculator.py; EFEL Measures List and Profiles_v8.xlsx; Toolkit_assumptions.xlsx; Toolkit_building.py; Toolkit_project.py.

5.1.7 Electrification for Occupant Health and Safety

In addition to all measure combinations which successfully screened for energy bill savings, Tables 5.8 through 5.15 include any which are known to provide occupant health and safety benefits, namely all residential and commercial electric cooking equipment. We recommend that UPPCO consider these as eligible measures per statute. To support this recommendation, we cite the UW-Madison Cost/Benefit Analysis Study conducted for UPPCO and Indiana-Michigan Power by Slipstream in 2023. This study, included as Appendix C in the plan, involved a cost-benefit analysis of converting existing kitchen ranges to induction ranges in Michigan. Health impacts were measured for asthma, Lower Respiratory Tract (LRT) issues, Chronic Obstructive Pulmonary Disease (COPD), and Autism Spectrum Disorder (ASD). Health impacts were monetized for three air pollutants: nitrogen dioxide (NO₂), carbon monoxide (CO), and PM_{2.5}. The study concludes on page 2 that "switching from gas to induction would provide significant health benefits due to the reduction of indoor air pollutants."

Commercial kitchens have been less extensively studied but are addressed in scientific literature and show similar effects to those found in residential kitchens.²⁴

Based on these research findings, Tables 5.8 through 5.15 include all cooking measure combinations as eligible whether or not they deliver customer bill savings.

5.1.8 Net Cost and Financing for Participating Customers

We recommend that UPPCO’s EFEL rebates be bundled with other incentives available to participating customers including MiHER rebates and federal tax credits. Because MiHER offerings differ for low-income and moderate-income residents, Tables 5.8 through 5.15 show different economic impacts for these groups. If UPPCO prefers, the treatment of income-qualified participants could align with its approach to EWR programming such that the computed low-income EFEL rebate amounts would be applied through a program delivery format other than direct rebates to customers.

We also recommend that UPPCO offer the Tariffed On-Bill (TOB) Program explained in Section 2.5.7 to residential EFEL participants to help pay for any remaining net cost for eligible measures after rebates and tax incentives are applied. Tables 5.8 through 5.15 show, Left to Right, the stepwise procedure for computing and applying UPPCO rebates and the maximum TOB amount which could be recovered. Details for these calculations can be found in Workpaper Rebate and OBR_v6.

To illustrate EFEL program arithmetic, consider the following example of a market rate customer on the A-1 tariff who wants to install a HPWH in measure scenario “Residential_NWS_WH1_propane” (see Table 5.10):

Measure cost:	3,829.00
MiHER rebate:	0.00
Federal tax credit:	2,000.00
UPPCO EFEL rebate:	846.00
Remaining net cost:	984.00
TOB recovery:	460.00
Co-Pay:	524.00

Here the customer receives the maximum UPPCO rebate of \$864.00 and is able to spend another \$460.00 through TOB recovery. Because not all measure costs are covered by these combined offers, the customer would need to pay another \$524.00 to install this measure. While not true in this example, UPPCO’s combined offering of rebates and TOB recovery could completely cover any remaining project costs in other situations.

To enhance energy bill savings and GHG emissions reduction, customers who install a heat pump for space heating should be encouraged to upgrade their building envelope to minimize the new equipment’s installed capacity. This

²⁴ Torkmahalleh, M.A., S. Gorjinezhad, H. S. Unluevcek, and P. K. Hople. Review of factors impacting emission/concentration of cooking generated particulate matter. May, 2017. Science of the Total Environment 586, pp 1046-1056. Available from <https://www.sciencedirect.com/science/article/abs/pii/S0048969717303297>.

approach would also improve system performance and occupant comfort over measure life. Section 2.7.8.2 provides an example of how EWR and EFEL incentives can be bundled to support whole-building improvements.

Given the inherent uncertainty in the representative calculations reflected in the results of Tables 5.8 through 5.15, it would be prudent for UPPCO in the initial years of this program to adjust the allowable TOB annual recovery downward from its maximum computed value of 100% of annual bill savings over measure life. Therefore, we recommend an adjustment to 80% of annual bill savings over a period of three years less than the average measure life. With experience that demonstrates predictable results, these requirements could be somewhat relaxed.

5.2 Program Strategy and Structure

The screening test results discussed in Section 5.1 demonstrate that UPPCO's initial list of eligible measures for the efficiency electrification program should be limited. While all measure scenarios that were modeled achieved energy savings and GHG emissions reductions over average measure life, the reality of current electricity and heating fuel prices in UPPCO's service area prevented most of the measure scenarios from achieving energy bill savings for customers. Those which did screen were typically measure scenarios with propane as the baseline energy source due to propane's relatively higher price per energy unit over natural gas. We expect this situation to change with time, particularly after UPPCO implements a load management tariff design which would unlock significant economic value from interconnected electric heating equipment actively responding to time-varying price signals.

In the meantime, we recommend that UPPCO focus its EFEL program on educating target customers about the benefits of efficient electrification, building a strong local network of trained and trusted installers, and executing successful EFEL projects for those measures which are now eligible.

Table 5.16 presents a strategic summary of the EFEL program in terms of measure eligibility, rebate structure, and TOB program availability to help customers adopt efficient electrification measures.

Table 5.16. Recommended Efficient Electrification Program Structure and Offerings

Measure Type	Program Element	Residential Customers	Commercial Customers
Space Heating	Eligibility	Propane to ccASHP or GSHP	
		Natural gas to GSHP	
	Rebates	Custom program (project-by-project basis)	
Differentiated by ccASHP and GSHP			
	TOB	Available for eligible measures	
Water Heating	Eligibility	Propane to Heat Pump Water Heater	Propane to Heat Pump Water Heater
	Rebates	Fixed offer differentiated by high draw, medium draw	Fixed offer differentiated by C-1, H-1, P-1 tariffs
	TOB	Available for eligible measures	Not available
Clothes Drying	Eligibility	Propane to heat pump dryers	
	Rebates	Fixed offer differentiated by Single Family, Multi-Family building types	
	TOB	Available for eligible measures	
Cooking	Eligibility	All measures (Occupant Health & Safety)	All measures (Occupant Health & Safety)
	Rebates	Fixed offer differentiated A-1, AH-1 tariffs	Custom program (project-by-project basis)
			Differentiated by C-1, H-1, P-1 tariffs
	TOB	Available for eligible measures	Not available

Tables 5.17 through 5.22 repeat the UPPCO rebates from Tables 5.8 through 5.15 and discussed in Section 5.1.7. Based on the eligibility screening results, we recommend that UPPCO provide fixed-offer rebates to residential customers for water heating, clothes drying and cooking EFEL measures, and to commercial customers for water heating EFEL measures only. The average figures at the bottom of Tables 5.18 through 5.21 suggest appropriate maximum fixed-offer rebate amounts depending on equipment characteristic, building type, or customer rate class.

For custom rebates to be computed on a project-by-project basis, the average figures at the bottom of Tables 5.17 and 5.22 provide reasonable estimates of what to expect for custom rebate amounts for residential space heating measures (by equipment type) and commercial cooking measures (by customer rate class).

The recommended rebate amounts shown in Tables 5.17 through 5.22 should be considered as the maximum incentives UPPCO can provide for installing eligible measures. If initial market outreach confirms that lesser rebates support measure adoption, then incentives should be adjusted accordingly.

Table 5.17. Recommended Maximum Rebates (Residential WS)

Scenario	Building Type	Baseline Fuel	Measure Code	Measure Life	Tariff (Pre)	Tariff (Post)	Existing Tariffs	LM Tariffs
							UPPCO Rebate (\$)	UPPCO Rebate (\$)
Residential_WS1	SF Detached	Natural Gas	GSHP (All-Electric)	15	A-1	AH-1	3,162	
Residential_WS2	SF Detached	Natural Gas	GSHP (All-Electric)	15	A-1	AH-1	3,230	
Residential_WS5	SF Detached	Propane	ccASHP (All-Electric)	15	A-1	AH-1	3,751	5,703
Residential_WS5	SF Detached	Propane	ccASHP (Dual-Fuel)	15	A-1	AH-1	3,676	5,597
Residential_WS5	SF Detached	Propane	GSHP (All-Electric)	15	A-1	AH-1	2,961	4,578
Residential_WS6	SF Detached	Propane	ccASHP (All-Electric)	15	A-1	AH-1	3,049	4,882
Residential_WS6	SF Detached	Propane	ccASHP (Dual-Fuel)	15	A-1	AH-1	2,982	4,786
Residential_WS6	SF Detached	Propane	GSHP (All-Electric)	15	A-1	AH-1	2,355	3,893
Residential_WS7	Mobile Home	Propane	ccASHP (All-Electric)	15	A-1	AH-1	2,527	3,562
Residential_WS7	Mobile Home	Propane	ccASHP (Dual-Fuel)	15	A-1	AH-1	2,475	3,489
Residential_WS7	Mobile Home	Propane	GSHP (All-Electric)	15	A-1	AH-1	2,012	2,829
Average Rebate, Rounded (ccASHP) >>							3,050	4,650
Average Rebate, Rounded (GSHP) >>							2,700	3,750

Table 5.18. Recommended Maximum Rebates (Residential Water Heaters)

Scenario	Building Type	Baseline Fuel	Measure Code	Measure	Tariff (Pre)	Tariff (Post)	Existing Tariffs	LM Tariffs
							UPPCO Rebate	UPPCO Rebate
Residential_NWS_WH1_Propane	SF Detached	Propane	N-RE-WH-010370-E-XX-XX-XX-XX-01	10	A-1	A-1	846	814
Residential_NWS_WH1_Propane	SF Detached	Propane	N-RE-WH-010370-E-XX-XX-XX-XX-01	10	AH-1	AH-1	536	716
Residential_NWS_WH2_Propane	SF Detached	Propane	N-RE-WH-010371-E-XX-XX-XX-XX-01	10	A-1	A-1	846	814
Residential_NWS_WH2_Propane	SF Detached	Propane	N-RE-WH-010371-E-XX-XX-XX-XX-01	10	AH-1	AH-1	536	716
Residential_NWS_WH3_Propane	SF Detached	Propane	N-RE-WH-010372-E-XX-XX-XX-XX-01	10	AH-1	AH-1	804	1,074
Residential_NWS_WH4_Propane	SF Detached	Propane	N-RE-WH-010373-E-XX-XX-XX-XX-01	10	A-1	A-1	1,268	1,221
Residential_NWS_WH4_Propane	SF Detached	Propane	N-RE-WH-010373-E-XX-XX-XX-XX-01	10	AH-1	AH-1	804	1,074
Residential_NWS_WH5_Propane	SF Detached	Propane	N-RE-WH-010374-E-XX-XX-XX-XX-01	10	A-1	A-1	481	463
Residential_NWS_WH5_Propane	SF Detached	Propane	N-RE-WH-010374-E-XX-XX-XX-XX-01	10	AH-1	AH-1	305	408
Residential_NWS_WH6_Propane	SF Detached	Propane	N-RE-WH-010375-E-XX-XX-XX-XX-01	10	A-1	A-1	481	463
Residential_NWS_WH6_Propane	SF Detached	Propane	N-RE-WH-010375-E-XX-XX-XX-XX-01	10	AH-1	AH-1	305	407
Residential_NWS_WH7_Propane	SF Detached	Propane	N-RE-WH-010376-E-XX-XX-XX-XX-01	10	AH-1	AH-1	458	611
Residential_NWS_WH8_Propane	SF Detached	Propane	N-RE-WH-010377-E-XX-XX-XX-XX-01	10	A-1	A-1	722	695
Residential_NWS_WH8_Propane	SF Detached	Propane	N-RE-WH-010377-E-XX-XX-XX-XX-01	10	AH-1	AH-1	458	611
Residential_NWS_WH9_Propane	SF Detached	Propane	N-RE-WH-010378-E-XX-XX-XX-XX-01	10	A-1	A-1	846	814
Residential_NWS_WH9_Propane	SF Detached	Propane	N-RE-WH-010378-E-XX-XX-XX-XX-01	10	AH-1	AH-1	536	716
Residential_NWS_WH10_Propane	SF Detached	Propane	N-RE-WH-010379-E-XX-XX-XX-XX-01	10	A-1	A-1	846	814
Residential_NWS_WH10_Propane	SF Detached	Propane	N-RE-WH-010379-E-XX-XX-XX-XX-01	10	AH-1	AH-1	536	716
Residential_NWS_WH11_Propane	SF Detached	Propane	N-RE-WH-010380-E-XX-XX-XX-XX-01	10	AH-1	AH-1	804	1,074
Residential_NWS_WH12_Propane	SF Detached	Propane	N-RE-WH-010381-E-XX-XX-XX-XX-01	10	A-1	A-1	1,268	1,221
Residential_NWS_WH12_Propane	SF Detached	Propane	N-RE-WH-010381-E-XX-XX-XX-XX-01	10	AH-1	AH-1	804	1,074
Residential_NWS_WH13_Propane	SF Detached	Propane	N-RE-WH-010382-E-XX-XX-XX-XX-01	10	A-1	A-1	481	463
Residential_NWS_WH13_Propane	SF Detached	Propane	N-RE-WH-010382-E-XX-XX-XX-XX-01	10	AH-1	AH-1	305	408
Residential_NWS_WH14_Propane	SF Detached	Propane	N-RE-WH-010383-E-XX-XX-XX-XX-01	10	A-1	A-1	481	463
Residential_NWS_WH14_Propane	SF Detached	Propane	N-RE-WH-010383-E-XX-XX-XX-XX-01	10	AH-1	AH-1	305	407
Residential_NWS_WH15_Propane	SF Detached	Propane	N-RE-WH-010384-E-XX-XX-XX-XX-01	10	AH-1	AH-1	458	611
Residential_NWS_WH16_Propane	SF Detached	Propane	N-RE-WH-010385-E-XX-XX-XX-XX-01	10	A-1	A-1	722	695
Residential_NWS_WH16_Propane	SF Detached	Propane	N-RE-WH-010385-E-XX-XX-XX-XX-01	10	AH-1	AH-1	458	611
Average Rebate, Rounded (High Draw) >>							800	900
Average Rebate, Rounded (Medium Draw) >>							450	500

Table 5.19. Recommended Maximum Rebates (Residential Clothes Dryers)

Scenario	Building Type	Baseline Fuel	Measure Code	Measure Life	Tariff (Pre)	Tariff (Post)	Existing Tariffs	LM Tariffs
							UPPCO Rebate (\$)	UPPCO Rebate (\$)
Residential_NWS_ClothDry2_Propane	SF Detached	Propane	N-RE-AP-010394-E-XX-XX-XX-XX-01	12	AH-1	AH-1	125	166
Residential_NWS_ClothDry3_Propane	Multifamily	Propane	N-MF-AP-020314-E-XX-XX-XX-XX-01	12	A-1	A-1	291	283
Residential_NWS_ClothDry3_Propane	Multifamily	Propane	N-MF-AP-020314-E-XX-XX-XX-XX-01	12	AH-1	AH-1	200	250
Average Rebate, Rounded (Single Family) >>							125	150
Average Rebate, Rounded (Multi-Family) >>							225	250

Table 5.20. Recommended Maximum Rebates (Residential Cooking)

Scenario	Building Type	Baseline Fuel	Measure Code	Measure Life	Tariff (Pre)	Tariff (Post)	Existing Tariffs	LM Tariffs
							UPPCO Rebate (\$)	UPPCO Rebate (\$)
Residential_NWS_Cooking1_NG	SF Detached	Natural Gas	N-RE-AP-010397-E-XX-XX-XX-XX-01	16	A-1	A-1	110	107
Residential_NWS_Cooking1_NG	SF Detached	Natural Gas	N-RE-AP-010397-E-XX-XX-XX-XX-01	16	AH-1	AH-1	71	95
Residential_NWS_Cooking1_Propane	SF Detached	Propane	N-RE-AP-010397-E-XX-XX-XX-XX-01	16	A-1	A-1	110	107
Residential_NWS_Cooking1_Propane	SF Detached	Propane	N-RE-AP-010397-E-XX-XX-XX-XX-01	16	AH-1	AH-1	71	94
Average Rebate, Rounded (A-1) >>							100	100
Average Rebate, Rounded (AH-1) >>							50	75

Table 5.21. Recommended Maximum Rebates (Commercial Water Heaters)

Scenario	Building Type	Baseline Fuel	Measure Code	Measure Life	Tariff (Pre)	Tariff (Post)	Existing Tariffs	LM Tariffs
							UPPCO Rebate (\$)	UPPCO Rebate (\$)
Commercial_NWS_WH1_Propane	Small Office	Propane	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	C-1	C-1	3,697	3,608
Commercial_NWS_WH1_Propane	Small Office	Propane	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	H-1	H-1	2,404	2,794
Commercial_NWS_WH1_Propane	Small Office	Propane	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	P-1	P-1	1,417	1,384
Commercial_NWS_WH1_Propane	Retail Stripmall	Propane	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	C-1	C-1	3,697	3,608
Commercial_NWS_WH1_Propane	Retail Stripmall	Propane	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	H-1	H-1	2,401	2,794
Commercial_NWS_WH1_Propane	Retail Stripmall	Propane	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	P-1	P-1	1,396	1,371
Commercial_NWS_WH1_Propane	Retail Standalone	Propane	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	C-1	C-1	3,697	3,608
Commercial_NWS_WH1_Propane	Retail Standalone	Propane	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	H-1	H-1	2,401	2,794
Commercial_NWS_WH1_Propane	Retail Standalone	Propane	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	P-1	P-1	1,417	1,360
Commercial_NWS_WH1_Propane	Full Service Restaurant	Propane	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	C-1	C-1	3,697	3,608
Commercial_NWS_WH1_Propane	Full Service Restaurant	Propane	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	H-1	H-1	2,401	2,794
Commercial_NWS_WH1_Propane	Full Service Restaurant	Propane	N-CO-WH-000507-G-XX-XX-XX-XX-03	10	P-1	P-1	1,411	1,370
Average Rebate, Rounded (C-1) >>							3,650	3,600
Average Rebate, Rounded (H-1) >>							2,400	2,750
Minimum Rebate, Rounded (P-1) >>							1,400	1,350

Table 5.22. Recommended Maximum Rebates (Commercial Cooking)

Scenario	Building Type	Baseline Fuel	Measure Code	Measure Life	Tariff (Pre)	Tariff (Post)	Existing Tariffs	LM Tariffs
							UPPCO Rebate (\$)	UPPCO Rebate (\$)
Commercial_NWS_Cooking1_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000350-E-XX-XX-XX-XX-04	12	C-1	C-1	21,496	21,761
Commercial_NWS_Cooking1_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000350-E-XX-XX-XX-XX-04	12	H-1	H-1	15,016	17,690
Commercial_NWS_Cooking1_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000350-E-XX-XX-XX-XX-04	12	P-1	P-1	8,010	8,192
Commercial_NWS_Cooking1_Propane	Full Service Restaurant	Propane	N-CO-KR-000350-E-XX-XX-XX-XX-04	12	C-1	C-1	21,496	21,761
Commercial_NWS_Cooking1_Propane	Full Service Restaurant	Propane	N-CO-KR-000350-E-XX-XX-XX-XX-04	12	H-1	H-1	15,016	17,690
Commercial_NWS_Cooking1_Propane	Full Service Restaurant	Propane	N-CO-KR-000350-E-XX-XX-XX-XX-04	12	P-1	P-1	8,010	8,192
Commercial_NWS_Cooking2_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000354-E-XX-XX-XX-XX-04	12	C-1	C-1	25,036	25,344
Commercial_NWS_Cooking2_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000354-E-XX-XX-XX-XX-04	12	H-1	H-1	17,489	20,604
Commercial_NWS_Cooking2_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000354-E-XX-XX-XX-XX-04	12	P-1	P-1	9,370	9,560
Commercial_NWS_Cooking2_Propane	Full Service Restaurant	Propane	N-CO-KR-000354-E-XX-XX-XX-XX-04	12	C-1	C-1	25,036	25,344
Commercial_NWS_Cooking2_Propane	Full Service Restaurant	Propane	N-CO-KR-000354-E-XX-XX-XX-XX-04	12	H-1	H-1	17,489	20,604
Commercial_NWS_Cooking2_Propane	Full Service Restaurant	Propane	N-CO-KR-000354-E-XX-XX-XX-XX-04	12	P-1	P-1	9,370	9,560
Commercial_NWS_Cooking3_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000344-G-XX-XX-XX-XX-02	12	C-1	C-1	26,331	26,655
Commercial_NWS_Cooking3_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000344-G-XX-XX-XX-XX-02	12	H-1	H-1	18,394	21,669
Commercial_NWS_Cooking3_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000344-G-XX-XX-XX-XX-02	12	P-1	P-1	9,867	10,061
Commercial_NWS_Cooking3_Propane	Full Service Restaurant	Propane	N-CO-KR-000344-G-XX-XX-XX-XX-02	12	C-1	C-1	26,331	26,655
Commercial_NWS_Cooking3_Propane	Full Service Restaurant	Propane	N-CO-KR-000344-G-XX-XX-XX-XX-02	12	H-1	H-1	18,394	21,669
Commercial_NWS_Cooking3_Propane	Full Service Restaurant	Propane	N-CO-KR-000344-G-XX-XX-XX-XX-02	12	P-1	P-1	9,867	10,061
Commercial_NWS_Cooking4_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000346-G-XX-XX-XX-XX-02	12	C-1	C-1	26,978	27,310
Commercial_NWS_Cooking4_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000346-G-XX-XX-XX-XX-02	12	H-1	H-1	18,846	22,202
Commercial_NWS_Cooking4_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000346-G-XX-XX-XX-XX-02	12	P-1	P-1	10,116	10,312
Commercial_NWS_Cooking4_Propane	Full Service Restaurant	Propane	N-CO-KR-000346-G-XX-XX-XX-XX-02	12	C-1	C-1	26,978	27,310
Commercial_NWS_Cooking4_Propane	Full Service Restaurant	Propane	N-CO-KR-000346-G-XX-XX-XX-XX-02	12	H-1	H-1	18,846	22,202
Commercial_NWS_Cooking4_Propane	Full Service Restaurant	Propane	N-CO-KR-000346-G-XX-XX-XX-XX-02	12	P-1	P-1	10,116	10,312
Commercial_NWS_Cooking5_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000357-G-XX-XX-XX-XX-02	12	C-1	C-1	39,093	39,574
Commercial_NWS_Cooking5_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000357-G-XX-XX-XX-XX-02	12	H-1	H-1	27,309	32,172
Commercial_NWS_Cooking5_NG	Full Service Restaurant	Natural Gas	N-CO-KR-000357-G-XX-XX-XX-XX-02	12	P-1	P-1	14,775	15,007
Commercial_NWS_Cooking5_Propane	Full Service Restaurant	Propane	N-CO-KR-000357-G-XX-XX-XX-XX-02	12	C-1	C-1	39,093	39,574
Commercial_NWS_Cooking5_Propane	Full Service Restaurant	Propane	N-CO-KR-000357-G-XX-XX-XX-XX-02	12	H-1	H-1	27,309	32,172
Commercial_NWS_Cooking5_Propane	Full Service Restaurant	Propane	N-CO-KR-000357-G-XX-XX-XX-XX-02	12	P-1	P-1	14,775	15,007
Average Rebate, Rounded (C-1) >>							27,750	28,100
Average Rebate, Rounded (H-1) >>							19,400	22,850
Minimum Rebate, Rounded (P-1) >>							10,400	10,600

5.3 Program Details

5.3.1 Residential

<p>Objective</p>	<p>To facilitate the adoption of efficient electrification measures which help UPPCO’s residential customers improve occupant health, safety and comfort; lower annual energy bills; and reduce on-site GHG emissions.</p>
<p>Target Market</p>	<p>Residential customers in single-family, multi-family, and manufactured homes with the following fuel and end use combinations who wish to electrify the respective end use are generally eligible for this program:</p> <ul style="list-style-type: none"> • Propane water heating • Natural gas cooking • Propane cooking • Propane clothes drying • Propane space heating <p>Additional fuel and end use combinations will be assessed on a project-by-project basis and may be eligible if the project meets all the required savings tests.</p> <p>Customers who are planning significant property retrofits or investments such as siding replacement, roof repair or replacement, basement waterproofing or post-flood cleanup, or installation of solar panels or an electric vehicle charger should be considered as potentially receptive audiences for EFEL program offerings.</p>
<p>Program Description</p>	<p>An EFEL Plan helps an electric provider’s customers achieve health and safety benefits within the premises they occupy OR reduce energy, greenhouse gas emissions, and annual average energy costs by installing specific electric appliances or equipment that displaces an end use that otherwise combusts a fossil fuel. Program expenditures on each measure must not have the effect of increasing electric rates for non-participating customers of the provider.</p> <p>UPPCO will provide both fixed offer rebates and custom rebates computed on project-by-project basis. For projects that result in overall energy bill savings, customers can take advantage of UPPCO’s TOB program to help pay any remaining project costs net of other incentives. Customers will be encouraged to fully leverage home energy tax credits and other funding opportunities such as Michigan Home Energy Rebate program offerings.</p>

	<p>The Residential Efficient Electrification Program will approach space heating electrification projects holistically, emphasizing the importance of building envelope improvements to reduce heating demand and minimize the installed capacity of heat pump equipment.</p>
<p>Eligible Measures</p>	<p>Eligible water heating, clothes drying, and cooking measures will include:</p> <ul style="list-style-type: none"> • Heat pump water heaters (120V and 240V) • Heat pump clothes dryers • Induction cooktops <p>For space heating electrification projects, UPPCO will use an energy modeling tool consistent with BPI 2400 standards such as Clarity HPTK to make savings determinations on a project-by-project basis. Rebates will be tied to equipment specs and anticipated electricity gross margin on incremental sales. Eligible space heating measures include:</p> <ul style="list-style-type: none"> • Ground-source heat pump (with desuperheater and without) • Cold-climate air source heat pumps (air-to-air or air-to-water, ducted or ductless) <p>Customers may also be eligible for wiring and panel upgrades needed to complete projects.</p> <p>Measures must have ENERGY STAR certification if such certification exists for the measure category.</p> <p>Building envelope efficiency improvements made in conjunction with an electrification project are incentivized through and credited towards the EWR program. Eligible measures include:</p> <ul style="list-style-type: none"> • Air sealing • Ventilation and ventilation controls • Wall insulation • Ceiling insulation • Efficient windows • Additional building envelope measures listed in MEMD for residential and multifamily use

<p>Implementation Strategy</p>	<p>UPPCO and its implementer will provide home energy assessments for customers where opportunities for electrification and/or energy waste reduction are identified. These assessments will help customers anticipate end-of-life replacement of space and water heating equipment before an emergency failure and identify buildings with older equipment installed.</p> <p>For customers interested in pursuing upgrades, UPPCO and its implementer will collect sufficient data on existing conditions and energy usage to estimate savings using a high-quality energy model. UPPCO and its implementer will propose a package of measures that meet statutory requirements and result in significant energy savings and other benefits.</p> <p>UPPCO will leverage its experience with the beneficial electrification EWR pilot program, the Michigan Home Energy Rebate program, and existing networks including the Michigan Heat Pump Collaborative in designing and delivering this program, while striving to simplify messaging for customers.</p>
<p>Marketing Strategy</p>	<p>UPPCO will utilize existing EWR marketing channels to inform customers about electrification programs, measures, and incentives, with a focus on difficult-to-reach customer groups such as low-income and multifamily households.</p> <p>To anticipate having EFEL measures on hand in response to short-notice replacement of space and water heating equipment, UPPCO will partner with manufacturers and distributors to have eligible heat pump equipment in stock. These efforts will be complemented by educating customers to plan ahead for EOL replacement of space and water heating equipment before emergency failure.</p> <p>Multifamily building electrification has unique challenges and barriers that often require specialized program designs. Because these building systems can be complex and involve multiple residents, programs must work with property managers to deliver a combination of measures including energy efficiency, electrification, and distributed energy solutions.</p>
<p>EM&V Requirements</p>	<p>Per U-21567, EFEL plans are not subject to UCT, but rather Sect. 72 which is the criteria used to build the measure list. UPPCO plans to include EFEL measures in its measured savings pilot.</p>

5.3.2 Commercial & Industrial

<p>Objective</p>	<p>To facilitate the adoption of efficient electrification measures to help UPPCO’s commercial and industrial customers improve occupant health, safety and comfort; lower annual energy bills; reduce on-site GHG emissions; and optimize industrial processes.</p>
<p>Target Market</p>	<p>Commercial and Industrial customers with the following fuel and end use combinations who wish to electrify the respective end use are generally eligible for this program:</p> <ul style="list-style-type: none"> • Propane water heating • Natural gas cooking • Propane cooking <p>Particularly receptive commercial kitchen customers might be smaller food service establishments with residential-style range cooking equipment and buildings without access to natural gas distribution</p> <p>Additional fuel and end use combinations will be assessed on a project-by-project basis and may be eligible if the project meets all the required savings tests.</p> <p>Customers already planning significant renovations or new tenant build-outs are especially encouraged to participate.</p> <p>As process heat accounts for over 50% of U.S. industrial emissions²⁵, industries with the potential to electrify and improve the efficiency of such heating will be targeted. These may include but are not limited to sawmills, dairy product manufacturing, animal slaughtering and processing, bakeries and other food manufacturing, beverages and distilleries, fiber and textiles, pulp, paper, and paper products, ethyl alcohol manufacturing, plastics manufacturing, and electrical equipment and appliance manufacturing.</p>
<p>Program Description</p>	<p>An EFEL Plan helps an electric provider’s customers achieve health and safety benefits within the premises they occupy OR reduce energy, greenhouse gas emissions, and annual average energy costs by installing specific electric appliances or equipment that displaces an end use that otherwise combusts a fossil fuel without having the effect of increasing electric rates for non-participating customers of the provider.</p>

²⁵ ACEEE - Net-zero industry by 2050: a scenario analysis of boiler replacement with industrial heat pumps, December 2024.

	<p>In addition to UPPCO incentives, customers are encouraged to utilize applicable tax credits and other funding opportunities.</p>
<p>Eligible Measures</p>	<p>General measure categories include:</p> <ul style="list-style-type: none"> • Heat pump water heaters (120V and 240V) • Industrial heat pumps • Commercial kitchen equipment including induction cooktops, fryers, convection ovens, steam cookers, and combination ovens <p>Customers may also be eligible for wiring and panel upgrades needed to complete projects.</p> <p>Measures must have ENERGY STAR certification if such certification exists for the measure category. Rebates will be tied to equipment specs and anticipated energy savings.</p>
<p>Implementation Strategy</p>	<p>UPPCO and its implementer will provide energy assessments for customers where opportunities for electrification and/or energy waste reduction are identified. These assessments will help customers anticipate end-of-life replacement of space and water heating equipment before an emergency failure and identify buildings with older equipment installed.</p> <p>For customers interested in pursuing upgrades, UPPCO and its implementer will collect sufficient data on existing conditions and energy usage to estimate savings. UPPCO and its implementer will propose measures that meet statutory requirements and result in significant energy savings and other benefits.</p> <p>Industrial electrification opportunities identified through UPPCO’s EWR Emerging Technology & Analytics pilot program will be referred to the electrification program for further project design and implementation. UPPCO will work with MSU-ITAC and other partners to complete industrial assessments and to braid UPPCO rebates with grants, tax credits, and other funding sources that may be available for industrial customers.</p>
<p>Marketing Strategy</p>	<p>UPPCO will leverage existing EWR marketing channels to inform both small commercial and large C&I customers about electrification programs, measures, and incentives. UPPCO will also explore using local, regional, and statewide economic development and professional networks such as chambers of commerce, MEDC’s Region 1 Collaborative, and the Michigan Manufacturers Association to reach C&I customers.</p> <p>UPPCO will leverage the services provided by the MSU Industrial Training and Assessment Center (MSU-ITAC). A Michigan-based program of U.S. DOE, ITAC has a</p>

	<p>dedicated presence in the UP through Michigan Technological University. The program provides no-cost ASHRAE-level technical assessments conducted by students and faculty for small and medium sized manufacturers and commercial buildings. By encouraging its industrial customers to participate in the MSU-ITAC program, UPPCO would then benefit from MSU-ITAC referrals to EWR and EFEL programs for installing measures recommended through these free energy audits. Additionally, DOE-funded ITAC implementation grants up to \$300,000 per manufacturer are available and the application process is straightforward. Applicants must demonstrate a 50/50 match toward which cash, personnel costs, the value of service, third-party in-kind contributions, utility rebates, and financing can contribute.</p> <p>To support adoption of EFEL measures by commercial kitchens, UPPCO may engage a commercial kitchen design firm to provide customer-focused educational programs. These efforts will need to address the most significant market barriers including a currently robust market for secondary kitchen equipment, and the reality that many high-end restaurants continue to favor cooking with natural gas.</p>
<i>EM&V Requirements</i>	Per U-21567, EFEL plans are not subject to UCT, but rather Sect. 72 which is the criteria used to build the measure list. UPPCO plans to include EFEL measures in its measured savings pilot.

Tariffed On-Bill Recovery

PURPOSE

The purpose of the Tariffed On-Bill (TOB) program (the “Program”) is to enable customers to make investments in energy waste reduction and efficient electrification measures (“Premise Improvements”) that will be repaid as part of their electric bill through a Monthly Premise Improvement Charge.

AVAILABILITY

Available to individually metered residential customers receiving concurrent service under a residential rate schedule.

The proposed project must also be approved by Upper Peninsula Power Company (“UPPCO”), at its sole discretion. Projects will be screened to determine whether estimated energy cost (electricity and heating fuel cost combined) savings resulting from the Premise Improvement measures exceed the customer costs. If energy savings do not exceed the customer costs, then UPPCO may require the customer to make a co-payment to participate. Projects must have an estimated energy savings, after the application of a co-payment if applicable, that is at least 10% greater than the Monthly Premise Improvement Charge.

LIST OF ELIGIBLE MEASURES

The Program is limited to energy efficiency and efficient electrification measures that have been approved by the Michigan Public Service Commission as part of UPPCO’s Energy Optimization Plan. A list of eligible measures (“Measures”) can be found on UPPCO’s website. Measures may include, but are not limited to, the following:

- Electric Heating, Ventilation, and Air Conditioning (HVAC) equipment, service, and controls, including smart thermostats
- Thermal boundary improvements such as air sealing and insulation
- HVAC duct sealing and replacement
- Heat Pump Water Heaters
- Other high efficiency equipment, products, and services as determined by UPPCO on a case-by-case basis.

CUSTOMER OR PARTICIPANT AGREEMENT

To participate in the Program, the UPPCO account holder at the participating location and the property owner, if different, must sign the Owner Participant Agreement. Participation in the Program will not require a credit check.

ACCOUNT STATUS

A residential customer's account shall be current and not be on an active arrearage payment plan before an in-home assessment may be scheduled and before the installation of any Measures.

EXISTING BUILDINGS

To qualify an existing building for participation in the Program, UPPCO must determine that the property is habitable for residential customers for the entire projected cost recovery period. Properties that UPPCO deems uninhabitable may be deemed habitable after improvements and upon inspection by UPPCO or an authorized agent. UPPCO, at its sole discretion, retains the right to deem properties habitable and to determine the appropriate improvements.

PARTICIPANT CO-PAYMENT

A participant has the option to make a co-payment at the beginning of the project to reduce the overall amount subject to cost recovery. Only the amount due for cost recovery would be subject to UPPCO's approved rate of return.

PARTICIPANT COSTS

UPPCO will recover the full cost of the Premise Improvements including installation, less any available rebates from UPPCO, and will receive its approved rate of return on the account balance. These costs are assigned to the location (point of service or meter) where Measures are installed and paid by Customers occupying that location until all costs specified in the Owner Participant Agreement, as applicable, have been recovered.

Monthly Premise Improvement Charge will be determined as the levelized monthly payment required for UPPCO to recover its investment and its pre-tax weighted average cost of capital as authorized by the Commission as of the time of the Owner Participant Agreement, with a planned cost recovery period of up to 12 years but not longer than the cost-weighted average expected life of the measures.

If Monthly Premise Improvement Charges are temporarily suspended for any reason or UPPCO has no customer at the location for a period of time, the term of recovery may be

extended for an equivalent period of time, but in any event the Cost Recovery Period will not exceed 12 years.

COST RECOVERY

No sooner than 30 days after UPPCO or its authorized agent notifies the customer of a completed project the Customer shall be billed the Monthly Premise Improvement Charge in accordance with this tariff and the Owner Participant Agreement. UPPCO will bill and collect Monthly Premise Improvement Charges until cost recovery is complete, except as described below. Prepayment of unbilled charges will not be permitted unless early termination and a final bill have been requested.

An account holder may request early termination and a final bill for all remaining payments at any time. When a customer requests early termination and a final bill for remaining payments, then amount due shall exclude the approved rate of return on the unpaid balance.

UPPCO will bill and collect Monthly Premise Improvement Charges until UPPCO recovers all costs as described above.

VACANCY

If a location at which Measures have been installed becomes vacant and electric service is disconnected, the Monthly Premise Improvement Charges will be suspended until such time as electric service is restored. If a property owner maintains service at an unoccupied residence, the Monthly Premise Improvement Charges may revert to the property owner, as described in the Owner Participant Agreement as applicable. In buildings with multiple rental units, UPPCO may require a property owner to maintain service for locations receiving Program Measures.

TERMINATION OF PREMISE IMPROVEMENT CHARGE

Monthly Premise Improvement Charges will no longer be billed after UPPCO has recovered the full cost of the Measure(s) and applicable fees, as described in the Owner Participant Agreement as applicable.

TIED TO THE LOCATION

Until Monthly Premise Improvement Charges are terminated, as described herein, the terms of this tariff together with the terms of the relevant "Owner Participant Agreement" shall be binding on any future account holder who shall receive service at a participating location.

DISCONNECTION FOR NON-PAYMENT

The Monthly Premise Improvement Charges shall be considered an essential part of the Customer's bill for electric service and will be subject to the same payment terms and conditions as regular electric service.

MAINTENANCE OF MEASURES

Participating Customers and property owners, if different, must keep the Measures in place for the duration of Monthly Premise Improvement Charges, maintain the Measures per the manufacturers' instructions, and report any failure of any Measures to UPPCO and/or UPPCO's Implementation Contractor as soon as possible and no more than 30 days after discovery of the malfunction. Participating Customers and building owners must also agree to allow UPPCO and/or UPPCO's TOB Implementation Contractor access to perform maintenance and make repairs or adjustment to the Measures. The next Monthly Premise Improvement Charge may be suspended if it cannot be repaired within five business days of notice to UPPCO or UPPCO's Implementation Contractor and may remain suspended until repairs are complete and equipment is operable. In the event that the billing cycle has commenced before the notification has been recorded, then the customer may request a credit. Payment amounts will not be pro-rated.

REPAIRS

If, during the cost recovery period, UPPCO or its agent determines that a Measure is no longer functioning as intended and that the failure was not caused by the property owner/occupant, or other occupants in the residence, UPPCO will arrange for repair of the Measure and may elect to suspend Monthly Premise Improvement Charges until repairs are complete.

If UPPCO determines that the property owner/occupant or other occupants in the residence deliberately caused the Measure's failure or that the Measure's failure was the result of gross negligence or willful misconduct, UPPCO may, in its sole discretion, seek to recover the costs of repairs from the Customer and/or seek immediate recovery of all remaining costs not to exceed the full cost of the Measure and applicable fees as specified in the Owner Participant Agreement as applicable. UPPCO may only invoke accelerated cost recovery of the Measures in the case of willful misconduct or gross negligence.

If UPPCO is not responsible for maintenance and repairs per the terms of the Owner Participant Agreement then this does not apply.

NOTIFICATION TO SUCCESSOR CUSTOMERS

UPPCO may file notice of the Premise Improvement charge in the real estate record with the appropriate County.

The Owner Participant Agreement will include a requirement that any successive owner, or any future tenant who will be an account holder at the location, is provided successor owner notice or successor renter notice, as applicable, of that location's enrollment in a tariffed on-bill program.

A landlord would be subject to a remedy as set forth in the Owner Participant Agreement for violating the terms of the Owner Participant Agreement.

UPPCO will also inform a successor account holder at the time of setting up a new service at a participating property that the monthly electric bill will include Monthly Premise Improvement Charges.

GENERAL

Services and offerings under this Program are subject to the authority of the Michigan Public Service Commission and are subject to changes or other modifications lawfully made thereby.

PAYMENT

Bills are due when rendered and are payable on the same terms as bills for electric service. If any bill is not so paid, UPPCO has the right to charge late fees and to suspend service in accordance with its Standard Rules and Regulations.

OWNER PARTICIPANT AGREEMENT

THIS OWNER PARTICIPANT AGREEMENT (“Agreement”), is made this _____ day of _____ by and between Upper Peninsula Power Company (“Utility”) and [insert owner name] (“Owner”) (collectively the “Parties”). Hereinafter Utility and Owner may be individually known as a “Party” and collectively as the “Parties.

WHEREAS, Owner owns [and resides at] the property, consisting of a [single/multiple] family residence, located at [Insert Property Address] (the “Property”);

WHEREAS, the Property is located in Utility’s service territory and occupants residing at the property are electric customers of the Utility and Owner desires to participate in the utility’s TOB Program (as defined below) pursuant to which certain energy efficiency and efficient electrification improvements will be made to the Property, as further described in Section 1 of this Agreement (the “Premise Improvements”);

WHEREAS, Utility is willing to provide the upfront payment for the procurement and installation of the Premise Improvements through its Tariffed on-Bill Program approved by the Michigan Public Service Commission (“Commission”), as may be modified from time to time (the “TOB Program”);

WHEREAS, in accordance with the TOB Program the Utility is authorized to recover the cost paid by the Utility for the Premise Improvements (“Premise Improvement Costs”) from the current electric customer(s) at the Property and subsequent electric customers (collectively “Current and Future Customers”) through a service charge on the customer’s monthly electric utility bill (“Premise Improvement Charges”) and pursuant to the terms of this Agreement;

WHEREAS, the TOB Program is being administered by an Implementation Contractor under contract with Utility (“Implementation Contractor”) and the current Implementation Contractor is [];

WHEREAS, Owner has provided an upfront Co-Payment to the Implementation Contractor to compensate the Utility for a portion of the Premise Improvement Costs as invoiced by the Implementation Contractor or its agent as specified below;

NOW, THEREFORE, each Party acknowledges and agrees as follows:

1. PREMISE IMPROVEMENTS. In accordance with the TOB Program and subject to the terms of this Agreement, Utility agrees to provide the below specified Premise Improvement Costs and to purchase and install the below described Premise

Improvements at the Property. The Premise Improvements may be installed by the Utility or by a Utility approved contractor. Owner agrees to allow Utility or its contractor access to the Property for the installation, repair and inspection of the Premise Improvements upon reasonable notice.

- A. The Premise Improvements to be installed at the Property are: [describe Premise Improvements – if description is lengthy an exhibit page can be attached]
- B. Co-Payment received from Owner if any: [insert amount of Co-Payment]
- C. The Premise Improvement Costs to be paid by Utility are: [insert amount of (Premise Improvement costs) – (Co-Payment received) = Premise Improvement Costs]

2. PREMISE IMPROVEMENT CHARGE. The Premise Improvement Costs shall be recovered by the Utility through a monthly service charge (“Premise Improvement Charge”) charged to the electric utility bill of the then current customer taking service at the Property. The Premise Improvement Charge will be charged to the customer account of record at the Property until repaid, regardless of actual usage at the Property.

- A. The monthly Premise Improvement Charge[, which includes a \$ Implementation Contractor fee] is: [Insert monthly Premise Improvement Charge]
- B. The total Premise Improvement Charge to be made during the repayment term will be: [Insert total Premise Improvement Service Charge over the term]

3. ESTIMATED ENERGY USAGE CHANGES. The annual energy usage change at the Property after the Premise Improvements have been completed is estimated to be as follows:

- A. Annual electricity usage change at the Property will be [Insert the estimated annual electricity usage change (in kilowatt hours and dollars)]
- B. Annual [enter heating fuel type] savings at the Property will be [insert the estimated annual savings of propane, fuel oil, or natural gas in commercial units]

The estimated annual energy usage changes specified in this Agreement are based on the results of the energy analysis conducted at the Property on [date] and on the following assumptions:

- average electricity charges at the Property over the past [months] of: [Insert average electricity charges over the past months]
- average heating fuel expenses at the Property over the past [months] of: [Insert average heating fuel expenses over the past months]

- [insert other assumptions as applicable]

Actual energy usage at the Property may vary based on usage patterns and other factors beyond the Utility's control and nothing stated herein is intended as a guaranty of a reduction in the actual energy usage at the Property.

4. TERM. This Agreement will remain in effect until all Premise Improvement Costs have been recovered by the Utility or until this Agreement is otherwise terminated in accordance with the terms of this Agreement.

5. REPAYMENT PERIOD. The initial repayment period for the Premise Improvement Charges shall be ___ (__) years of regular payment, provided however, if at any time during the Term, the Utility has no electric service customer of record at the Property, the repayment period will be extended for an equivalent period of time, but not to exceed twelve (12) years, and the Utility will continue to collect Premise Improvement Charges from Current or Future Customers at the Property during that extended Term until the Premise Improvement Charges have been recovered in full.

6. NO PREPAYMENT. Owner acknowledges that Premise Improvement Charges cannot be pre-paid unless in connection with an early termination as permitted under Section 15(C). In the absence of a request for early termination, any payment made to the Utility in excess of current charges will be held as a credit on the appropriate customer account and applied to charges, including electric charges, as they become due. During the Term of this Agreement, Utility will provide Owner with an accounting of Premise Improvement Charges received so far and remaining Premise Improvement Charges upon request.

7. PAYMENT OBLIGATION TIED TO LOCATION. Owner acknowledges that pursuant to the TOB Program approved by the Commission, Current and Future Customers at the Property are obligated to pay the Premise Improvement Charges for cost recovery as provided in this Agreement.

8. SERVICE TO REVERT TO OWNER. It is the intent of the Parties that electric service will be maintained at the Property for the entire Term. If Owner is not residing at the Property and where there is no tenant residing and taking electric service at the Property the Owner shall have electric service revert to Owner, and the account holder will be responsible for the Premise Improvement Charges incurred during such periods of non-tenancy.

9. NOTIFICATIONS BY OWNER TO TENANTS AND SUBSEQUENT OWNERS.

In order to provide advance notice to Future Customers and subsequent owners of the Property, Owner agrees as follows:

A. Owner or its leasing agent or subsequent owner, as applicable, shall notify any future tenant that a monthly Premise Improvement Charge will be charged to the tenant's electric utility bill at the Property.

B. Owner will notify any successive owner of the Property prior to of the execution of any purchase agreement or transfer of Property ownership that a monthly Premise Improvement Charge will be charged to the tenant's electric utility bill at the Property.

10. NOTIFICATION BY UTILITY TO FUTURE CUSTOMERS. In further effort to provide notice to Future Customers the Utility shall provide the following notices:

A. Prior to the commencement of new service at the Property, Utility shall provide notice to prospective new customers seeking service at any Property that Premise Improvement Charges are tied to the Property and will be the obligation of Future Customers.

B. Utility may but shall not be obligated to file a notice of the obligations of Current and Future Customers under this Agreement in the real estate records in the county where the Property is located and Owner hereby authorizes the Utility to file such notice.

11. DISCONNECTION FOR NON-PAYMENT. Subject to any other Commission or Utility rules or policies, the Premise Improvement Charges shall be considered as an essential part of the customer's bill for electric service, and the Utility may disconnect the Property for non-payment of Premise Improvement Charges under the same provisions as for any other utility service. Notwithstanding the foregoing, the Utility may not disconnect the Property for non-payment of Premise Improvement Charges if (i) the Customer has, in good faith, notified the Implementation Contractor in writing that the Premise Improvement must be repaired; and (ii) the Implementation Contractor has not yet reached a determination pursuant to section 13 as to whether the Premise Improvements are functioning as intended and who is responsible for any failure of the Premise Improvements.

12. OWNER OBLIGATIONS AND AGREEMENTS. In consideration of the Premise Improvements funded by the Utility in accordance with the terms of the TOB Program as memorialized in this Agreement and intending to be legally bound, Owner covenants and agrees to comply with each of the following:

A. Maintenance of Premise Improvements. Owner agrees to keep the Premise Improvements in place for the term of this Agreement, to maintain the Premise Improvements per manufacturers' instructions, and report the failure of any Premise Improvements to the Implementation Contractor as soon as reasonably possible and shall

endeavor to report such failure to the Utility or its Implementation Contractor not more than thirty (30) days after discovery of the failure or malfunction.

B. Access to the Property. Owner agrees to allow Utility and/or the Implementation Contractor access to the Property to inspect, perform maintenance and make repairs or adjustment to the Premise Improvements upon reasonable request by the Utility. If the Property is occupied by a tenant that is not a party to this Agreement, Owner shall make arrangements with the tenant to facilitate access to the Property by the Utility in accordance with this Section.

C. Reporting Obligations. Owner and each subsequent owner agree to reasonably cooperate with Utility in connection with the collection of information regarding the Property's participation in the TOB Program as may be necessary or requested by the Utility to complete periodic reports regarding the TOB Program or to comply with information requested by the Commission, including, without limitation, providing the Utility with access to the Property to inspect the Premise Improvements upon reasonable request.

D. Tax Liability. Owner assumes all responsibilities for any and all tax liabilities resulting from the Premise Improvement Costs provided by the Utility hereunder.

13. REPAIRS. Should the Implementation Contractor determine that the Premise Improvements are no longer functioning as intended, the Implementation Contractor will undertake to determine whether the failure of the Premise Improvements was caused by the Owner, Current or Future Customers, or other occupants at the Property.

A. If the Implementation Contractor determines that the failure of the Premise Improvements was not caused by the Owner, Current or Future Customers, or other occupants at the Property, the Utility shall suspend future, un-billed Premise Improvement Charges until such time as the Premise Improvements are repaired or this Agreement is terminated pursuant to section 15. Notwithstanding the foregoing, previously billed charges shall not be suspended or refunded.

B. If Implementation Contractor determines that the failure of the Premise Improvements was the result of the gross negligence or intentional misconduct of the Owner, a Current or Future Customer, or other occupants at the Property, the Utility may, in its discretion: (i) seek to recover the costs of repairs from the responsible party, (ii) suspend the Premise Improvement Charges, and (iii) seek to immediately recover from Owner all remaining Premise Improvement Charges to complete cost recovery.

14. APPEAL TO UTILITY. In the event Owner disagrees with a determination by Implementation Contractor under sections 13 or 14, Owner may initiate an appeal by

providing notice to Utility at [dedicated email address] or by telephone at [dedicated phone number]. The appeal will be considered by Utility and a decision provided within 30 days.

15. TERMINATION:

A. Expiration Upon Payment in Full. This Agreement shall terminate when the Utility has fully recovered the Premise Improvement Costs through Premise Improvement Charges or from Owner pursuant to section 13.B, or 15(C).

B. Early Termination by Utility. In the event that the Premise Improvements fail and the Utility or its Implementation Contractor determines that the Owner or Current or Futures Customers, or other occupant at the Property, did not deliberately by willful misconduct or through gross negligence cause the failure of the Premise Improvements, and if, in the Utility's sole discretion, the Premise Improvements cannot be repaired or replaced in a cost-effective manner, the Utility will waive recovery of any outstanding Premise Improvement Costs and this Agreement shall terminate.

C. Early Termination by Owner. If Owner desires to terminate this Agreement prior to the end of the term the Owner may request, in writing, a final bill of all amounts due under this Agreement together with notice of its desire to terminate the Agreement. Upon receipt of Owner's request as permitted above, the Utility will prepare the final bill, which will consist of all remaining Premise Improvement Charge payments due, excluding the Approved Rate of Return on the unpaid balance included as a component of the remaining Premise Improvement Charge in accordance with the TOB Program. When all amounts due under this Agreement have been irrevocably paid in full to the Utility, the Agreement shall be terminated and notice of the termination will be provided to the Owner and the current Customer at the Property. The failure to pay the full amount due under the final bill by the specified due date will result in the termination of the request for early termination and the Owner will be deemed to have withdrawn the termination request and the Agreement will continue in accordance with its terms.

16. CONTACT INFORMATION:

Utility:

[insert central notice recipient here] Owner:

17. LIMITATION OF LIABILITY. NOTWITHSTANDING ANY PROVISION TO THE CONTRARY, IN NO EVENT SHALL EITHER PARTY BE LIABLE UNDER THIS AGREEMENT TO THE OTHER PARTY OR ANY THIRD PARTY FOR ANY CONSEQUENTIAL, INCIDENTAL, INDIRECT, EXEMPLARY, SPECIAL OR PUNITIVE DAMAGES, INCLUDING ANY DAMAGES FOR BUSINESS INTERRUPTION OR LOSS OF USE OR DATA, WHETHER ARISING OUT OF BREACH OF

CONTRACT, TORT (INCLUDING NEGLIGENCE) OR OTHERWISE, REGARDLESS OF WHETHER SUCH DAMAGES WERE FORESEEABLE AND WHETHER OR NOT ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

18. INDEMNIFICATION. Owner agrees to indemnify and hold Utility, its agents, employees, officers, directors, shareholders, representatives, parent and other affiliates harmless from and against any loss, liability, claim, cost, damage or expense (including reasonable attorney's fees) arising out of or in connection with any of the following:

- A. any inaccuracy in or breach of any of the representations or warranties of Owner contained in this Agreement;
- B. any breach or non-fulfillment of any covenant, agreement or obligation to be performed by Owner pursuant to this Agreement;
- C. any acts or omissions of, or as a result of acts or inactions by Owner or its contractors or agents, or as a result of negligence by Owner, its contractors, or agents, which resulted in: (i) injury (including mental or emotional injuries) to or death of any person or (ii) damage to, destruction of or loss of any property.

19. OWNERSHIP OF INSTALLED PREMISE IMPROVEMENTS. The Premise Improvements installed at Owner's Property under this Agreement shall be considered Owner's property at all times during the Term and Owner shall be responsible for all maintenance and risk of loss with respect to the Premise Improvements upon installation at the Property. In no event shall the Premise Improvements be deemed to be owned by the Utility.

20. INSURANCE. Commencing with the installation of the Premise Improvements at the Property, and continuing until the termination or expiration of the Owner, shall maintain a home owners insurance policy covering the Premise Improvements against [all forms of casualty and loss for full replacement value]. Evidence of such coverage shall be provided in the form of a certificate of insurance furnished to Utility prior to the installation of the Premise Improvements, upon any policy replacement or renewal and upon Utility's request. Any failure to comply with all of these provisions shall constitute an event of default by Owner. In the event that the Premise Improvements are destroyed or rendered inoperable due to a casualty event or loss, the Owner shall replace the Premise Improvements with like kind equipment, approved by Utility and shall continue to pay the monthly Premise Improvement Charges until paid in full. If the property is a total loss, this Agreement will be terminated and the unpaid Premise Improvement Charges (excluding the Approved Rate of Return on the unpaid balance) will be due and payable to the Utility within 30 days notice by Utility.

21. ENVIRONMENTAL ATTRIBUTES AND DEMAND REDUCTION BENEFITS.

Owner acknowledges and agrees that upon installation of the Premise Improvements at the Property by the Utility, the Utility will be entitled to any and all environmental, energy efficiency, and demand reduction benefits and attributes, including all reporting and compliance rights, associated with the energy efficiencies resulting from the Premise Improvements without further consideration or charge.

22. ASSIGNMENT. Agreement shall be automatically assigned to subsequent owners of the Property without further action provided however, Owner shall notify Utility of any change of ownership within 30 days of closing.

23. ENTIRE AGREEMENT AND SEVERABILITY. This Agreement contains the entire agreement with respect to the subject matter of the Agreement. In the event of a conflict between this agreement and the Utility's Tariff, the Tariff shall govern. Further, the operation and effectiveness of this Agreement shall not continue if such continuance would violate any applicable statute, regulation or other jurisdictional authority.

24. MODIFICATION. Any modification or addition to this Agreement must be in writing and signed by each Party to this Agreement.

25. CHOICE OF LAW. This Agreement will be construed in accordance with the laws of the State of Michigan.

26. SURVIVAL. Section 12(C) (Reporting Obligations), Section 17 (Limitation of Liability), Section 18 (Indemnification), and Section 21 (Environmental Attributes and Demand Reduction Benefits) shall survive the termination, cancellation, or expiration of this Agreement.

27. COUNTERPARTS. This Agreement may be executed in counterparts. Signature by facsimile or PDF shall be deemed an original signature for the purposes of this Agreement.

IN WITNESS THEREOF, the Parties have executed this Agreement or caused this Agreement to be executed by their duly authorized representatives effective as of the date first written above Date.

Upper Peninsula Power Company

By:

Name:

Title:

Date:

[Owner - individual person]

Signature:

Printed Name:

Date:

Market Analysis: Investigating the Potential for Electrification and Space Heating Demand Reduction in the UPPCO Service Area

Designing an effective building electrification program requires understanding the market potential for electrifying various heating end uses and reducing these heating loads where possible. The market analysis for this plan primarily used region-specific data on building characteristics from the ResStock and ComStock tools developed by the U.S. Department of Energy's National Renewable Energy Laboratory (NREL). These results were compared to other sources of information, mainly NREL's U.S. Building Stock Characterization Study published in July 2022, and a potential study conducted for UPPCO by Slipstream in 2021.

Introduction to ResStock and ComStock

ResStock and ComStock were used to systematically describe relevant features of the residential and commercial building stocks in the UPPCO service area. These tools were developed to help municipalities, utility companies, and other stakeholders identify which building stock improvements can save energy and money and reduce greenhouse gas emissions. As NREL states, it developed ResStock and ComStock by combining large public and private data sources, statistical sampling, detailed sub-hourly building simulations, and high-performance computing to achieve unprecedented granularity and accuracy in modeling the diversity of residential and commercial stock and the distributional impacts of building technologies in different communities.

ResStock and ComStock incorporate individual building energy models—550,000 and 350,000 respectively—which reflect physical characteristics such as building type, location, annual energy consumption by fuel type, equipment and fuel type for various end uses, vintage, wall construction, insulation levels, and other features. Weighting factors are then assigned to each building model to simulate the U.S. building stock. Aggregated results are available at different geographic scales including national, state, county, and PUMA. In addition, both tools generate 15-minute energy profiles by end use and fuel type for each building model. These timeseries data, which can be aggregated over the same geographical scales as the metadata, compile both electricity and on-site fuel consumption in kilowatt-hours for weather year 2018.

Housing units in ResStock fall under five residential building types: Mobile Home, Multi-Family 2-4 Units, Multi-Family 5+ Units, Single-Family Attached, and Single-Family Detached. Not included are dormitories, prisons, assisted care facilities, and other congregate housing situations outside of Multi-Family types. ComStock covers fourteen of the more common U.S. building types: Small Office, Medium Office, Large Office, Retail, Strip Mall, Warehouse, Primary School, Secondary School, Full-Service Restaurant, Quick-Service Restaurant, Small Hotel, Large Hotel, Hospital, and Outpatient. Together these types comprise about 65 percent of commercial sector floor area in the United States according to U.S. EIA's Commercial Building Energy Consumption Survey (CBECS).

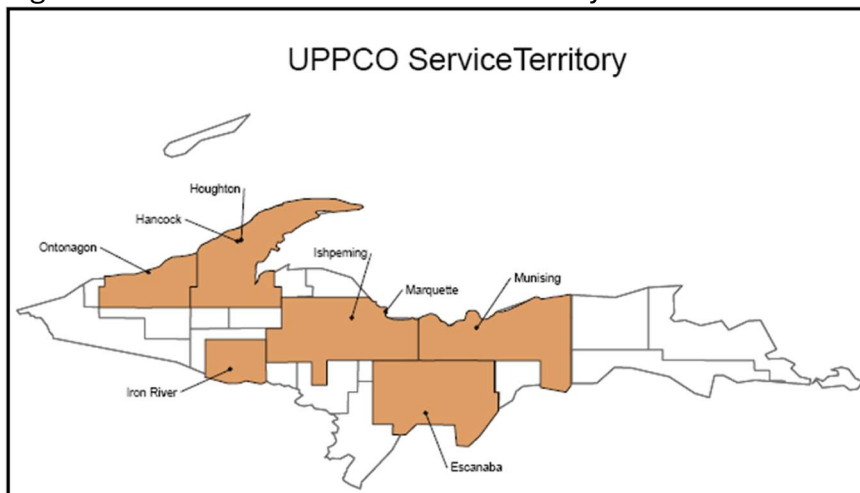
More details and technical documentation about these tools can be found online at NREL:

- For ResStock: <https://www.nrel.gov/buildings/resstock>
- For ComStock: <https://www.nrel.gov/buildings/comstock>
- For End-Use Load Profiles: <https://www.nrel.gov/buildings/end-use-load-profiles>

ResStock and ComStock Data Compiled for UPPCO Counties

For this market analysis, ResStock and ComStock results were compiled for the ten counties in which UPPCO operates to serve as a proxy for the utility's service area.¹ This geography is shown in Figure X.1.

Figure X.1. UPPCO Service Area and County Boundaries



Three discrepancies between the ten-county region and UPPCO's actual territory are noted: Some of these counties are only partially served by UPPCO (leads to overcounting of UPPCO customers). Several municipal electric utilities operate in this geography (leads to overcounting of UPPCO customers). And ComStock is limited to fourteen common commercial building types (leads to undercounting ComStock customers). The impacts from two of these three discrepancies are not easily quantified. Nevertheless, the aggregated county results provide a reasonable approximation of the UPPCO customer base from which to glean useful information from the NREL datasets.

To examine the validity of using NREL metadata at this geographical level, results were compared for three levels of data aggregation: all ten UPPCO counties, all fifteen UP counties, and all 83 Michigan counties. For nearly every building characteristic, the observed distribution of elements within each characteristic appeared to be similar across these three geographies with several notable exceptions. Specifically, compared to Michigan as a whole:

¹ These are the Upper Peninsula counties of Alger, Baraga, Delta, Houghton, Iron, Keweenaw, Marquette, Menominee, Ontonagon, and Schoolcraft. Map source: UPPCO Rate Book Sheet No. A-21.00.

- Relatively more housing units in UP and UPPCO counties use delivered fuels and are seasonal homes;
- Relatively fewer housing units in UP and UPPCO counties have air conditioning or installed ducting;
- UP and UPPCO counties have relatively fewer warehousing and educational building types;
- Somewhat less housing and commercial construction occurred in UP and UPPCO counties during the immediate post-war decade.

Because these observed differences between statewide and UP metadata are consistent with information from other sources about the regional composition of Michigan’s building stock, it was concluded that using ResStock and ComStock results for the ten UPPCO counties is reasonable for this market analysis.

NREL Metadata Results Compared to Other Building Characterization Data Sources

NREL’s formal protocol for validating ResStock and ComStock data relies heavily on the U.S. Census, American Community Survey (ACS), and EIA’s Residential Energy Consumption Survey (RECS) and Commercial Building Energy Consumption Survey (CBECS). Therefore, the NREL metadata are consistent with information provided by these official databases. Another useful source of information from NREL, the U.S. Building Stock Characterization Study published in July 2022 (“NREL Characterization Study”), was developed directly from ResStock and ComStock. Therefore, its findings are entirely in line with conclusions drawn directly from NREL metadata itself.

Another point of reference for comparison is the UPPCO Market Characterization conducted by Slipstream and published in two phases in February 2021 and September 2021 (“Slipstream Potential Study”). Results of this previous potential study mostly comport with ResStock and ComStock metadata for numerous residential and commercial building parameters in the UP context. One discrepancy is the percentage reported for housing units without air conditioning (62% by Slipstream and 39% per NREL metadata). Different methodologies and sampling techniques likely contribute to the size of this difference. Nevertheless, both sources concur that air conditioning is notably less frequent in the UP than downstate.

The Michigan Baseline Housing Study (May 2021) was done by Cadmus for Consumers Energy and DTE Energy to analyze baseline energy conditions in single family homes and multifamily buildings. Because the study is focused on the Lower Peninsula within two climate zones (5 and 6), it provides an imperfect comparison to NREL metadata for UP counties. With this limitation in mind, the Baseline Study’s finding that about 20% of single-family dwellings used window air conditioners as their only source of mechanical cooling is similar to NREL metadata for UP counties. In addition, the Baseline Study concluded that Michigan homes are exceptionally variable, and that a home’s age had the strongest

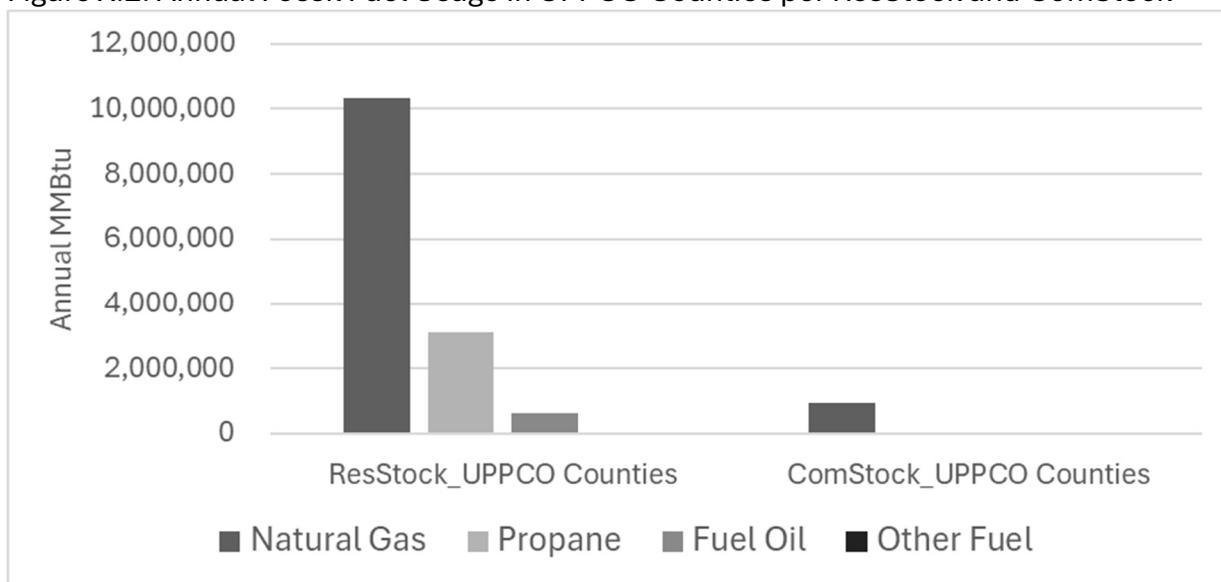
correlation with levels of insulation—both potentially useful considerations for UPPCO program design to the extent these LP results are valid in the UP.

Distribution of On-Site Fuel Consumption in the UPPCO Service Area

To assess the market potential for fuel-switching by UPPCO customers, it is useful to quantify the total amount of fossil fuels consumed within the service area. UPPCO customers can purchase natural gas from either SEMCO or DTE Gas. Because gas sales data specific to the service area were unavailable, these figures had to be estimated. Similarly, a lack of public sales data for propane and heating oil sold only to UPPCO customers required similar estimates for these, too.

Figure X.2 shows the amount of each fossil fuel consumed in residential and commercial buildings in the ten UPPCO counties as reported in ResStock and ComStock. These results are discussed in more detail below.

Figure X.2. Annual Fossil Fuel Usage in UPPCO Counties per ResStock and ComStock



Residential Fossil Fuel Consumption

For the Residential Sector, the next three figures show relative consumption of total on-site fossil fuels by fuel type (Fig. X.3) and building type (Fig. X.4), and fossil fuel mix within each building type (Fig. X.5). All three figures reflect ResStock metadata compiled for the ten UPPCO counties.

Figure X.3. Relative Mix of Residential On-Site Fossil Fuel Use by Fuel Type

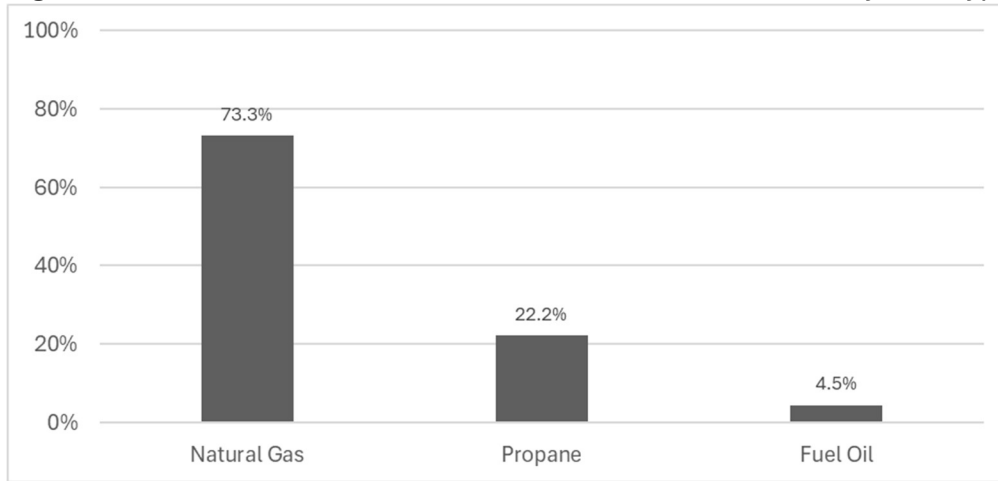


Figure X.4. Relative Mix of Residential On-Site Fossil Fuel Use by Building Type

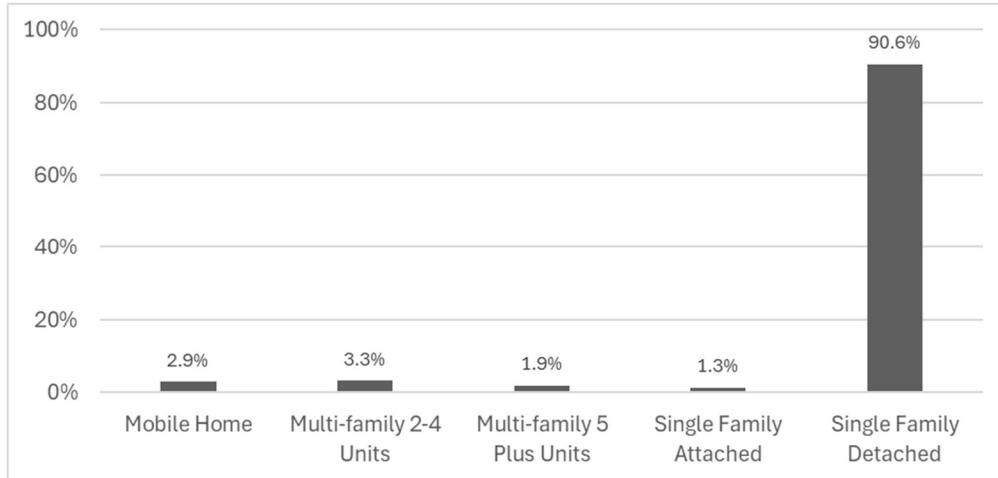
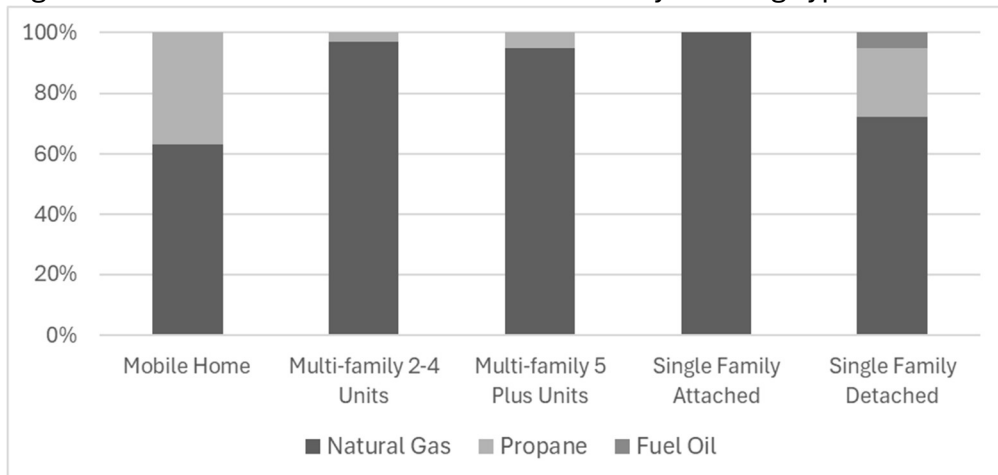


Figure X.5. Residential On-Site Fossil Fuel Mix by Building Type



To understand more specifically how fossil fuels are utilized by UPPCO households, Table X.1 presents, per ResStock, the breakdown of total on-site fuel consumption (natural gas, propane, fuel oil) by end use for the Single Family Detached building type in the ten UPPCO counties.

Table X.1. Household Fossil Fuel Consumption by End Use, Single Family Detached

Household End Use	Annual Fossil Fuel Consumption by End Use	
Space Heating	91.0%	99.6%
Water Heating	7.8%	
Cooking	0.6%	
Clothes Drying	0.2%	
Pool Heating	0.2%	0.4%
Fireplace	0.1%	
Hot Tub Heating	0.1%	
Grilling	0.0%	
Lighting	0.0%	

Based on Figures X.3 through X. 5 and Table X.1, the following observations can be made regarding residential on-site fossil fuel consumption in the UPPCO service area:

- Natural gas accounts for nearly 75% of household fuel consumption;
- Propane accounts for more than 80% of delivered fuel consumption;
- The Single Family Detached building type dominates household fuel consumption;
- Propane is used mostly in Single Family Detached and Mobile Home building types;
- Assuming Single Family Detached as a proxy for the residential building stock, four end uses account for nearly all fuel consumption: (1) Space Heating; (2) Water Heating; (3) Cooking; and (4) Clothes Drying
- Of the top four fuel-consuming end uses, space heating dominates at over 90% with water heating second at nearly 8%

Commercial Fossil Fuel Consumption

Two factors limit ComStock’s ability to represent the commercial building inventory as comprehensively as ResStock can reflect the residential inventory. One is that ComStock only models two-thirds of all commercial building types by floorspace. This will appear as underreported fuel usage for this sector in Figure X.2. Another is that ComStock provides fewer details on end use energy consumption. With these limitations in mind, useful inferences can still be made about commercial fuel consumption in the UPPCO service area.

Figure X.6 shows relative consumption of total on-site fossil fuels by fuel type. In ComStock, all delivered fuels are combined into a type category called “Other Fuel” making it impossible to distinguish propane, heating oil, or other delivered fuels.

Figure X.6. Relative Mix of Commercial On-Site Fossil Fuel Use by Fuel Type

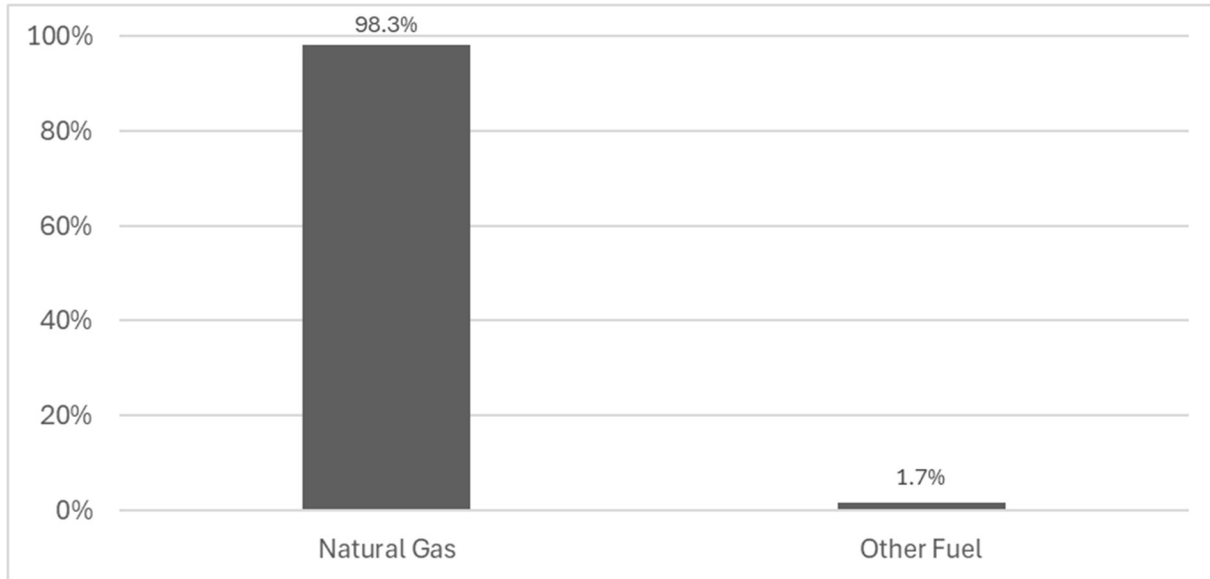
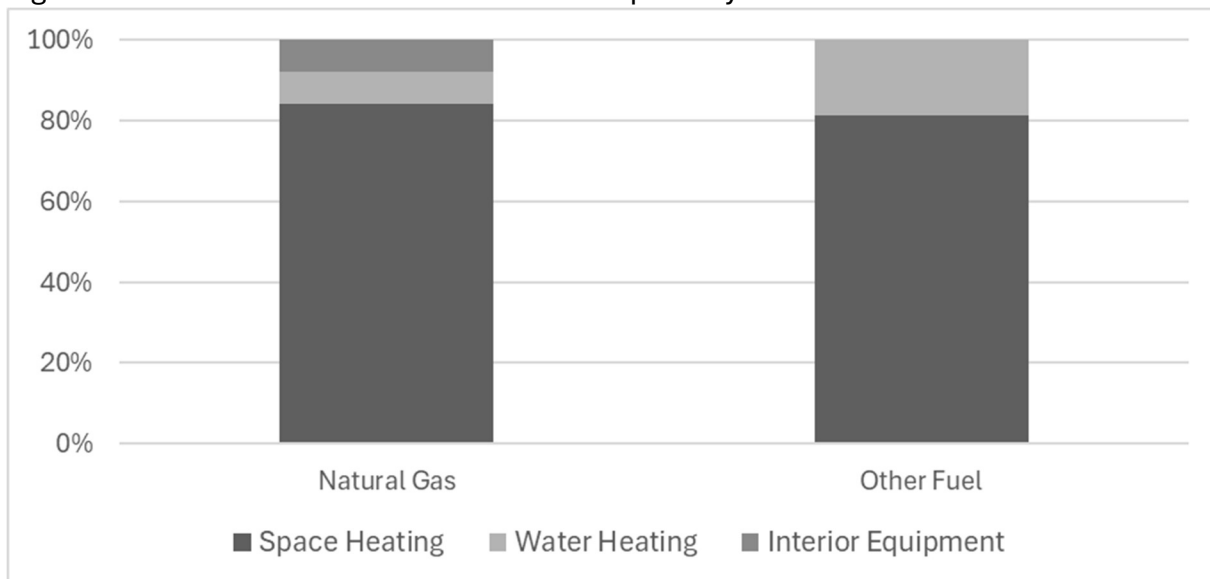


Figure X.7 shows the breakdown of commercial fuel consumption into separate end uses for all ComStock buildings combined. The reason for not extending this analysis for each ComStock building type is that energy usage can vary significantly for commercial buildings even within the same functional category such as office, healthcare, education, etc.

Figure X.7. Commercial On-Site Fuel Consumption by End Use



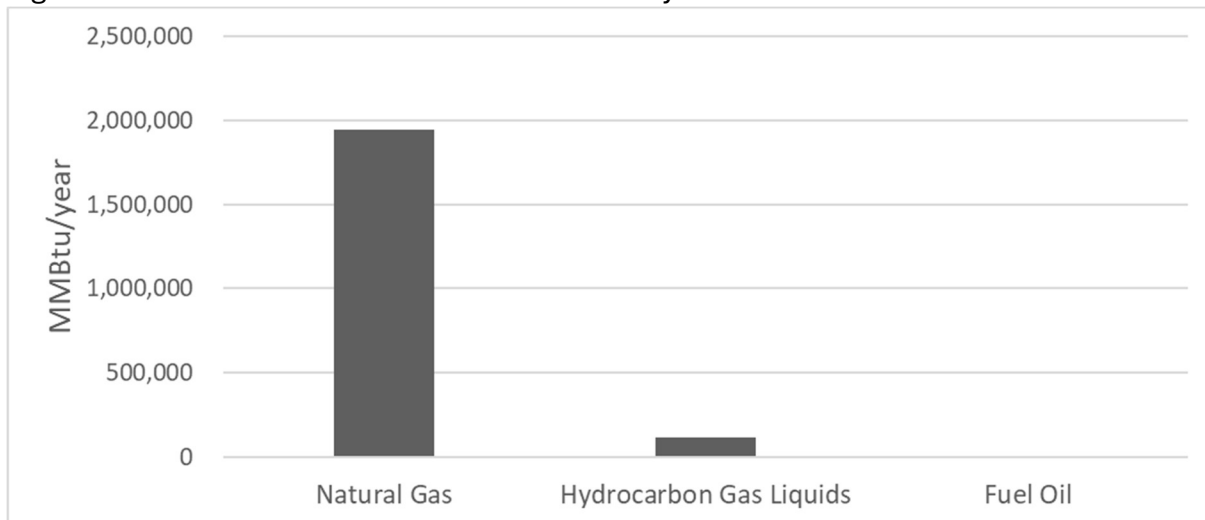
Based on Figures X.6 and X. 7, the following observations can be made regarding commercial on-site fossil fuel consumption in the UPPCO service area:

- Fuel consumption in ComStock building types is dominated by natural gas with less than 2% reported for delivered fuels;
- Of the three fuel-consuming end use categories, space heating dominates at over 80%

Industrial On-Site Fuel Consumption

NREL has no industrial building energy dataset similar to ResStock and ComStock. Therefore, an order-of-magnitude estimate for industrial fuel consumption was conducted for the UPPCO service area. Using data from U.S. EIA’s 2018 Manufacturing Energy Consumption Survey, average consumption ratios for electricity to other fuels were computed for Midwest NAICS codes 31-33 combined. These ratios were then applied to UPPCO’s 2023 industrial sales. The resulting estimates are shown in Figure X.Z. The purpose of this analysis was to roughly gauge the theoretical upper boundary of fuel-switching potential in this sector.

Figure X.Z. Estimated Annual On-Site Fuel Use by UPPCO Industrial Customers



Residential Electrification Potential

To better understand market segments related to fuel switching and reducing space heating demand in the UPPCO service area, the distributions of various building characteristics were investigated using NREL metadata for the ten-county region. Beginning with the residential sector, Fig. 8 shows the relative mix of ResStock building types. Nearly 80% of all units are Single Family Detached making this a key target market for achieving meaningful adoption of EFEL measures.

Figure X.8. Mix of ResStock Building Types in the Ten UPPCO Counties

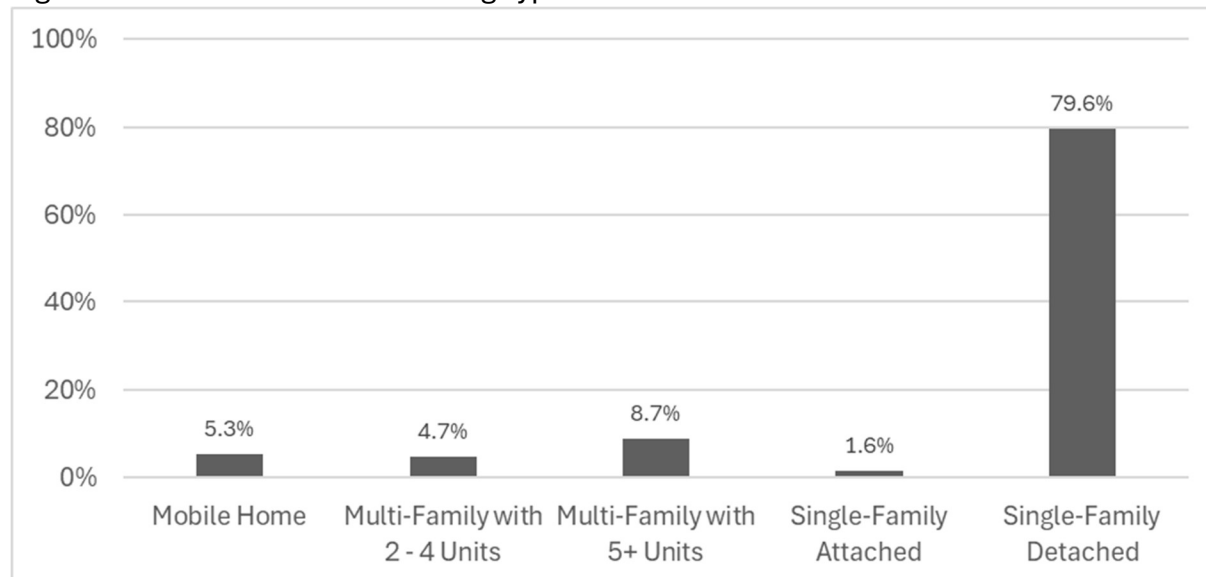


Table X.2 summarizes primary space heating fuel types for housing units within each building type. For example, 3.7% of Mobile Home units use electricity as a primary space heating fuel. From these results, the most frequently used heating fuel in all building types is natural gas. Also, significant portions of Single Family Detached and Mobile Home units heat with delivered fuels, mostly propane. Electric heating occurs most frequently in Multi-Family units and less than 5% in Single Family and Mobile Home units.

Table X.2. ResStock UPPCO counties; space heating fuel mix by building type

Heating Fuel	Mobile Home	Multi-Family 2 - 4 Units	Multi-Family 5+ Units	Single Family Attached	Single Family Detached
Electricity	3.7%	16.7%	47.7%	0.0%	4.5%
Natural Gas	51.9%	79.2%	50.0%	100.0%	58.3%
Propane	37.0%	4.2%	2.3%	0.0%	20.6%
Fuel Oil	0.0%	0.0%	0.0%	0.0%	4.2%
Other Fuel	7.4%	0.0%	0.0%	0.0%	12.4%
	100.0%	100.0%	100.0%	100.0%	100.0%

Given that ResStock metadata include municipal utility customers in the ten-county region, and because the ratio of natural gas to delivered fuels is greater for these households than county averages, it is likely that Table X.2 underreports the portion of housing units using delivered fuels in the more rural UPPCO service area.

With regard to the Mobile Home type, the NREL Characterization Study observes that these units have relatively high energy intensity and reflect a meaningful low-income population. Therefore, the Mobile Home segment is an important target segment for efforts to manage energy burden despite their relatively fewer numbers in the UPPCO service area. In

addition, the Slipstream Potential Study found that more low-income customers in the UP use electric space heating in general than other parts of Michigan.

For all housing units which heat with electricity (all building types combined), Table X.3 shows the mix of units using electricity versus a fossil fuel (natural gas, propane, or fuel oil) for water heating, cooking, and clothes drying. In each case, only housing units with each type of end use equipment are reflected in the table. For example, any unit without a clothes dryer is not included in the third numerical column in Table X.3 but is included in the first numerical column if the same unit has a water heater.

Table X.3.

Space Heating	Water Heating		Cooking		Clothes Drying	
		Percent		Percent		Percent
Electric	Electric	97.7%	Electric	86.4%	Electric	86.7%
	Fossil Fuel	2.3%	Fossil Fuel	13.6%	Fossil Fuel	13.3%
	100.0%		100.0%		100.0%	

Similarly, for all housing units which heat using a fossil fuel, Table X.4 shows the mix of energy sources (electricity or fossil fuels) used for water heating, cooking, and clothes drying.

Table X.4.

Space Heating	Water Heating		Cooking		Clothes Drying	
		Percent		Percent		Percent
Fossil Fuel	Electric	21.7%	Electric	46.8%	Electric	78.4%
	Fossil Fuel	78.3%	Fossil Fuel	53.2%	Fossil Fuel	21.6%
	100.0%		100.0%		100.0%	

Based on this information, it is uncommon to find electric space heating paired with non-electric water heating (2.3%), cooking (13.6%), or clothes drying (13.3%) in the region. By comparison, homes with fossil fuel space heating are more likely to use a fossil fuel for water heating (78.3%), cooking (53.2%), or clothes drying (21.6%). A programming implication is that fewer opportunities exist to electrify other end uses when a home already has electric space heating. But for homes which heat with fossil fuel, there is more potential to simultaneously electrify other end uses, especially water heating. A more detailed breakdown of the data summarized in Tables X.3 and X.4 is presented below in Table X.5.

Table X.5. Combinations of Space Heating and Other End Use Fuel Types by Residential Building Type

Building Type	Space Heating Fuel	Water Heating		Cooking		Clothes Drying	
		Fuel	Percent	Fuel	Percent	Fuel	Percent
Mobile Home	Electricity	Electricity	0.0%	Electricity	0.2%	Electricity	0.2%
		Fossil Fuel	0.2%	Fossil Fuel	0.0%	Fossil Fuel	0.0%
	Natural Gas	Electricity	0.4%	Electricity	1.3%	Electricity	3.2%
		Fossil Fuel	2.6%	Fossil Fuel	1.8%	Fossil Fuel	0.0%
	Propane	Electricity	1.3%	Electricity	1.3%	Electricity	2.0%
		Fossil Fuel	0.9%	Fossil Fuel	0.9%	Fossil Fuel	0.2%
	Fuel Oil	Electricity	0.0%	Electricity	0.0%	Electricity	0.0%
		Fossil Fuel	0.0%	Fossil Fuel	0.0%	Fossil Fuel	0.0%
Multi-Family with 2 - 4 Units	Electricity	Electricity	0.7%	Electricity	0.7%	Electricity	1.0%
		Fossil Fuel	0.0%	Fossil Fuel	0.2%	Fossil Fuel	0.0%
	Natural Gas	Electricity	0.0%	Electricity	2.0%	Electricity	3.2%
		Fossil Fuel	4.2%	Fossil Fuel	2.2%	Fossil Fuel	0.2%
	Propane	Electricity	0.2%	Electricity	0.2%	Electricity	0.0%
		Fossil Fuel	0.0%	Fossil Fuel	0.0%	Fossil Fuel	0.0%
	Fuel Oil	Electricity	0.0%	Electricity	0.0%	Electricity	0.0%
		Fossil Fuel	0.0%	Fossil Fuel	0.0%	Fossil Fuel	0.0%
Multi-Family with 5+ Units	Electricity	Electricity	4.6%	Electricity	4.0%	Electricity	2.0%
		Fossil Fuel	0.0%	Fossil Fuel	0.7%	Fossil Fuel	0.0%
	Natural Gas	Electricity	0.2%	Electricity	2.2%	Electricity	2.7%
		Fossil Fuel	4.6%	Fossil Fuel	2.4%	Fossil Fuel	0.0%
	Propane	Electricity	0.2%	Electricity	0.0%	Electricity	0.2%
		Fossil Fuel	0.0%	Fossil Fuel	0.2%	Fossil Fuel	0.0%
	Fuel Oil	Electricity	0.0%	Electricity	0.0%	Electricity	0.0%
		Fossil Fuel	0.0%	Fossil Fuel	0.0%	Fossil Fuel	0.0%
Single-Family Attached	Electricity	Electricity	0.0%	Electricity	0.0%	Electricity	0.0%
		Fossil Fuel	0.0%	Fossil Fuel	0.0%	Fossil Fuel	0.0%
	Natural Gas	Electricity	0.0%	Electricity	0.9%	Electricity	1.2%
		Fossil Fuel	1.8%	Fossil Fuel	0.7%	Fossil Fuel	0.7%
	Propane	Electricity	0.0%	Electricity	0.0%	Electricity	0.0%
		Fossil Fuel	0.0%	Fossil Fuel	0.0%	Fossil Fuel	0.0%
	Fuel Oil	Electricity	0.0%	Electricity	0.0%	Electricity	0.0%
		Fossil Fuel	0.0%	Fossil Fuel	0.0%	Fossil Fuel	0.0%
Single-Family Detached	Electricity	Electricity	4.0%	Electricity	3.6%	Electricity	3.2%
		Fossil Fuel	0.0%	Fossil Fuel	0.4%	Fossil Fuel	1.0%
	Natural Gas	Electricity	4.6%	Electricity	21.8%	Electricity	40.5%
		Fossil Fuel	47.2%	Fossil Fuel	30.0%	Fossil Fuel	14.9%
	Propane	Electricity	9.7%	Electricity	9.1%	Electricity	15.6%
		Fossil Fuel	8.6%	Fossil Fuel	9.3%	Fossil Fuel	3.9%
	Fuel Oil	Electricity	2.9%	Electricity	3.3%	Electricity	4.1%
		Fossil Fuel	0.9%	Fossil Fuel	0.4%	Fossil Fuel	0.0%
		100.0%		100.0%		100.0%	

Residential Space Heating Demand Reduction Potential

An important goal of UPPCO programming is to integrate building electrification with opportunities to reduce space heating demand. This can be informed by examining the distributions of various building characteristics related to improving envelope and heating system performance. Results for the frequency of space heating fuel types paired with other salient building characteristics are presented in Tables X.6 and X.7. Both tables, which reflect ResStock data for the ten UPPCO counties, combine all Multi-Family units together and exclude Single Family Attached units which are few compared to other building types.

In Table X.6, space heating fuel type is cross-tabulated separately with air infiltration level, building vintage, and wall construction type. A common pattern of infiltration level emerges across all building and space fuel types. Specifically, most units perform at 5-15 ACH50 (air changes per hour at 50 pounds per square inch of pressure) followed by >15 ACH50 and <5 ACH50. In other words, residential building infiltration follows a similar distribution with a meaningful number above 15 ACH50 and even fewer performing below 5 ACH50. This suggests a general opportunity to improve infiltration in residential units. This opportunity is underscored by the NREL Characterization Study's finding that infiltration is the largest contributing factor to residential heating load.

For building age distribution, most electric space heating occurs in units constructed after 1940 although older housing with electric heating does exist. In terms of sheer numbers, two vintages of units heated with natural gas account for over 44% of all housing units (18.4% <1940 and 26.0% 1940-1979). Finally, delivered fuel space heating in older buildings occurs in meaningful numbers only for Single Family Detached. More generally, the NREL Characterization Study concludes that many measure packages to reduce heating demand are transferable between residential building types and vintages.

For wall type, by definition all Mobile Home units reflect wood or steel frame construction which also accounts for most Multi-Family and Single Family Detached units. But masonry construction also occurs in Multi-Family and Single Family Detached units with all space heating fuel types.

In Table X.7, space heating fuel type is cross-tabulated separately with ceiling insulation, wall insulation, and foundation wall insulation. For ceiling insulation, similar patterns emerge for all space heating fuel types. Most Mobile Home units have some level of ceiling insulation. A significant portion of Multi-Family units are uninsulated. The most commonly reported ceiling insulation level for Single Family Detached units is R-7 to R-38 followed by > R-38 with the fewest number being uninsulated.

For wall insulation, the majority of Mobile Homes units have some level of insulation; the greatest portion of units insulated above R15 heat with propane. A meaningful portion of other building types, whether heated with electric or fossil fuel, are uninsulated. In

particular, Multi-Family and Single Family Detached units heated with natural gas are most likely to be uninsulated.

And while some units have foundation wall insulation, the frequency of uninsulated units is high for all combinations of building type and space heating fuel type.

Table X.6. Residential Distributions of Infiltration, Vintage, and Wall Construction by Building Type and Space Heating Type

Building Type	Space Heating Fuel	Infiltration		Vintage		Wall Construction	
		Level	Percent	Year Built	Percent	Type	Percent
Mobile Home	Electricity	< 5 ACH50	0.0%	<1940	0.0%	Brick	0.0%
		5-15 ACH50	0.0%	1940-1979	0.2%	Concrete	0.0%
		> 15 ACH50	0.2%	>1979	0.0%	Wood or Steel Frame	0.2%
	Natural Gas	< 5 ACH50	0.0%	<1940	0.0%	Brick	0.0%
		5-15 ACH50	2.2%	1940-1979	1.6%	Concrete	0.0%
		> 15 ACH50	0.9%	>1979	1.6%	Wood or Steel Frame	3.1%
	Propane	< 5 ACH50	0.2%	<1940	0.0%	Brick	0.0%
		5-15 ACH50	1.6%	1940-1979	0.4%	Concrete	0.0%
		> 15 ACH50	0.4%	>1979	1.8%	Wood or Steel Frame	2.2%
	Fuel Oil	< 5 ACH50	0.0%	<1940	0.0%	Brick	0.0%
		5-15 ACH50	0.0%	1940-1979	0.0%	Concrete	0.0%
		> 15 ACH50	0.0%	>1979	0.0%	Wood or Steel Frame	0.0%
Multi-Family	Electricity	< 5 ACH50	0.9%	<1940	1.1%	Brick	0.7%
		5-15 ACH50	2.9%	1940-1979	1.3%	Concrete	0.2%
		> 15 ACH50	1.8%	>1979	3.1%	Wood or Steel Frame	4.7%
	Natural Gas	< 5 ACH50	0.2%	<1940	2.5%	Brick	2.0%
		5-15 ACH50	5.4%	1940-1979	4.5%	Concrete	0.0%
		> 15 ACH50	3.6%	>1979	2.2%	Wood or Steel Frame	7.2%
	Propane	< 5 ACH50	0.0%	<1940	0.0%	Brick	0.2%
		5-15 ACH50	0.4%	1940-1979	0.4%	Concrete	0.0%
		> 15 ACH50	0.0%	>1979	0.0%	Wood or Steel Frame	0.2%
	Fuel Oil	< 5 ACH50	0.0%	<1940	0.0%	Brick	0.0%
		5-15 ACH50	0.0%	1940-1979	0.0%	Concrete	0.0%
		> 15 ACH50	0.0%	>1979	0.0%	Wood or Steel Frame	0.0%
Single-Family Detached	Electricity	< 5 ACH50	0.2%	<1940	0.4%	Brick	0.2%
		5-15 ACH50	2.5%	1940-1979	1.6%	Concrete	0.0%
		> 15 ACH50	1.3%	>1979	2.0%	Wood or Steel Frame	3.8%
	Natural Gas	< 5 ACH50	2.0%	<1940	18.4%	Brick	23.8%
		5-15 ACH50	27.4%	1940-1979	26.0%	Concrete	0.7%
		> 15 ACH50	23.3%	>1979	8.3%	Wood or Steel Frame	28.3%
	Propane	< 5 ACH50	1.8%	<1940	3.1%	Brick	5.2%
		5-15 ACH50	11.0%	1940-1979	6.7%	Concrete	0.4%
		> 15 ACH50	5.8%	>1979	8.7%	Wood or Steel Frame	13.0%
	Fuel Oil	< 5 ACH50	0.2%	<1940	1.6%	Brick	1.6%
		5-15 ACH50	2.2%	1940-1979	1.8%	Concrete	0.4%
		> 15 ACH50	1.3%	>1979	0.4%	Wood or Steel Frame	1.8%
		100.0%		100.0%		100.0%	

Table X.7. Residential Distributions of Ceiling, Wall, and Foundation Wall Insulation by Building Type and Space Heating Type

Building Type	Space Heating Fuel	Ceiling Insulation		Wall Insulation		Foundation Wall Insul.	
		Level	Percent	Level	Percent	Level	Percent
Mobile Home	Electricity	Uninsulated	0.0%	Uninsulated	0.0%	Uninsulated	0.2%
		R-7 to R-38	0.0%	R-7 to R-15	0.2%	R-5 to R-10	0.0%
		> R-38	0.2%	> R-15	0.0%	> R-10	0.0%
	Natural Gas	Uninsulated	0.0%	Uninsulated	0.4%	Uninsulated	3.1%
		R-7 to R-38	1.6%	R-7 to R-15	2.7%	R-5 to R-10	0.0%
		> R-38	1.6%	> R-15	0.0%	> R-10	0.0%
	Propane	Uninsulated	0.0%	Uninsulated	0.0%	Uninsulated	2.2%
		R-7 to R-38	1.1%	R-7 to R-15	2.0%	R-5 to R-10	0.0%
		> R-38	1.1%	> R-15	0.2%	> R-10	0.0%
	Fuel Oil	Uninsulated	0.0%	Uninsulated	0.0%	Uninsulated	0.0%
		R-7 to R-38	0.0%	R-7 to R-15	0.0%	R-5 to R-10	0.0%
		> R-38	0.0%	> R-15	0.0%	> R-10	0.0%
Multi-Family	Electricity	Uninsulated	5.6%	Uninsulated	1.8%	Uninsulated	5.6%
		R-7 to R-38	0.0%	R-7 to R-15	2.9%	R-5 to R-10	0.0%
		> R-38	0.0%	> R-15	0.9%	> R-10	0.0%
	Natural Gas	Uninsulated	9.2%	Uninsulated	5.4%	Uninsulated	9.2%
		R-7 to R-38	0.0%	R-7 to R-15	3.6%	R-5 to R-10	0.0%
		> R-38	0.0%	> R-15	0.2%	> R-10	0.0%
	Propane	Uninsulated	0.4%	Uninsulated	0.4%	Uninsulated	0.4%
		R-7 to R-38	0.0%	R-7 to R-15	0.0%	R-5 to R-10	0.0%
		> R-38	0.0%	> R-15	0.0%	> R-10	0.0%
	Fuel Oil	Uninsulated	0.0%	Uninsulated	0.0%	Uninsulated	0.0%
		R-7 to R-38	0.0%	R-7 to R-15	0.0%	R-5 to R-10	0.0%
		> R-38	0.0%	> R-15	0.0%	> R-10	0.0%
Single-Family Detached	Electricity	Uninsulated	0.4%	Uninsulated	1.3%	Uninsulated	3.6%
		R-7 to R-38	2.2%	R-7 to R-15	2.2%	R-5 to R-10	0.4%
		> R-38	1.3%	> R-15	0.4%	> R-10	0.0%
	Natural Gas	Uninsulated	1.8%	Uninsulated	38.1%	Uninsulated	49.6%
		R-7 to R-38	35.2%	R-7 to R-15	12.8%	R-5 to R-10	2.9%
		> R-38	15.7%	> R-15	1.8%	> R-10	0.2%
	Propane	Uninsulated	0.4%	Uninsulated	7.2%	Uninsulated	14.8%
		R-7 to R-38	10.8%	R-7 to R-15	9.4%	R-5 to R-10	3.4%
		> R-38	7.4%	> R-15	2.0%	> R-10	0.4%
	Fuel Oil	Uninsulated	0.0%	Uninsulated	2.7%	Uninsulated	3.6%
		R-7 to R-38	3.1%	R-7 to R-15	1.1%	R-5 to R-10	0.2%
		> R-38	0.7%	> R-15	0.0%	> R-10	0.0%
		100.0%		100.0%		100.0%	

Distributions of several other building characteristics can be used to inform utility programming aimed particularly at end use electrification and space heating demand reduction. Table X.8 shows that most residential units in the region have HVAC ducting although units without ducting are common.

Table X.8. Occurrence of HVAC Ducting in Residential Units by Building Type

Ducting System	Mobile Home	Multi-Family (All Units)	Single Family Detached
Yes	81.5%	57.4%	68.7%
No	18.5%	42.6%	31.3%
	100.0%	100.0%	100.0%

Table X.9 breaks down each space heating fuel by system type. The most common setups in Mobile Home and Single Family Detached units are natural gas and propane furnaces. This is followed by natural gas boilers in Single Family Detached units. Most Multi-Family units are equipped with natural gas furnace, natural gas shared heating, electric baseboard, and electric furnace systems.

Table X.9. Heating System and Fuel Combinations in Residential Units by Building Type

Heating Type and Fuel	Mobile Home	Multi-Family (All Units)	Single Family Detached
Electricity Baseboard	0.0%	16.2%	2.2%
Electricity Electric Boiler	0.0%	1.5%	0.2%
Electricity Electric Furnace	3.7%	11.8%	1.7%
Electricity Electric Wall Furnace	0.0%	0.0%	0.2%
Electricity Shared Heating	0.0%	7.4%	0.0%
Natural Gas Fuel Furnace	40.7%	27.9%	37.2%
Natural Gas Fuel Wall/Floor Furnace	7.4%	7.4%	9.7%
Natural Gas Shared Heating	0.0%	17.6%	0.0%
Propane Fuel Boiler	3.7%	0.0%	1.5%
Propane Fuel Furnace	29.6%	2.9%	14.1%
Propane Fuel Wall/Floor Furnace	3.7%	0.0%	5.0%
Fuel Oil Fuel Boiler	0.0%	0.0%	1.5%
Fuel Oil Fuel Furnace	0.0%	0.0%	2.7%
Natural Gas Fuel Boiler	3.7%	7.4%	11.4%
None	7.4%	0.0%	12.4%
	100.0%	100.0%	100.0%

A related finding from ResStock metadata is that among all installed natural gas and propane furnaces and boilers in the ten UPPCO counties, those with Annual Fuel Utilization Efficiency (AFUE) around 80 are twice as common as those with a higher AFUE around 92.5. For furnaces and boilers fired with heating oil, this ratio is nearly an order of magnitude. And according to the Slipstream Potential Study, about half of UP housing units use supplemental heating—suggesting a potential market especially for mini-split heat pumps—and thermostat functionality is generally underutilized in the UPPCO service area.

Finally, Table X.10. shows that while more than half of all building type/heating fuel combinations have some form of air conditioning installed (either central AC or window AC), a significant number of homes in the region still do not have AC.

Table X.10. Frequency of AC Equipment in Residential Units by Building Type and Space Heating Fuel Type

Building Type	Space Heating Fuel	Either Central AC or Window AC	Percent
Mobile Home	Electricity	Yes	0.2%
		No	0.0%
	Fossil Fuel	Yes	4.0%
		No	1.3%
Multi-Family	Electricity	Yes	2.7%
		No	2.7%
	Fossil Fuel	Yes	6.3%
		No	3.4%
Single Family Detached	Electricity	Yes	2.9%
		No	1.1%
	Fossil Fuel	Yes	46.3%
		No	29.0%
			100.0%

Commercial Electrification and Space Heating Demand Reduction Potential

As with the residential sector, UPPCO programming for commercial customers can be informed by examining the distributions of various building characteristics related to fuel switching and improving envelope and heating system performance. Importantly, the NREL Characterization Study concludes that there is considerable variation in thermal load intensity even within identical building types. For a general understanding of the region’s commercial inventory, Table X.6 presents distributions for relevant characteristics for all building types combined. Again, ComStock metadata are limited to fourteen of the most common types of commercial buildings.

Table X.11. ComStock Metadata for UPPCO Counties

Space Heating Fuel	Percent
Electricity	7.2%
Natural Gas	89.7%
Propane	1.5%
Fuel Oil	0.0%
District Heating	1.5%
100.0%	

Water Heating Fuel	Percent
Electricity	34.4%
Natural Gas	64.6%
Propane	0.5%
Fuel Oil	0.0%
District Heating	0.5%
100.0%	

HVAC Category	Percent
Zone-by-Zone	11.3%
Multizone CAV/VAV	24.6%
Residential Style Central Systems	15.9%
Small Packaged Unit	48.2%
100.0%	

Wall Construction Type	Percent
Mass	25.1%
Metal Building	0.0%
Steel Framed	56.9%
Wood Framed	17.9%
100.0%	

Airtightness (m3 per m2-s)	Percent
5	3.1%
10	10.3%
15	20.0%
20	15.4%
25	12.8%
30	7.2%
35	6.7%
40	8.2%
45	2.6%
50	5.6%
55	3.1%
60	1.0%
65	1.5%
70	0.0%
75	2.6%
100.0%	

Vintage	Percent
Before 1946	31.3%
1946 to 1959	11.3%
1960 to 1969	7.7%
1970 to 1979	17.4%
1980 to 1989	11.3%
1990 to 1999	11.8%
2000 to 2012	7.7%
2013 to 2018	1.5%
100.0%	

Floor Area (sqft)	Percent
Up to 1000	2.6%
1001-5000	16.9%
5001-10000	25.6%
10001-25000	31.3%
25001-50000	16.9%
50001 and above	6.7%
100.0%	

As with UPPCO’s residential customers, natural gas is the predominant space and water heating fuel in the commercial sector with electricity providing a larger share of water heating than space heating. This points to commercial water heating as a potentially significant target market for EWR measures that replace electric resistance with heat pump equipment. For more information, Table X.12 presents the relative frequency of space and water heating combinations by fuel type.

Table X.12. ComStock Space Heating and Water Heating Fuel Combinations, UPPCO Counties

Space Heating Fuel	Water Heating Fuel	Percent
Electricity	Electricity	4.6%
	Natural Gas	2.6%
Natural Gas	Electricity	27.7%
	Natural Gas	62.1%
Propane	Electricity	1.0%
	Propane	0.5%
District Heating	Electricity	1.0%
	District Heating	0.5%
		100.0%

Other observations from Table X.11 include the following:

- HVAC categories are broadly distributed with Single Packaged Units (SPUs) occurring in nearly half of all ComStock building types. This comports with the NREL Characterization Study’s finding that upgrading SPUs presents a significant cross-sector opportunity.
- Broad distributions occur with commercial floor area, air tightness (with nearly half of buildings performing in the range of 5-20 m3 per m2-s), and vintage (with pre-1946 buildings being common in the region).
- About a quarter of commercial structures have masonry wall construction with the balance being steel and wood frame types in a ratio of roughly 3:1.

Additional findings for the commercial sector are these:

- ComStock metadata results for the distribution of building height: one story (63.1%), two stories (31.8%), and three or more stories (5.1%).
- The Slipstream Potential Study found that about 20% of UP commercial buildings have commercial kitchens with specific frequencies provided for these four segments: food service (83%), food sales (50%), office (8%), and retail (3%).

Finally, it is worth noting these general conclusions from the NREL Characterization Study:

- Commercial building solutions are likely transferable between segments with much of the focus being on equipment retrofits rather than envelope upgrades.
- Ventilation is a main driver of energy use and accounts for a large share of thermal load intensity and total thermal loads.
- Energy recovery ventilation (ERV) could be integrated into replacement unit. Or, decouple ventilation and space conditioning by replacing central unit with ERV plus zone-level split heat pumps

Industrial Electrification and Space Heating Demand Reduction Potential

Compared to UPPCO’s residential and commercial market segments, the industrial sector reflects many fewer customers and much more site-specific energy behavior and performance even within similar economic subsectors. Therefore, industrial programming will feature more unique solution packages and be more custom-driven in general.

To help program implementers segment the broader commercial and industrial market in the UPPCO service area, Table X.13 summarizes businesses in the ten-county region by 2-digit North American Industry Classification System (NAICS) code per U.S. Census data. Table X.14 lists the more detailed 4-digit NAICS codes of UPPCO’s largest, mostly industrial customers.

Table X.13. UPPCO Counties, NAICS 2-Digit Code Tally

NAICS 2017 Code	NAICS 2017 Category Label	UPPCO Counties	
		Frequency (2022)	Percent
11	Agriculture, forestry, fishing and hunting	128	2.5%
21	Mining, quarrying, and oil and gas extraction	10	0.2%
22	Utilities	23	0.5%
23	Construction	552	10.9%
31-33	Manufacturing	267	5.2%
42	Wholesale trade	140	2.8%
44-45	Retail trade	823	16.2%
48-49	Transportation and warehousing	182	3.6%
51	Information	97	1.9%
52	Finance and insurance	293	5.8%
53	Real estate and rental and leasing	157	3.1%
54	Professional, scientific, and technical services	357	7.0%
55	Management of companies and enterprises	8	0.2%
56	Admin and support; waste management; remediation services	179	3.5%
61	Educational services	38	0.7%
62	Health care and social assistance	537	10.6%
71	Arts, entertainment, and recreation	95	1.9%
72	Accommodation and food services	633	12.4%
81	Other services (except public administration)	567	11.1%
		5,086	100.0%

Table X.14. NAICS Categories of Largest Customers in UPPCO Service Area

NAICS Code	NAICS Description
1119	Other Crop Farming (Cannabis)
2122	Metal Ore Mining
2213	Water, Sewage and Other Systems
2373	Highway, Street, and Bridge Construction
3100	Manufacture of Furniture
3211	Sawmills and Wood Preservation
3219	Other Wood Product Manufacturing
3221	Pulp, Paper, and Paperboard Mills
3252	Resin, Synthetic Rubber, and Artificial and Synthetic Fibers and Filaments Manufacturing
3300	Metal Products
3313	Alumina and Aluminum Production and Processing
3339	Other General Purpose Machinery Manufacturing
3359	Other Electrical Equipment and Component Manufacturing
3364	Aerospace Product and Parts Manufacturing
4451	Grocery and Convenience Retailers
4821	Rail Transportation
4861	Pipeline Transportation of Crude Oil
6111	Elementary and Secondary Schools
6113	Colleges, Universities, and Professional Schools
6221	General Medical and Surgical Hospitals
7211	Traveler Accommodation (Note: Casino)
9221	Justice, Public Order, and Safety Activities (Note: Correctional Facility)
9251	Administration of Housing Programs, Urban Planning, and Community Development

Transitioning to Induction Stoves in Michigan: A Cost-Benefit Analysis

Prepared for

Slipstream, Upper Peninsula Power Company (UPPCO),
and Indiana Michigan Power (I&M)

By

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Abbreviations

ASD	Autism Spectrum Disorder
CO	Carbon Monoxide
COPD	Chronic Obstructive Pulmonary Disease
CVD	Cardiovascular Diseases
DALY	Disability-Adjusted Life Year
EIA	Energy Information Administration
EOL	End of Life
GHG	Greenhouse Gas
I&M	Indiana Michigan Power
IRA	Inflation Reduction Act
LRT	Lower Respiratory Tract
NFPA	National Fire Protection Association
NO ₂	Nitrogen Dioxide
PAF	Population Attributable Fraction
PM _{2.5}	Particulate Matter at least 2.5 micrometers in diameter
PVNB	Present Value of Net Benefits
RD	Respiratory Diseases
SRB	School Refusal Behavior
UPPCO	Upper Peninsula Power Company
U.S. EIA	United States Energy Information Administration
YLDs	Years Lived with a Disability
YLLs	Years of Life Lost
VLY	Value of a Life Year
VSL	Value of a Statistical Life

Executive Summary

This report was prepared for the Upper Peninsula Power Company (UPPCO), Indiana Michigan Power (I&M), and Slipstream. It contains a cost-benefit analysis on the potential outcomes of converting existing kitchen ranges to induction ranges in Michigan. The induction range uses an electromagnetic field to heat up the cookware directly without relying on external heat source and conduction like transitional stoves, and it is believed to provide faster heating and rapid cool down time. The major driving factors of this analysis come from the concerns of the health and environmental impacts caused by the indoor pollutants and greenhouse gas emitted from gas stoves during cooking. Our study compares three kinds of kitchen ranges: gas, electric resistance, and induction. For gas ranges, we follow previous studies and do not distinguish those using natural gas, propane, and other fossil fuel types, and we assume they have the same impact. For electric resistance ranges, we look into two types: an older design that uses resistance coil, and a more modern design that has ceramic glass cover on the top, offering a flat and smooth range surface. To distinguish between electric resistance and induction stoves, we focus on the resistance coil range models.

In the following sections, our team examines three potential policy alternatives in comparison with the status quo. We look into the health and environmental impacts on an average per-household basis in Michigan. Other health and environmental impacts could happen on the production end since the majority of the stoves are manufactured abroad, but these impacts are out of scope as our analysis focuses in impacts in the state of Michigan. In the status quo scenario, we assume that all households in Michigan will continue to use the same stove type after their current appliances reach the end of their life cycle. The first alternative we propose is to encourage Michigan households with gas ranges to switch to induction ranges, as well as to encourage households with have electric resistance stoves to remain unchanged. Under this alternative, we assume that all households with gas ranges will convert their cooking ranges to induction ranges at the same time, and they will start to gain the net benefits from this alternative at once. These assumptions are not realistic, but they let us identify the upper end of the net benefits for this alternative and estimate health and environmental impacts. The second alternative is to encourage Michigan households with electric resistance range to switch to induction. Similar to the first alternative, we assume that all households with electric resistance ranges will convert their kitchen ranges to the induction range and that households with gas ranges remain unchanged. To estimate the maximum benefit under this alternative, we also assume that all households that have electric resistance ranges will make the transition simultaneously. The third alternative is to encourage Michigan households that have either gas or electric resistance range to make a comprehensive conversion of their appliances into induction ranges. Under this alternative, to estimate the maximum benefit over the product life years, we assume that the comprehensive conversion will take place at the same time. For each alternative, we assume that all households have stoves that are at the end of their lives. We also assume that households are choosing between buying an induction stove or purchasing the same type of stove they currently have. This is not realistic, but it gives us the upper bound of benefits possible for Michigan.

We analyzed the cost and benefit of each policy alternative over these monetized impact factors: upfront cost, general health impacts, air pollutant impacts, safety risks, maintenance, energy efficiency, and environmental impacts. For the upfront cost, we monetize this factor based on three values: purchase and installation cost of the new stove; purchase and installation of a 240 Volt circuit required for the high wattage stoves; and the cost to replace current cookware, as an induction stove requires the cookware to be made of ferrous materials such as cast iron or stainless steel. In our overall analysis, we measured the health benefit by counting individual air pollutant impacts. We also examined the general health impact of switching from gas

and electric stoves to induction stoves since existing literature measures health impact with this approach, and the discrepancy underscores the importance for policymakers to adopt an appropriate method aligned with their specific objectives to attain the most insightful results and based on data availability. For the safety risk, we analyze this factor by calculating the monetary values associated with fire, burning injuries, and deaths caused by stoves. The maintenance factor was monetized based on the time to clean the stoves, minimum hourly wage in Michigan as people's opportunity cost of their spare times which are used for cleaning the stoves, the annual cost for purchasing cleaning supplies, the cost of replacement parts and labor, and the lifespan of each stove type. The energy consumption factor is monetized by the annual energy bill associated with stove usage for each household. Under the maintenance and energy consumption categories, we assumed electric stoves had the traditional coil design, and we provided maintenance data for ceramic glass top design for future analysis. For greenhouse gas and other life cycle impacts, we investigated the life cycle environmental impacts of induction, electric resistance, and gas cooktops across three distinct scenarios reflecting Michigan's electricity mix in 2022. Our analysis utilized the specifications for the cooktops as outlined in the 2023 study by Sanglard et al. which employs the life cycle Recipe methodology, and we evaluated the environmental impacts across 13 different categories. These impacts were subsequently monetized using the shadow prices listed in the Environmental Price Handbook. We do notice that there are non-monetizable factors when it comes to stove conversion, such as cultural heritage of cooking on open flames, cooking experiences on different types of stoves, and learning curve of each stove type. Quantifying these aspects is challenging due to their intrinsic and subjective nature. In our analysis, we do not monetize these aspects.

To minimize the impact of uncertain factors, we conducted a Monte Carlo simulation on each of our policy alternatives to determine a mean Present Value of Net Benefits using a 2 percent discount rate that the Office of Management and Budget uses for 10-year projects. We also conducted three sensitivity analyses: we compared pollutant specific health impacts and general health impacts; we compared the greenhouse gas and life cycle impacts from Michigan's 2022 electricity mix, projected 2040 electricity mix, and coal-free projected 2040 electricity mix; and we compared our Present Value of Net Benefits (PVNB), after changing the discount rate from 2 percent to 3 and 7 percent. The 2 percent is the recommended real discount rate for a 10-year project in 2023 by the White House, and we used the 3 and 7 percent discount rates to determine whether our results would change if we placed less emphasis on future costs and benefits.

After conducting Monte Carlo simulations, our result shows that converting gas range to induction range results in the highest net benefit gain of \$196.20 billion, with a range between \$15.11 billion and \$457.65 billion. The standard deviation of this alternative is \$97.18 billion, which suggests high uncertainty, but the overall trend indicates that converting gas stoves to induction stove is a viable policy approach. The electric-to-induction alternative resulted in an expected mean of \$-7.65 billion net cost with a range between \$-28.64 billion and \$23.93 billion. The standard deviation is \$3.58 billion for this alternative. The negative mean suggests that converting electric resistance stoves to induction stoves would very likely result in a net social cost for Michigan, and we could be certain with this outcome. The negative net benefit comes from the health impact category, as switching from gas to induction would provide significant health benefits due to the reduction of indoor air pollutants, but since electric resistance stoves generate far less pollution compared to gas stoves, the benefit from the transition is very limited. The comprehensive conversion also results in a positive net benefit for Michigan, but for individual households we expect there would be a loss, as the electric resistance range to induction conversion alone would lead to a net cost under the statewide and per-household standing.

After comparing these alternatives, we recommend that our clients encourage households with gas stoves to transition to induction stoves, taking advantage of the Inflation Reduction Act's Home Electrification and Appliance Rebate Program, as it results in the highest net benefit for Michigan.

Introduction

In response to the growing environmental and health concerns linked to the use of gas stoves, discussions about potential transitions to cleaner alternatives like induction stoves have gained prominence on regulatory agendas. An induction stove is a modern and efficient cooking appliance that relies on electromagnetic technology to generate heat directly in the cookware, which needs to be made of ferrous materials.¹ When an induction-compatible cookware is placed on the cooktop, an electric current generates a magnetic field, heating the cookware directly and rapidly. This heating method differs from the traditional gas or electric resistance stoves, which rely on conduction via external heating sources like flame or heated coils.

Recognizing their substantial contribution of greenhouse gas emissions and various indoor pollutants, the role of gas stoves in residential kitchens is being examined by researchers and policy makers, and there are also debates among the general public regarding the impacts of gas stoves since January 2023.^{2,3,4} This shift in focus towards environmental and health considerations has brought the gas stove conversation to the forefront of regulatory and public discourse, emphasizing the necessity for a thorough examination of both the environmental and health implications tied to continued gas stove usage.

Data from the U.S. Energy Information Administration (EIA) reveals that approximately 38 percent of U.S. households use natural gas for cooking, with rates exceeding 60 percent in states such as California, Illinois, New York, and New Jersey.⁵ Electric cooking appliance usage among the U.S. households on the other hand, is about 68 percent. There are households that have both gas and electric stoves for cooking, and in this report we consider these households as natural-gas-using households. This report's area of interest is Michigan: the residential energy consumption survey conducted by EIA in 2020 shows that 45% of Michigan households use natural gas as energy source for kitchen stoves, which is above the average of the U.S. household value.⁶

Two primary concerns loom over the use of natural gas in kitchens: carbon emissions and health threats arising from harmful indoor air pollutants emitted by gas appliances. Methane, the principal component of natural gas, has a significant environmental impact, being 86 times more potent than carbon dioxide (CO₂) over a 20-year period. Alongside methane emissions, gas stoves contribute to the production of particulate matter (PM_{2.5}), nitrogen dioxide (NO₂), polycyclic aromatic hydrocarbons, formaldehyde, carbon monoxide, and

¹ Welles, Bill. 2021. "Don's Appliances | Don's Appliances | Pittsburgh, PA." Don's Appliances. March 30, 2021. <https://www.donsappliances.com/blog/what-is-induction-cooking-and-how-does-it-work>.

² Natter, Ari. 2023. "US Safety Agency to Consider Ban on Gas Stoves amid Health Fears." Bloomberg.com, January 9, 2023. <https://www.bloomberg.com/news/articles/2023-01-09/us-safety-agency-to-consider-ban-on-gas-stoves-amid-health-fears>.

³ Baker, Gerard. 2023. "Opinion | How the Gas Stove in Your Kitchen Became a Symbol of Freedom." WSJ. January 16, 2023. <https://www.wsj.com/articles/how-the-gas-stove-in-your-kitchen-became-a-symbol-of-freedom-culture-war-gop-democrats-kitchen-appliances-11673882810>.

⁴ Fox, Justin. 2023. "Gas Stoves Are Barely a Blip in US Home Energy Consumption." Bloomberg.com, July 18, 2023. <https://www.bloomberg.com/news/articles/2023-07-18/us-gas-stove-energy-consumption-is-a-fraction-of-total-fuel-usage>.

⁵ Beall, Ross. 2022. "In 2020, Most U.S. Households Prepared at Least One Hot Meal a Day at Home." www.eia.gov. August 15, 2022. <https://www.eia.gov/todayinenergy/detail.php?id=53439>.

⁶ U.S. Energy Information Administration. 2023. "Residential Energy Consumption Survey: 2020 RECS Survey Data." Wwww.eia.gov. June 23, 2023. [https://www.eia.gov/consumption/residential/data/2020/index.php?view=state&src=%E2%80%B9%20Consumption%20%20%20%20%20%20Residential%20Energy%20Consumption%20Survey%20\(RECS\)-f3](https://www.eia.gov/consumption/residential/data/2020/index.php?view=state&src=%E2%80%B9%20Consumption%20%20%20%20%20%20Residential%20Energy%20Consumption%20Survey%20(RECS)-f3).

ultrafine particles.⁷ These pollutants are known for their adverse effects on the environment and human health, prompting a reevaluation of the environmental and public health implications associated with gas stoves.

Our team, commissioned by the Upper Peninsula Power Company (UPPCO) and Indiana Michigan Power (I&M), in collaboration with Slipstream, is currently conducting a cost-benefit analysis as part of an ongoing planning project. The project aims to incentivize the conversion of existing cooking stoves to induction stoves. Our clients' target area encompasses the Michigan Upper Peninsula, where natural gas serves as the primary source of cooking stove energy due to existing infrastructure and low gas prices in the region. For our analysis, we take the standing of the entire state, and we consider the impact of conversion to induction stove across the state, not just the Upper Peninsula region. Our expected Present Value of Net Benefits is the sum of the average per-household benefits across the entirety of Michigan.

This analysis involves evaluating the costs and benefits of replacing current prevalent stove options with induction stoves, targeting electric resistance, natural gas, and propane users. For our study, we compare three different kinds of kitchen ranges: gas ranges, electric resistance ranges, and induction ranges. For gas ranges, we do not distinguish ranges using natural gas, propane, and other fossil fuel types, and we assume they have the same impact, as previous studies do not clarify their use of the term "gas stoves." For electric resistance ranges, we look into two specific types: an older design that uses resistance coil, and a more modern design that has ceramic glass cover on the top, offering a flat and smooth range surface. To distinguish between electric resistance and induction stoves, we focus on the resistance coil range models, and the following analysis will be based on this specific range type.

For this project analysis, we take the upfront cost of transition, safety, health, maintenance, energy consumption, greenhouse gas emission, and life cycle under consideration and monetize these categories. In this analysis, we will be using the term cooking range and cooking stove interchangeably. Both terms refer to the same kitchen appliance.

We consider three potential alternatives relative to the status quo scenario. In each scenario, the net benefit is calculated for us to determine the alternative that results in the most social surplus to Michigan. For each alternative, we calculate the costs and benefits for a lifespan of 10 years, which is the estimated life of an induction stove.⁸ Unless specified otherwise, we also use a 2 percent discount rate, the Office of Management and Budget's 2023 real discount rate for a 10-year project.⁹

⁷ Balmes, John R, Stephanie M Holm, Meredith C McCormack, Nadia N Hansel, Lynn B Gerald, and Jerry A Krishnan. 2023. "Cooking with Natural Gas: Just the Facts, Please." *American Journal of Respiratory and Critical Care Medicine* 207 (8): 996–97. <https://doi.org/10.1164/rccm.202302-0278vp>.

⁸ B. Sanglard et al., "Life Cycle Assessment of a Parabolic Solar Cooker and Comparison with Conventional Cooking Appliances," *Sustainable Production and Consumption* 42 (November 2023): 211–33, <https://doi.org/10.1016/j.spc.2023.09.018>.

⁹ "Circular No. A-4" (Washington, D.C.: Office of Management and Budget, November 9, 2023), <https://www.whitehouse.gov/wp-content/uploads/2023/11/CircularA-4.pdf>.

Status quo

Under the status quo, we assume that, at the end of their current stoves' lives, households do not make transition to induction stoves. Rather, when household stoves reach the end of their lives, the households replace the stoves with the same stove type they had before.

Alternatives

Gas to induction

This alternative envisions a scenario wherein households with gas stoves (both natural gas and propane) transition to induction stoves at the end of their current stoves' lives. Meanwhile, households with electric stoves do not. We assume eligible households use the Inflation Reduction Act's Home Electrification and Appliance Rebates Program to purchase an induction stove (see the [Induction stove purchase and installation](#) section).

Electric to induction

In this scenario, households with conventional electric stoves transition to induction stoves at the end of their current stoves' lives. This alternative leaves natural gas and propane ranges unaffected.

Comprehensive transition to induction

Under this alternative, both households with gas stoves and households with conventional electric stoves transition to induction stoves at the end of their current stoves' lives. We assume eligible households with gas stoves use the Inflation Reduction Act's Home Electrification and Appliance Rebates Program to purchase an induction stove (see the [Induction stove purchase and installation](#) section).

Upfront Costs

To calculate the upfront costs for each policy alternative, we estimated the additional costs of purchasing and installing an induction stove, relative to replacing the existing gas or electric stove, at the end of the existing stove's life. We also estimated the cost of purchasing and installing a 240 Volt circuit and replacing cookware for each type of transition. Table 1 presents our estimated per-household upfront costs for each transition type. All values are in 2023 dollars.

Table 1: Annual Household Upfront Costs by Transition Type

Cost Category	Gas to Induction	Electric to Induction
Purchase and Installation Costs	\$76.46	\$781.35
240 Volt Circuit Purchase and Installation Costs	\$572.00	\$0
Cookware Replacement Costs	\$288.84	\$288.84
Total Upfront Costs	\$937.30	\$1,070.19

Induction stove purchase and installation

To transition to induction, each household must purchase and install an induction stove. In our analysis, we estimate that a household with an electric stove will spend an average of \$781.35 more to purchase and install an induction stove than they would have spent on an electric stove. However, we estimate that households with natural gas and propane stoves will spend an average of \$76.46 more than they would have spent on a gas stoves.

Purchase and installation costs differ between households with gas and electric stoves. This is because some households with gas stoves qualify for the Inflation Reduction Act's Home Electrification and Appliance Rebate Program. This rebate can cover some or all purchase and installation costs, depending on the household's median income. However, households can only use the rebate to replace a gas stove.¹⁰ Therefore, on average, a household with an electric stove will pay the full cost of purchasing and installing an electric stove, while a household with a gas stove will pay a reduced cost.

¹⁰ United States Department of Energy, "Inflation Reduction Act Home Energy Rebates: Home Efficiency Rebates Program and Home Electrification and Appliances Rebates Program" (Washington, D.C.: Office of State and Community Energy Programs, October 13, 2023), https://www.energy.gov/sites/default/files/2023-10/home-energy-rebate-programs-requirements-and-application-instructions_10-13-2023.pdf.

To calculate the additional cost of purchasing and installing an induction stove for households with electric stoves, we subtracted the cost of an electric stove from the cost of an induction stove. To calculate the cost of purchasing and installing an induction stove for households with gas stoves, we performed multiple calculations. First, we adjusted the cost of an induction stove by multiplying the cost of an induction stove with the proportion of the stove the rebate did not cover. Then we multiplied the adjusted cost by the proportion of households that were eligible for the rebate. Because there were three eligibility categories — ineligible for a rebate, eligible for a 50 percent rebate, and eligible for a complete rebate — we repeated this formula for all three categories and summed the results. This gave us the induction stove purchase and installation cost for a household with a gas stove. Finally, we subtracted the cost of purchasing and installing a gas stove from the cost of purchasing and installing an induction stove. See [Appendix A](#) for the methodology for monetizing induction stove purchase and installation costs.

240 Volt circuit purchase and installation

Before transitioning to an induction stove, households with natural gas or propane stoves will likely need to buy and install a new 240 Volt, 40- or 50-Amp circuit.¹¹ In our analysis, we estimate each household with a gas stove will spend an average of \$572 to purchase and install a 240 Volt circuit. We include the full cost of the 240 Volt circuit in our upfront costs because if a household with a gas stove did not transition to an induction stove it would not need a 240 Volt circuit.

We calculated this average from a range of values provided by Slipstream, which estimated the cost for purchasing and installing a 240 Volt circuit to be from \$150 to \$1,000. We provide estimates from other sources in [Appendix B](#) for reference.

Households with gas stoves may bear additional rewiring costs, depending on a residence's existing electrical load capacity. We do not monetize these costs in our analysis due to a lack of available research about Michigan households' electrical load capacity.

Replacement cookware purchase

Because induction stoves produce heat by generating a magnetic field, they are only compatible with cookware made from magnetic material, including cast iron, stainless steel, and carbon steel.¹² To transition to an induction stove, households may need to purchase cookware made of these materials.

We estimate that each household will spend an average of \$288.84 to purchase compatible cookware. We calculated this value by multiplying the common quantity of cookware in a set by the portion of cookware that is made from induction-incompatible cookware. Next, we multiplied the product by the average price per induction-stove-compatible pan. We include the full cost of the cookware in our upfront costs because if a household with a gas stove did not transition to an induction stove it would not need to replace its cookware. See [Appendix C](#) for the methodology for monetizing replacement cookware purchase costs.

¹¹ Rewiring America, "Cook Faster, Better, and Safer without Gas," Rewiring America, accessed November 21, 2023, <https://homes.rewiringamerica.org/projects/cooking-homeowner>.

¹² NMR Group, Inc. and Three, "Residential Gas-to-Induction Stovetop Conversion NEIs Study," January 12, 2023.

Annual Benefits

To calculate the benefits for each policy alternative, we estimated the annual household benefits of the changes in indoor air pollution, stove-related safety risks, maintenance and cleaning requirements, and greenhouse gas and life cycle impacts for each type of transition. Table 2 presents the estimated values of these annual benefits per household for each transition type. We estimated each benefit using the mean values from a Monte Carlo simulation. All values are in 2023 dollars.

Table 2: Annual Household Benefits by Transition Type

Benefit Category	Gas to Induction	Electric to Induction
NO ₂ Health Impacts	\$1,796.721	\$0
CO Health Impacts	\$83.80	\$0
PM _{2.5} Health Impacts	\$8,030.97	\$0
Safety Impacts	\$ -34.54	\$4.22
Maintenance and Cleaning Impacts	\$145.46	\$ -282.00
Energy Consumption Cooking Impacts	\$ -41.70	\$6.61
Greenhouse Gas and Life Cycle Impacts (2022)	\$ -20.00	\$5.00
Total Benefits	\$9,960.71	\$ -266.17

For better illustration, saved cost from health impacts measured from three air pollutants are illustrated below in Table 3. DALYs are disability-adjusted life years: the sum of the years of life lost (YLLs) and years lived with a disability (YLDs) due to a health condition.

Table 3: Annual Health Household Benefits (by Air Pollutant) Breakdown

Health Impact Measurement	Mean Value
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NO ₂ Asthma DALYs	\$ 180.24
NO ₂ Asthma Medical Treatment	\$ 44.29
NO ₂ Asthma Productivity Benefits	\$ 2.85
NO ₂ COPD DALYs	\$ 1,368.44
NO ₂ COPD Medical Treatment	\$ 189.24
NO ₂ COPD Productivity Benefits	\$ 11.65
CO Poisoning DALYs	\$ 83.79
CO Poisoning Medical Treatment	\$ 0.01
CO Poisoning Productivity Benefits	\$ 0.00
PM _{2.5} Cardiovascular & Respiratory Diseases DALYs	\$ 7,901.31
PM _{2.5} Cardiovascular & Respiratory Diseases Medical Treatment	\$ 122.82
PM _{2.5} Cardiovascular & Respiratory Diseases Productivity Benefits	\$ 6.83

We also estimated alternate values benefits for health and life cycle costs for our sensitivity analyses. We estimated the general health benefits for gas-to-induction transitions; the greenhouse gas and life cycle impacts based on Michigan’s projected 2040 electricity mix; and the greenhouse gas and life cycle impacts based on Michigan’s projected 2040 electricity mix if coal is excluded. Table 4 presents our estimated values of these benefits for each transition type. We estimated each benefit using the mean values from a Monte Carlo simulation. All values are in 2023 dollars.

Table 4: Alternate Estimates of Annual Household Benefits by Transition Type

Benefit Category	Gas to Induction	Electric to Induction
General Health Impacts	\$530.06	\$0
Greenhouse Gas and Life Cycle Impacts (2040)	\$ -8.00	\$3.00
Greenhouse Gas and Life Cycle Impacts (2040, No Coal)	\$ -4.00	\$3.00

For better illustration, saved cost from health impacts measured from general diseases associated with gas stove use are illustrated below in Table 5.

Table 5: Annual Health Household Benefits (by Disease) Breakdown

Health Impact Measurement	Mean Value
Asthma Medical Treatment	\$ 309.36
Asthma Productivity Benefits	\$ 21.36
LRT Medical Treatment	\$ 8.84
LRT Productivity Benefits	\$ 6.55
COPD Medical Treatment	\$ 165.14
COPD Productivity Benefits	\$ 6.55
Child ASD Medical Treatment	\$ 11.96
Child ASD Productivity Benefits	\$ 0.30

We use the Value of a Statistical Life (VSL) and Value of a Life Year (VLY) at various points when calculating our benefits. We use the Environmental Protection Agency’s VSL, which is \$7.4 million in 2006 dollars, or \$10,792,889.04 in 2023 dollars.¹³ We derived VLY from the VSL using the following formula from Boardman and colleagues, where 0.035 is the social discount rate and t is the remaining life expectancy:¹⁴

$$VLY = \frac{VSL}{[1 - (1 + 0.035)^t] / 0.035}$$

Unless specified otherwise, t is 38.2, the median life years remaining of an average person.¹⁵ This provides a VLY of \$516,552.20 in 2023 dollars. However, when estimating the health impacts of COPD, we also calculate VLY for an adult, assuming 19.1 years remaining. The VLY of an adult is \$784,317.03 in 2023 dollars.

¹³ United States Environmental Protection Agency, “Mortality Risk Valuation,” United States Environmental Protection Agency, accessed November 21, 2023, <https://www.epa.gov/environmental-economics/mortality-risk-valuation>.

¹⁴ Boardman, Anthony E., David H. Greenberg, Aidan R. Vining, and David L. Weimer. Cost-Benefit Analysis: Concepts and Practice. 5th ed. Cambridge, UK: Cambridge University Press, 2018.

¹⁵ Centers for Disease Control and Prevention. “Life Expectancy.” Centers for Disease Control and Prevention. Accessed November 21, 2023. <https://www.cdc.gov/nchs/fastats/life-expectancy.htm>.

At various points when calculating general and air-pollutant-specific health impacts, we had to calculate a risk ratio from an odds ratio. A risk ratio is the probability of an event given the occurrence of a second event, divided by the probability of an event without the occurrence of a second event. Risk is the ratio of the probabilities of events in the exposed group to the probabilities of cases in the non-exposed group.

An odds ratio is the odds of an event, given the occurrence of a second event, divided by the odds of an event without the occurrence of a second event. Odds is the ratio of events to non-events, or the number of events divided by the number of non-events.¹⁶

When monetizing some of our health impacts, we needed to know the increased probability of a health condition (risk ratio), but we only found an odds ratio. To convert odds ratio to risk ratio, we used the following formula, where RR is the risk ratio for a health condition given a change in air pollutants, OR is the odds ratio of a health condition given a change in air pollutants, and p is the prevalence, or risk, of a health condition in the general population, which not exposed to a change in air pollutants:¹⁷

$$RR = \frac{OR}{(1 - p + (p \times OR))}$$

The derivation of the formula is illustrated here:

$$\begin{aligned}
 RR &= \frac{P_1}{P_0} \\
 \frac{OR}{1 - p + (p \times OR)} &= \frac{\frac{\frac{P_1}{1 - P_1}}{\frac{P_0}{1 - P_0}}}{1 - P_0 + P_0 \times \frac{\frac{P_1}{1 - P_1}}{\frac{P_0}{1 - P_0}}} = \frac{\frac{P_1 \times (1 - P_0)}{P_0 \times (1 - P_1)}}{1 - P_0 + \frac{P_1 \times (1 - P_0)}{1 - P_1}} \\
 &= \frac{\frac{P_1 \times (1 - P_0)}{P_0 \times (1 - P_1)}}{\frac{P_0(1 - P_0)(1 - P_1)}{P_0 \times (1 - P_1)} + \frac{P_0 P_1 (1 - P_0)}{P_0 (1 - P_1)}} = \frac{P_1 \times (1 - P_0)}{(1 - P_0)(P_0 - P_0 P_1 + P_0 P_1)} = \frac{P_1}{P_0} = RR
 \end{aligned}$$

Where P_1 is the incidence in an exposed population and P_0 is the incidence in a non-exposed population. For our purposes, P_1 would be the incidence of a health condition in the population exposed to a change in an indoor air pollutant; meanwhile, P_0 would be the incidence of the same health condition in the general population — that is, in the population that is not exposed to a change in an indoor air pollutant.

¹⁶ Audrey Schnell, “The Difference Between Relative Risk and Odds Ratios,” The Analysis Factor, n.d., <https://www.theanalysisfactor.com/the-difference-between-relative-risk-and-odds-ratios/>.

¹⁷ Jun Zhang and Kai F. Yu, “What’s the Relative Risk? A Method of Correcting the Odds Ratio in Cohort Studies of Common Outcomes,” JAMA 280, no. 19 (November 18, 1998): 1690–91, <https://doi.org/10.1001/jama.280.19.1690>.

General health impacts

Four factors are included in the measurement of general health impacts: asthma, Lower Respiratory Tract (LRT) issues, Chronic Obstructive Pulmonary Disease (COPD), and Autism Spectrum Disorder (ASD). In the analysis, the marginal risk of a certain disease given exposure to a gas stove is presented. The values exist for COPD and ASD in literature, which are captured by $P(\text{decrease of COPD})$ and $P(\text{decrease of ASD})$. For asthma, $P(\text{decrease of asthma})$ is calculated as $P(MI\ asthma) \times (RR(\text{asthma}|gas) - 1)$, which is the attributable risk associated with the exposure to a gas stove. The same formula holds for LRT.

The marginal risks are then multiplied by the associated costs of diseases, which include: (1) medical treatment costs, (2) opportunity cost of missing school days, and (3) missing work days are included. Hence, for each of the four health impacts, a similar formula is adopted.

Asthma is a chronic respiratory condition characterized by inflammation and narrowing of the airways, leading to symptoms such as wheezing, shortness of breath, chest tightness, and coughing. Gas stoves release combustion byproducts, including nitrogen dioxide (NO₂), which can trigger or exacerbate asthma symptoms. Induction stoves, by virtue of not producing combustion byproducts, have the potential of reducing NO₂ emissions. Hence, switching from gas to induction stoves may reduce the exposure to respiratory irritants, thereby benefiting individuals with asthma. The estimated saved annual cost from transitioning from gas stoves to induction stoves is \$330.72 per household, and the formula used for estimation is:

$$\begin{aligned} \text{saved cost from asthma} &= P(MI\ asthma) \times (RR(\text{asthma}|gas) - 1) \\ &\times (P(\text{child}|asthma) \times \text{persons per MI household} \times P(\text{children}) \\ &\quad \times (\text{medical cost per person}(\text{asthma}) \\ &\quad + \text{daily wage}(\text{school}) \times \text{school days lost}(\text{asthma})) \\ &\quad + P(\text{adult}|asthma) \times \text{persons per MI household} \times P(\text{adult}) \\ &\quad \times (\text{medical cost per person}(\text{asthma}) \\ &\quad + \text{daily wage}(\text{work}) \times \text{work days lost}(\text{asthma}))) \end{aligned}$$

Lower Respiratory Tract (LRT) issues encompass various conditions affecting the lungs and airways, including bronchitis and pneumonia. Gas stove emissions, such as NO₂ and particulate matter, can irritate the respiratory system, potentially exacerbating lower respiratory tract issues. Induction stoves do not produce combustion byproducts, offering a potential reduction in indoor air pollutants associated with gas combustion. The estimated saved annual cost from transitioning from gas stoves to induction stoves is \$15.39 per household, and the formula used for estimation is:

$$\begin{aligned} \text{saved cost from LRT} &= P(MI\ LRT) \times (RR(LRT|gas) - 1) \\ &\times (P(\text{child}|LRT) \times \text{persons per MI household} \times P(\text{children}) \times (\text{medical cost per person}(LRT) \\ &\quad + \text{daily wage}(\text{school}) \times \text{school days lost}(LRT)) \\ &\quad + P(\text{adult}|LRT) \times \text{persons per MI household} \times P(\text{adult}) \\ &\quad \times (\text{medical cost per person}(LRT) + \text{daily wage}(\text{work}) \times \text{work days lost}(LRT))) \end{aligned}$$

Chronic Obstructive Pulmonary Disease (COPD) is a progressive lung disease characterized by airflow limitation, making breathing difficult. It can be caused by various air pollutants, including PM, NO₂, VOCs, etc. Switching to induction stoves may reduce the risk of exacerbations and improve indoor air quality for

individuals with COPD. The estimated annual cost saved from transitioning from gas stoves to induction stoves is \$171.69 per household, and the formula used for estimation is:

$$\begin{aligned}
 & \textit{saved cost from COPD} \\
 & = P(\textit{decrease of COPD}) \times P(\textit{COPD}) \times \textit{persons per MI household} \\
 & \times (\textit{medical cost per person(COPD)} + \textit{hospitalization cost(COPD)}) \\
 & + P(\textit{SRB}) \times \textit{school days lost(ASD)} \times \textit{Daily wage(school)}
 \end{aligned}$$

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by challenges in social interaction, communication, and repetitive behaviors. If women cook during pregnancy, the air pollutants released in the air during the cooking process may cause ASD in their children. ASD can be caused by cooking oil burning with higher cooking temperatures. Depending on the relative cooking habits of using gas and induction stoves, the value saved could be positive or negative. The estimated saved annual cost from transitioning from gas stoves to induction stoves is \$12.26 per household, and the formula used for estimation is:

$$\begin{aligned}
 & \textit{saved cost from ASD} \\
 & = P(\textit{decrease of ASD}) \times P(\textit{ASD|child}) \times \textit{persons per MI household} \\
 & \times P(\textit{children}) \times (\textit{medical cost per person(ASD)}) \\
 & + P(\textit{SRB}) \times \textit{school days lost(ASD)} \times \textit{Daily wage(school)}
 \end{aligned}$$

The values of all the four symptoms sum up to \$530.06 per household per year. See [Appendix D](#) for more details about the methodology for monetizing general health impacts.

Air pollutant health impacts

We monetized health impacts for three air pollutants: nitrogen dioxide (NO₂), carbon monoxide (CO), and PM_{2.5}. We chose these air pollutants for our analysis after consultation with Kevin Gries from Slipstream and Dr. Tracey Holloway from the University of Wisconsin–Madison.

For all air pollutants, we used Disability-Adjusted Life Years (DALYs) per household as an estimate of health impacts. DALYs are the number of years lost to a health condition. DALYs include years lost due to death, or Years of Life Lost (YLLs), and years lost due to the reduced quality of life, or Years Lived with a Disability (YLDs). Therefore, DALYs are the sum of YLLs and YLDs. To calculate the household value of saved DALYs for each health condition, we multiplied the attributable number of DALYs by the Value of a Life Year (VLY).

For NO₂ ([Appendix E](#)) and PM_{2.5} ([Appendix G](#)), we calculate the DALYs saved from a particular health condition per household by multiplying the household YLLs for MI of a particular health condition by its mortality population-attributable fraction (PAF) and repeated the calculation for YLDs and the morbidity PAF. The mortality PAF is the proportion of saved health condition-related deaths that are due to the reduction in air pollutant concentrations. Likewise, morbidity PAF is the proportion of prevented cases of a health

condition that are due to the reduction in the air pollutants. PAF is calculated using the following formula, where $P(gas_MI)$ is the proportion of gas stoves in Michigan and $AdjustedRR$ is the adjusted risk ratio:¹⁸

$$PAF = \frac{P(gas\ stoves_{MI})(AdjustedRR - 1)}{P(gas\ stoves_{MI})(AdjustedRR - 1) + 1}$$

An adjusted risk ratio is the risk ratio of a health condition, given the change in air pollutant concentrations that occurs during a gas-to-induction transition. It is called an adjusted risk ratio because it is derived from a risk ratio we found in the literature for a certain change in air pollutant concentrations. To calculate the adjusted risk ratio, we multiply the study’s risk ratio by the proportion of the change in the air pollutant concentrations we found to the change in concentrations a study found. This gives us a risk ratio for the change in pollutants we estimate, not the change in pollutants the study estimated.

An adjusted risk ratio is calculated using the following formula, where $Change\ in\ concentration_{gastoinduction}$ is the change in air pollutant concentrations expected when transitioning from gas to induction, $Change\ in\ concentration_{research}$ is the change in air pollutant concentration for which the risk ratio was calculated in the study, and RR is the risk ratio calculated in the study for the change in air pollutant concentrations:

$$AdjustedRR = 1 + \left[\frac{Change\ in\ concentration_{gastoinduction}}{Change\ in\ concentration_{research}} \times (RR - 1) \right]$$

When calculating the adjusted risk ratio, we assume linearity. That is, we assume that the risk of a health condition increases proportional to the increase in the air pollutant concentration. For example, if a study declares that a 10-unit increase is associated with a 1.2 risk ratio, or 20 percent increased risk, we assume that a 5-unit increase is associated with a 1.1 risk ratio, or 10 percent increased risk.

NO₂

Natural gas and propane stoves generate heat through combustion, which produces several air pollutants, including nitrogen dioxide (NO₂). As such, households with gas stoves have higher NO₂ concentrations than households with electric or induction stoves.¹⁹

Because NO₂ is linked to respiratory health impacts, households with natural gas and propane stoves also tend to have higher risks of certain health conditions, including asthma and chronic obstructive pulmonary disorder (COPD).²⁰ NO₂ concentrations would decrease after a household replaces its gas stove with an induction stove; as a result, these health risks would decrease as well.

¹⁸ Sanglard et al., “Life Cycle Assessment of a Parabolic Solar Cooker and Comparison with Conventional Cooking Appliances.”

¹⁹ Brady Anne Seals and Andee Krasner, “Health Effects From Gas Stove Pollution” (Mothers Out Front, Physicians for Social Responsibility, Rocky Mountain Institute, Sierra Club, 2020), <https://rmi.org/insight/gas-stoves-pollution-health>.

²⁰ National Center for Environmental Assessment-RTP Division. 2016. “Table 5-39: Summary of evidence for a causal relationship between short-term nitrogen dioxide exposure and respiratory effects.” *Integrated Science Assessment for Oxides of Nitrogen–Health Criteria*, 5-253. U.S. Environmental Protection Agency. <https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=310879>.

In our analysis, we estimate the decreased risk of asthma and COPD caused by transitioning from a natural gas or propane stove to an induction stove is associated with a benefit of \$1,796.72 per household per year.

To reach this estimate, we performed several calculations. First, we calculated the benefits from reducing the morbidity — or prevalence — of asthma by reducing gas stove NO₂ concentrations. To calculate these annual asthma-related benefits, we summed the annual values of saved Years Lived with a Disability (YLDs), the saved medical costs, and the saved productivity costs per household per year that resulted from reducing asthma morbidity. We use YLDs instead of DALYs here because we had insufficient data to estimate YLLs.

Second, we calculated the benefits from reducing the prevalence and death (morbidity and mortality) of COPD by reducing gas stove NO₂ concentrations. To calculate these annual COPD-related benefits, we summed the annual values of saved Disability-Adjusted Life Years (DALYs), saved medical costs, and saved productivity costs that resulted from reducing COPD morbidity and mortality.

For each disease, we calculated the saved medical and productivity costs by multiplying the average costs per household by the morbidity population-attributable fraction (PAF) of the disease. To calculate household medical costs, we multiplied the prevalence of the disease, the number of people per household, and the per-person medical cost. To calculate household productivity costs, we multiplied the prevalence of the disease, the number of people per household, the average number of days lost of those affected, and the daily wage of those affected.

See [Appendix E](#) for the methodology for monetizing NO₂-related health impacts.

CO

Gas stove combustion also produces carbon monoxide (CO). CO concentrations in households with gas stoves do not tend to be high enough to cause significant respiratory health impacts, nor do they tend to be significantly higher than CO concentrations in households with induction or electric stoves (see [Appendix E](#)).

However, replacing a household's natural gas or propane stove with an induction stove would reduce the household's risk of CO poisoning because it would eliminate a source of carbon monoxide. Therefore, in our analysis, we monetize the benefits from reducing the risk of carbon monoxide poisoning when transitioning from a gas stove to an induction stove.

We estimate that the reduced risk of CO poisoning for a gas-to-induction transition is associated with a benefit of \$83.80 per household per year. To reach this estimate, we added the saved number of CO-poisoning-related DALYs, medical costs, and productivity costs per household per year.

Unlike the calculations for NO₂ and CO, we do not multiply a morbidity and mortality PAFs by household YLDs and YLLs to get the number of households DALYs saved. Instead, we multiply the number of households DALYs by the proportion of CO poisoning incidents — deaths and cases — that are associated with gas stoves in Michigan. This proportion is essentially a PAF, but it is not labeled as a PAF in our [appendix](#) or our Stata code. Instead, it is labeled as *Proportion CO poisoning(stove)*.

We calculated saved CO poisoning medical costs by multiplying non-fatal household CO poisoning cases, the portion of non-fatal cases that resulted in hospitalization, and the average hospitalization cost of CO poisoning cases. Similarly, we calculated saved CO poisoning productivity costs by multiplying non-fatal household CO poisoning cases, the portion of non-fatal cases that resulted in hospitalization, the average days stayed per CO-poisoning hospitalization, and the daily wage.

See [Appendix F](#) for the methodology for monetizing CO-related health impacts.

PM_{2.5}

While complete combustion of natural gas yields minimal particulate matter, its incomplete combustion is a source of concern, producing particles smaller than 2.5 micrometers (PM_{2.5}) and even ultrafine aerosols measuring less than 10 nanometers. This is particularly pertinent given that a shift from gas to electric cooktops has been shown to reduce indoor air PM_{2.5} concentrations by 0 to 70 percent, as indicated in Table G.1 of the referenced studies in [Appendix G](#).

The health impacts of these pollutants are multifaceted and have been monetized in three primary aspects: medical costs, loss in productivity, and the loss of the value of life. Exposure to PM_{2.5} is notably linked to respiratory and cardiovascular diseases. To quantify this impact, the relative risk ratios and the prevalence of gas cooking are employed to calculate the population attributable fraction (PAF). This metric estimates the fraction of the total Disability Adjusted Life Years (DALYs) from respiratory diseases (RD) and cardiovascular diseases (CVD) in Michigan that can be attributed to increased PM_{2.5} concentrations resulting from gas stove usage.

Furthermore, the PAF is used to determine the number of hospitalizations attributable to gas stove use. These hospitalizations are monetized based on the cost per visit and the average length of stay. Additionally, the time lost due to hospital visits is calculated to assess the loss in wages, serving as a monetary indicator of lost productivity.

In conclusion, by monetizing all the aspects discussed above in addition to the DALYs using the statistical value of life, it was found that the total health benefits from transitioning from gas to electric cooktops amount to approximately \$8030 per household per year.

Safety

Because induction stoves produce heat by generating a magnetic field, transitioning from an electric stove to an induction stove reduces the likelihood of soft tissue and burn injuries.²¹ However, induction stoves are a type of electric stove; electric stoves, in turn, are associated with 68 percent of stove-related injuries, 78 percent of stove fire-related deaths, and 81 percent of stove fires.²² Additionally, research does not suggest that induction stoves reduce the risk of fire comparable to electric stoves; on the contrary, one study suggests that induction stoves have poor fire safety features and do not reduce the risk of fire.²³ Therefore, we assume that, like electric stoves, induction stoves are more likely to be associated with injuries and home cooking fires than gas stoves.

In our analysis, we estimate transitioning from an electric stove to an induction stove is associated with an annual safety benefit of \$4.22 per household, but transitioning from a natural gas or propane stove to an induction stove is associated with an annual negative benefit of \$ -34.54 per household. To calculate the estimate for an electric-to-induction transition, we took the difference of the value of annual household injuries between

²¹ NMR Group, Inc. and Three, “Residential Gas-to-Induction Stovetop Conversion NEIs Study.”

²² National Electronic Injury Surveillance System, “National Estimate of Injuries Treated in Emergency Departments by PROD, Treatment Dates: 2016, 2017, 2018, 2019, 2020,” 201-2020, <https://www.cpsc.gov/Research--Statistics/NEISS-Injury-Data>; Shelby Hall and Tucker McGree, “Home Cooking Fires: Supporting Tables” (National Fire Protection Association, September 2023).

²³ Arthur K. K. Wong and N. K. Fong, “Experimental Study of Induction Cooker Fire Hazard,” *Procedia Engineering* 52 (2013): 13–22, <https://doi.org/10.1016/j.proeng.2013.02.098>.

electric and induction stoves. To calculate the estimate for a gas-to-induction transition, we took the difference in the value of annual household injuries, deaths, and property damage between gas and induction stoves. There were no differences in household deaths or property damage between electric and induction stoves, so we did not include those differences in our electric-to-induction scenarios.

To calculate the difference in the value of annual household stove-related injuries, we had to calculate the value of stove-related injuries for gas, electric, and induction stoves. We used the following formula, where $P(\text{injury}|\text{stove})$ is the probability of injury given the presence of a type of stove, $P(\text{hosp})$ is the probability of hospitalization, $\text{Shadow price}(\text{hosp})$ is the shadow price of hospitalized injuries, $P(\text{no hosp})$ is the probability of no hospitalization, and $\text{Shadow price}(\text{no hosp})$ is the shadow price of non-hospitalized injuries:

$$\begin{aligned} \text{Injuries}(\text{stove}) = & [P(\text{injury}|\text{stove}) \times P(\text{hosp}) \times \text{Shadow price}(\text{hosp})] \\ & + [P(\text{injury}|\text{stove}) \times P(\text{no hosp}) \times \text{Shadow price}(\text{no hosp})] \end{aligned}$$

To calculate the difference in the value of annual household stove fire-related deaths, we calculated the value of stove fire-related deaths for gas and electric stoves. We did not calculate the value of stove fire-related deaths for induction stoves because we assumed it was the same value as for electric stoves, given no evidence to the contrary. We used the following formula, where $P(\text{death}|\text{stove})$ is the probability of death given the presence of a type of stove and VSL is the Value of a Statistical Life:

$$\text{Deaths}(\text{stove}) = P(\text{death}|\text{stove}) \times VSL$$

To calculate the difference in the value of annual household stove fire-related property damage, we calculated the value of stove fire-related property damage for gas and electric stoves. We did not calculate the value of stove fire-related property damage for induction stoves because we assumed it was the same value as for electric stoves, given no evidence to the contrary. We used the following formula, where $P(\text{fire}|\text{stove})$ is the probability of fire given the presence of a type of stove, $\text{Total Property Damage}(\text{stove})$ is the total annual property damage associated with the type of stove, and $\text{Fires}(\text{stove})$ is the annual number of fires associated with the type of stove.

$$\text{Property damage}(\text{stove}) = P(\text{fire}|\text{stove}) \times \frac{\text{Total Property Damage}(\text{stove})}{\text{Fires}(\text{stove})}$$

$P(\text{injury}|\text{stove})$, $P(\text{death}|\text{stove})$, and $P(\text{fire}|\text{stove})$ were calculated using Bayes' Theorem. Bayes' Theorem is as follows, where $P(A|B)$ is the probability of event A given event B, $P(B|A)$ is the probability of event B given event A, $P(A)$ is the probability of event A, and $P(B)$ is the probability of event B:

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

The probability of A given B means the probability of A happening if B has already taken place. For example, $P(\text{gas}|\text{fire})$ is the probability of a gas stove being associated with a stove-related fire after a stove-related fire has occurred.

See [Appendix H](#) for the methodology for monetizing safety impacts.

Maintenance and cleaning

The cost of maintenance and cleaning of each stove type varies depending on the materials and structural designs. Gas cooking ranges often require more time and effort for cleaning and maintenance compared to other types of stoves, primarily due to their structural complexity. The intricate design of gas ranges, which includes burners, grates, and additional components, provides more areas for dirt, grease, and food residue to accumulate. Cleaning these components individually, along with the presence of burner caps and igniters, adds to the overall complexity. Additionally, the presence of gas ports and the need to ensure the proper functioning of gas lines contribute to the meticulous nature of maintenance. This structural intricacy increases the time and attention required for thorough cleaning and maintenance, making gas cooking ranges more labor-intensive compared to simpler alternatives like electric resistance or induction cooktops.

Electric resistance coil stoves, while generally simpler than gas ranges, can also require additional time for cleaning due to the exposed coil design. The exposed nature of the heating coils on these stoves allows food particles, spills, and grease to accumulate directly on the coil surface. Cleaning the coils requires careful attention, as residue can easily get lodged in the spaces between the coils. Additionally, the need to wait for the coils to cool down before cleaning adds to the overall cleaning time.

The maintenance factor was monetized based on the time to clean the stoves, minimum hourly wage in Michigan as people's opportunity cost of their times, the annual cost for purchasing cleaning supplies, the cost of replacement parts and labors, and the lifespan of each stove type. The cool down time is also an important advantage for induction range, yet people tend not to simply wait until the stove cools down without doing anything else in the meantime. Thus, the opportunity cost of people's time during this cooling period may not accurately reflect the true monetary value. We decided not to include this category and treat this as a non-monetizable factor, since people's preferences during this time varies individually. We then calculate the present value of each stove's maintenance factor using the following equations and calculate the annualized net benefit for maintenance:

Gas stove:

Maintenance cost over product lifespan:

$$\sum_{t=1}^{15} \frac{(Time\ to\ clean * hourly\ wage) * annual\ cooking\ days + Cleaning\ product}{(1 + discount\ rate)^{t-0.5}} + \frac{Preplacement\ parts + Plabor * repair\ time}{(1 + discount\ rate)^5} + \frac{Replacement\ parts + Labor * repair\ time}{(1 + discount\ rate)^{10}}$$

$$Annuity(gas) = Gas\ stove\ maintenance\ cost\ over\ product\ lifespan / Annuity\ Factor$$

Induction stove:

Maintenance cost over product lifespan:

$$\sum_{t=1}^{10} \frac{(Time\ to\ clean * hourly\ wage) * annual\ cooking\ days + Cleaning\ product}{(1 + discount\ rate)^{t-0.5}} + \frac{Replacement\ parts + Labor * repair\ time}{(1 + discount\ rate)^{t-0.5}}$$

$$Annuity(induction) = Induction\ stove\ maintenance\ cost\ over\ product\ lifespan / Annuity\ Factor$$

Electric resistance stove:

Maintenance cost over product lifespan:

$$\sum_{t=1}^{14} \frac{(Time\ to\ clean * hourly\ wage) * annual\ cooking\ days + Cleaning\ product}{(1 + discount\ rate)^{t-0.5}} + \frac{Replacement\ parts + Labor * repair\ time}{(1 + discount\ rate)^{t-0.5}}$$

$$Annuity(electric) = Electric\ resistance\ stove\ maintenance\ cost\ over\ product\ lifespan / Annuity\ Factor$$

In our analysis, we estimated that converting gas range to induction range results in a positive maintenance and cleaning difference of \$145.56 per household per year, while converting electric resistance range to induction range results in a negative maintenance and cleaning difference of \$-282 per household per year. See [Appendix I](#) for more on the methodology for monetizing the change in maintenance and cleaning costs.

Annual energy consumption by cooking range type

To monetize the energy efficiency of each cooking range, we estimated the annual energy bill. We calculated the annual energy bill using the analysis report from Frontier Energy in 2019 to get the total units of energy used for each stove type, and the per unit energy rate of natural gas and electricity in Michigan. In our analysis, the transition from gas stove to induction stove resulted in a negative net benefit value of \$-41.70 per household per year, while the transition from electric resistance stove to induction stove resulted in a positive value of \$6.61 per household per year. See [Appendix J](#) for the methodology for monetizing the change in the costs for energy efficiency in cooking performance.

Greenhouse gas and other life cycle impacts

We investigated the life cycle environmental impacts of induction, electric resistance, and gas cooktops across three distinct scenarios reflecting Michigan's electricity mix for the years 2022, 2040, and an alternate 2040 with no coal usage. The scenario names correspond to the projected energy compositions for Michigan in the specified years. Additionally, the emissions associated with gas distribution and combustion were held constant for each scenario. However, given the assumption that most of the production takes place outside the United States, the construction impacts (excluding carbon emissions) were not factored into the state or national environmental assessments. Our analysis utilized the specifications for the cooktops as outlined in the 2023 study by Sanglard et al. and employed the ReCiPe methodology to evaluate the environmental impacts across 13 different categories.²⁴ These impacts were subsequently monetized using the shadow prices listed in the Environmental Price Handbook.²⁵

²⁴ B. Sanglard et al., "Life Cycle Assessment of a Parabolic Solar Cooker and Comparison with Conventional Cooking Appliances," *Sustainable Production and Consumption* 42 (November 2023): 211–33, <https://doi.org/10.1016/j.spc.2023.09.018>.

²⁵ de Bruyn, Sander, Marijn Bijleveld, Lonneke de Graaff, Ellen Schep, Arno Schrotten, Robert Vergeer, and Saliha Ahdour. "Environmental Prices Handbook." CE Delft: Delft, The Netherlands (2018), https://cedelft.eu/wp-content/uploads/sites/2/2021/04/CE_Delft_7N54_Environmental_Prices_Handbook_EU28_version_Def_VS2020.pdf

The results of this analysis indicated a notable finding: transitioning from a gas to an induction cooktop at the end of the gas cooktop's life in 2023 would result in a negative environmental benefit, calculated to be approximately \$20 per year for each household. This outcome underscores the importance of the life cycle perspective in assessing the sustainability of household appliances. See [Appendix K](#) for the methodology for monetizing the change in energy uses and greenhouse gas emissions.

Non-monetizable costs and benefits

Our analysis, while comprehensive in many respects, does not include several potential costs and benefits of a transition to induction stoves. Among these, the cultural and traditional significance of gas stoves stands out. For many, cooking methods involving open flames are a part of familial and culinary heritage. Associations as such, which result from emotional value of the cooking style or simply an ease of use, result in a substantial influence on the preference for gas stoves. Quantifying this aspect is challenging due to its intrinsic subjective nature.

Furthermore, the actual experience of cooking on gas stoves is a key factor. The ability to instantly adjust the flame and visually assess heat levels through the flame size provides a level of feedback and interaction that may be indispensable for many. This direct, tactile engagement with the cooking process, which gas stoves facilitate, is somewhat lost in induction cooktops. In addition, the reliability of gas stoves, especially in power outages, offers a significant practical benefit. This is especially relevant in areas prone to frequent electricity disruptions. The assurance of a consistent cooking method, combined with the ease and familiarity associated with gas stoves, plays a crucial role in the decision-making process.

Primary Analysis

In our primary analysis, we used a Monte Carlo analysis to determine the Present Value of Net Benefits (PVNB) of our different policy alternatives. We used the health impacts from individual air pollutants and the greenhouse gas and life cycle impacts from Michigan’s 2022 electricity mix. We also used a 2 percent discount rate.

The PVNB for each alternative is listed in Table 6. See [Appendix L](#) for the formula we used to calculate the PVNB of each policy alternative.

Table 6: PVNB of Primary Analysis Policy Alternatives

Transition Type	Mean	Minimum	Maximum	Standard Deviation
Gas to Induction	\$196.20 billion	\$15.11 billion	\$457.65 billion	\$97.18 billion
Electric to Induction	\$ -7.65 billion	\$ -28.64 billion	\$23.93 billion	\$3.58 billion
Comprehensive Transition to Induction	\$188.54 billion	\$1.67 billion	\$454.70 billion	\$97.44 billion

The gas-to-induction alternative resulted in an expected mean of \$196.20 billion net benefit with a range between \$15.11 billion and \$457.65 billion, which suggests that converting existing gas stoves to induction stove would generate social surplus to the Michigan state. The standard deviation of \$97.18 billion suggests high uncertainty, but the overall trend indicates that converting gas stoves to induction stove is a viable policy approach. Figure 1 presents the distribution for this alternative.

The electric-to-induction alternative resulted in an expected mean of \$ -7.65 billion net cost with a range between \$ -28.64 billion and \$23.93 billion. While the uncertainty is low under this alternative with a standard deviation of \$3.58 billion, the negative mean suggests that converting electric resistance stoves to induction stoves would very likely result in a net social cost for Michigan state, considering all factors mentioned above. Figure 2 presents the distribution for this alternative.

Comprehensive transition to induction stove showed an expected mean of \$188.54 billion with a range between \$1.67 billion and \$454.70 billion and a standard deviation of \$41.44 billion. The mean suggests that this transition would generate a net benefit, with a high degree of uncertainty. Figure 3 presents the distribution for this alternative.

Figure 1: Gas to Induction Primary Analysis Histogram

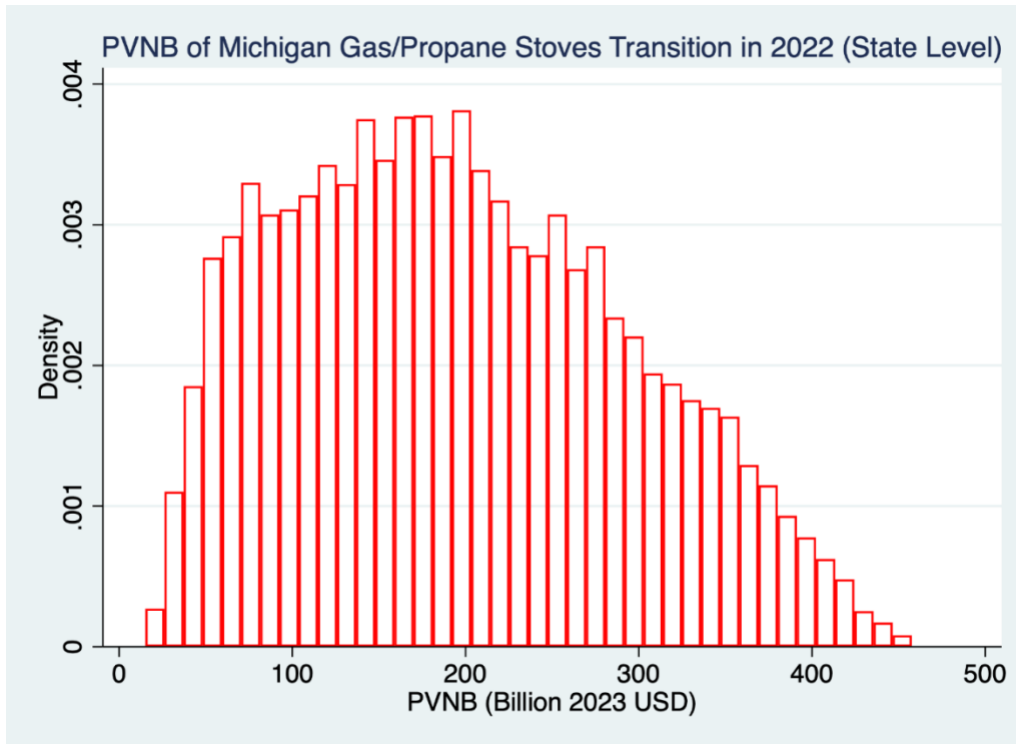


Figure 2: Electric to Induction Primary Analysis Histogram

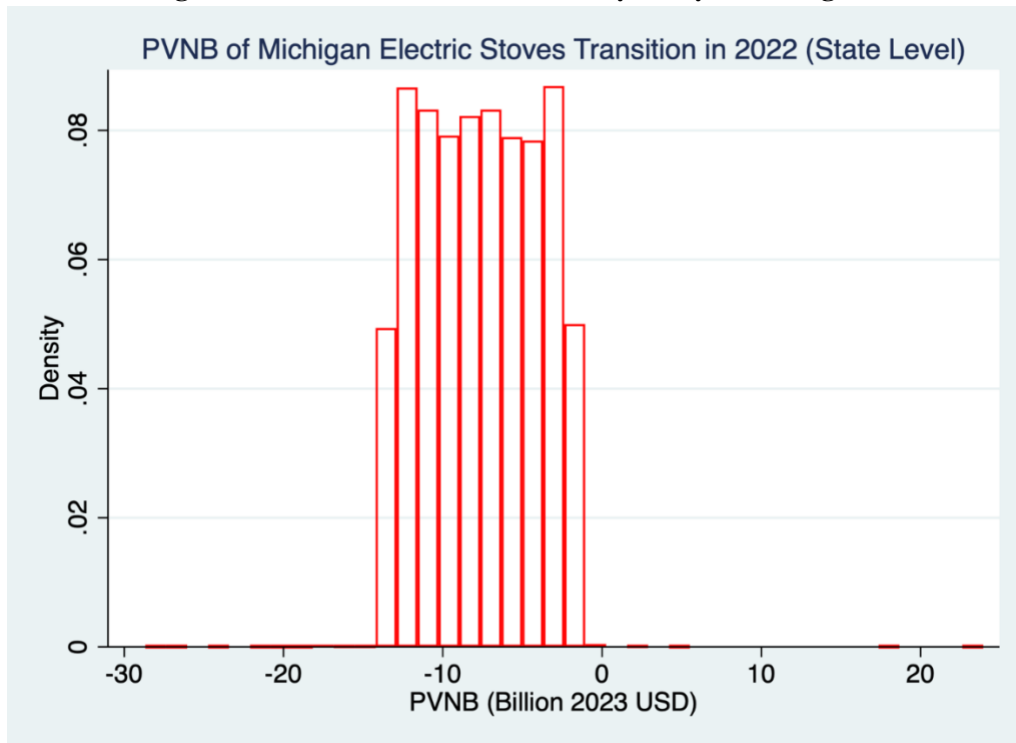
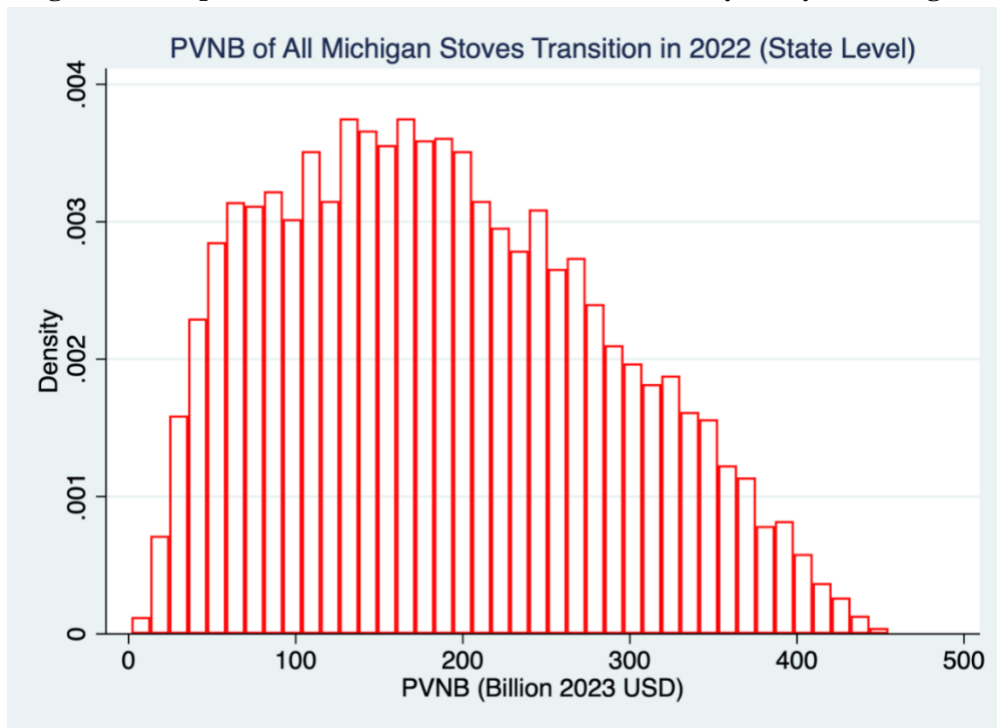


Figure 3: Comprehensive Transition to Induction Primary Analysis Histogram



Sensitivity Analyses

For our sensitivity analyses, we used Monte Carlo simulations to estimate the value of our policy alternatives after varying the values of our health impacts, greenhouse gas and life cycle impacts, and discount rate.

Air pollutant vs. general health impacts

In our first sensitivity analysis, we compared our estimated health impacts from individual air pollutants with our estimated health impacts from gas stoves in general. Because our air pollutant and general health impacts both only apply to gas-to-induction transitions, we only look at the gas-to-induction alternative. We used a 2 percent discount rate and estimated our greenhouse gas and life cycle impacts using Michigan's 2022 electricity mix.

The PVNB for each alternative is in Table 7, listed by health impact measure. See [Appendix M](#) for the formula we used to calculate the PVNB of the gas-to-induction alternative using general health impacts.

Table 7: PVNB of General Health Sensitivity Analysis Policy Alternatives

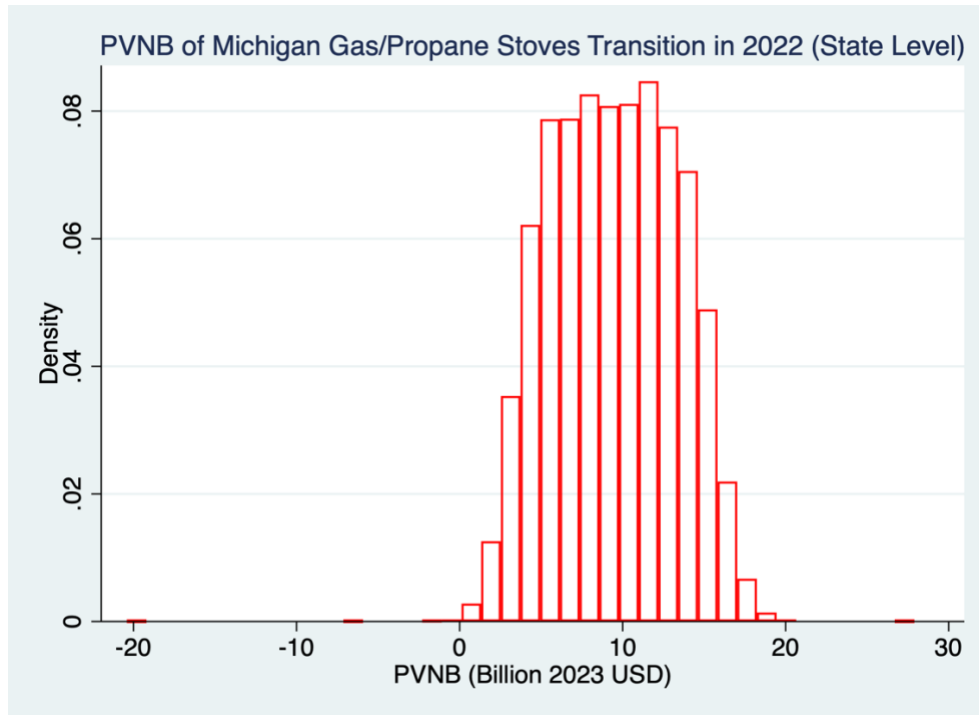
Health Impact Category	Mean	Minimum	Maximum	Standard Deviation
Gas to Induction				
Air Pollutant Health Impacts	\$196.20 billion	\$15.11 billion	\$457.65 billion	\$97.18 billion
General Health Impacts	\$9.47 billion	\$ -20.42 billion	\$27.90 billion	\$3.82 billion

Analyzing the table above reveals a significant disparity in the Present Value of Net Benefits (PVNB) associated with transitioning from gas stoves to induction stoves, particularly when shifting the focus from health impacts measured by air pollutants to those evaluated based on general health symptoms and diseases associated with stove usage. This is because in the primary analysis, three main air pollutants (CO, NO₂ and PM_{2.5}) are selected and analyzed. In reality, there are other air pollutants that can potentially cause human health impacts.²⁶ However, the effects will be small compared with the main ones.

The mean value derived from assessing general health impacts sees a reduction from \$196.20 billion to \$9.47 billion, with estimated values ranging from a minimum of \$ -20.42 billion to a maximum of \$27.90 billion. In stark contrast, all possible values of PVNB from the air pollutants perspective are positive. Figure 4 shows the distribution of the PVNB for the general health gas-to-induction alternative.

²⁶ World Health Organization. 2021. "Types of Pollutants." <https://www.who.int/teams/environment-climate-change-and-health/air-quality-and-health/health-impacts/types-of-pollutants>

Figure 4: General Health Sensitivity Analysis Gas to Induction Histogram



From a methodological standpoint, both measurement approaches incorporate the effects of air pollutants and related health symptoms, albeit in distinct ways. In the air pollutant methodology, values are computed as the sum of the medical costs, productivity costs, Years of Life Lost due to Disability Adjusted Life Years (DALY) (which is composed of premature mortality (YLLs) and the Years Lived with a Disability (YLDs) resulting from NO₂, CO, and PM_{2.5} — three primary air pollutants emanating from gas stove usage. Conversely, the general health methodology calculates values by summing the medical and productivity costs associated with asthma, LRT issues, COPD, and ASD in children, stemming from the cumulative impact of all air pollutants linked to gas stoves and cooking oil burning. One notable reason accounting for the disparity between the two methods is the absence of DALY in the general health perspective. Given that we estimated the value of a life year to be \$516,552.2 based on data from the Environmental Protection Agency (EPA), its exclusion significantly influences the final value.

This general health impact measurement is commonly used in existing reports. However, a comparison of values between the methodologies highlights the substantial differences arising from assessing impacts based on air pollutants or health symptoms, as well as the inclusion or exclusion of DALY. This discrepancy underscores the importance for policymakers to adopt an appropriate method aligned with their specific objectives and data availability to attain the most insightful results.

2022 vs. 2040 vs. coal-free 2040 greenhouse gas and life cycle impacts

In our second sensitivity analysis, we compared the greenhouse gas and life cycle impacts from Michigan's 2022 electricity mix, projected 2040 electricity mix, and coal-free projected 2040 electricity mix, as shown in Table

K.127 Following a similar methodology as the primary analysis, we used the ReCiPe model within SimaPro to calculate the impacts across 13 categories, and monetized these impacts for each scenario using the environmental price handbook.²⁸ Results from the calculations are presented in Table 6 using a discount rate of 2 percent and air pollution health impacts.

The PVNB for each alternative is in Table 8, listed by greenhouse gas (GHG) and life cycle impact measure. See [Appendix N](#) for the formula we used to calculate the PVNB of the alternatives using 2040 greenhouse gas and life cycle impacts. See [Appendix O](#) for the formula we used to calculate the PVNB using no-coal 2040 greenhouse gas and life cycle impacts.

Table 8: PVNB of GHG and Life Cycle Impact Sensitivity Analysis Policy Alternatives

GHG and Life Cycle Category	Mean	Minimum	Maximum	Standard Deviation
Gas to Induction				
2022 Greenhouse Gas and Life Cycle Impacts	\$196.20 billion	\$15.11 billion	\$457.65 billion	\$97.18 billion
2040 Greenhouse Gas and Life Cycle Impacts	\$196.43 billion	\$15.35 billion	\$457.89 billion	\$97.18 billion
2040 Greenhouse Gas and Life Cycle Impacts (No Coal)	\$196.51 billion	\$15.43 billion	\$457.97 billion	\$97.18 billion
Electric to Induction				
2022 Greenhouse Gas and Life Cycle Impacts	\$ -7.65 billion	\$ -28.64 billion	\$23.93 billion	\$3.58 billion
2040 Greenhouse Gas and Life Cycle Impacts	\$ -7.69 billion	\$ -28.72 billion	\$23.90 billion	\$3.58 billion

²⁷ “U.S. Energy Information Administration - EIA - Independent Statistics and Analysis,” n.d., <https://www.eia.gov/outlooks/aeo/data/browser/#/?id=67-AEO2023>.

²⁸ de Bruyn, Sander, Marijn Bijleveld, Lonneke de Graaff, Ellen Schep, Arno Schrotten, Robert Vergeer, and Saliha Ahdour. "Environmental Prices Handbook." CE Delft: Delft, The Netherlands (2018), https://cedelft.eu/wp-content/uploads/sites/2/2021/04/CE_Delft_7N54_Environmental_Prices_Handbook_EU28_version_Def_VS2020.pdf

2040 Greenhouse Gas and Life Cycle Impacts (No Coal)	\$ -7.69 billion	\$ -28.72 billion	\$23.90 billion	\$3.58 billion
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Comprehensive Transition to Induction

2022 Greenhouse Gas and Life Cycle Impacts	\$188.54 billion	\$1.67 billion	\$454.70 billion	\$97.44 billion
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2040 Greenhouse Gas and Life Cycle Impacts	\$188.74 billion	\$1.87 billion	\$454.90 billion	\$97.44 billion
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2040 Greenhouse Gas and Life Cycle Impacts (No Coal)	\$188.82 billion	\$1.95 billion	\$454.98 billion	\$97.44 billion
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The PVNB across all scenarios for the gas-to-induction transition show positive benefits, of \$196.20 billion in 2022, \$196.43 billion in 2040, and \$196.51 billion in the 2040 scenario with no coal. Despite the drastic changes in energy mix over time, this consistency emphasizes the robustness of the benefits associated with transitioning from gas to induction stoves, primarily driven by health improvements from reduced indoor air pollution. The standard deviation remains constant at \$97.18 billion across these scenarios, indicating a wide range of possible outcomes, as shown in figures 1, 5, and 8.

Conversely, the electric-to-induction transition consistently shows negative benefits, with a mean PVNB ranging from \$ -7.65 billion in 2022 to \$ -7.69 billion in both 2040 and 2040 with no coal scenarios. This suggests that the efficiency gains and reduced greenhouse gas emissions are insufficient to offset the financial and environmental costs of this transition. The standard deviation for these scenarios is significantly lower at \$3.58 billion, reflecting a narrower confidence interval, as shown in Figures 2, 6, and 9.

The comprehensive transition, encompassing both gas and electric scenarios, leans toward positive benefits, influenced predominantly by the substantial gains from the gas to induction switch, as shown in Figures 3, 7, and 10. However, these benefits are slightly offset by the negative impacts of the electric-to-induction transition.

The underlying electricity mix in Michigan, undergoing significant changes between 2022 and 2040, particularly with the reduction in coal usage and increase in renewable sources like wind and solar, plays a critical role in these analyses. By 2040 (no coal), the reliance on coal drops to 0 percent, while wind and solar together comprise over 50 percent of the mix, significantly reducing the carbon intensity of the grid. This shift is crucial for understanding the environmental impacts of the induction cooktops, which are more reliant on the electricity grid compared to gas cooktops. The transition to a cleaner energy mix by 2040 enhances the environmental benefits of induction cooktops, as evidenced by the slightly higher PVNB in the 2040 scenarios compared to 2022.

In summary, the PVNB analysis suggests that, while transitioning from gas to induction cooktops is beneficial primarily from a health perspective, the switch from electric to induction is less advantageous due to financial and safety considerations. The evolving energy mix in Michigan, especially the shift toward renewables, also plays a role in shaping these outcomes.

Figure 5: 2040 Gas to Induction GHG and Life Cycle Sensitivity Analysis Histogram

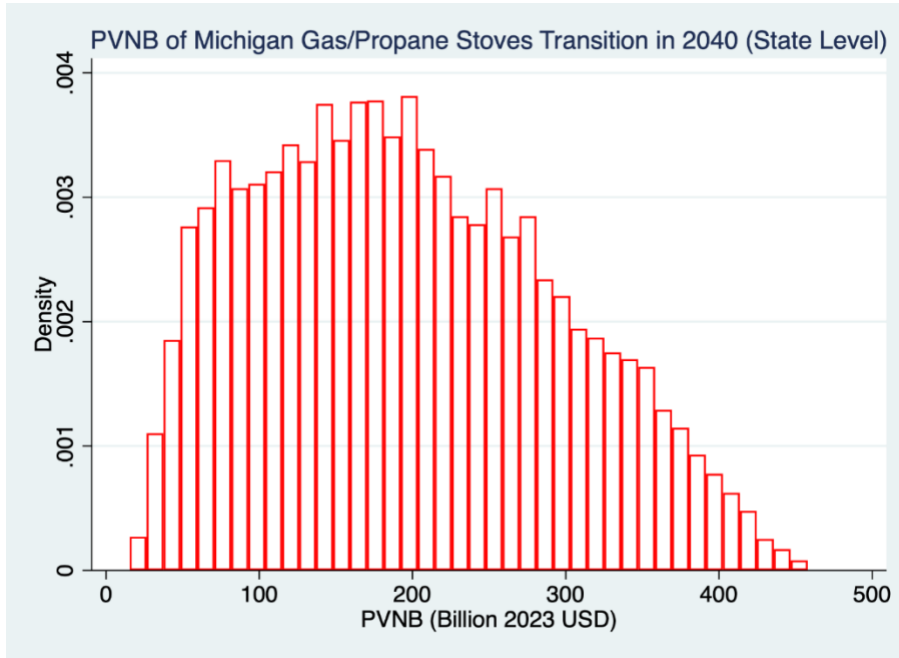


Figure 6: 2040 Electric to Induction GHG and Life Cycle Sensitivity Analysis Histogram

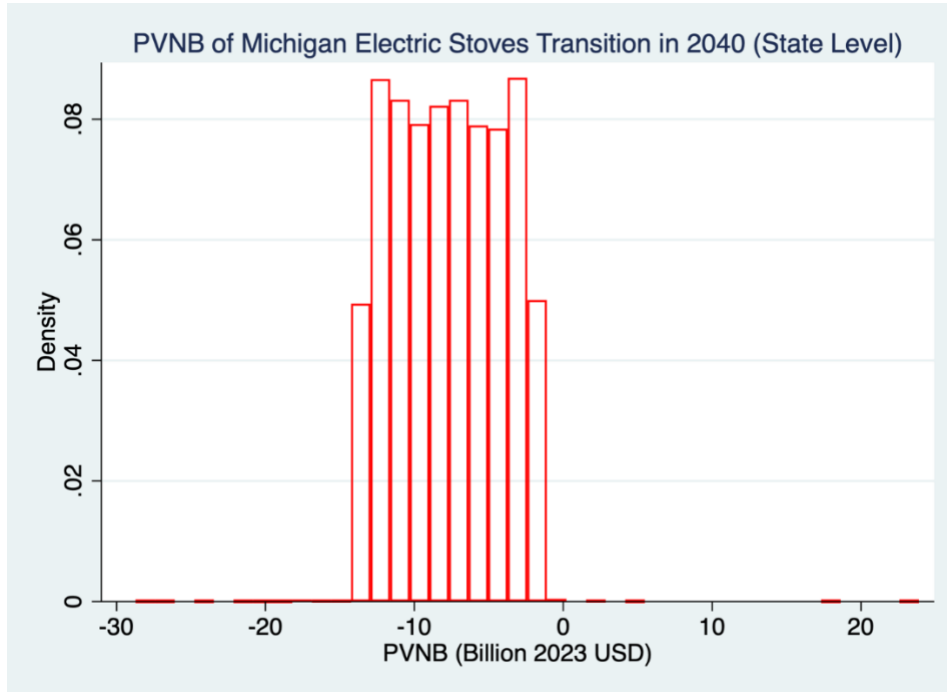


Figure 7: 2040 Comprehensive Transition GHG and Life Cycle Sensitivity Analysis Histogram

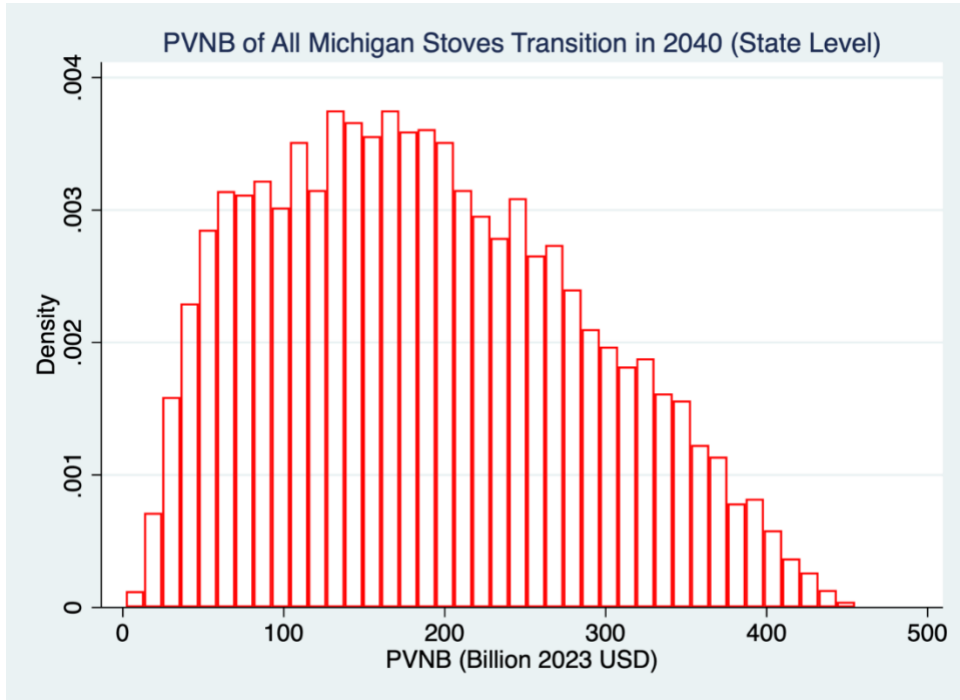


Figure 8: No Coal 2040 Gas to Induction GHG and Life Cycle Sensitivity Analysis Histogram

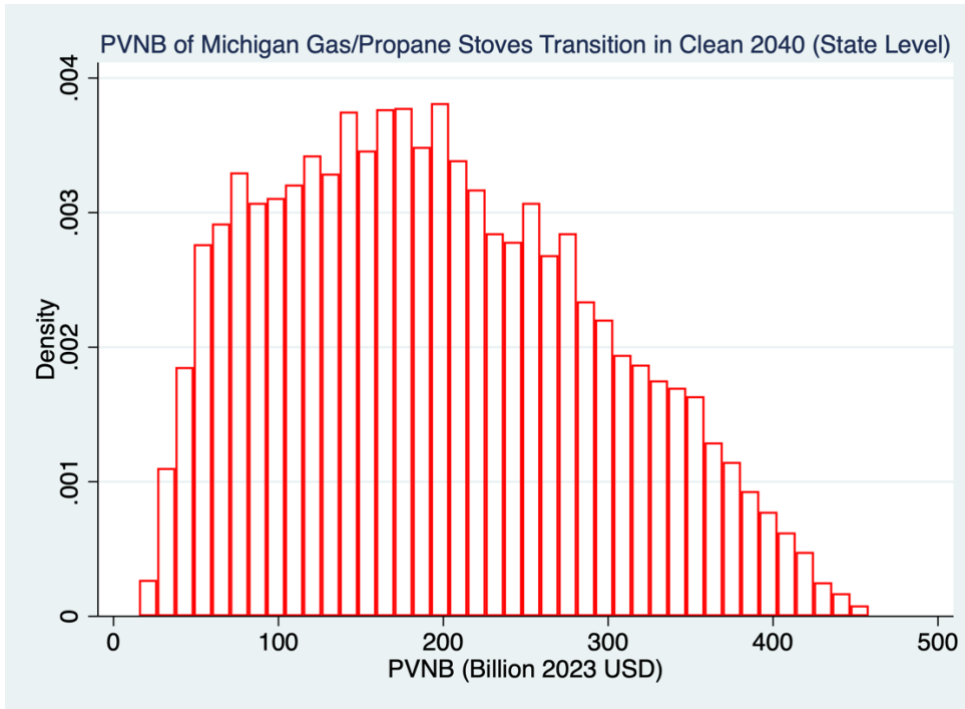


Figure 9: No Coal 2040 Electric to Induction GHG and Life Cycle Sensitivity Analysis Histogram

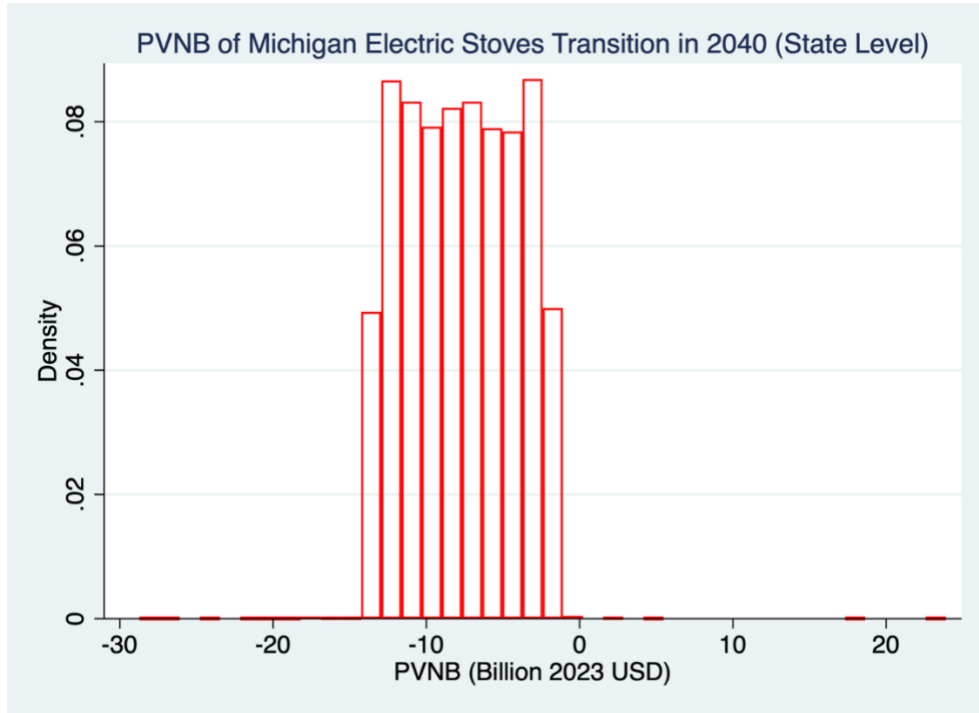
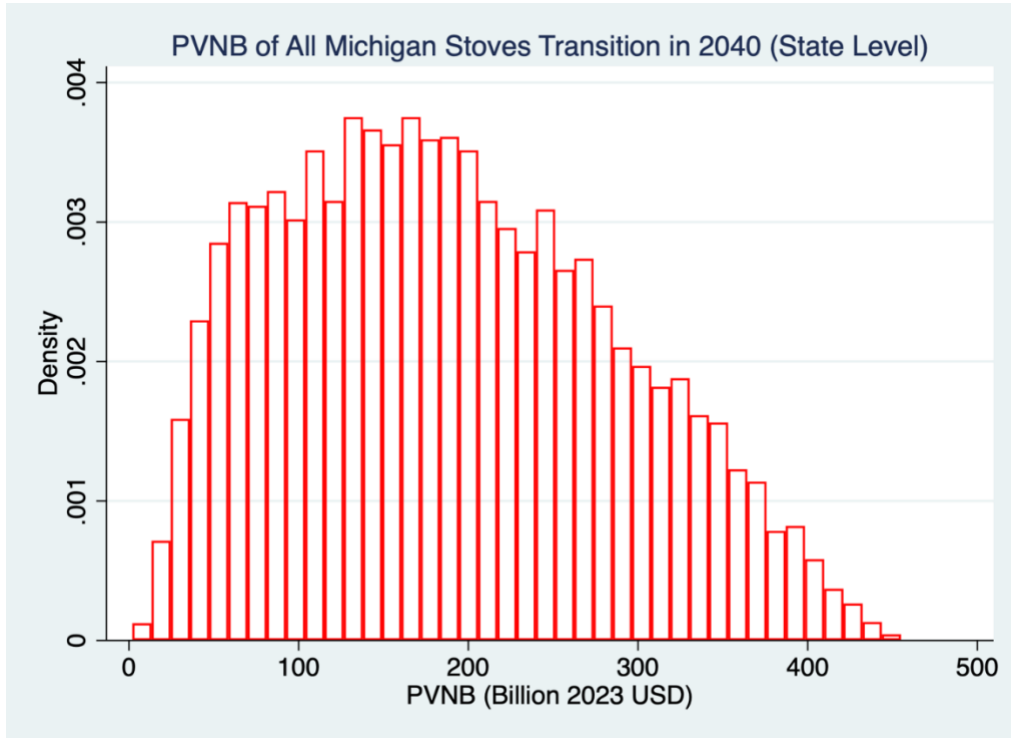


Figure 10: No Coal 2040 Comprehensive Transition GHG and Life Cycle Sensitivity Analysis Histogram



Discount rate variations

In our third sensitivity analysis, we compared our Present Value of Net Benefits (PVNB) after changing the discount rate from 2 percent to 3 and 7 percent. 2 percent is the real discount rate for a 10-year project in 2023 recommended by the White House.²⁹ 3 percent and 7 percent are the recommended lower bound and upper bound rates for public policy discounting.³⁰ The 2023 Circular No. A-4 document states that the 2003 Circular No. A-4 is officially replaced, which implies that 3 percent and 7 percent may be of less guidance in the future. We still provide the sensitivity analysis here since they were well within the range of historical real OMB discount rates, offering some variability. We used air pollutant health impacts and estimated our greenhouse gas and life cycle impacts using Michigan’s 2022 electricity mix.

The PVNB for each alternative is in Table 9, listed by discount rate. See [Appendix P](#) for the formula we used to calculate the PVNB of the alternatives using different discount rates.

Table 9: PVNB of Discount Rate Variation Sensitivity Analysis Policy Alternatives

Transition Type	Mean	Minimum	Maximum	Standard Deviation
Gas to Induction				
2%	\$196.20 billion	\$15.11 billion	\$457.65 billion	\$97.18 billion
3%	\$187.14 billion	\$14.29 billion	\$436.71 billion	\$92.74 billion
7%	\$156.75 billion	\$11.54 billion	\$366.42 billion	\$77.83 billion
Electric to Induction				
2%	\$ -7.65 billion	\$ -28.64 billion	\$23.93 billion	\$3.58 billion
3%	\$ -7.44 billion	\$ -27.51 billion	\$22.69 billion	\$3.44 billion
7%	\$ -6.71 billion	\$ -23.55 billion	\$18.53 billion	\$2.94 billion

²⁹ “Circular No. A-4.” Washington, D.C.: Office of Management and Budget, November 9, 2023.

<https://www.whitehouse.gov/wp-content/uploads/2023/11/CircularA-4.pdf>.

³⁰ “Discounting for Public Policy: Theory and Recent Evidence on the Merits of Updating the Discount Rate.” 2017. https://obamawhitehouse.archives.gov/sites/default/files/page/files/201701_cea_discounting_issue_brief.pdf

Comprehensive Transition to Induction

2%	\$188.54 billion	\$1.67 billion	\$454.70 billion	\$97.44 billion
3%	\$179.71 billion	\$1.30 billion	\$433.79 billion	\$92.99 billion
7%	\$150.05 billion	\$0.08 billion	\$363.57 billion	\$78.05 billion

Our primary analysis used a 2 percent discount rate. The mean, minimum, and maximum PVNBs we calculated using this 2 percent discount rate were lower than both the 3 and 7 percent discount rates for all transition types.

Compared to a 2 percent discount rate, the 3 percent discount rate provided a slightly less extreme mean, minimum, and maximum PVNB for our alternatives. As such, the standard deviation for the 3 percent discount rate PVNB distribution was slightly lower than those for the 2 percent discount rate across all alternatives. The histograms for each policy alternative, given a 3 percent discount rate, can be found below in Figures 11, 12, and 13.

Figure 11: Gas to Induction 3% Discount Rate Sensitivity Analysis Histogram

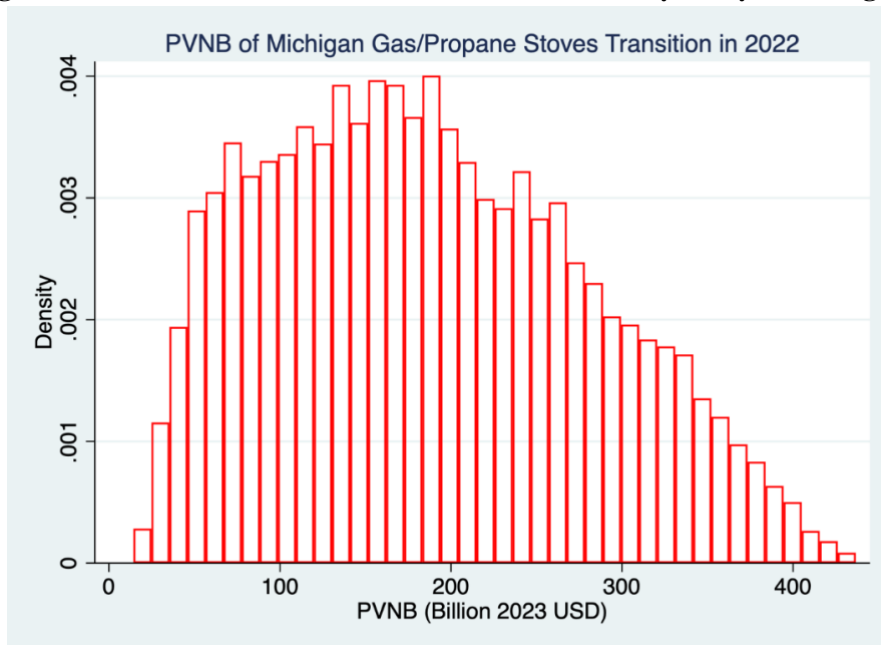


Figure 12: Electric to Induction 3% Discount Rate Sensitivity Analysis Histogram

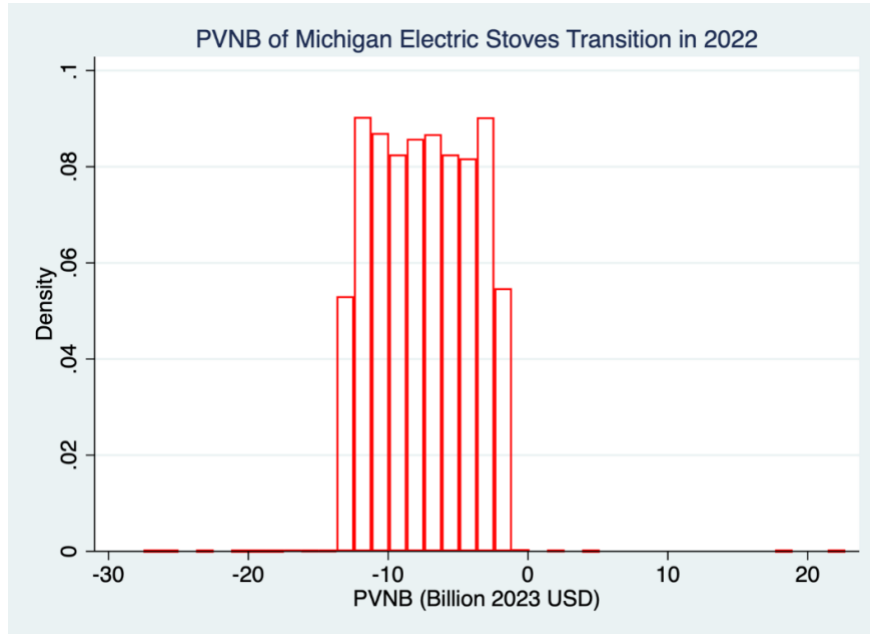
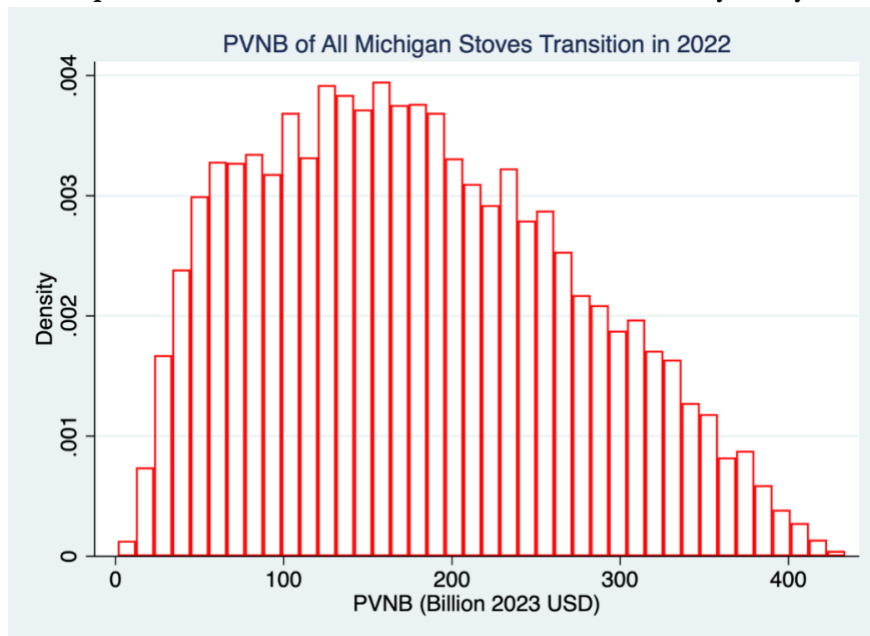


Figure 13: Comprehensive Transition 3% Discount Rate Sensitivity Analysis Histogram



Compared to the 2 percent discount rate, the 7 percent discount rate provided a much less extreme mean, minimum, and maximum PVNB across all alternatives. The standard deviation for the 3 percent discount rate PVNB distribution was also significantly lower than those for the 2 and 3 percent discount rates.

The histograms for each policy alternative, given a 7 percent discount rate, are below as Figures 14, 15, and 16.

Figure 14: Gas to Induction 7% Discount Rate Sensitivity Analysis Histogram

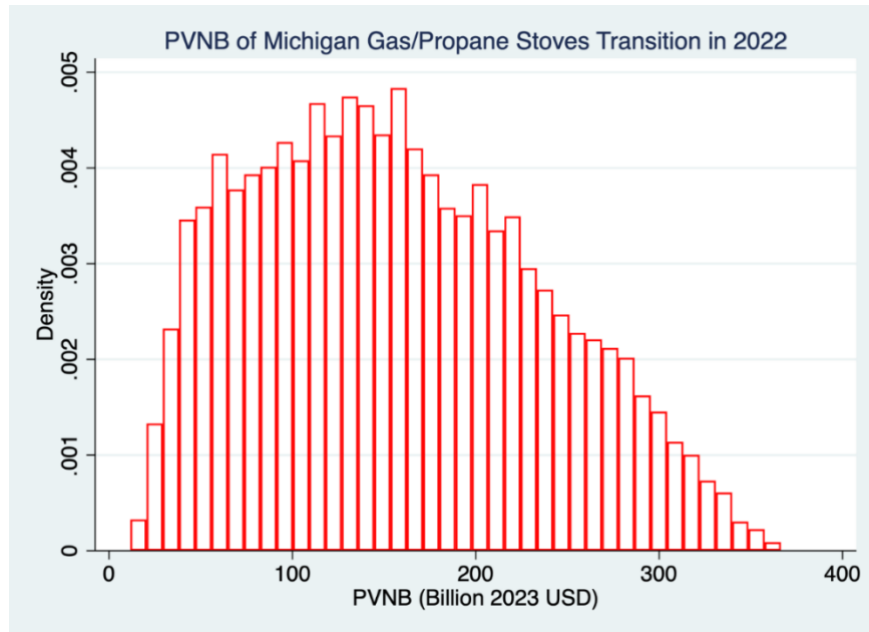


Figure 15: Electric to Induction 7% Discount Rate Sensitivity Analysis Histogram

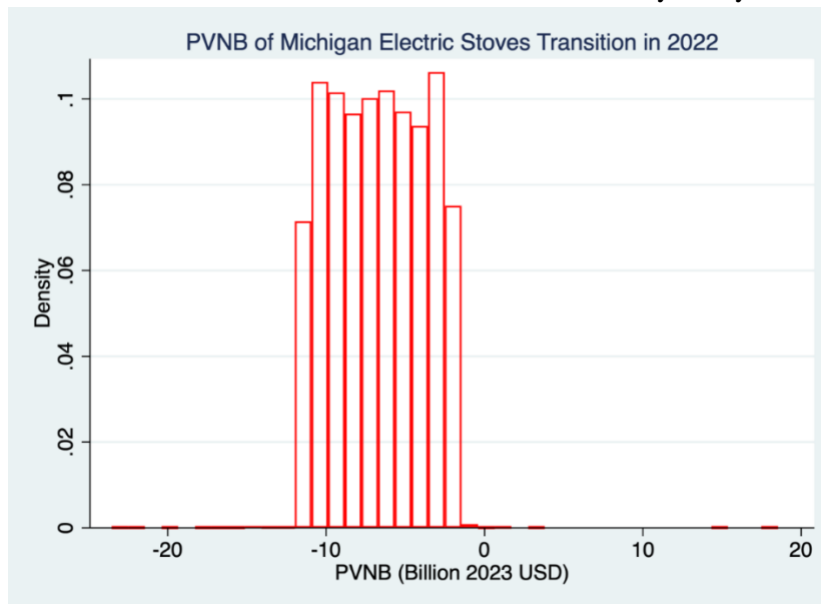
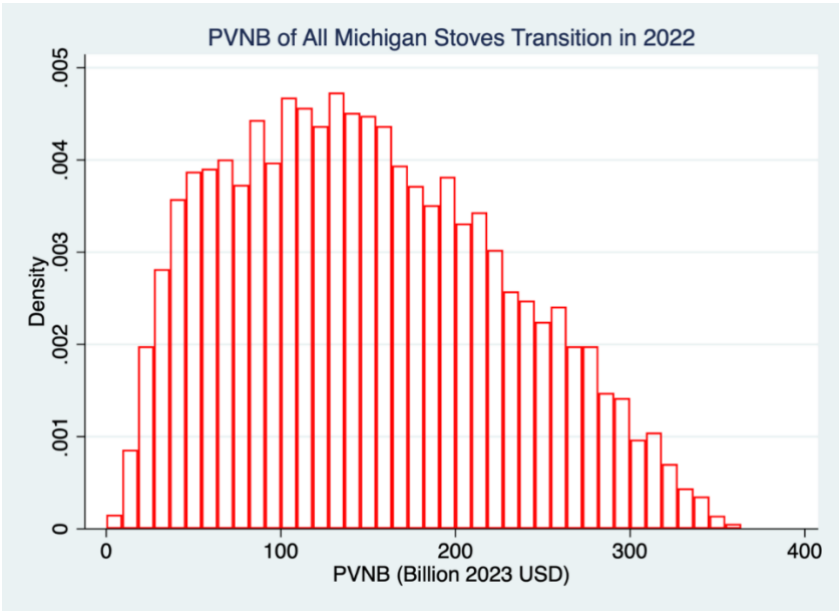


Figure 16: Comprehensive Transition to Induction 7% Discount Rate Sensitivity Analysis Histogram



This sensitivity analysis demonstrates that increasing the discount rate makes the mean, minimum, and maximum PVNB distribution less extreme, increasing positive values and decreasing negative values. This makes sense from a theoretical standpoint because increasing the discount rate effectively minimizes the costs and benefits accrued in the future. However, even after varying the discount rate, all our alternatives have the same sign for the mean, minimum, and maximum PVNB. Therefore, our choice of a discount rate did not have a significant impact on our results.

Limitations

Our analysis has several limitations.

First, there are no distinguishing features of natural gas stoves and propane stoves in the existing literature and reports that we have collected so far. As a result, we treat natural gas stoves and propane stoves as the same, assigning them the same properties and coefficients. Propane stoves are specifically designed for use with propane tanks and are often portable, suitable for outdoor use. Given that our analysis focuses on household indoor cooking, this assumption has its validity. In reality, however, the two stove types differ. Compared with natural gas stoves, propane has a higher energy content and can generate higher heat. In relation to our analysis, this means that propane stoves are more likely to result in cooking oil burning and related health symptoms, as well as induce higher energy use and energy bills.

Second, we analyzed the costs and benefits of transitioning stoves at the household level and the Michigan state level, but not at the national level. This is because we chose households in Michigan as our focus, as Slipstream is currently installing air quality monitors in Michigan households. When data becomes available, this report can be easily replicated with updated data. It is important to note that global benefits and costs will be affected if anything changes in Michigan. For example, the reduction in air pollutants can contribute to decreasing global greenhouse gas (GHG) emissions.

Third, we restricted our analysis in the life cycle impact part to the usage stage of the stoves instead of the entire life cycle. Hence, the production and recycling of stoves are not considered. Existing literature has considered that most induction stoves are produced in China.³¹ This indicates that if a significant number of households currently using gas or electric stoves choose to switch to induction stoves, the emissions from the production and transportation process will increase, leading to life cycle costs for China and other related countries as well as global impacts from differences in GHG emissions from the different manufacturing processes. However, the value from production, after discounting, will be small compared to the more straightforward estimations at the usage stage. This can be verified with our life cycle analysis in the [Table K.2](#). Therefore, excluding these values should not significantly affect our results.

Fourth, we did not take account of the grid upgrading cost that households with gas stoves may face when transitioning to induction stoves. This is because existing literature provides no estimation on the proportion of households that may need a grid upgrade or the cost of upgrading. Hence we assume the upfront costs cover just the stove purchase cost, installation cost, 240 Volt circuit purchase and installation costs, and cookware replacement costs.

Finally, we assume that all the stoves are at the end of their lives. Hence if stove transitioning happens, all households in Michigan will switch at the same time. Households will likely switch at the end of their current stove lifespan, and some proportion of households will continue using gas/electric stoves. However, no data is available to estimate the age of current stoves in Michigan households, and no better assumptions can be made about when and what proportion of households in Michigan will switch. Therefore, we use the current assumptions and provide an upper bound estimation of the net benefits estimation.

³¹ B. Sanglard et al., “Life Cycle Assessment of a Parabolic Solar Cooker and Comparison with Conventional Cooking Appliances,” *Sustainable Production and Consumption* 42 (November 2023): 211–33, <https://doi.org/10.1016/j.spc.2023.09.018>.

Conclusion and Final Recommendation

We recommend that our clients encourage households with gas stoves to transition to induction stoves, taking advantage of the Inflation Reduction Act's Home Electrification and Appliance Rebate Program. We make this recommendation because the gas-to-induction alternative has the most positive Present Value of Net Benefits (PVNB) across all policy alternatives in our analyses.

Additionally, our gas-to-induction alternative still had the highest comparable net benefits, even after we varied certain values of costs and benefits, including the discount rate and the makeup of Michigan's energy grid. Similarly, our gas-to-induction alternative still had a positive mean PVNB when we used a different methodology to monetize health impacts; however, the mean PVNB decreased significantly, and its distribution included negative PVNB values.

Our findings have several limitations and do not include some non-monetizable costs and benefits. These limitations, including our non-monetizable costs and benefits, qualify our recommendation. However, they are not significant enough to prevent us from recommending that our clients encourage households with gas stoves to transition to induction stoves.

Appendices

Appendix A: Induction stove purchase and installation monetization methodology

Return to [Induction stove purchase and installation](#) section.

We calculated the average additional induction stove purchase and installation cost for homes with gas and electric households, compared to purchasing and installing a replacement gas or electric stove, using the following formulas:

$$Induction\ Stove_{electric} = Stove\ Cost_{induction} - Stove\ Cost_{electric}$$

$$Induction\ Stove_{gas} = [P(80to150) \times (1 - Rebate_{80to150}) \times Stove\ Cost_{induction} + P(below80) \times (1 - Rebate_{below80}) \times Stove\ Cost_{induction} + P(above150) \times Stove\ Cost_{induction}] - Stove\ Cost_{gas}$$

Where:

- $Stove\ Cost_{induction}$ is the cost of purchasing and installing an induction stove,
- $Stove\ Cost_{electric}$ is the cost of purchasing and installing an electric stove,
- $P(80to150)$ is the proportion of Michigan households between 80 percent and 150 percent of the state median income,
- $Rebate_{80to150}$ is the proportion of the stove purchase and installation cost covered by the IRA rebate for households with 80 to 150 percent of the area's median income,
- $P(below80)$ is the proportion of Michigan households below 80 percent of the state median income,
- $Rebate_{below80}$ is the proportion of stove purchase and installation cost covered by the IRA Rebate for households below 80 percent of the area's median income, and
- $Stove\ Cost_{gas}$ is the cost of purchasing and installing a gas stove.

$P(above150)$ is calculated using the following formula:

$$P(above150) = 1 - [P(below80) + P(80to150)]$$

The variables for calculating $Induction\ Stove$ are presented in Table A.1.

Table A.1: Variables for Induction Stove Purchase and Installation Cost

Variable	Estimate	Lower Bound	Upper Bound	Description	Source	Distribution
P(80to150)	0.308			Proportion of Michigan households between 80% and 150% of the state	United States Census	

				median income	Bureau 2022 ³²	
P(below80)	0.374			Proportion of Michigan households below 80% of the state median income	United States Census Bureau 2022 ³³	
Rebate_80to150	0.50			Proportion of stove price covered by the IRA rebate for gas households with 80 to 150% of the area's median income	Committees on Energy & Commerce and Ways & Means n.d. ³⁴	
Rebate_below80	1.00			Proportion of stove price covered by the IRA Rebate for gas households below 80% of the area's median income	Committees on Energy & Commerce and Ways & Means n.d. ³⁵	
Stove Cost_Induction	\$1500	-	-	Cost of purchasing and installing an induction stove	Slipstream	-
Stove Cost_Electric	\$718.65	-	-	Cost of purchasing and installing an electric stove, based on the ratio of the average cost of an electric stove to the average cost of an induction stove	See Estimated Stove Cost (Table A.2)	-
Stove Cost_Gas	\$631.54	-	-	Cost of purchasing and installing a gas stove, based on the ratio of the average cost of a gas stove to the average cost of an induction stove	See Estimated Stove Cost (Table A.2)	-

³² United States Census Bureau, "Income in the Past 12 Months (in 2022 Inflation-Adjusted Dollars)" (ACS 1-Year Estimates Subject Tables, Table S1901: American Community Survey, 2022), [https://data.census.gov/table/ACSST1Y2022.S1901?q=median household income&g=040XX00US26](https://data.census.gov/table/ACSST1Y2022.S1901?q=median%20household%20income&g=040XX00US26).

³³ United States Census Bureau, "Income in the Past 12 Months (in 2022 Inflation-Adjusted Dollars)."

³⁴ Committees on Energy and Commerce and Ways and Means, "The Inflation Reduction Act: Information on Energy Rebates and Tax Credits Available to Constituents to Help Them Save Money" (House Committee on Ways & Means and House Committee on Energy & Commerce, n.d.), https://himes.house.gov/_cache/files/9/0/90c319bf-e2d5-4ccb-a5fc-009008ab7fa3/CA4ED41AF3577148294B021D364B62B4.inflation-reduction-act-ec.pdf.

³⁵ Committees on Energy and Commerce and Ways and Means, "The Inflation Reduction Act: Information on Energy Rebates and Tax Credits Available to Constituents to Help Them Save Money."

Induction stove_gas is calculated differently than *Induction stove_electric* because households with gas stoves are eligible for the Inflation Reduction Act's Home Electrification and Appliance Rebates Program when purchasing an electric stove, but households with electric stoves are not.³⁶ Because induction stoves are a type of electric stove, households can use this rebate to purchase induction stoves.

P(80to150) is the proportion of Michigan households with gas stoves that are eligible for a 50 percent rebate for purchasing and installing an electric stove. Households are eligible for the 50 percent rebate if their income falls between 80 and 150 percent of their local Area Median Income.³⁷ Because we were looking at all households across Michigan, we assumed that the proportion of households that fell between 80 and 150 percent of the state area median income would be similar to the proportion of households with gas stoves that fell between 80 and 150 percent of their local area median income. According to the Census Bureau, Michigan's median income in 2022 was \$66,986, 80 percent of which is \$53,588.80, and 150 percent of which is \$100,479. Therefore, we decided to take the proportion of households that fell within the \$50,000–\$74,999 and \$75,000–\$99,999 income brackets. These proportions were 17.6 percent and 13.2 percent, respectively, which sum to a total proportion of 30.8 percent.³⁸

P(below80) is the proportion of Michigan households with gas stoves eligible for a 100 percent rebate for purchasing and installing an electric stove. Households are eligible for the rebate if their income falls below 80 percent of their local Area Median Income.³⁹ Therefore, we decided to use the proportion of households that fell below the \$50,000–\$74,999 income brackets, which was 37.4 percent.⁴⁰

Slipstream provided us with *Stove Cost*, an estimate of how much it would cost to purchase and install an induction stove in Michigan. This estimate of \$1,500 is lower than the average cost of the top 10 bestselling induction stoves at Home Depot, Lowe's, and Best Buy (see Table A.2). However, because induction stoves are so new, we could not find any government or academic research that specified the average cost, or distribution of costs, of purchasing or installing an induction stove. Additionally, Slipstream's estimate has validity because it is based on the costs Slipstream bore when purchasing and installing induction stoves for the participants in their induction cooking monitoring project.

Gas Stove Cost and *Electric Stove Cost* are estimated by taking a proportion of the estimated induction stove cost. We found the proportions by dividing the average single-oven gas stove cost with the average single-oven induction stove cost, and by dividing the average single-oven electric stove cost with the average single-

³⁶ United States Department of Energy, "Inflation Reduction Act Home Energy Rebates: Home Efficiency Rebates Program and Home Electrification and Appliances Rebates Program" (Washington, D.C.: Office of State and Community Energy Programs, October 13, 2023), https://www.energy.gov/sites/default/files/2023-10/home-energy-rebate-programs-requirements-and-application-instructions_10-13-2023.pdf.

³⁷ Democratic staff of the Committees on Energy and Commerce and Ways and Means, "The Inflation Reduction Act: Information on Energy Rebates and Tax Credits Available to Constituents to Help Them Save Money" (House Committee on Ways & Means and House Committee on Energy & Commerce, n.d.), <https://himes.house.gov/cache/files/9/0/90c319bf-e2d5-4ccb-a5fc-009008ab7fa3/CA4ED41AF3577148294B021D364B62B4.inflation-reduction-act-ec.pdf>.

³⁸ United States Census Bureau, "Income in the Past 12 Months (in 2022 Inflation-Adjusted Dollars)," American Community Survey, ACS 1-Year Estimates Subject Tables, Table S1901, 2022, [https://data.census.gov/table/ACSST1Y2022.S1901?q=median household income&g=040XX00US26](https://data.census.gov/table/ACSST1Y2022.S1901?q=median%20household%20income&g=040XX00US26). Accessed on December 4, 2023.

³⁹ Democratic staff of the Committees on Energy and Commerce and Ways and Means, "The Inflation Reduction Act: Information on Energy Rebates and Tax Credits Available to Constituents to Help Them Save Money."

⁴⁰ United States Census Bureau, "Income in the Past 12 Months (in 2022 Inflation-Adjusted Dollars)."

oven induction stove cost. We found the average costs of each stove by taking the average of the costs of the top ten bestselling stoves across Home Depot, Lowe’s, and Best Buy. Table A.2 presents the range of costs for each stove type at each website, the average cost of each stove type across all websites, and each stove type as the proportion of the average cost of an induction stove.

Table A.2: Induction Stove Purchase Costs

Gas Stove Costs	Electric Stove Costs	Induction Stove Costs	Description	Source
\$498.00 - \$1,798.00	\$548.00 - \$2,398.00	\$898.00 - \$6,199.00	Range of the costs of top 10 stoves, sorted by top seller	Home Depot 2023 ⁴¹
\$479.00 - \$1,299.00	\$479.00 - \$1,099.00	\$899.00 - \$3,499.00	Range of the costs of top 10 stoves, sorted by best sellers	Lowe’s 2023 ⁴²
\$598.99 - \$2,749.99	\$849.99 - \$1,754.99	\$899.99 - \$5,399.99	Range of the costs of top 10 stoves, sorted by best selling	Best Buy 2023 ⁴³
\$1,084.90	\$953.40	\$2,264.46	Average cost of top 10 bestselling stoves, across all websites.	Home Depot 2023, Lowe’s 2023, Best Buy

⁴¹ The Home Depot, “Induction Ranges,” The Home Depot, accessed December 13, 2023, https://www.homedepot.com/b/Appliances-Ranges-Induction-Ranges/N-5yc1vZc9px?irgwc=1&im_rewards=1&cm_mmc=afl-ir-2003851-1420157-EdgeBingFlow&clickid=3iHWjE3LxyPR2h1Hw0gNUODUKFXQyvcES0uRI0; The Home Depot, “Single Oven Electric Ranges,” The Home Depot, accessed December 13, 2023, <https://www.homedepot.com/b/Appliances-Ranges-Electric-Ranges-Single-Oven-Electric-Ranges/N-5yc1vZc3q6>; The Home Depot, “Single Oven Gas Ranges,” The Home Depot, accessed December 13, 2023, https://www.homedepot.com/b/Appliances-Ranges-Gas-Ranges-Single-Oven-Gas-Ranges/N-5yc1vZc3ps?irgwc=1&im_rewards=1&cm_mmc=afl-ir-2003851-1420157-EdgeBingFlow&clickid=Xd2VP9ROKxyPR7kz1iThoxF7UkH01ER0ES0rxU0.

⁴² Lowe’s, “Induction Ranges,” Lowe’s, accessed December 13, 2023, <https://www.lowes.com/pl/Induction-ranges-Ranges-Appliances/4294580350>; Lowe’s, “Single Oven Electric Ranges,” Lowe’s, accessed December 13, 2023, https://www.lowes.com/pl/Single-oven-electric-ranges-Electric-ranges-Ranges-Appliances/1101947645?sortMethod=sortBy_bestSellers; Lowe’s, “Single Oven Gas Ranges,” Lowe’s, accessed December 13, 2023, https://www.lowes.com/pl/Single-oven-gas-ranges-Gas-ranges-Ranges-Appliances/1608347072?sortMethod=sortBy_bestSellers.

⁴³ Best Buy, “Electric Ranges,” Best Buy, accessed December 13, 2023, <https://www.bestbuy.com/site/ranges/electric-ranges/pcmcat196400050016.c?id=pcmcat196400050016>; Best Buy, “Gas Ranges,” Best Buy, accessed December 13, 2023, <https://www.bestbuy.com/site/ranges/gas-ranges/pcmcat196400050015.c?id=pcmcat196400050015>; Best Buy, “Induction Ranges,” Best Buy, accessed December 13, 2023, <https://www.bestbuy.com/site/ranges/induction-ranges/pcmcat1660745100989.c?id=pcmcat1660745100989>.

0.4791	0.4210	1	Proportion of induction (ratio of average cost of stove to average cost of induction stove)
\$718.65	\$631.54	\$1,500	Estimated stove cost (proportion of induction* <i>Induction Stove Price</i>)

We base the proportion on the average purchasing costs of the different induction stoves, not the average purchase and installation costs. This is because we could only find ranges of purchase and installation costs, not average purchase or installation costs. Therefore, we assume the proportions of gas and electric stove purchasing costs to induction stove purchasing costs is similar to the proportions of gas and electric stove purchasing and installation costs to induction stove purchasing and installation costs.

⁴⁴ Best Buy, “Electric Ranges”; Best Buy, “Gas Ranges”; Best Buy, “Induction Ranges”; Lowe’s, “Induction Ranges”; Lowe’s, “Single Oven Electric Ranges”; Lowe’s, “Single Oven Gas Ranges”; The Home Depot, “Induction Ranges”; The Home Depot, “Single Oven Electric Ranges”; The Home Depot, “Single Oven Gas Ranges.”

Appendix B: 240 Volt circuit purchase and installation monetization methodology

Return to [240 Volt circuit purchase and installation](#) section.

According to Rewiring America, households with a natural gas or propane stove will likely need a new 240 Volt, 40- or 50-Amp circuit.⁴⁵ A 2022 study conducted by Slipstream uses anecdotal data to estimate that a new dedicated 240 Volt, 30-amp circuit will typically cost \$400, with a range of \$150 to \$1,000. We use this estimate, presented in Table B.0, in our analysis. We use the range of \$150 to \$1,000, assuming uniform distribution. We also considered using Rewiring America’s range of wiring costs per circuit — \$800 to \$1,500 — but decided to use Slipstream’s range instead because it was provided by our client and was specific to a 240 Volt circuit.

Table B.0: 240 Volt Circuit Purchase and Installation Costs for NG/Propane Stoves

Estimate	Lower Bound	Upper Bound	Description	Source	Distribution
\$400	\$150	\$1,000	Estimate for a new dedicated 240V, 30-amp circuit from the appliance to the panel	Slipstream 2022	Uniform

We could not find any academic sources that provided a distribution of costs for a 240 Volt circuit. However, to provide more context, we conducted a brief review of estimated costs from various websites, the results of which are provided in Table B.1. Some sources estimate the costs to be lower, estimating values as low as \$250, while others include costs beyond installing the outlet itself, estimating values as high as \$3,600. Indeed, households with gas stoves may bear additional electrical upgrade costs; however, we do not monetize those in our report because we could not find the appropriate data about the electrical capacities of households with gas stoves in Michigan.

Table B.1: Estimates of 240 Volt Circuit Purchase and Installation Costs for NG/Propane Stoves

Estimate	Description	Source
\$400 \$150 - \$1,000	Estimate and range for a new dedicated 240V, 30-amp circuit from the appliance to the panel	Slipstream 2022

⁴⁵ Rewiring America, “Cook Faster, Better, and Safer without Gas.”

\$800 - \$1,500	Range of costs of wiring per circuit.	Rewiring America n.d. ⁴⁶
\$987	Average cost of all electrical work for induction installation	Purdy n.d. ⁴⁷
\$450 \$250 - \$800	Average cost of a 240V outlet Range of costs of a 240V outlet	Cramer 2023 ⁴⁸
\$300	Estimate of cost to install a 250V outlet	Lloyd et al. 2023 ⁴⁹
\$267.81 - \$324.08	Range of average cost per electric outlet installation	Homewyse 2023 ⁵⁰
\$300 - \$3,600	Range of costs of installing a 240V outlet and/or laying new wire and/or updating the electrical panel.	Hitchcock 2023 ⁵¹

⁴⁶ Rewiring America, “Wire Your Home for Electrification,” Rewiring America, accessed November 21, 2023, <https://homes.rewiringamerica.org/projects/electrical-panel-homeowner#learn-more>.

⁴⁷ Kevin Purdy, “How Much Does an Induction Stove Cost?,” *Carbon Switch* (blog), accessed November 21, 2023, <https://carbonswitch.com/induction-stove-costs-and-prices/>.

⁴⁸ Kristen Cramer, “Cost to Install a 220V or 240V Outlet,” HomeGuide, April 5, 2023, <https://homeguide.com/costs/cost-to-install-a-220v-or-240v-outlet>.

⁴⁹ Lauren Lloyd, Corinne Tynan, and Samantha Allen, “How Much Does A New Outlet Installation Cost?,” Forbes, September 13, 2023, <https://www.forbes.com/home-improvement/electrical/outlet-installation-cost/>.

⁵⁰ Homewyse, “Cost to Install an Electrical Outlet,” Homewyse, June 2023, https://www.homewyse.com/services/cost_to_install_electrical_outlet.html.

⁵¹ Kristin Hitchcock, “How Much Does It Cost to Install a 240V Outlet in 2023?,” House Grail, January 8, 2023, <https://housegrail.com/cost-to-install-a-240v-outlet/>.

Appendix C: Replacement cookware purchase monetization methodology

Return to [Replacement cookware purchase](#) section.

Induction stove compatible cookware replacement costs are estimated to be, on average, \$288.84 per household.

Table C.0: Replacement Cookware Costs for All Stoves

Estimate	Lower Bound	Upper Bound	Description	Source	Distribution
\$288.84	-	-	Estimate assuming each household, on average, will need replace half of their cookware	-	-

We calculated the expected cost of purchasing induction-friendly cookware using the following formula:

$$\text{Cookware cost} = \text{Cookware price} \times (\text{Replaceable portion} \times \text{Cookware count})$$

Where:

- *Cookware price* is the average price per an induction stove-compatible pot or pan,
- *Replaceable portion* is the approximate portion of non-induction-friendly cookware, and
- *Cookware count* is the common number of pots and pans in an average cookware set.

The price and general methodology were derived from NMR Group, Inc. and Three’s 2023 study.⁵² This study assumed 15 percent of households would have to replace some cookware and 15 percent would have to replace all cookware. However, because about 50 percent of cookware is made of non-induction friendly materials, we assume that on average each household will replace 50 percent of its cookware.⁵³ The variables for calculating *Cookware cost* are presented in Table C.1.

Table C.1: Expected Cost of Replaced Cookware per Household

Variable	Estimate	Lower Bound	Upper Bound	Description	Source	Distribution
Cookware price	\$96.28	-	-	Average price per induction stove-compatible pan	NMR Group, Inc. and Three	-

⁵² NMR Group, Inc. and Three, “Residential Gas-to-Induction Stovetop Conversion NEIs Study,” January 12, 2023.

⁵³ Grand View Research. “Cookware Market Size, Share & Trends Analysis Report By Product (Cooking Tools, Pots And Pans), By Material (Stainless Steel, Aluminum), By Application, By Distribution Channel, By Region, And Segment Forecasts, 2022 - 2030.” Grand View Research, n.d.

2023⁵⁴

Replaceable portion	0.50	-	-	Approximate portion of non-stainless steel cookware as a portion of the cookware market	Grand View Research n.d. ⁵⁵	-
Cookware count	6	-	-	Common quantity of cookware in a set	NMR Group, Inc. and Three 2023 ⁵⁶	-

⁵⁴ NMR Group, Inc. and Three, “Residential Gas-to-Induction Stovetop Conversion NEIs Study.”

⁵⁵ Grand View Research, “Cookware Market Size, Share & Trends Analysis Report By Product (Cooking Tools, Pots And Pans), By Material (Stainless Steel, Aluminum), By Application, By Distribution Channel, By Region, And Segment Forecasts, 2022 - 2030.”

⁵⁶ NMR Group, Inc. and Three, “Residential Gas-to-Induction Stovetop Conversion NEIs Study.”

Appendix D: General health impacts monetization methodology

Return to the [General health impacts](#) section.

1. Household asthma impacts (annual)

Calculations for Asthma from natural gas/propane to electric/induction stoves adopts the formula below:

$$\begin{aligned} \text{saved cost from asthma} = & P(MI \text{ asthma}) \times (RR(\text{asthma}|gas) - 1) \\ & \times (P(\text{child}|\text{asthma}) \times \text{persons per MI household} \times P(\text{children}) \\ & \quad \times (\text{medical cost per person}(\text{asthma}) \\ & \quad + \text{daily wage}(\text{school}) \times \text{school days lost}(\text{asthma})) \\ & + P(\text{adult}|\text{asthma}) \times \text{persons per MI household} \times P(\text{adult}) \\ & \quad \times (\text{medical cost per person}(\text{asthma}) \\ & \quad + \text{daily wage}(\text{work}) \times \text{work days lost}(\text{asthma})) \end{aligned}$$

Where:

- $P(MI \text{ asthma})$ is the MI rate of current asthma among U.S. adults,
- $RR(\text{asthma}|gas)$ is the risk ratio of asthma given gas cooking exposure,
- $P(\text{child}|\text{asthma})$ is the probability of being a child given asthma, or the proportion of asthma cases that are children,
- $\text{Persons per MI household}$ is the mean persons per household in Michigan according to the U.S. Census Bureau's 2017–2021 estimates,
- $P(\text{children})$ is the proportion of children in Michigan,
- $\text{Medical cost per person}(\text{asthma})$ is the annual per-person incremental medical cost of asthma,
- $\text{Daily wage}(\text{school})$ is the mean daily wage for school days lost,
- $\text{School days lost}(\text{asthma})$ is the incremental school days lost due to asthma per person per year,
- $P(\text{adult}|\text{asthma})$ is the probability of being an adult given asthma, or the proportion of asthma cases that are adults,
- $P(\text{adult})$ is the proportion of adults in Michigan,
- $\text{Daily wage}(\text{work})$ is the mean daily wage for work days lost,
- $\text{Work days lost}(\text{asthma})$ is the incremental work days lost due to asthma per person per year.

$RR(\text{asthma}|gas)$ is calculated based on the odds ratios from the literature:

$$RR(\text{asthma}|gas) = \frac{OR(\text{asthma}|gas)}{(1 - P(MI \text{ asthma}) + (P(MI \text{ asthma}) \times OR(\text{asthma}|gas)))}$$

Where:

- $OR(\text{asthma}|gas)$ is the odds ratio for childhood asthma given the presence of gas stoves, and
- $P(MI \text{ asthma})$ is the prevalence of asthma in Michigan.

$P(\text{child}|\text{asthma})$ is calculated using Bayes' Theorem:

$$P(\text{child}|\text{asthma}) = \frac{P(\text{asthma}|\text{child}) \times P(\text{child})}{P(\text{US asthma})}$$

Where:

- $P(\text{asthma}|\text{child})$ is the proportion of children with asthma in the U.S.,
- $P(\text{children})$ is the proportion of children in Michigan, and
- $P(\text{US asthma})$ is the rate of asthma among the U.S. population.

$P(\text{adult}|\text{asthma})$ is also calculated using Bayes' Theorem:

$$P(\text{adult}|\text{asthma}) = \frac{P(\text{asthma}|\text{adult}) \times P(\text{adult})}{P(\text{US asthma})}$$

Where:

- $P(\text{asthma}|\text{adult})$ is the proportion of adults with asthma in the U.S.,
- $P(\text{adult})$ is the proportion of adults in Michigan, and
- $P(\text{US asthma})$ is the rate of asthma among the U.S. population.

The formulas, values, and sources for each variable — as well as the ranges and distributions for uncertain estimates — are presented in Table X.1.

Table D.1: Variables for Saved Household Asthma Costs

Variable	Estimate	Lower Bound	Upper Bound	Description	Source	Distribution
OR(asthma gas)	1.42	1.23	1.54	Summary odds ratio of current asthma and gas cooking exposure	Lin et al. 2013 ⁵⁷	Uniform
P(MI asthma)	0.1150	0.1195	0.1105	Michigan rate of current asthma among U.S. adults	Centers for Disease Control and Prevention 2021 ⁵⁸	Normal SE: 0.0045
P(asthma child)	0.065	0.0618	0.0682	P(asthma child): proportion of	Centers for Disease Control	Normal SE: 0.0032

⁵⁷ Weiwei Lin, Bert Brunekreef, and Ulrike Gehrig, “Meta-Analysis of the Effects of Indoor Nitrogen Dioxide and Gas Cooking on Asthma and Wheeze in Children,” *International Journal of Epidemiology* 42 (2013): 1724–37, <https://doi.org/10.1093/ije/dyt150>.

⁵⁸ Centers for Disease Control and Prevention, “Most Recent State or Territory Asthma Data,” Centers for Disease Control and Prevention, 2021, https://www.cdc.gov/asthma/most_recent_data_states.htm.

				children with asthma	and Prevention 2021 ⁵⁹	
P(child)	0.21	-	-	Proportion of children in Michigan	United States Census Bureau 2017–2021 ⁶⁰	-
P(US asthma)	0.077	0.0752	0.0788	Proportion of U.S. population with asthma	Centers for Disease Control and Prevention 2021 ⁶¹	Normal SE: 0.0018
Persons per MI household	2.48	-	-	Mean persons per household in Michigan	United States Census Bureau 2017–2021 ⁶²	-
P(asthma adult)	0.08	0.078	0.082	Proportion of adults with asthma	Centers for Disease Control and Prevention 2021 ⁶³	Normal SE: 0.002
P(adult)	0.79	-	-	Proportion of adults in Michigan	United States Census Bureau 2017–2021 ⁶⁴	-
Medical cost per person(asthma)	\$4,009.57	\$3,298.63	\$4,719.53	Annual per-person incremental medical cost of asthma	Nurmagambetov et al. 2018 ⁶⁵	Normal SE: \$710
Daily wage(school)	\$113.55	-	-	Mean daily wage for school day lost	Nurmagambetov et al. 2018 ⁶⁶	-

⁵⁹ Centers for Disease Control and Prevention, “Most Recent State or Territory Asthma Data.”

⁶⁰ United States Census Bureau, “QuickFacts: Michigan,” United States Census Bureau, 2021 2017, <https://www.census.gov/quickfacts/fact/table/MI/PST045222>.

⁶¹ Centers for Disease Control and Prevention, “Most Recent State or Territory Asthma Data.”

⁶² United States Census Bureau, “QuickFacts: Michigan.”

⁶³ Centers for Disease Control and Prevention, “Most Recent State or Territory Asthma Data.”

⁶⁴ United States Census Bureau, “QuickFacts: Michigan.”

⁶⁵ Tursynbek Nurmagambetov, Robin Kuwahara, and Paul Garbe, “The Economic Burden of Asthma in the United States, 2008–2013,” *Annual American Thoracic Society* 15, no. 3 (March 2018): 348–56, <https://doi.org/10.1513/AnnalsATS.201703-259OC>.

⁶⁶ Nurmagambetov, Kuwahara, and Garbe, “The Economic Burden of Asthma in the United States, 2008–2013.”

School days lost(asthma)	2.3	1.9	2.7	Incremental school days lost due to asthma per person per year	Nurmagambetov et al. 2018 ⁶⁷	Normal SE: 0.4
Daily wage(work)	\$153.11	-	-	Mean daily wage for work day lost	Nurmagambetov et al. 2018 ⁶⁸	
Work days lost(asthma)	1.8	1.2	2.4	Incremental work days lost due to asthma per person per year	Nurmagambetov et al. 2018 ⁶⁹	Normal SE: 0.6

2. Household LRT symptom impacts (annual)

Calculations for LRT symptoms from natural gas/propane to electric/induction stoves adopts the formula below:

$$\begin{aligned}
 \text{saved cost from LRT} = & P(MI \text{ LRT}) \times (RR(LRT|gas) - 1) \\
 \times & (P(child|LRT) \times \text{persons per MI household} \times P(children) \times (\text{medical cost per person}(LRT) \\
 & + \text{daily wage}(school) \times \text{school days lost}(LRT)) \\
 & + P(adult|LRT) \times \text{persons per MI household} \times P(adult) \\
 \times & (\text{medical cost per person}(LRT) + \text{daily wage}(work) \times \text{work days lost}(LRT))
 \end{aligned}$$

Where:

- $P(MI \text{ LRT})$ is the MI rate of current LRT symptoms among U.S. adults,
- $RR(LRT|gas)$ is the risk ratio of LRT symptoms given gas cooking exposure,
- $P(child|LRT)$ is the probability of being a child given LRT symptoms, or the proportion of LRT symptoms cases that are children,
- $\text{Persons per MI household}$ is the mean persons per household in Michigan according to the U.S. Census Bureau's 2017–2021 estimates,
- $P(children)$ is the proportion of children in Michigan,
- $\text{Medical cost per person}(LRT)$ is the annual per-person incremental medical cost of LRT symptoms,
- $\text{Daily wage}(school)$ is the mean daily wage for school days lost,
- $\text{School days lost}(LRT)$ is the incremental school days lost due to LRT symptoms per person per year,
- $P(adult|LRT)$ is the probability of being an adult given LRT symptoms, or the proportion of LRT symptoms cases that are adults,

⁶⁷ Nurmagambetov, Kuwahara, and Garbe, “The Economic Burden of Asthma in the United States, 2008–2013.”

⁶⁸ Nurmagambetov, Kuwahara, and Garbe, “The Economic Burden of Asthma in the United States, 2008–2013.”

⁶⁹ Nurmagambetov, Kuwahara, and Garbe, “The Economic Burden of Asthma in the United States, 2008–2013.”

- $P(\text{adult})$ is the proportion of adults in Michigan,
- $\text{Daily wage}(\text{work})$ is the mean daily wage for work days lost,
- $\text{Work days lost}(\text{LRT})$ is the incremental work days lost due to LRT symptoms per person per year.

$RR(\text{LRT}|\text{gas})$ is calculated based on the odds ratios from the literature:

$$RR(\text{LRT}|\text{gas}) = \frac{OR(\text{LRT}|\text{gas})}{(1 - P(\text{MI LRT})) + (P(\text{MI LRT}) \times OR(\text{LRT}|\text{gas}))}$$

Where:

- $OR(\text{LRT}|\text{gas})$ is the odds ratio for LRT symptoms given the presence of gas stoves, and
- $P(\text{MI LRT})$ is the prevalence of LRT symptoms in Michigan.

For $P(\text{MI LRT})$, the global age-standardized incidence and death rates for LRIs were 6,295 (5,887.4–6,737.3) and 34.3 (31.1–37.9) per 100,000 in 2019, which represents a 23.9% (22.5–25.4) and 48.5% (42.9–54.0) decrease since 1990, respectively.⁷⁰ However, the unadjusted incidence of LRTI per 1,000 person-years in the age group over 60 years old was 248.3 (95% CI = 229.3-268.8).⁷¹ Given that LRT symptoms are more common for the elderly group than the working age group, and this report assumes that the prevalence rate among children is similar to the prevalence rate among elderly people, the probability here represents the whole group. Hence, values from the latter estimation are adopted.

$P(\text{adult}|\text{LRT})$ is calculated using Bayes' Theorem:

$$P(\text{adult}|\text{LRT}) = \frac{P(\text{LRT}|\text{adult}) \times P(\text{adult})}{P(\text{US LRT})}$$

Where:

- $P(\text{LRT}|\text{adult})$ is the proportion of adults with LRT symptoms in the U.S.,
- $P(\text{adult})$ is the proportion of adults in Michigan, and
- $P(\text{US LRT})$ is the rate of LRT symptoms among the U.S. population.

Hence:

$$P(\text{child}|\text{LRT}) = 1 - P(\text{adult}|\text{LRT})$$

Where:

⁷⁰ Safiri, S., Mahmoodpoor, A., Kolahi, A., Nejadghaderi, S. A., Sullman, M. J. M., Mansournia, M. A., Ansarin, K., Collins, G. S., Kaufman, J. S., & Abdollahi, M. (2023). Global burden of lower respiratory infections during the last three decades. *Frontiers in Public Health*, 10. <https://doi.org/10.3389/fpubh.2022.1028525>.

⁷¹ Kumar, R., Dar, L., Amarchand, R., Saha, S. S., Lafond, K. E., Purakayastha, D. R., Kumar, R., Choudekar, A., Gopal, G., Dhakad, S., Narayan, V. V., Wahi, A., Chhokar, R., Lindstrom, S., Whitaker, B., Choudhary, A., Dey, A., & Krishnan, A. (2021). Incidence, risk factors, and viral etiology of community-acquired acute lower respiratory tract infection among older adults in rural north India. *Journal of Global Health*, 11. <https://doi.org/10.7189/jogh.11.04027>.

- $P(\text{adult}|\text{LRT})$ is the probability of being an adult given LRT symptoms, or the proportion of LRT symptoms cases that are adults.

The formulas, values, and sources for each variable — as well as the ranges and distributions for uncertain estimates — are presented in Table D.2.

Table D.2: Variables for Saved Household LRT Costs

Variable	Estimate	Lower Bound	Upper Bound	Description	Source	Distribution
P(MI LRT)	0.2483	0.2293	0.2688	MI rate of current LRT symptoms among U.S. adults	Kumar et al. 2021 ⁷²	Normal SE: 0.0197
OR(LRT gas)	1.23	-	-	Odds ratio for LRT symptoms given the presence of gas stoves	Chauhan and Johnston 2003 ⁷³	-
P(US LRT)	0.0046	-	-	Rate of LRT symptoms among the U.S. population	Weycker et al. 2022 ⁷⁴	-
P(LRT adult)	0.0046	-	-	Proportion of adults with LRT symptoms in the U.S.	Weycker et al. 2022 ⁷⁵	-
P(adult)	0.79	-	-	Proportion of adults in Michigan	United States Census Bureau	-

⁷² Kumar, R., Dar, L., Amarchand, R., Saha, S. S., Lafond, K. E., Purakayastha, D. R., Kumar, R., Choudekar, A., Gopal, G., Dhakad, S., Narayan, V. V., Wahi, A., Chhokar, R., Lindstrom, S., Whitaker, B., Choudhary, A., Dey, A., & Krishnan, A. (2021). Incidence, risk factors, and viral etiology of community-acquired acute lower respiratory tract infection among older adults in rural north India. *Journal of Global Health*, 11. <https://doi.org/10.7189/jogh.11.04027>

⁷³ Chauhan, A., & Johnston, S. L. (2003). Air pollution and infection in respiratory illness. *British Medical Bulletin*, 68(1), 95–112. <https://doi.org/10.1093/bmb/ldg022>

⁷⁴ Weycker, D., Averin, A., Houde, L., Ottino, K., Shea, K. M., Gessner, B. J., Yacisin, K., Curcio, D., Begier, E., & Rozenbaum, M. H. (2022). 2207. Rates of lower respiratory tract infections among US adults aged ≥18 years with and without chronic medical conditions. *Open Forum Infectious Diseases*, 9(Supplement_2). <https://doi.org/10.1093/ofid/ofac492.1826>

⁷⁵ Weycker, D., Averin, A., Houde, L., Ottino, K., Shea, K. M., Gessner, B. J., Yacisin, K., Curcio, D., Begier, E., & Rozenbaum, M. H. (2022). 2207. Rates of lower respiratory tract infections among US adults aged ≥18 years with and without chronic medical conditions. *Open Forum Infectious Diseases*, 9(Supplement_2). <https://doi.org/10.1093/ofid/ofac492.1826>

					2017–2021 ⁷⁶	
Medical cost per person(LRT)	\$ 305.83	-	-	Annual per-person incremental medical cost of LRT symptoms	AHRQ 2020 ⁷⁷	-
Daily wage(school)	\$113.55	-	-	Mean daily wage for school day lost	Nurmagambetov et al. 2018 ⁷⁸	-
School days lost(LRT)	0.8	-	-	Incremental school days lost due to LRT symptoms per person per year	McLean et al. 2017 ⁷⁹	-
Daily wage(work)	\$153.11	-	-	Mean daily wage for work day lost	Nurmagambetov et al. 2018 ⁸⁰	-
Work days lost(LRT)	3	-	-	Incremental work days lost due to LRT symptoms per person per year	Wormer et al. 2017 ⁸¹	-

3. Household COPD impacts (annual)

Calculations for COPD impacts from natural gas/propane to electric/induction stoves adopts the formula below:

⁷⁶ United States Census Bureau, “QuickFacts: Michigan.”

⁷⁷ Agency for Healthcare Research and Quality. (n.d.). Medical Expenditure Panel Survey Topics. https://meps.ahrq.gov/mepsweb/data_stats/MEPS_topics.jsp

⁷⁸ Nurmagambetov, Kuwahara, and Garbe, “The Economic Burden of Asthma in the United States, 2008–2013.”

⁷⁹ McLean, H. Q., Peterson, S. H., King, J., Meece, J. K., & Belongia, E. A. (2017). School absenteeism among school-aged children with medically attended acute viral respiratory illness during three influenza seasons, 2012–2013 through 2014–2015. *Influenza and Other Respiratory Viruses*, 11(3), 220–229. <https://doi.org/10.1111/irv.12440>

⁸⁰ Nurmagambetov, Kuwahara, and Garbe, “The Economic Burden of Asthma in the United States, 2008–2013.”

⁸¹ Van Wormer, J. J., King, J., Gajewski, A., McLean, H. Q., & Belongia, E. A. (2017). Influenza and workplace productivity loss in working adults. *Journal of Occupational and Environmental Medicine*, 59(12), 1135–1139. <https://doi.org/10.1097/jom.0000000000001120>

saved cost from COPD

$$\begin{aligned} &= P(\text{decrease of COPD}) \times P(\text{COPD}) \times \text{persons per MI household} \\ &\times (\text{medical cost per person(COPD)} + \text{hospitalization cost(COPD)}) \\ &+ \text{work days lost(COPD)} \times \text{daily wage(work)} \end{aligned}$$

Where:

- *P(decrease of COPD)* is the estimated percent reduction in COPD resulting from removal of gas stovetop,
- *P(COPD)* is the age-adjusted prevalence of COPD in MI in 2020,
- *Persons per MI household* is the mean persons per household in Michigan according to the U.S. Census Bureau's 2017–2021 estimates,
- *Medical cost per person(COPD)* is the annual per-person incremental medical cost of COPD,
- *Hospitalization cost(COPD)* is the annual per-person hospitalization cost of COPD,
- *Work days lost(COPD)* is the incremental work days lost due to COPD annually per person,
- *Daily wage(work)* is the mean daily wage for work days lost.

The formulas, values, and sources for each variable — as well as the ranges and distributions for uncertain estimates — are presented in Table D.3.

Table D.3: Variables for Saved Household COPD Costs

Variable	Estimate	Lower Bound	Upper Bound	Description	Source	Distribution
P(decrease of COPD)	0.046	-	-	Estimated percent reduction in COPD resulting from removal of gas stovetop	Morgan et al. 1998 ⁸²	-
P(COPD)	0.075	0.068	0.083	Age-adjusted prevalence of COPD in MI in 2020.	Centers for Disease Control and Prevention n.d. ⁸³	Normal SE: 0.007
Persons per MI household	2.48	-	-	Mean persons per household in Michigan	United States Census Bureau 2017–2021 ⁸⁴	-
Medical cost per person (COPD)	\$ 12,440	-	-	Annual per-person incremental medical cost of COPD	Rehman et al. 2019 ⁸⁵	-
Hospitalization cost (COPD)	\$ 8,222	-	-	Annual per-person hospitalization cost of COPD	Rehman et al. 2019 ⁸⁶	-
Work days lost (COPD)	5	-	-	Incremental work days lost due to COPD annually per person	Westbroek et al. 2020 ⁸⁷	-
Daily wage(work)	\$153.11	-	-	Mean daily wage for work day lost	Nurmagambetov et al. 2018 ⁸⁸	-

⁸² Morgan, G., S. Corbett, and J. Wlodarczyk. “Air Pollution and Hospital Admissions in Sydney, Australia, 1990 to 1994.” *American Journal of Public Health* 88, no. 12 (December 1998): 1761–66. <https://doi.org/10.2105/ajph.88.12.1761>.

⁸³ Centers for Disease Control and Prevention, “COPD: State-Level Estimates,” Centers for Disease Control and Prevention, accessed November 21, 2023, <https://www.cdc.gov/copd/data-and-statistics/state-estimates.html>.

4. Household children ASD impacts (annual)

Calculations for child ASD from women cooking during pregnancy transit from natural gas/propane to electric/induction stoves adopt the formula below:

$$\begin{aligned} & \textit{saved cost from ASD} \\ &= P(\textit{decrease of ASD}) \times P(\textit{ASD|child}) \times \textit{persons per MI household} \\ & \times P(\textit{children}) \times (\textit{medical cost per person(ASD)} \\ & + P(\textit{SRB}) \times \textit{school days lost(ASD)} \times \textit{Daily wage(school)}) \end{aligned}$$

Where:

- $P(\textit{decrease of ASD})$ is the percentage decrease of ASD when a household adopts electric/induction stoves compared to NG/ propane stoves,
- $P(\textit{ASD|child})$ is the probability of children been identified with autism spectrum disorder (ASD),
- $\textit{Persons per MI household}$ is the mean persons per household in Michigan according to the U.S. Census Bureau's 2017–2021 estimates,
- $P(\textit{children})$ is the proportion of children in Michigan,
- $\textit{Medical cost per person (ASD)}$ is the annual per-person incremental medical cost of child ASD,
- $P(\textit{SRB})$ is the probability of school refusal behavior (SRB) for ASD children,
- $\textit{School days lost (ASD)}$ is the incremental school days lost due to SRB annually per ASD children,
- $\textit{Daily wage (school)}$ is the mean daily wage for school days lost.

$P(\textit{decrease of ASD})$ is calculated based on the odds ratios from the literature:

$$P(\textit{decrease of ASD}) = \frac{OR(\textit{ASD|Electric})}{1 + OR(\textit{ASD|Electric})} - \frac{OR(\textit{ASD|NG})}{1 + OR(\textit{ASD|NG})}$$

Where:

- $OR(\textit{ASD|Electric})$ is the odds ratio of children ASD given electric/induction stove,
- $OR(\textit{ASD|NG})$ is the odds ratio of children ASD given natural gas/propane stove,

⁸⁴ United States Census Bureau, "QuickFacts: Michigan."

⁸⁵ Anees Ur Rehman et al., "The Economic Burden of Chronic Obstructive Pulmonary Disease (COPD) in the USA, Europe, and Asia: Results from a Systematic Review of the Literature," *Expert Review of Pharmacoeconomics & Outcomes Research* 20, no. 6 (November 1, 2020): 661–72, <https://doi.org/10.1080/14737167.2020.1678385>.

⁸⁶ Rehman et al., "The Economic Burden of Chronic Obstructive Pulmonary Disease (COPD) in the USA, Europe, and Asia."

⁸⁷ Lotte F Westbroek et al., "Reducing the Number of Hospitalization Days for COPD: Setting up a Transmural-Care Pathway," *International Journal of Chronic Obstructive Pulmonary Disease* Volume 15 (September 2020): 2367–77, <https://doi.org/10.2147/COPD.S242914>.

⁸⁸ Nurmagametov, Kuwahara, and Garbe, "The Economic Burden of Asthma in the United States, 2008–2013."

School days lost (ASD) takes values from Munkhaugen et al. 2017, in which the authors estimated the SRB from ASD children in a 20-day period.⁸⁹ Among 68 students in the primary and secondary schools, 29 students showed SRB. The duration of days with SRB in primary and secondary schools differed for those students, too: 12 students had SRB for 1–3 days, 11 students had SRB for 4–7 days, 6 students had SRB for 11–20 days. Given that there are 180 school days in the U.S. every year, this estimation expands the estimated annual SRB days by 9 times and takes the mean of each estimated category.

The formulas, values, and sources for each variable — as well as the ranges and distributions for uncertain estimates — are presented in Table D.4.

Table D.4: Variables for Saved Household Children ASD Costs

Variable	Estimate	Lower Bound	Upper Bound	Description	Source	Distribution
OR(ASD NG)	0.66	-	-	Odds ratio of children ASD given natural gas/propane stove	Yang et al. 2022 ⁹⁰	-
OR(ASD Electric)	0.98	-	-	Odds ratio of children ASD given electric/induction stove	Yang et al. 2022 ⁹¹	-
P(ASD child)	0.04	-	-	Probability of children been identified with	CDC 2023 ⁹²	-

⁸⁹ Munkhaugen, E. K., Gjevik, E., Pripp, A. H., Sponheim, E., & Diseth, T. H. (2017). School refusal behaviour: Are children and adolescents with autism spectrum disorder at a higher risk? *Research in Autism Spectrum Disorders*, 41–42, 31–38. <https://doi.org/10.1016/j.rasd.2017.07.001>.

⁹⁰ Yang, J., Strodl, E., Wu, C., Hou, X., Yin, X., Wen, G., Sun, D., Xian, D., Chen, J., Chen, Y., Chen, J., & Chen, W. (2022). Maternal exposure to cooking oil fumes during pregnancy and autistic-like behaviors in Chinese preschoolers. *Environmental Science and Pollution Research*, 29(49), 74688–74698. <https://doi.org/10.1007/s11356-022-21113-0>

⁹¹ Yang, J., Strodl, E., Wu, C., Hou, X., Yin, X., Wen, G., Sun, D., Xian, D., Chen, J., Chen, Y., Chen, J., & Chen, W. (2022). Maternal exposure to cooking oil fumes during pregnancy and autistic-like behaviors in Chinese preschoolers. *Environmental Science and Pollution Research*, 29(49), 74688–74698. <https://doi.org/10.1007/s11356-022-21113-0>

⁹² Centers for Disease Control and Prevention. “Data & Statistics on Autism Spectrum Disorder.” Centers for Disease Control and Prevention, 2023. <https://www.cdc.gov/ncbddd/autism/data.html>.

				autism spectrum disorder (ASD)		
Persons per MI household	2.48	-	-	Mean persons per household in Michigan	United States Census Bureau 2017–2021 ⁹³	-
P(children)	0.21	-	-	Proportion of children in Michigan	United States Census Bureau 2017–2021 ⁹⁴	-
Medical cost per person (ASD)	\$ 5,876.7	\$4,685.4	\$ 7,068	Annual per-person incremental medical cost of child ASD,	NCSL ⁹⁵	Normal SE: 1191.3
P(SRB)	0.43	-	-	Probability of school refusal behavior (SRB) for ASD children	Munkhaugen et al. 2017 ⁹⁶	-
School days lost (ASD)	76.5	18	135	Incremental school days lost due to SRB annually per ASD children	Munkhaugen et al. 2017 ⁹⁷	Normal SE: 58.5

⁹³ United States Census Bureau, “QuickFacts: Michigan.”

⁹⁴ United States Census Bureau, “QuickFacts: Michigan.”

⁹⁵ Autism and insurance coverage state laws. (2023, December 5). <https://www.ncsl.org/health/autism-and-insurance-coverage-state-laws#:~:text=Costs%20include%20health%20care%2C%20education,%2460%2C000%20per%20child%20per%20year.>

⁹⁶ Munkhaugen, E. K., Gjevik, E., Pripp, A. H., Sponheim, E., & Diseth, T. H. (2017). School refusal behaviour: Are children and adolescents with autism spectrum disorder at a higher risk? *Research in Autism Spectrum Disorders*, 41–42, 31–38. <https://doi.org/10.1016/j.rasd.2017.07.001>

⁹⁷ Munkhaugen, E. K., Gjevik, E., Pripp, A. H., Sponheim, E., & Diseth, T. H. (2017). School refusal behaviour: Are children and adolescents with autism spectrum disorder at a higher risk? *Research in Autism Spectrum Disorders*, 41–42, 31–38. <https://doi.org/10.1016/j.rasd.2017.07.001>

Daily wage (school)	\$ 113.55	-	-	Mean daily wage for school days lost	Nurmagambetov et al. 2018 ⁹⁸	-
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⁹⁸ Nurmagambetov, Kuwahara, and Garbe, “The Economic Burden of Asthma in the United States, 2008–2013.”

Appendix E: NO₂ health impacts monetization methodology

Return to [NO₂ health impacts](#) section.

The value of the NO₂ health impacts for gas and propane stoves, when transitioning to an induction stove, can be written using the following formula:

$$NO_2(\text{gas}) = \text{Asthma YLDs} + \text{Asthma Medical Costs} + \text{Asthma Productivity Costs} \\ + \text{COPD DALYs} + \text{COPD Medical Costs} + \text{COPD Productivity Costs}$$

In its 2016 Integrated Science Assessment for the Oxides of Nitrogen – Health Impacts report, the Environmental Protection Agency (EPA) found evidence that nitrogen dioxide exposure is linked to respiratory effects. Specifically, the EPA found consistent evidence linking NO₂ to asthma exacerbation, inconsistent evidence linking NO₂ to chronic obstructive pulmonary disorder (COPD) exacerbation, and evidence with varying degrees of consistency linking NO₂ to respiratory infections.⁹⁹ The EPA also found some evidence linking nitrogen dioxide to cardiovascular effects and total mortality, but in both cases the evidence was not sufficient to infer a causal relationship.¹⁰⁰

In this analysis, we monetize the health impacts of asthma and COPD exacerbation, caused by a 7.19 ppb change in NO₂ concentrations. We explore these health impacts for the transitions of natural gas to induction stoves and propane to induction stoves. Because electric stoves do not run on natural gas or propane, there are no NO₂-related health impacts for an electric-to-induction transition.

Limitations

We monetize the impacts of the change in mean baseline NO₂ concentrations between gas and induction stoves. However, we do not monetize the impacts of the change in peak or cooking period NO₂ concentrations due to a lack of research (see [Section 1](#), Decrease in NO₂, for more details).

We did not monetize the health impacts for respiratory infections because we could not find a relative risk ratio for respiratory infection given a change in NO₂ concentration. The general health impacts section, however, monetizes the increased risk of respiratory infection given the presence of gas stoves (see [Appendix D](#)).

We monetized the health impacts for asthma given a change in NO₂ concentrations, but the odds-risk ratio we used reflects the increased risk of childhood asthma, not population-wide asthma. That said, we decided to use the childhood asthma odds-risk ratio for the entire population. We made this decision partly because NMR Group, Inc. and Three used a similar methodology in their study on non-energy impacts of gas-to-

⁹⁹ National Center for Environmental Assessment-RTP Division. 2016. “Table 5-39: Summary of evidence for a causal relationship between short-term nitrogen dioxide exposure and respiratory effects.” *Integrated Science Assessment for Oxides of Nitrogen–Health Criteria*, 5-253. U.S. Environmental Protection Agency. <https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=310879>.

¹⁰⁰ National Center for Environmental Assessment-RTP Division. 2016. “Table ES-1.” *Integrated Science Assessment for Oxides of Nitrogen–Health Criteria*, lxxxii. U.S. Environmental Protection Agency. <https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=310879>.

induction stovetop conversion.¹⁰¹ We also made this decision due to a lack of research; we could not find the increased risk of adult asthma linked to a change in NO₂ concentrations.¹⁰²

We could not find a risk ratio for asthma mortality given a change in NO₂ concentrations. Therefore, we only monetize the change in asthma-related Years of Life with a Disability (YLD) and do not monetize the change in asthma-related Years of Life Lived (YLL). While this is a definite limitation of our methodology, we do not believe this excluded value greatly impacts our analysis because asthma does not cause many deaths. In fact, YLLs per 100,000 people make up only 8 percent of DALYs per 100,000 people (DALYs are the sum of YLLs and YLDs). See [Section E.2.1](#) for more details.

When monetizing COPD health impacts, we use an odds risk ratio from Zhang and colleagues’ 2018 study.¹⁰³ However, their ratio is for NO₂ concentrations outdoors, not indoors. Despite this, we use this ratio for two reasons. First, we could not find any available research identifying a risk ratio for COPD morbidity and mortality, given a change in NO₂ concentrations. Second, we use this study so we can monetize the COPD impacts of NO₂, rather than not monetize it and implicitly assume that an increase in NO₂ is not related to any COPD impacts. Because outdoor air pollutant concentrations impact people differently than indoor air pollutant concentrations, this is a limitation of our analysis.

1. Decrease in NO₂ emissions from a gas-to-induction transition

On average, a transition from a natural gas/propane stove to an electric/induction stove is associated with an average 7.19 ppb decrease of NO₂. 7.19 ppb is the average decrease in NO₂ concentrations across three studies, as shown in Table E.1.

Table E.1: Changes in Mean Baseline NO₂ Concentrations

Change in Mean Baseline NO₂ Concentration (NG/Propane to Electric/Induction)	Source	Measurement Methodology
7 ppb (18 ppb to 11 ppb)	WeAct 2023 ¹⁰⁴	Air monitoring for 5 minutes before the controlled cooking test
7.28 ppb (12.11 ppb to 4.84 ppb)	Dédélé and Miškinytė	Sampling for 14 days during 4 seasons using passive samplers

¹⁰¹ NMR Group, Inc. and Three, “Residential Gas-to-Induction Stovetop Conversion NEIs Study.”

¹⁰² We Act for Environmental Justice, “Out of Gas, In with Justice: Studying the Impacts of Induction Stoves on Indoor Air Quality in Affordable Housing” (We Act for Environmental Justice, 2023), <https://www.weact.org/campaigns/out-of-gas/>.

¹⁰³ Zili Zhang, Jian Wang, and Wenju Lu, “Exposure to Nitrogen Dioxide and Chronic Obstructive Pulmonary Disease (COPD) in Adults: A Systematic Review and Meta-Analysis,” *Environmental Science and Pollution Research* 25 (2018): 15133–45, <https://doi.org/10.1007/s11356-018-1629-7>.

¹⁰⁴ We Act for Environmental Justice, “Out of Gas, In with Justice: Studying the Impacts of Induction Stoves on Indoor Air Quality in Affordable Housing” (We Act for Environmental Justice, 2023), <https://www.weact.org/campaigns/out-of-gas/>.

2016¹⁰⁵

7.3 ppb (15.5 ppb to 8.2 ppb)

Paulin et al. 2014¹⁰⁶

Median 7-day integrated NO₂ samples

Average Concentration Decrease: 7.19 ppb

These three studies that measured the baseline NO₂ concentrations before and after a gas-to-electric or gas-to-induction transition. The WeAct study examined the transition from gas to induction stoves; the other two studies explored the transition from gas to electric stoves. Two additional studies reported baseline NO₂ estimates for gas stoves but not for electric or induction stoves, thus thwarting our ability to compare concentrations between households in similar environments.¹⁰⁷

Because electric stoves and induction stoves are both powered by electricity instead of gas, we assume that the mean change in baseline concentrations when transitioning from gas to electric stoves would be the same as when transitioning from gas to induction stoves. Also, readers should note that the three studies above examined gas stoves but did not specify whether those stoves were natural gas or propane stoves. We assume that the mean change in baseline concentrations when transitioning from gas stoves can be applied to both natural gas and propane stoves.

Only two studies looked at the cooking NO₂ concentrations before and after a gas-to-electric or gas-to-induction transition, which varied from 32 ppb to 183 ppb.¹⁰⁸ Due to the lack of existing research and the discrepancy between the two applicable studies, we do not monetize the health impacts of reduced cooking NO₂ concentrations.

2. Household asthma impacts (annual)

2.1 Decreased risk of asthma

We calculated our estimate for a decreased risk of asthma given a 7.19 decrease in baseline NO₂ concentrations using an adjusted risk ratio. An adjusted risk ratio is the increased risk of asthma given a 7.19 increase in baseline NO₂ concentrations. To calculate the adjusted risk ratio, we used the following formula:

$$\text{Adjusted } RR_{\text{asthma}}(\text{NO}_2) = \left[\frac{7.19 \text{ ppb}}{15 \text{ ppb}} \times (RR(\text{asthma}|15 \text{ ppb change}) - 1) \right] + 1$$

¹⁰⁵ Audrius Dėdelė and Auksė Miškinytė, “Seasonal Variation of Indoor and Outdoor Air Quality of Nitrogen Dioxide in Homes with Gas and Electric Stoves,” *Environmental Science Pollution Research International* 23 (2016): 17784–92, <https://doi.org/10.1007/s11356-016-6978-5>.

¹⁰⁶ L. M. Paulin et al., “Home Interventions Are Effective at Decreasing Indoor Nitrogen Dioxide Concentrations,” *Indoor Air* 24, no. 4 (August 2014): 416–24, <https://doi.org/10.1111/ina.12085>.

¹⁰⁷ Josiah L. Kephart et al., “Nitrogen Dioxide Exposures from LPG Stoves in a Cleaner-Cooking Intervention Trial,” *Environmental International* 146 (January 2021): 1–11, <https://doi.org/10.1016/j.envint.2020.106196>, Jennifer M. Logue et al., “Pollutant Exposures from Natural Gas Cooking Burners: A Simulation-Based Assessment for Southern California,” *Environmental Health Perspectives* 122, no. 1 (January 2014), <https://doi.org/10.1289/ehp.1306673>.

¹⁰⁸ Roy Fortmann, Peter Kariher, and Russ Clayton, “Indoor Air Quality: Residential Cooking Exposures” (Research Triangle Park, NC 27709: ARCADIS Geraghty & Miller, Inc., November 30, 2001); We Act for Environmental Justice, “Out of Gas, In with Justice: Studying the Impacts of Induction Stoves on Indoor Air Quality in Affordable Housing.”

where $RR(asthma|15\text{ ppb change})$ is the risk ratio of asthma given a 15 ppb change in NO_2 . The risk ratio is the probability of asthma given a 15-ppb change in NO_2 divided by the probability of asthma given no change in NO_2 .

$RR(asthma|15\text{ ppb change})$ is calculated from an odds ratio. A 2013 study, conducted by Lin and colleagues, estimated an odds ratio of 1.09 (95% CI: 0.91 - 1.31) for childhood asthma due to an increase of 15 ppb NO_2 .¹⁰⁹ The odds ratio is the odds of asthma given a 15 ppb change in NO_2 exposure divided by the odds of asthma given no change in NO_2 exposure. We assume the range is from 1 to 1.31, instead of 0.91 to 1.31, because we assume that an increase in NO_2 does not result in a reduction of risk of asthma; at best, it is not associated with an increased risk of asthma. The odds ratio is converted into a risk ratio using the following formula, derived from a formula by Zhang and colleagues:¹¹⁰

$$RR(asthma|15\text{ ppb change}) = \frac{OR(asthma|15\text{ ppb change})}{(1 - P(MI\text{ asthma}) + (P(MI\text{ asthma}) \times OR(asthma|15\text{ ppb change})))}$$

Where:

- $P(MI\text{ asthma})$ is the Michigan rate of current asthma among U.S. adults, and
- $OR(asthma|15\text{ ppb change})$ is the odds ratio of asthma morbidity, or having asthma, given a 15 ppb change in NO_2 .

Notably, Lin and colleagues’ meta-analysis focuses on the odds of developing childhood asthma. We apply the childhood asthma development odds ratio to the entire population. We decided to use this approach due to lack of available research on the link between NO_2 concentrations and adult asthma development. According to the CDC, the proportion of children and adults with current asthma only differ by 0.2 percent.¹¹¹ However, we do not know if changes in NO_2 concentrations impact adults the same way they do children.

$P(asthma)$, the asthma prevalence rate, is the adult asthma prevalence rate for Michigan. In this calculation, we implicitly assume the adult asthma prevalence rate to be similar for children. We make this assumption because we could not find population-wide asthma prevalence rates for Michigan.

The values and sources for each variable — as well as the ranges and distributions for uncertain estimates — are presented in Table E.2.1.

Table E.2.1: Variables for Decreased Risk of Asthma

Variable	Estimate	Lower Bound	Upper Bound	Description	Source	Distribution
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¹⁰⁹ Lin, Brunekreef, and Gehrig, “Meta-Analysis of the Effects of Indoor Nitrogen Dioxide and Gas Cooking on Asthma and Wheeze in Children.”

¹¹⁰ Zhang and Yu, “What’s the Relative Risk? A Method of Correcting the Odds Ratio in Cohort Studies of Common Outcomes.”

¹¹¹ Cynthia A. Pate et al., “Asthma Surveillance — United States, 2006–2018,” *Surveillance Summaries* 70, no. 5 (September 17, 2021): 1–32, <https://doi.org/10.15585/mmwr.ss7005a1>.

OR(asthma 15 ppb)	1.09	1	1.31	Odds ratio of asthma morbidity per 15 ppb decrease in NO ₂	Lin et al. 2013 ¹¹²	Uniform
P(MI asthma)	0.1150	0.1195	0.1105	Michigan rate of current asthma among U.S. adults	Centers for Disease Control and Prevention 2021 ¹¹³	Normal SE: 0.0045

2.2 Saved asthma years of life with a disability

We estimated the value of saved asthma years lived with a disability (YLDs) from a 7.19 ppb NO₂ reduction using the following formula:

$$\begin{aligned}
 & \text{Asthma YLDs}(NO_2) \\
 &= \frac{YLDs(asthma)}{100,000} \times PAF_{morbidity}(asthma_{NO_2}) \times VLY \\
 & \times \text{Persons per MI Household}(Census)
 \end{aligned}$$

Where:

- $YLDs(asthma)$ are the years of life lived with a disability for asthma per 100,000 persons in Michigan,
- $PAF_{morbidity}(asthma_{NO_2})$ is the population attributable fraction of asthma morbidity attributed to the higher NO₂ concentrations that are present in homes with gas stoves,
- VLY is value of a life year for a typically aged population, and
- $\text{Persons per MI household}(Census)$ is the mean persons per household in Michigan according to the U.S. Census Bureau's 2017–2021 estimates.

$YLDs(asthma)$ is reported by the Institute for Health Metrics and Evaluation and comes from the 2019 Global Burden of Disease study.¹¹⁴ Scholars often use this study estimate DALYs associated with health conditions.¹¹⁵ $YLDs(asthma)$ are divided by 100,000 to get an estimate of DALYs per person.

¹¹² Lin, Brunekreef, and Gehrig, “Meta-Analysis of the Effects of Indoor Nitrogen Dioxide and Gas Cooking on Asthma and Wheeze in Children.”

¹¹³

Centers for Disease Control and Prevention, “Most Recent State or Territory Asthma Data.”

¹¹⁴ University of Washington, “Global Burden of Disease Compare,” Institute for Health Metrics and Evaluation, 2019, <https://vizhub.healthdata.org/gbd-compare/#>.

¹¹⁵ Saeid Safiri et al., “Prevalence, Deaths, and Disability-Adjusted Life-Years Due to Asthma and Its Attributable Risk Factors in 204 Countries and Territories, 1990-2019” 161, no. 2 (February 2022): 318–29, <https://doi.org/10.1016/j.chest.2021.09.042>; Fei Liu, Xiangjie Lin, and Mao Zhang, “Global, Regional, and National Burden of Accidental Carbon Monoxide Poisoning, 1990–2019: A Systematic Analysis for the Global Burden of Disease Study 2019,” *JSRN*, December 30, 2020, <https://doi.org/10.2139/ssrn.3745098>.

$PAF_{morbidity}(asthma_{NO_2})$ is a population attributable fraction (PAF).¹¹⁶ A PAF is a fraction of all cases of a health condition that is attributable to a given risk factor. Here, $PAF_{morbidity}(asthma_{NO_2})$ is the fraction of asthma morbidity — or asthma cases — attributable to the 7.19 ppb-higher NO_2 concentrations present in homes with gas stoves. $PAF_{morbidity}(asthma_{NO_2})$ can be calculated as follows:

$$PAF_{morbidity}(asthma_{NO_2}) = \frac{P(gas_{MI}) \times [AdjustedRR_{asthma\ morbidity}(NO_2) - 1]}{P(gas_{MI}) \times [AdjustedRR_{asthma\ morbidity}(NO_2) - 1] + 1}$$

Where:

- $P(gas_{MI})$ is the proportion of households exposed to increased NO_2 , or the proportion of households with gas stoves in Michigan, and
- $AdjustedRR_{asthma\ morbidity}(NO_2)$ is the risk ratio for asthma morbidity given a 7.19-ppb increase in NO_2 concentrations, where morbidity means having asthma.

Ideally, we would calculate two separate PAFs: one for mortality and one for morbidity given an increase in NO_2 concentrations. Mortality is the increased risk of death from a health condition and morbidity is the increased risk of suffering from the health condition. Then, we would multiply the mortality PAF by the number of years of life lost (YLL) to asthma and the morbidity PAF by the number of years lived with a disability (YLD) from asthma. However, because we could not find a risk ratio for the asthma-related death given an increase in NO_2 concentrations, we could not calculate the mortality PAF. Therefore, we only calculate the value of reduced YLDs, multiplying $PAF_{morbidity}(asthma_{NO_2})$ by the total Michigan asthma YLDs to get the saved YLDs that would be attributable to the decrease in NO_2 concentrations.

Although we do not estimate the value of reduced YLLs, we do not believe this excluded value greatly impacts our analysis because asthma does not cause many deaths. In fact, YLLs per 100,000 people make up only 8 percent, or 362.13, of DALYs per 100,000 people.¹¹⁷

The value of a life year (VLY) is derived from the Environmental Protection Agency’s Value of a Statistical Life (VSL), which is \$10,792,889.04 in 2023 dollars. The VSL was then divided by the annuity factor, which assumed a 3.5% social discount rate and a 38.2-year life expectancy.¹¹⁸ VLY was calculated using the following formula:

$$VLY = \frac{VSL}{[1 - (1 + 0.035)^{38.2}] / 0.035}$$

¹¹⁶ Cheng-Kuan Lin and Szu-Ta Chen, “Estimation and Application of Population Attributable Fraction in Ecological Studies,” *Environmental Health* 18, no. 52 (2019), <https://doi.org/10.1186/s12940-019-0492-4>.

¹¹⁷ University of Washington, “Global Burden of Disease Compare,” Institute for Health Metrics and Evaluation, 2019, <https://vizhub.healthdata.org/gbd-compare/#>.

¹¹⁸ This methodology and the discount rate came from Anthony E. Boardman et al., *Cost-Benefit Analysis: Concepts and Practice*, 5th ed. (Cambridge, UK: Cambridge University Press, 2018).

The 38.2-year life expectancy was calculated by dividing the average life expectancy in the United States, 76.4, by 2.¹¹⁹ Therefore, we assume a VSL for a population that is not skewed older or younger.

The values and sources for each variable — as well as the ranges and distributions for uncertain estimates — are presented in Table E.2.2.

Table E.2.2: Variables for Saved Asthma YLDs

Variable	Estimate	Lower Bound	Upper Bound	Description	Source	Distribution
YLDs(asthma)	362.13	-	-	Asthma YLDs per 100,000 population in Michigan	University of Washington 2019 ¹²⁰	-
AdjustedRR_asthma(NO ₂)	See Section E.2.1	See Section E.2.1	See Section E.2.1	See Section E. 2.1		
VLY	\$516,552.20	-	-	Value of a Life Year (VLY), adjusted to 2023 dollars.	United States Environmental Protection Agency n.d. ¹²¹	-
Persons per MI household (Census)	2.48	-	-	Mean persons per household in Michigan	United States Census Bureau 2017–2021 ¹²²	-
P(gas_MI)	0.49			Percentage of households with gas cooktops	Brossman et al. 2023 ¹²³	

2.3 Saved asthma medical costs

The estimate of the saved asthma medical costs from a 7.19 NO₂ reduction was calculated using the following formula:

¹¹⁹ Centers for Disease Control and Prevention, “Life Expectancy,” Centers for Disease Control and Prevention, accessed November 21, 2023, <https://www.cdc.gov/nchs/fastats/life-expectancy.htm>.

¹²⁰ University of Washington, “Global Burden of Disease Compare.”

¹²¹ United States Environmental Protection Agency, “Mortality Risk Valuation,” United States Environmental Protection Agency, accessed November 21, 2023, <https://www.epa.gov/environmental-economics/mortality-risk-valuation>.

¹²² United States Census Bureau, “QuickFacts: Michigan,” United States Census Bureau, 2017-2021, <https://www.census.gov/quickfacts/fact/table/MI/PST045222>.

¹²³ Jes Brossman et al., “State Level Residential Building Stock and Energy Efficiency & Electrification Packages Analysis,” National Renewable Energy Laboratory, 2023.

Asthma Medical Costs(NO₂)

$$= P(MI\ asthma) \times PAF_{morbidity}(asthma_{NO_2}) \\ \times Persons\ per\ MI\ household(Census) \times Medical\ cost\ per\ person(asthma)$$

Where:

- *P(MI asthma)* is the Michigan rate of current asthma among U.S. adults,
- *PAF(asthma_NO₂)* is the population attributable fraction of asthma morbidity attributed to the higher NO₂ concentrations that are present in homes with gas stoves,
- *Persons per MI household(Census)* is the mean persons per household in Michigan according to the U.S. Census Bureau’s 2017–2021 estimates, and
- *Medical cost per person(asthma)* is the annual per-person incremental medical cost of asthma.

Nurmagambetov and colleagues reported a \$3,265.60 (95% CI: \$2,686.90-\$3,844.30) annual per-person incremental medical cost of asthma in 2015 dollars. The medical cost included hospitalizations, prescriptions, clinical visits, and other costs. This value was converted to 2023 dollars using the 2015 CPI-U annual value and the 2023 CPI-U half1 value.¹²⁴ The CPI-U values were based on the U.S. city average for all medical care items.

The formulas, values, and sources for each variable — as well as the ranges and distributions for uncertain estimates — are presented in Table E.2.3.

Table E.2.3: Variables for Saved Asthma Medical Costs

Variable	Estimate	Lower Bound	Upper Bound	Description	Source	Distribution
P(MI asthma)	0.1150	0.1195	0.1105	Michigan rate of current asthma among U.S. adults	Centers for Disease Control and Prevention 2021 ¹²⁵	Normal SE: 0.0045
PAF_morbidity(asthma_NO ₂)	See section E.2.2.	See section E.2.2.	See section E.2.2.	See section E.2.2.		
Persons per MI household(Census)	2.48	-	-	Mean persons per household in Michigan	United States Census Bureau 2017–2021 ¹²⁶	-
Medical cost per person(asthma)	\$4,009.57	\$3,298.63	\$4,719.53	Annual per-person incremental medical	Nurmagambetov	Normal SE: \$710

¹²⁴ The 2023 CPI-U half1 value was used because, at the time of the report, the 2023 annual value had not been released.

¹²⁵ Centers for Disease Control and Prevention, “Most Recent State or Territory Asthma Data.”

¹²⁶ United States Census Bureau, “QuickFacts: Michigan.”

2.4 Saved asthma productivity costs

We calculated the estimate of the saved asthma productivity costs from a 7.19 ppb NO₂ reduction using the following formula:

$$\begin{aligned} \text{Asthma Productivity Costs}(NO_2) &= [P(\text{MI asthma}) \times PAF_{\text{morbidity}}(\text{asthma}_{NO_2}) \times \text{Persons per MI household} \\ &\times P(\text{adult}|\text{asthma}) \times \text{Work days lost}(\text{asthma}) \times \text{Daily wage}(\text{work})] \\ &+ [P(\text{MI asthma}) \times PAF_{\text{morbidity}}(\text{asthma}_{NO_2}) \times \text{Persons per MI household} \\ &\times P(\text{child}|\text{asthma}) \times \text{School days lost}(\text{asthma}) \times \text{Daily wage}(\text{school})] \end{aligned}$$

Where:

- $P(\text{MI asthma})$ is the MI rate of current asthma among U.S. adults,
- $PAF(\text{asthma}_{NO_2})$ is the population attributable fraction of asthma morbidity attributed to the higher NO₂ concentrations that are present in homes with gas stoves,
- $\text{Persons per MI household}(\text{Census})$ is the mean persons per household in Michigan according to the U.S. Census Bureau's 2017–2021 estimates, and
- $P(\text{adult}|\text{asthma})$ is the probability of being an adult given asthma, or the proportion of asthma cases that are adults,
- $\text{Work days lost}(\text{asthma})$ is the incremental work days lost due to asthma per person per year,
- $\text{Daily wage}(\text{work})$ is the mean daily wage for work days lost,
- $P(\text{child}|\text{asthma})$ is the probability of being a child given asthma, or the proportion of asthma cases that are children,
- $\text{School days lost}(\text{asthma})$ is the incremental school days lost due to asthma per person per year, and
- $\text{Daily wage}(\text{school})$ is the mean daily wage for school days lost.

We calculated $P(\text{adult}|\text{asthma})$ using Bayes' Theorem:

$$P(\text{adult}|\text{asthma}) = \frac{P(\text{asthma}|\text{adult}) \times P(\text{adult})}{P(\text{US asthma})}$$

Where:

- $P(\text{asthma}|\text{adult})$ is the proportion of adults with asthma in the U.S.,
- $P(\text{adult})$ is the proportion of adults in Michigan, and
- $P(\text{US asthma})$ is the rate of asthma among the U.S. population.

We also calculated $P(\text{child}|\text{asthma})$ using Bayes' Theorem:

¹²⁷ Nurmagambetov, Kuwahara, and Garbe, "The Economic Burden of Asthma in the United States, 2008–2013."

$$P(\text{child}|\text{asthma}) = \frac{P(\text{asthma}|\text{child}) \times P(\text{child})}{p(\text{US asthma})}$$

Where:

- $P(\text{asthma}|\text{child})$ is the proportion of children with asthma in the U.S.,
- $P(\text{child})$ is the proportion of children in Michigan, and
- $P(\text{US asthma})$ is the rate of asthma among the U.S. population.

The variables *mean daily wage(work)* and *mean daily wage(school)* were estimated by Nurmagambetov and colleagues. They reported a \$120 (95% CI: \$118.20-\$122.60) mean daily wage for a day of work lost and a \$89.00 (95% CI: \$86.40-\$91.80) mean daily wage for a day of school lost, all in 2015 dollars. These values were converted to 2023 dollars using the 2015 CPI-U annual value and the 2023 CPI-U half1 value.¹²⁸ The CPI-U values were based on the U.S. city average for all items.

We present the formulas, values, and sources for each variable — as well as the ranges and distributions for uncertain estimates — in Table E.2.4.

Table E.2.4: Variables for Saved Asthma Productivity Costs

Variable	Estimate	Lower Bound	Upper Bound	Description	Source	Distribution
P(MI asthma)	0.1150	0.1195	0.1105	Michigan rate of current asthma among U.S. adults	Centers for Disease Control and Prevention 2021 ¹²⁹	Normal SE: 0.0045
PAF_morbidity(asthma_NO ₂)	See section E.2.2.	See Section E.2.2.	See Section E.2.2.	See Section E.2.2.		
Persons per MI household(Census)	2.48	-	-	Mean persons per household in Michigan	United States Census Bureau 2017–2021 ¹³⁰	-
P(asthma adult)	0.08	0.078	0.082	Proportion of adults with asthma	Centers for Disease Control and Prevention 2021 ¹³¹	Normal SE: 0.002
P(adult)	0.79	-	-	Proportion of	United States	-

¹²⁸ The 2023 CPI-U half1 value was used because, at the time of the report, the 2023 annual value had not been released.

¹²⁹ Centers for Disease Control and Prevention, “Most Recent State or Territory Asthma Data.”

¹³⁰ United States Census Bureau, “QuickFacts: Michigan.”

¹³¹ Centers for Disease Control and Prevention, “Most Recent State or Territory Asthma Data.”

				adults in Michigan	Census Bureau 2017–2021 ¹³²	
P(US asthma)	0.077	0.0752	0.0788	Proportion of U.S. population with asthma	Centers for Disease Control and Prevention 2021 ¹³³	Normal SE: 0.0018
Work days lost(asthma)	1.8	1.2	2.4	Incremental work days lost due to asthma per person per year	Nurmagambeto v et al. 2018 ¹³⁴	Normal SE: 0.6
Daily wage(work)	\$153.11	-	-	Mean daily wage for work day lost	Nurmagambeto v et al. 2018 ¹³⁵	
P(asthma child)	0.065	0.0618	0.0682	P(asthma child): proportion of children with asthma	Centers for Disease Control and Prevention 2021 ¹³⁶	Normal SE: 0.0032
P(child)	0.21	-	-	P(child): proportion of children in Michigan	United States Census Bureau 2017–2021 ¹³⁷	-
School days lost(asthma)	2.3	1.9	2.7	Incremental school days lost due to asthma per person per year	Nurmagambeto v et al. 2018 ¹³⁸	Normal SE: 0.4
Daily wage(school)	\$113.55	-	-	Mean daily wage for school day lost	Nurmagambeto v et al. 2018 ¹³⁹	-

¹³² United States Census Bureau, “QuickFacts: Michigan.”

¹³³ Centers for Disease Control and Prevention, “Most Recent State or Territory Asthma Data.”

¹³⁴ Nurmagambetov, Kuwahara, and Garbe, “The Economic Burden of Asthma in the United States, 2008–2013.”

¹³⁵ Nurmagambetov, Kuwahara, and Garbe, “The Economic Burden of Asthma in the United States, 2008–2013.”

¹³⁶ Centers for Disease Control and Prevention, “Most Recent State or Territory Asthma Data.”

¹³⁷ United States Census Bureau, “QuickFacts: Michigan.”

¹³⁸ Nurmagambetov, Kuwahara, and Garbe, “The Economic Burden of Asthma in the United States, 2008–2013.”

¹³⁹ Nurmagambetov, Kuwahara, and Garbe, “The Economic Burden of Asthma in the United States, 2008–2013.”

3. Household COPD impacts (annual)

3.1 Decreased risk of COPD

I calculated the estimate for a decreased risk of COPD morbidity and mortality given a 7.19 decrease in baseline NO₂ concentrations using the following formulas:

$$AdjustedRR_{COPD\ morbidity}(NO_2) = \left[\frac{7.19\ ppb}{5.31\ ppb} \times (RR(COPD\ morbidity|NO_2) - 1) \right] + 1$$

$$AdjustedRR_{COPD\ mortality}(NO_2) = \left[\frac{7.19\ ppb}{5.31\ ppb} \times (RR(COPD\ mortality|NO_2) - 1) \right] + 1$$

Where:

- $RR(COPD\ morbidity|NO_2)$ is the risk ratio of COPD prevalence given a 5.31 ppb change in NO₂, and
- $RR(COPD\ mortality|NO_2)$ is the risk ratio of COPD mortality given a 5.31 ppb change in NO₂.

Here, a risk ratio is the probability of asthma morbidity or mortality given a 5.31 ppb change in NO₂ divided by the probability of COPD given no change in NO₂.

$RR(COPD\ morbidity|NO_2)$ comes from a 2018 meta-analysis, conducted by Zhang and colleagues, that estimated an relative risk ratio of 1.17 (95% CI: 1.046-1.308) — or 1.7% (95% CI: 4.6%-3.1%) increased odds — for adult COPD prevalence due to an increment of 10 ug/m³ of outdoor NO₂ concentrations, which is roughly 5.31 ppb.¹⁴⁰ Assuming linearity, we estimated a 1.23 relative risk ratio (95% CI: 1.06-1.42) — or 23% increased risk (95% CI: 6%-42%) — for COPD risk associated with a 5.31 ppb increase in NO₂.

$RR(COPD\ mortality|NO_2)$ comes from the same analysis. Zhang and colleagues estimated a relative risk ratio of 1.026 (95% CI: 1.017-1.035) — or 2.6% (95% CI: 1.7%-3.5%) increased odds — for adult COPD mortality due to an increment of 5.31 ppb NO₂. Assuming linearity, we estimated a 1.035 relative risk ratio (95% CI: 1.023-1.047) — or 3.5% increased risk (95% CI: 2.3%-4.7%) — for COPD risk associated with a 5.31 ppb increase in NO₂.

We present the estimates and sources — as well as the ranges and distributions — for the variables in Table E.3.1.

Table E.3.1: Variables for Decreased Risk of COPD

Variable	Estimate	Lower Bound	Upper Bound	Description	Source	Distribution
RR(COPD morbidity)	1.17	1.046	1.308	Decreased risk of COPD prevalence per 5.31 ppb decrease in NO ₂	Zhang et al.	Uniform

¹⁴⁰ This conversion was made using the following formula: 24.45 x concentration (ug/m³) ÷ molecular weight. The molecular weight of NO₂ is 46.005 g·mol⁻¹.

NO ₂)					2018 ¹⁴¹	
RR(COPD mortality NO ₂)	1.026	1.017	1.035	Decreased risk of COPD mortality per 5.31 ppb decrease in NO ₂	Zhang et al. 2018 ¹⁴²	Uniform

3.2 Saved COPD DALYs

We estimated the saved COPD DALYs from a 5.31 ppb NO₂ reduction using the following formula:

$$\begin{aligned}
 &COPD\ DALYs(NO_2) \\
 &= \left(\frac{YLDs(COPD)}{100,000}\right) \times PAF_{morbidity}(COPD_{NO_2}) \times VLY(adult) \times Adults\ per\ MI\ Household \\
 &+ \left(\frac{YLLs(COPD)}{100,000}\right) \times PAF_{mortality}(COPD_{NO_2}) \times VLY(adult) \times Adults\ per\ MI\ Household
 \end{aligned}$$

Where:

- $YLDs(COPD)$ are the years lived with a disability for COPD per 100,000 persons in Michigan,
- $YLLs(COPD)$ are the years of life lost for COPD per 100,000 persons in Michigan,
- $PAF_{morbidity}(COPD_{NO_2})$ is the population attributable fraction of COPD morbidity attributed to the higher NO₂ concentrations that are present in homes with gas stoves,
- $PAF_{mortality}(COPD_{NO_2})$ is the population attributable fraction of COPD mortality attributed to the higher NO₂ concentrations that are present in homes with gas stoves,
- $VLY(adult)$ is value of a life year for an adult population, and
- $Adults\ per\ MI\ household(Census)$ is the mean adults per household in Michigan.

$YLDs(COPD)$ and $YLLs(COPD)$ come from the Institute for Health Metrics and Evaluation’s 2019 Global Burden of Disease study.¹⁴³ $COPD\ YLLs$ are calculated using the following formula:

$$YLLs(COPD) = DALYs(COPD) - YLDs(COPD)$$

Where $DALYs(COPD)$ are the disability-adjusted life years for COPD per 100,000 persons in Michigan. $YLDs(COPD)$ and $YLLs(COPD)$ are divided by 100,000 to get per-person estimates.

¹⁴¹ Zili Zhang, Jian Wang, and Wenju Lu, “Exposure to Nitrogen Dioxide and Chronic Obstructive Pulmonary Disease (COPD) in Adults: A Systematic Review and Meta-Analysis,” *Environmental Science and Pollution Research* 25 (2018): 15133–45, <https://doi.org/10.1007/s11356-018-1629-7>.

¹⁴² Zhang, Wang, and Lu, “Exposure to Nitrogen Dioxide and Chronic Obstructive Pulmonary Disease (COPD) in Adults: A Systematic Review and Meta-Analysis.”

¹⁴³ University of Washington, “Global Burden of Disease Compare.”

$PAF_{morbidity}(COPD_{NO_2})$ and $PAF_{mortality}(COPD_{NO_2})$ are population attributable fractions (PAFs). A PAF is a fraction of all cases of a health condition that is attributable to a given risk factor.¹⁴⁴ Here, $PAF_{morbidity}(COPD_{NO_2})$ is the fraction of COPD morbidity — or COPD cases — attributable to the 7.19 ppb-higher NO_2 concentrations present in homes with gas stoves. $PAF_{morbidity}(COPD_{NO_2})$ can be calculated as follows:

$$PAF_{morbidity}(COPD_{NO_2}) = \frac{P(gas_{MI}) \times [AdjustedRR_{COPD\ morbidity}(NO_2) - 1]}{P(gas_{MI}) \times [AdjustedRR_{COPD\ morbidity}(NO_2) - 1] + 1}$$

Where:

- $P(gas_{MI})$ is the proportion of households exposed to increased NO_2 , or the proportion of households with gas stoves in Michigan, and
- $AdjustedRR_{COPD\ morbidity}(NO_2)$ is the risk ratio for COPD morbidity given a 7.19-ppb increase in NO_2 concentrations, where morbidity means having COPD.

Similarly, $PAF_{mortality}(COPD_{NO_2})$ is the fraction of COPD mortality — or COPD deaths — attributable to the 7.19 ppb-higher NO_2 concentrations present in homes with gas stoves. $PAF_{mortality}(COPD_{NO_2})$ can be calculated as follows:

$$PAF_{mortality}(COPD_{NO_2}) = \frac{P(gas_{MI}) \times [AdjustedRR_{COPD\ mortality}(NO_2) - 1]}{P(gas_{MI}) \times [AdjustedRR_{COPD\ mortality}(NO_2) - 1] + 1}$$

Where:

- $P(gas_{MI})$ is the proportion of households exposed to increased NO_2 , or the proportion of households with gas stoves in Michigan, and
- $AdjustedRR_{COPD\ mortality}(NO_2)$ is the risk ratio for COPD mortality given a 7.19-ppb increase in NO_2 concentrations, where mortality means dying from COPD.

The value of a life year (VLY) is derived from the Environmental Protection Agency’s Value of a Statistical Life (VSL), which is \$10,792,889.04 in 2023 dollars. The VSL was then divided by the annuity factor, which assumed a 3.5% social discount rate and a 19.1-year life expectancy.¹⁴⁵

$$VLY = \frac{VSL}{[1 - (1 + 0.035)^{19.1}] / 0.035}$$

We calculated the 19.1-year life expectancy by multiplying the average life expectancy in the United States, 76.4, by 0.25.¹⁴⁶ We chose a 0.25 multiplicative factor to assume a VSL for an adult population, or a

¹⁴⁴ Cheng-Kuan Lin and Szu-Ta Chen, “Estimation and Application of Population Attributable Fraction in Ecological Studies,” *Environmental Health* 18, no. 52 (2019), <https://doi.org/10.1186/s12940-019-0492-4>.

¹⁴⁵ This methodology and the discount rate came from Boardman et al., *Cost-Benefit Analysis: Concepts and Practice*.

¹⁴⁶ Centers for Disease Control and Prevention, “Life Expectancy.”

population with 25 percent of life expectancy remaining. We assumed a VSL for an adult population because, while COPD may be influenced by early life events, it tends to develop in adulthood.¹⁴⁷

The formula includes *Adults per MI household(Census)* instead of *Persons per MI household (Census)* because while COPD development may be influenced by early life events, it tends to develop in adulthood.¹⁴⁸ *Adults per MI household(Census)* is calculated via the following formula:

$$\text{Adults per MI household(Census)} = \text{Persons per MI household(Census)} \times \text{Portion of adults in MI (Census)}$$

Where:

- *Persons per MI household(Census)* is the mean persons per household in Michigan according to the U.S. Census Bureau’s 2017–2021 estimates, and
- *Portion of adults in MI(Census)* is the portion of the Michigan population that is 18 years old or older, according to the U.S. Census Bureau’s 2017–2021 estimates.

We present the values and sources for each variable — as well as the ranges and distributions for uncertain estimates — in Table E.3.2.

Table E.3.2: Variables for Saved COPD DALYs

Variable	Estimate	Lower Bound	Upper Bound	Description	Source	Distribution
DALYs(COPD)	1,797.32	-	-	COPD DALYs per 100,000 population in Michigan	University of Washington 2019 ¹⁴⁹	-
YLDs(COPD)	677.45	-	-	COPD YLDs per 100,000 population in Michigan	University of Washington 2019 ¹⁵⁰	-
AdjustedRR_COPD morbidity(NO ₂)	See Section E.3.1	See Section E.3.1	See Section E.3.1	See Section E.3.1		
AdjustedRR_COPD mortality(NO ₂)	See Section E.3.1	See Section E.3.1	See Section E.3.1	See Section E.3.1		
VLY(adult)	\$784,317.03	-	-	Value of a Life	United States	-

¹⁴⁷ Bush, “COPD: A Pediatric Disease.”

¹⁴⁸ Andrew Bush, “COPD: A Pediatric Disease,” *COPD* 5, no. 1 (February 2008): 53–67, <https://doi.org/10.1080/15412550701815965>.

¹⁴⁹ University of Washington, “Global Burden of Disease Compare.”

¹⁵⁰ University of Washington, “Global Burden of Disease Compare.”

				Year (VLY), adjusted to 2023 dollars.	Environmental Protection Agency n.d. ¹⁵¹	
Persons per MI household (Census)	2.48	-	-	Mean persons per household in Michigan	United States Census Bureau 2017–2021 ¹⁵²	-
Portion of adults in MI(census)	0.79	-	-	Percent of the population 18 years or older	United States Census Bureau 2017–2021 ¹⁵³	-
P(gas_MI)	0.49	-	-	Percentage of households with gas cooktops	Brossman et al. 2023 ¹⁵⁴	

3.3 Saved COPD medical costs

We estimated the saved COPD medical costs from a 5.31-ppb NO₂ reduction using the following formula:

$$\begin{aligned}
 & COPD\ Medical\ Costs(NO_2) \\
 &= P(MI\ COPD) \times PAF_{morbidity}(COPD_{NO_2}) \times Adults\ per\ MI\ household(Census) \\
 &\quad \times Medical\ cost\ per\ person(COPD)
 \end{aligned}$$

Where:

- $P(MI\ COPD)$ is the Michigan prevalence rate of COPD among U.S. adults,
- $PAF_{morbidity}(COPD_{NO_2})$ is the population attributable fraction of COPD morbidity attributed to the higher NO₂ concentrations that are present in homes with gas stoves,
- $Adults\ per\ MI\ household(Census)$ is the mean adults per household in Michigan, and
- $Medical\ cost\ per\ person(COPD)$ is the annual per-person incremental medical cost of COPD.

$P(MI\ COPD)$ is the adult COPD prevalence rate for Michigan. We could not find population-wide or child COPD prevalence rates for Michigan, so we only estimate the medical costs for adults with COPD. We were comfortable using this estimate because, while COPD may be influenced by early life events, it tends to develop in adulthood.¹⁵⁵

We present the formulas, values, and sources for each variable — as well as the ranges and distributions for uncertain estimates — in Table E.3.3.

¹⁵¹ United States Environmental Protection Agency, “Mortality Risk Valuation.”

¹⁵² United States Census Bureau, “QuickFacts: Michigan.”

¹⁵³ United States Census Bureau, “QuickFacts: Michigan.”

¹⁵⁴ Brossman et al., “State Level Residential Building Stock and Energy Efficiency & Electrification Packages Analysis.”

¹⁵⁵ Bush, “COPD: A Pediatric Disease.”

Table E.3.3: Variables for Saved COPD Medical Costs

Variable	Estimate	Lower Bound	Upper Bound	Description	Source	Distribution
P(MI COPD)	0.0750	0.0680	0.0830	Michigan rate of COPD among U.S. adults (assumed to be same for persons in MI homes with gas stoves)	Centers for Disease Control and Prevention n.d. ¹⁵⁶	Normal SE: 0.007
PAF_morbidity(COPD_NO ₂)	See section E.3.2.	See Section E.3.2.	See Section E.3.2.	See Section E.3.2.		
Adults per MI household(Census)	See Section E.3.2	See Section E.3.2	See Section E.3.2	See Section E.3.2		
Medical cost per person (COPD)	\$ 12,440	-	-	Annual per-person incremental medical cost of COPD	Rehman et al. 2019 ¹⁵⁷	-

3.4 Saved COPD productivity costs

We estimated the saved COPD productivity costs from a 5.31 ppb NO₂ reduction using the following formula:

$$\begin{aligned}
 &COPD \text{ Productivity Costs}(NO_2) \\
 &= [P(MI \text{ COPD}) \times PAF_{morbidity}(COPD_{NO_2}) \times Adults \text{ per MI household} \\
 &\times Work \text{ days lost}(COPD) \times Daily \text{ wage}(work)]
 \end{aligned}$$

Where:

- $P(MI \text{ COPD})$ is the Michigan rate of COPD among U.S. adults,
- $PAF_{morbidity}(COPD_{NO_2})$ is the population attributable fraction of COPD morbidity attributed to the higher NO₂ concentrations that are present in homes with gas stoves,
- $Adults \text{ per MI household}(Census)$ is the mean adults per household in Michigan,
- $Work \text{ days lost}(COPD)$ is the incremental work days due to COPD per person per year, and
- $Daily \text{ wage}(work)$ is the mean daily wage for work days lost.

¹⁵⁶ Centers for Disease Control and Prevention, “COPD: State-Level Estimates,” Centers for Disease Control and Prevention, accessed November 21, 2023, <https://www.cdc.gov/copd/data-and-statistics/state-estimates.html>.

¹⁵⁷ Rehman et al., “The Economic Burden of Chronic Obstructive Pulmonary Disease (COPD) in the USA, Europe, and Asia.”

For *Daily wage(work)*, we use the mean daily wage, in 2023 dollars, for work days lost that was estimated by Nurmagambetov and colleagues. We used this same value to calculate saved asthma productivity costs. By using the daily wage from Nurmagambetov and colleagues, we assume that the population affected by asthma is likely to have similar incomes as those affected by COPD.

As with our estimates of saved medical costs, we only estimate the saved COPD productivity costs for adults. This is due to a lack of available data and the fact that COPD tends to develop in adulthood.¹⁵⁸

The formulas, values, and sources for each variable — as well as the ranges and distributions for uncertain estimates — are presented in Table E.3.4.

Table E.3.4: Variables for Saved COPD Productivity Costs

Variable	Estimate	Lower Bound	Upper Bound	Description	Source	Distribution
P(MI COPD)	0.0750	0.0680	0.0830	Michigan rate of COPD among U.S. adults (assumed to be same for persons in MI homes with gas stoves)	Centers for Disease Control and Prevention n.d. ¹⁵⁹	Normal SE: 0.008
PAF_morbidity(COPD_NO ₂)	See section E.3.2.	See section E.3.2.	See section E.3.2.	See section E.3.2.		
Adults per MI household(Census)	See section E.3.2.	See section E.3.2.	See section E.3.2.	See section E.3.2.		
Work days lost (COPD)	5	-	-	Incremental work days lost due to COPD annually per person	Westbroek et al. 2020 ¹⁶⁰	-
Daily wage(work)	\$153.11	-	-	Mean daily wage for work day lost	Nurmagambetov et al. 2018 ¹⁶¹	

¹⁵⁸ Bush, “COPD: A Pediatric Disease.”

¹⁵⁹ Centers for Disease Control and Prevention, “COPD: State-Level Estimates.”

¹⁶⁰ Westbroek et al., “Reducing the Number of Hospitalization Days for COPD.”

¹⁶¹ Nurmagambetov, Kuwahara, and Garbe, “The Economic Burden of Asthma in the United States, 2008–2013.”

Appendix F: CO health impacts monetization methodology

Return to [CO health impacts](#) section.

The value of the CO health impacts for gas and propane stoves, when transitioning to an induction stove, can be written using the following formula:

$$CO(gas) = CO\ Poisoning\ DALYs + CO\ Poisoning\ Medical\ Costs + CO\ Poisoning\ Productivity\ Costs$$

We do not monetize the health impacts in the change of carbon monoxide (CO) concentrations because CO concentrations do not change drastically between homes with natural gas/propane stoves and homes with electric/induction stoves. We found one study that compared CO concentrations between gas stoves with induction stoves and concluded that the 24-hour mean baseline concentrations differed only by 0.6 ppm.¹⁶² Additionally, in all research we found, homes with gas, electric, and induction stoves all reported cooking and baseline CO concentrations within safe bounds, as estimated by the World Health Organization.¹⁶³

1. Saved CO poisoning DALYs per household (annual)

We estimated the saved CO poisoning disability-adjusted life years (DALYs) from a gas-to-induction transition using the following formula:

¹⁶² We Act for Environmental Justice, “Out of Gas, In with Justice: Studying the Impacts of Induction Stoves on Indoor Air Quality in Affordable Housing.”

¹⁶³ Guidelines Review Committee, “WHO Guidelines for Indoor Air Quality: Selected Pollutants” (World Health Organization, 2010), <https://www.bing.com/ck/a?!&&p=a457ae36102d0811JmltdHM9MTcwMjUxMjAwMCZpZ3VpZD0wYmNiOWNhNi00YWM4LTZkYzAtMDgyMC04ZjlmNGJiYzZjOTcmaW5zaWQ9NTIwNA&ptn=3&ver=2&hsh=3&felid=0bcb9ca6-4ac8-6dc0-0820-8f2f4bbc6c97&psq=WHO+guidelines+for+indoor+air+quality%3a+selected+pollutants&u=a1aHR0cHM6Ly93d3cuZ2hvLmludC9wdWJsaWNhdGlvbnMtZGV0YWlsLXJlZGlyZWNoLzk3ODkyODkwMDIxMzQ&ntb=1>; We Act for Environmental Justice, “Out of Gas, In with Justice: Studying the Impacts of Induction Stoves on Indoor Air Quality in Affordable Housing”; Roy Fortmann, Peter Kariher, and Russ Clayton, “Indoor Air Quality: Residential Cooking Exposures” (Research Triangle Park, NC 27709: ARCADIS Geraghty & Miller, Inc., November 30, 2001); Haryono S. Huboyo, Susumu Tohno, and Renqiu Cao, “Indoor PM2.5 Characteristics and CO Concentration Related to Water-Based and Oil-Based Cooking Emissions Using a Gas Stove,” *Aerosol and Air Quality Research* 11, no. 4 (2011): 401–11, <https://doi.org/10.4209/aaqr.2011.02.0016>; Daniel Pope et al., “Real-Life Effectiveness of ‘Improved’ Stoves and Clean Fuels in Reducing PM 2.5 and CO: Systematic Review and Meta-Analysis,” *Environment International* 101 (April 2017): 7–18, <https://doi.org/10.1016/j.envint.2017.01.012>; Vinod Joon, Harshika Kumari, and Avinash Chandra, “Predicting Exposure Levels of Respirable Particulate Matter (PM2.5) and Carbon Monoxide for the Cook from Combustion of Cooking Fuels,” *International Conference on Chemistry and Chemical Process* 10 (2011): 229–32; Jennifer M. Logue et al., “Pollutant Exposures from Natural Gas Cooking Burners: A Simulation-Based Assessment for Southern California,” *Environmental Health Perspectives* 122, no. 1 (January 2014), <https://doi.org/10.1289/ehp.1306673>; L P Naeher et al., “Indoor and Outdoor PM2.5 and CO in High- and Low-Density Guatemalan Villages,” *Journal of Exposure Science & Environmental Epidemiology* 10, no. 6 (November 1, 2000): 544–51, <https://doi.org/10.1038/sj.jea.7500113>.

CO Poisoning DALYs

$$= \frac{DALYs(CO\ Poisoning)}{10,000} \times Proportion\ CO\ poisoning(stove) \times VLY \\ \times Persons\ per\ MI\ household(Census)$$

Where:

- *DALYs(CO Poisoning)* are the disability-adjusted life years for asthma per 10,000 persons in Michigan,
- *Proportion CO poisoning(stove)* is the mean proportion of CO poisoning cases attributable to gas stoves in Michigan (2010–2013),
- *VLY* is the value of a life year for the general population, and
- *Persons per MI household(Census)* is the mean persons per household in Michigan according to the U.S. Census Bureau’s 2017–2021 estimates.

DALYs(CO Poisoning) comes from a 2020 study by Liu and colleagues, which draws data from the 2019 Global Burden of Disease study.¹⁶⁴ *DALYs(CO Poisoning)* are divided by 10,000 to get an estimate of DALYs per person.

We calculated *Proportion CO poisoning(stove)*, or the proportion of CO poisoning attributable to gas stoves in Michigan, by taking the average of the portion of CO poisoning deaths attributable to gas stoves reported in 2010, 2011, 2012, and 2013.¹⁶⁵

We derived the value of a life year (VLY) from the Environmental Protection Agency’s Value of a Statistical Life (VSL), which is \$10,792,889.04 in 2023 dollars.¹⁶⁶ Then, we divided the VSL by the annuity factor, which assumed a 3.5% social discount rate and a 38.2-year life expectancy:

$$VLY = \frac{VSL}{[1 - (1 + 0.035)^{38.2}] / 0.035}$$

The 38.2-year life expectancy was calculated by taking 50 percent of the average life expectancy in the United States, 76.4.¹⁶⁷ Therefore, we assume a VSL for a population that is not skewed older or younger.

We present the values and sources for each variable — as well as the ranges and distributions for uncertain estimates — in Table F.1.

Table F.1: Variables for Saved CO DALYs

Variable	Estimate	Lower	Upper	Description	Source	Distribution
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¹⁶⁴ Fei Liu, Xiangjie Lin, and Mao Zhang, “Global, Regional, and National Burden of Accidental Carbon Monoxide Poisoning, 1990–2019: A Systematic Analysis for the Global Burden of Disease Study 2019,” SSRN, December 30, 2020, <https://doi.org/10.2139/ssrn.3745098>.

¹⁶⁵ Michigan Department of Health and Human Services, “Carbon Monoxide Reports,” Michigan Department of Health and Human Services, 2010-2013, <https://www.michigan.gov/mdhhs/safety-injury-prev/environmental-health/topics/carbonmonoxide/reports>.

¹⁶⁶ This methodology and the discount rate came from Boardman et al., Cost-Benefit Analysis: Concepts and Practice.

¹⁶⁷ Centers for Disease Control and Prevention, “Life Expectancy.”

		Bound	Bound			
DALYs(CO Poisoning)	16.15	-	-	CO poisoning DALYs per 10,000 in high-income North America	Liu et al. 2020 ¹⁶⁸	-
Proportion CO poisoning(stove)	0.0405	-	-	Mean proportion of CO poisoning attributable to gas stoves in Michigan, 2010–2013	Michigan Department of Health and Human Services 2010–2013 ¹⁶⁹	-
VLY	\$516,552.20	-	-	Value of a Life Year (VLY), adjusted to 2023 dollars.	United States Environmental Protection Agency n.d. ¹⁷⁰	-
Persons per MI household(Census)	2.48	-	-	Persons per household in Michigan	United States Census Bureau 2017–2021 ¹⁷¹	-

2. Saved CO poisoning medical hospitalization costs per household (annual)

We estimated the saved carbon monoxide poisoning medical costs from gas-to-induction transition using the following formula:

$$\begin{aligned}
 & \text{CO Poisoning Medical Costs} \\
 & = \frac{(MI \text{ CO poisoning cases} - MI \text{ CO poisoning deaths}) \times \text{Proportion CO poisoning(stove)}}{MI \text{ population}(2010\text{to}2013)} \\
 & \times \text{Proportion of poisonings}(ED \text{ visits}) \times \text{Proportion of ED visits}(hospitalization) \\
 & \times \text{CO poisoning hospitalization cost} \times \text{Persons per MI household}(Census)
 \end{aligned}$$

Where:

- *MI CO poisoning cases* is the mean annual Michigan CO poisoning cases from 2010–2013,

¹⁶⁸ Fei Liu, Xiangjie Lin, and Mao Zhang, “Global, Regional, and National Burden of Accidental Carbon Monoxide Poisoning, 1990–2019: A Systematic Analysis for the Global Burden of Disease Study 2019,” *SSRN*, December 30, 2020, <https://doi.org/10.2139/ssrn.3745098>.

¹⁶⁹ Michigan Department of Health and Human Services, “Carbon Monoxide Reports,” Michigan Department of Health and Human Services, 2010-2013, <https://www.michigan.gov/mdhhs/safety-injury-prev/environmental-health/topics/carbonmonoxide/reports>.

¹⁷⁰ United States Environmental Protection Agency, “Mortality Risk Valuation.”

¹⁷¹ United States Census Bureau, “QuickFacts: Michigan.”

- *MI CO poisoning deaths* is the mean annual Michigan CO poisoning deaths from 2010–2013,
- *Proportion CO poisoning(stove)* is the mean proportion of CO poisoning attributable to gas stoves in Michigan from 2010–2013,
- *MI population(2010to2013)* is the mean Michigan population from 2010–2013,
- *Proportion of poisonings(ED visits)* is the proportion of non-fatal CO poisonings that result in emergency department visits,
- *Proportion of ED visits(hospitalization)* is the proportion of CO poisoning emergency department visits that result in hospitalizations,
- *CO poisoning hospitalization cost* is the average cost per CO poisoning hospitalization, and
- *Persons per MI household(Census)* is the mean persons per household in Michigan according to the U.S. Census Bureau’s 2017–2021 estimates.

MI CO poisoning cases, *MI CO poisoning deaths*, and *Proportion CO poisoning(stoves)* was calculated manually by taking the average of each value from the CO poisoning reports published by the Michigan Department of Health and Human Services from 2010 to 2013. *Mean MI population* was calculated manually by taking the average of the Michigan population estimates in 2010, 2011, 2012, and 2013, as estimated by the National Center for Health Statistics.

CO poisoning hospitalization cost comes from a 2012 study. In this study, Iqbal and colleagues reported a \$11,381 (SE: \$2,522) average per-person cost of a CO poisoning hospitalization in 2007 dollars. This value was converted to 2023 dollars using the 2007 CPI-U annual value and the 2023 CPI-U half1 value.¹⁷² The CPI-U values were based on the U.S. city average for all medical care items.

The values and sources for each variable — as well as the ranges and distributions for uncertain estimates — are presented in Table F.2.

Table F.2: Variables for Saved CO Poisoning Medical Hospitalization Costs

Variable	Estimate	Lower Bound	Upper Bound	Description	Source	Distribution
MI CO poisoning cases	877	-	-	Mean annual Michigan CO poisoning cases, 2010–2013	Michigan Department of Health and Human Services 2010–2013 ¹⁷³	-
MI CO poisoning deaths	26	-	-	Mean annual Michigan CO poisoning deaths, 2010–2013	Michigan Department of Health and Human Services	-

¹⁷² The 2023 CPI-U half1 value was used because, at the time of the report, the 2023 annual value had not been released.

¹⁷³ Michigan Department of Health and Human Services, “Carbon Monoxide Reports.”

					2010–2013 ¹⁷⁴	
Proportion CO poisoning(stove)	0.0405	-	-	Mean proportion of CO poisoning attributable to gas stoves in Michigan, 2010–2013	Michigan Department of Health and Human Services 2010–2013 ¹⁷⁵	-
MI population (2010-2013)	9,892,533	-	-	Mean Michigan population, 2010–2013	National Center for Health Statistics 2020 ¹⁷⁶	-
Proportion of poisonings(ED visits)	0.54	-	-	Proportion of non-fatal CO poisonings that result in ED visits	Hampson 2015 ¹⁷⁷	-
Proportion of ED visits(hospitalizations)	0.095	0.08	0.11	Proportion of ED visits that result in hospitalizations	Hampson 2015 ¹⁷⁸	Uniform
CO poisoning hospitalization costs	\$17,780.94	\$13,840.73	\$21,721.15	Average cost per CO poisoning hospitalization	Iqbal et al. 2012 ¹⁷⁹	Normal SE: 3940.21
Persons per MI household(Census)	2.48	-	-	Persons per household in Michigan	United States Census Bureau 2017–2021 ¹⁸⁰	-

3. Saved CO poisoning productivity hospitalization costs per household (annual)

The estimate of the saved CO poisoning productivity hospitalization costs from a gas-to-induction transition was calculated using the following formula:

¹⁷⁴ Michigan Department of Health and Human Services, “Carbon Monoxide Reports.”

¹⁷⁵ Michigan Department of Health and Human Services, “Carbon Monoxide Reports.”

¹⁷⁶ National Center for Health Statistics, “Total & Senior (Ages 65 & Over) Population, Michigan 2000-2021.”

¹⁷⁷ Neil B. Hampson, “Cost of Accidental Carbon Monoxide Poisoning: A Preventable Expense,” *Preventative Medicine Reports* 3 (2015): 21–24, <https://doi.org/10.1016/j.pmedr.2015.11.010>.

¹⁷⁸ Hampson, “Cost of Accidental Carbon Monoxide Poisoning: A Preventable Expense.”

¹⁷⁹ Shahed Iqbal et al., “Hospital Burden of Unintentional Carbon Monoxide Poisoning in the United States, 2007,” *American Journal of Emergency Medicine* 30 (2012): 657–64, <https://doi.org/10.1016/j.ajem.2011.03.003>.

¹⁸⁰ United States Census Bureau, “QuickFacts: Michigan.”

CO Poisoning Productivity Costs

$$= \frac{(MI\ CO\ poisoning\ cases - MI\ CO\ poisoning\ deaths) \times Proportion\ CO\ poisoning(stove)}{MI\ population(2010 - 2013)}$$

$$\times Proportion\ of\ poisonings(ED\ visits) \times Proportion\ of\ ED\ visits(hospitalization)$$

$$\times [(P(child|CO\ hosp) \times Length\ of\ stay(CO) \times Daily\ wage(school))]$$

$$+ (P(adult|CO\ hosp) \times Length\ of\ stay(CO) \times Daily\ wage(work))]$$

$$\times Persons\ per\ MI\ household(Census)$$

Where:

- *MI CO poisoning cases* is the mean annual Michigan CO poisoning cases from 2010–2013,
- *MI CO poisoning deaths* is the mean annual Michigan CO poisoning deaths from 2010–2013,
- *Proportion CO poisoning(stove)* is the mean proportion of CO poisoning attributable to gas stoves in Michigan from 2010–2013,
- *MI population(2010-2013)* is the mean Michigan population from 2010 to 2013,
- *Proportion of poisonings(ED visits)* is the proportion of non-fatal CO poisonings that result in emergency department visits,
- *Proportion of ED visits(hospitalization)* is the proportion of CO poisoning emergency department visits that result in hospitalizations,
- *P(child|CO hosp)* is the probability of being a child given a carbon monoxide poisoning hospitalization, or the portion of CO poisoning hospitalizations that are children,
- *Length of stay(CO)* is the mean length of stay, in days, of a CO poisoning hospitalization,
- *Daily wage(school)* is the mean daily wage for school days lost, and
- *P(adults|CO hosp)* is the probability of being an adult given a carbon monoxide poisoning hospitalization, or the portion of CO poisoning hospitalizations that are adults,
- *Daily wage(work)* is the mean daily wage for work days lost,
- *Persons per MI household(Census)* is the mean persons per household in Michigan according to the U.S. Census Bureau’s 2017–2021 estimates.

MI CO poisoning cases, *MI CO poisoning deaths*, and *Proportion CO poisoning(stoves)* was calculated manually by taking the average of each value from the CO poisoning reports published by the Michigan Department of Health and Human Services from 2010 to 2013. *Mean MI population* was calculated manually by taking the average of the Michigan population estimates in 2010, 2011, 2012, and 2013, as estimated by the National Center for Health Statistics.

For *Daily wage(work)* and *Daily wage(school)*, we use the same value that we used in calculating saved asthma productivity costs — the mean daily wage, in 2023 dollars, for work days lost that was estimated by Nurmagambetov and colleagues. By using this value, we assume that the population affected by asthma is likely to have similar incomes as those affected by CO poisoning.

We present the values and sources for each variable — as well as the ranges and distributions for uncertain estimates — in Table F.3.

Table F.3: Calculations for Saved CO Poisoning Productivity Hospitalization Costs

Variable	Estimate	Lower Bound	Upper Bound	Description	Source	Distribution
MI CO poisoning cases	877	-	-	Mean annual Michigan CO poisoning cases, 2010–2013	Michigan Department of Health and Human Services 2010–2013 ¹⁸¹	-
MI CO poisoning deaths	26	-	-	Mean annual Michigan CO poisoning deaths, 2010–2013	Michigan Department of Health and Human Services 2010–2013 ¹⁸²	-
Proportion CO poisoning(stove)	0.0405	-	-	Mean proportion of CO poisoning attributable to gas stoves in Michigan, 2010–2013	Michigan Department of Health and Human Services 2010–2013 ¹⁸³	-
MI population (2010-2013)	9,892,533	-	-	Mean Michigan population, 2010–2013	National Center for Health Statistics 2020 ¹⁸⁴	-
Proportion of poisonings(ED visits)	0.54	-	-	Proportion of non-fatal CO poisonings that result in ED visits	Hampson 2015 ¹⁸⁵	-
Proportion of ED visits(hospitalizations)	0.095	0.08	0.11	Proportion of ED visits that result in hospitalizations	Hampson 2015 ¹⁸⁶	Uniform
P(child CO hosp)	0.079	-	-	Proportion of people hospitalized for CO	Iqbal et al.	-

¹⁸¹ Michigan Department of Health and Human Services, “Carbon Monoxide Reports.”

¹⁸² Michigan Department of Health and Human Services, “Carbon Monoxide Reports.”

¹⁸³ Michigan Department of Health and Human Services, “Carbon Monoxide Reports.”

¹⁸⁴ National Center for Health Statistics, “Total & Senior (Ages 65 & Over) Population, Michigan 2000-2021.”

¹⁸⁵ Hampson, “Cost of Accidental Carbon Monoxide Poisoning: A Preventable Expense.”

¹⁸⁶ Hampson, “Cost of Accidental Carbon Monoxide Poisoning: A Preventable Expense.”

				poisoning that are children	2012 ¹⁸⁷	
Length of stay(CO)	4.9	-	-	Mean length of stay (days)	Iqbal et al. 2012 ¹⁸⁸	-
Daily wage(school)	\$113.55	-	-	Mean daily wage for school day lost	Nurmagambetov et al. 2018 ¹⁸⁹	-
P(adult CO hosp)	0.921	-	-	Proportion of people hospitalized for CO poisoning that are adults	Iqbal et al. 2012 ¹⁹⁰	-
Daily wage(work)	\$153.11	-	-	Mean daily wage for work day lost	Nurmagambetov et al. 2018 ¹⁹¹	
Persons per MI household(Census)	2.48	-	-	Persons per household in Michigan	United States Census Bureau 2017–2021 ¹⁹²	-

¹⁸⁷ Iqbal et al., “Hospital Burden of Unintentional Carbon Monoxide Poisoning in the United States, 2007.”

¹⁸⁸ Iqbal et al., “Hospital Burden of Unintentional Carbon Monoxide Poisoning in the United States, 2007.”

¹⁸⁹ Nurmagambetov, Kuwahara, and Garbe, “The Economic Burden of Asthma in the United States, 2008–2013.”

¹⁹⁰ Iqbal et al., “Hospital Burden of Unintentional Carbon Monoxide Poisoning in the United States, 2007.”

¹⁹¹ Nurmagambetov, Kuwahara, and Garbe, “The Economic Burden of Asthma in the United States, 2008–2013.”

¹⁹² United States Census Bureau, “QuickFacts: Michigan.”

Appendix G: PM_{2.5} health impacts monetization methodology

Return to the [PM_{2.5} health impacts](#) section.

Concentration reductions in indoor PM_{2.5} from switching to induction from gas cooktops.

Table G.1: Studies on the PM_{2.5} Emission Reductions as Result of Switching from Gas to Electric Cooktops

Reductions in concentration of PM _{2.5} in indoor air	Units	Study
23.4	%	Buonanno et al. (2009) ¹⁹³
19.3	%	Zhang et al. (2010) ¹⁹⁴
77.7	%	Wallace et al. (2008) ¹⁹⁵
0	%	Rim et al. (2012a) ¹⁹⁶

The background concentration of PM_{2.5} for households in Michigan households with gas cooktops was measured to be around 25 µg/m³. Studies have shown a switch from gas to induction leads to an indoor PM_{2.5} reduction of around 30 percent on average compared to the background concentration with gas cooktops (shown in table above). There for the reduction in Michigan household is calculated as 0.3*25=7.5 µg/m³

Reduction in background P2.5 concentration = Percent reduction in concentration × Background concentration

$$\text{Adjusted RR} = 1 + \frac{\text{Reduction in background PM}_{2.5} \text{ concentration (\%)}}{10 \mu\text{g}/\text{m}^3} \times [\text{RR}(\text{RD}|10\mu\text{g}/\text{m} - 1)]$$

$$\text{Population Attributable Fraction (PAF)} = \frac{P(\text{gas}_M)(\text{adjustedRR} - 1)}{P(\text{gas}_{MI})(\text{adjustedRR} - 1) + 1}$$

¹⁹³ Buonanno, G., Lidia Morawska, and L. J. A. E. Stabile. "Particle emission factors during cooking activities." *Atmospheric Environment* 43, no. 20 (2009): 3235-3242.

¹⁹⁴ Zhang, Qunfang, Roja H. Gangupomu, David Ramirez, and Yifang Zhu. "Measurement of ultrafine particles and other air pollutants emitted by cooking activities." *International journal of environmental research and public health* 7, no. 4 (2010): 1744-1759.

¹⁹⁵ Wallace, Lance, and Wayne Ott. "Personal exposure to ultrafine particles." *Journal of exposure science & environmental epidemiology* 21, no. 1 (2011): 20-30.

¹⁹⁶ Rim, Donghyun, Michal Green, Lance Wallace, Andrew Persily, and Jung-Il Choi. "Evolution of ultrafine particle size distributions following indoor episodic releases: relative importance of coagulation, deposition and ventilation." *Aerosol Science and Technology* 46, no. 5 (2012): 494-503.

Where P is the prevalence of gas cooktops.¹⁹⁷

Table G.2: Summary of Data on Health Impacts in the Form of Respiratory Diseases, Used to Calculate the Impact Burden Attributable to Gas Cooktops

Variable	Estimate	Lower Bound	Upper Bound	Description	Source	Distribution
DALYs (RD)	2468	-	-	RD DALYs per 100,000 population in Michigan	University of Washington 2019 ¹⁹⁸	-
YLL: Year of life lost	1307	-	-	RD YLL per 100,000 population in Michigan	University of Washington 2019 ¹⁹⁹	
YLD: Year lived with disability	1161	-	-	RD YLD per 100,000 population in Michigan	University of Washington 2019 ²⁰⁰	
RR mortality (RD 10ug/m ³)	1.0069	1.0057	1.0096	Relative risk of mortality associated with each 10 µg/m ³ increase in indoor PM _{2.5}	Samoli et al., 2013 ²⁰¹ Lee et al., 2015 ²⁰² Li et al., 2013 ²⁰³	Uniform

¹⁹⁷ Levin, M. L. "Symposium on epidemiology of cancer of lung: Occurrence of lung cancer in man." *Acta Unio Int Contra Cancrum* 9 (1953): 531-541.

¹⁹⁸ University of Washington, "Global Burden of Disease Compare."

¹⁹⁹ University of Washington, "Global Burden of Disease Compare."

²⁰⁰ University of Washington, "Global Burden of Disease Compare."

²⁰¹ Samoli, Evangelia, Massimo Stafoggia, Sophia Rodopoulou, Bart Ostro, Christophe Declercq, Ester Alessandrini, Julio Díaz et al. "Associations between fine and coarse particles and mortality in Mediterranean cities: results from the MED-PARTICLES project." *Environmental health perspectives* 121, no. 8 (2013): 932-938.

²⁰² Lee, Hyewon, Yasushi Honda, Masahiro Hashizume, Yue Leon Guo, Chang-Fu Wu, Haidong Kan, Kweon Jung, Youn-Hee Lim, Seungmuk Yi, and Ho Kim. "Short-term exposure to fine and coarse particles and mortality: a multicity time-series study in East Asia." *Environmental Pollution* 207 (2015): 43-51.

²⁰³ vent

Adjusted RR of mortality	1.005	-	-	-	-	
RR morbidity (RD 10ug/m ³)	1.015	1.001	1.05	Relative risk of morbidity associated with each 10 µg/m ³ increase in indoor PM _{2.5}	Rodopoulou et al. 2014 ²⁰⁴ ; Michikawa et al. 2014 ²⁰⁵ ; Li et al. 2013 ²⁰⁶	Uniform
Adjusted RR of morbidity	1.01125		-	-	-	
P(gas_MI)	0.49			Percentage of households with gas cooktops	Brossman et al. 2023 ²⁰⁷	
VLY	\$516,552.20	-	-	Value of a Life Year (VLY), adjusted to 2023 dollars.	United States Environmental Protection Agency n.d. ²⁰⁸	-
Persons per MI household (Census)	2.48	-	-	Mean persons per household in Michigan	United States Census Bureau 20172021 ²⁰⁹	-

²⁰⁴ Rodopoulou, Sophia, Evangelia Samoli, Marie-Cecile G. Chalbot, and Ilias G. Kavouras. "Air pollution and cardiovascular and respiratory emergency visits in Central Arkansas: a time-series analysis." *Science of the total environment* 536 (2015): 872-879.

²⁰⁵ Michikawa, Takehiro, Kayo Ueda, Ayano Takeuchi, Makoto Kinoshita, Hiromi Hayashi, Takamichi Ichinose, and Hiroshi Nitta. "Impact of short-term exposure to fine particulate matter on emergency ambulance dispatches in Japan." *J Epidemiol Community Health* 69, no. 1 (2015): 86-91.

²⁰⁶ Li, Zhisheng, Qingmei Wen, and Ruilin Zhang. "Sources, health effects and control strategies of indoor fine particulate matter (PM_{2.5}): A review." *Science of the Total Environment* 586 (2017): 610-622.

²⁰⁷ Brossman et al., "State Level Residential Building Stock and Energy Efficiency & Electrification Packages Analysis."

²⁰⁸ United States Environmental Protection Agency, "Mortality Risk Valuation."

²⁰⁹ United States Census Bureau, "QuickFacts: Michigan."

$$YLL = DALYs - YLD$$

$$\text{Attributable DALYs from RD to shift from gas to induction} = YLL_{RD} * PAF_{\text{mortality}} + YLD_{RD} * PAF_{\text{morbidity}}$$

DALYs from Cardiovascular diseases

Table G.3: Summary of Data on Health Impacts in the Form of Cardiovascular Diseases, Used to Calculate the Impact Burden Attributable to Gas Cooktops

Variable	Estimate	Lower Bound	Upper Bound	Description	Source	Distribution
DALYs (CVD)	6516	-	-	CVD DALYs per 100,000 population in Michigan	University of Washington 2019 ²¹⁰	-
YLL	5640			CVD YLL per 100,000 population in Michigan	University of Washington 2019 ²¹¹	
YLD	876			CVD YLD per 100,000 population in Michigan	University of Washington 2019 ²¹²	
RRmortality(RD 10ug/m ³)	1.07	1.04	1.14	Relative risk of mortality associated with each 10 µg/m ³ increase in indoor PM _{2.5}	Lepeule et al., 2012 ²¹³ (Harvard six cities study)	Uniform
Adjusted RR of mortality	1.0525					
RRmorbidity(RD 10ug/m ³)	1.015	1.01	1.042	Relative risk of morbidity associated with each 10 µg/m ³ increase in indoor PM _{2.5}	Rodopoulou et al.,	Uniform

²¹⁰ University of Washington, "Global Burden of Disease Compare."

²¹¹ University of Washington, "Global Burden of Disease Compare."

²¹² University of Washington, "Global Burden of Disease Compare."

²¹³ Lepeule, Johanna, Francine Laden, Douglas Dockery, and Joel Schwartz. "Chronic exposure to fine particles and mortality: an extended follow-up of the Harvard Six Cities study from 1974 to 2009." *Environmental health perspectives* 120, no. 7 (2012): 965-970.

2015²¹⁴

(for Arkansas)

Adjusted RR of morbidity 1.01125

P(gas_MI) 0.49

Percentage of households with gas cooktops

Brossman et al. 2023²¹⁵

VLY \$516,552.2 - -
0

Value of a Life Year (VLY), adjusted to 2023 dollars.

United States Environmental Protection Agency n.d.²¹⁶ -

Persons per MI household (Census) 2.48 - -

Mean persons per household in Michigan

United States Census Bureau 2017–2021²¹⁷ -

$YLL = DALYs - YLD$

Attributable DALYs from CVD to shift from gas to induction =

$$YLL_{CVD} * PAF_{mortality} + YLD_{CVD} * PAF_{morbidity}$$

Avoided productivity costs

Table G.4: Summary of Data on Hospitalization Due to RD and CVD for Michigan (Year 2020)

Variable	Estimate by disease	Units	Source
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²¹⁴ Rodopoulou, Sophia, Evangelia Samoli, Marie-Cecile G. Chalbot, and Ilias G. Kavouras. "Air pollution and cardiovascular and respiratory emergency visits in Central Arkansas: a time-series analysis." *Science of the total environment* 536 (2015): 872-879.

²¹⁵ Brossman et al., "State Level Residential Building Stock and Energy Efficiency & Electrification Packages Analysis."

²¹⁶ United States Environmental Protection Agency, "Mortality Risk Valuation."

²¹⁷ United States Census Bureau, "QuickFacts: Michigan."

Number of hospital visits due to RD and CVD	RD: 3340 CVD: 28090	number/100000 residents	MDCH 2020 ²¹⁸
Average length of hospital visit for RD patient	RD: 3.7 CVD: 5.4	Days per visit	MDCH 2020 ²¹⁹
Average cost of hospitalization for RD and CVD treatment	RD: 9000 CVD: 15000	\$/visit	McDermott and Roemer 2021 ²²⁰

$\$ = (\text{Number of hospital visits due to RD} * \text{PAF morbidity} * \text{average length of visit} + \text{Number of hospital visits due to CVDD} * \text{PAF morbidity} * \text{average length of visit}) * \text{Daily wage}$

Avoided medical costs

RD \$ = Number of hospitals visits due to RD * PAF morbidity * average cost of hospitalization per visit

CVD \$ = Number of hospitals visits due to CVD * PAF morbidity * average cost of hospitalization per visit

Total avoided costs

$$PM2.5(gas) = \frac{\text{Avoided medical cost} + \text{Avoided loss of productivity cost} + (\text{DALYs from CVD and RD}) * VLY}{100000} \times 2.48 \text{ per Household}$$

²¹⁸ Michigan Department of Community Health (MDCH): Top 20 hospitalization conditions, Michigan 2020. (n.d). <https://www.mdch.state.mi.us/osr/chi/HOSPDX/YEAR/DIAGAGE/LHDs/LST31L15.ASP>

²¹⁹ Michigan Department of Community Health (MDCH): Top 20 hospitalization conditions, Michigan 2020. (n.d). <https://www.mdch.state.mi.us/osr/chi/HOSPDX/YEAR/DIAGAGE/LHDs/LST31L15.ASP>

²²⁰ McDermott, Kimberly W., and Marc Roemer. "Most frequent principal diagnoses for inpatient stays in US hospitals, 2018." (2021).

Appendix H: Safety impacts monetization methodology

Return to the [Safety impacts](#) section.

The value of the safety impacts for households with gas and propane stoves, when transitioning to an induction stove, can be written using the following formula:

$$\text{Safety}(gas) = [\text{Injuries}(gas) - \text{Injuries}(induction)] + [\text{Deaths}(gas) - \text{Deaths}(electric)] \\ + [\text{Property damage}(gas) - \text{Property damage}(electric)]$$

As this formula shows, we assume that the rate of deaths and property damage caused by stove-related fires does not differ between electric and induction stoves.

The value of the safety impacts for households with electric stoves, when transitioning to an induction stove, can be written using the following formula:

$$\text{Safety}(electric) = \text{Injuries}(electric) - \text{Injuries}(induction)$$

Because we assume that the rate of deaths and property damage caused by stove-related fires does not differ between electric and induction stoves, the only difference in safety impacts between gas and induction stoves is in the frequency of injury.

1. Stove-related injuries per household (annual)

1.1 Expected cost of stove-related injuries per household with a gas stove

We estimated the average value of stove-related injuries in a household with a gas stove using the following formula:

$$\text{Injuries}(gas) = [P(\text{injury}|gas) \times P(\text{hosp}) \times \text{Shadow price}(\text{hosp})] \\ + [P(\text{injury}|gas) \times P(\text{no hosp}) \times \text{Shadow price}(\text{no hosp})]$$

Where:

- $P(\text{injury}|gas)$ is the probability of a stove-related burn or soft tissue injury given the presence of a gas stove,
- $P(\text{hosp})$ is the probability of hospitalization from a stove-related injury,
- $\text{Shadow price}(\text{hosp})$ is the shadow price of hospitalized injuries,
- $P(\text{no hosp})$ is the probability of not being hospitalized from a stove-related injury, and
- $\text{Shadow price}(\text{no hosp})$ is the shadow price of non-hospitalized injuries.

We calculated $P(\text{injury}|gas)$ using the Bayes' Theorem:

$$P(\text{injury}|gas) = \frac{P(gas|\text{injury}) \times P(\text{injury})}{P(gas)}$$

Where:

- $P(gas|injury)$ is the probability of a gas stove being associated with a stove-related burn or soft tissue injury,
- $P(injury)$ is the probability of a stove-related burn or injury for households with stoves, and
- $P(gas)$ is the probability of a household having a gas stove.

We calculated $P(gas|injury)$, $P(injury)$, and $P(gas)$ using the following formulas:

$$P(gas|injury) = \frac{Injury(gas)}{Injury(stove\ specified)}$$

Where:

- $Injury(gas)$ is the annual number of burns and soft tissue injuries specified as involving gas stoves in the U.S., and
- $Injury(stove\ specified)$ is the annual number of U.S. annual burns and soft tissue injuries where the stove was specified.

$$P(injury) = \frac{Injury(all\ stoves)}{EIA\ Households(all\ stoves)}$$

Where:

- $Injury(all\ stoves)$ is the annual number of stove-related burns and soft tissue injuries in the U.S., and
- $EIA\ Households(all\ stoves)$ is the number of households with stoves in the U.S.

$$P(gas) = \frac{EIA\ Households(gas)}{EIA\ Households(all\ stoves)}$$

Where:

- $EIA\ Households(gas)$ is the number of households with gas stoves in the U.S., and
- $EIA\ Households(all\ stoves)$ is the number of households with stoves in the U.S.

We calculated $EIA\ Households(gas)$ and $EIA\ Households(all\ stoves)$ — the number of households with gas and all stoves — by taking the average of the 2016 and 2020 number of households that have natural gas and propane stoves from the U.S. Energy Information Administration’s Residential Energy Consumption Survey. We took the average of the 2016 and 2020 estimates because the NEISS stove-related injury data spanned from 2016 to 2020.

Boardman and colleagues estimated a \$75,020.00 shadow price of hospitalized injuries and a \$1,337.82 shadow price of non-hospitalized injuries in 2016 dollars. This value was converted to 2023 dollars using the 2016 CPI-U annual value and the 2023 CPI-U half1 value. We used the 2023 CPI-U half1 value because, at the time of the report, the 2023 annual value had not been released. The CPI-U values were based on the U.S. city average for all medical care items.

We present the values and sources for each variable — as well as the ranges and distributions for uncertain estimates — in Table H.1.1.

Table H.1.1: Variables for Stove-Related Injuries per Household with NG/Propane Stove

Variable	Estimate	Lower Bound	Upper Bound	Description	Source	Distribution
EIA Households(gas)	40,250,000	-	-	U.S. households with natural gas or propane stoves (average of 2015 and 2020 national estimates)	U.S. EIA 2015; U.S. EIA 2020 ²²¹	-
EIA Households(all stoves)	109,160,000	-	-	U.S. households with stoves	U.S. EIA 2015; U.S. EIA 2020 ²²²	-
Injury(gas)	4,554	3,020	6,089	U.S. annual burns and soft tissue injuries specified as involving gas stoves	NEISS 2016–2020 ²²³	Normal SE: 1535
Injury(stove specified)	19,862	11,065	28,659	Number of U.S. annual burns and soft tissue injuries where the stove was specified	NEISS 2016–2020 ²²⁴	Normal SE: 8797
Injury(all stoves)	136,999	105,627	168,370	Number of U.S. annual stove-related burns and soft tissue injuries	NEISS 2016–2020 ²²⁵	Normal SE: 31372
P(hosp)	0.0560	-	-	Probability of hospitalization from a stove-related injury	Sivam et al.	-

²²¹ United States Energy Information Administration, “2015 RECS Survey Data” (Residential Energy Consumption Survey, 2015), <https://www.eia.gov/consumption/residential/data/2015/>; United States Energy Information Administration, “2020 RECS Survey Data” (Residential Energy Consumption Survey, 2020), <https://www.eia.gov/consumption/residential/data/2020/index.php?view=characteristics#appliances>.

²²² United States Energy Information Administration, “2015 RECS Survey Data”; United States Energy Information Administration, “2020 RECS Survey Data.”

²²³ National Electronic Injury Surveillance System, “National Estimate of Injuries Treated in Emergency Departments by PROD, Treatment Dates: 2016, 2017, 2018, 2019, 2020,” 2020 2016, <https://www.cpsc.gov/Research--Statistics/NEISS-Injury-Data>.

²²⁴ National Electronic Injury Surveillance System, “National Estimate of Injuries Treated in Emergency Departments by PROD, Treatment Dates: 2016, 2017, 2018, 2019, 2020.”

²²⁵ National Electronic Injury Surveillance System, “National Estimate of Injuries Treated in Emergency Departments by PROD, Treatment Dates: 2016, 2017, 2018, 2019, 2020.”

					2013 ²²⁶	
Shadow price(hosp)	\$88,738.38	-	-	Shadow price of hospitalized injuries	Boardman et al. 2016 ²²⁷	-
P(no hosp)	0.9440	-	-	P(no hosp) — probability of not being hospitalized from a stove-related injury	Sivam et al. 2013 ²²⁸	-
Shadow price(no hosp)	\$ 1,337.82	-	-	Shadow price of non-hospitalized injuries	Boardman et al. 2016 ²²⁹	-

1.2 Expected cost of stove-related injuries per household with an electric stove

We calculated the average value of stove-related injuries in a household with an electric stove using the following formula:

$$\begin{aligned}
 \text{Injuries}(\text{electric}) &= [P(\text{injury}|\text{electric}) \times P(\text{hosp}) \times \text{Shadow price}(\text{hosp})] \\
 &+ [P(\text{injury}|\text{electric}) \times P(\text{no hosp}) \times \text{Shadow price}(\text{no hosp})]
 \end{aligned}$$

Where:

- $P(\text{injury}|\text{electric})$ is the probability of a stove-related burn or soft tissue injury given the presence of an electric stove,
- $P(\text{hosp})$ is the probability of hospitalization from a stove-related injury,
- $\text{Shadow price}(\text{hosp})$ is the shadow price of hospitalized injuries,
- $P(\text{no hosp})$ is the probability of not being hospitalized from a stove-related injury, and
- $\text{Shadow price}(\text{no hosp})$ is the shadow price of non-hospitalized injuries.

$P(\text{injury}|\text{electric})$ was calculated using the Bayes' Theorem:

$$P(\text{injury}|\text{electric}) = \frac{P(\text{electric}|\text{injury}) \times P(\text{injury})}{P(\text{electric})}$$

Where:

- $P(\text{electric}|\text{injury})$ is the probability of an electric stove being associated with a stove-related burn or soft tissue injury,

²²⁶ Anita Sivam, Lynne M. Rochette, and Gary A. Smith, "Stove-Related Injuries Treated in EDs in the United States, 1990-2010" 31, no. 11 (September 14, 2013): 1571–77, <https://doi.org/10.1016/j.ajem.2013.07.034>.

²²⁷ Boardman et al., *Cost-Benefit Analysis: Concepts and Practice*.

²²⁸ Sivam, Rochette, and Smith, "Stove-Related Injuries Treated in EDs in the United States, 1990-2010."

²²⁹ Boardman et al., *Cost-Benefit Analysis: Concepts and Practice*.

- $P(injury)$ is the probability of a stove-related burn or injury for households with stoves, and
- $P(electric)$ is the probability of a household having an electric stove.

$P(electric|injury)$, $P(injury)$, and $P(electric)$ are calculated using the following formulas:

$$P(electric|injury) = \frac{Injury(electric)}{Injury(stove\ specified)}$$

Where:

- $Injury(electric)$ is the annual number of burns and soft tissue injuries specified as involving electric stoves in the U.S., and
- $Injury(stove\ specified)$ is the annual number of U.S. annual burns and soft tissue injuries where the stove was specified.

$$P(injury) = \frac{Injury(all\ stoves)}{EIA\ Households(all\ stoves)}$$

Where:

- $Injury(all\ stoves)$ is the annual number of stove-related burns and soft tissue injuries in the U.S., and
- $Households(all\ stoves)$ is the number of households with stoves in the U.S.

$$P(electric) = \frac{EIA\ Households(electric)}{EIA\ Households(all\ stoves)}$$

Where:

- $EIA\ Households(electric)$ is the number of households with electric stoves in the U.S., and
- $EIA\ Households(all\ stoves)$ is the number of households with stoves in the U.S.

We calculated $EIA\ Households(electric)$ and $EIA\ Households(all\ stoves)$ — the number of households with electric and all stoves — by taking the average of the 2016 and 2020 number of households that have natural gas and propane stoves from the U.S. Energy Information Administration’s Residential Energy Consumption Survey. We took the average of the 2016 and 2020 estimates because the NEISS stove-related injury data spanned from 2016 to 2020.

Boardman and colleagues estimated a \$75,020.00 shadow price of hospitalized injuries and a \$1,337.82 shadow price of non-hospitalized injuries in 2016 dollars. This value was converted to 2023 dollars using the 2016 CPI-U annual value and the 2023 CPI-U half1 value. The CPI-U values were based on the U.S. city average for all medical care items.

We present the values and sources for each variable – as well as the ranges and distributions for uncertain estimates – in Table H.1.2.

Table H.1.2: Variables for Stove-Related Injuries per Household with Electric Stove

Variable	Estimate	Lower Bound	Upper Bound	Description	Source	Distribution
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EIA Households(electric)	65,980,000	-	-	U.S. households with electric stoves (average of 2015 and 2020 national estimates)	U.S. EIA 2015; U.S. EIA 2020 ²³⁰	-
EIA Households(all stoves)	109,160,000	-	-	U.S. households with stoves	U.S. EIA 2015; U.S. EIA 2020 ²³¹	-
Injury(electric)	13,560	7,333	19,786	U.S. annual burns and soft tissue injuries specified as involving electric	NEISS 2016–2020 ²³²	Normal SE: 6227
Injury(stove specified)	19,862	11,065	28,659	Number of U.S. annual burns and soft tissue injuries where the stove was specified	NEISS 2016–2020 ²³³	Normal SE: 8797
Injury(all stoves)	136,999	105,627	168,370	Number of U.S. annual stove-related burns and soft tissue injuries	NEISS 2016–2020 ²³⁴	Normal SE: 31372
P(hosp)	0.0560	-	-	Probability of hospitalization from a stove-related injury	Sivam et al. 2013 ²³⁵	-
Shadow price(hosp)	\$88,738.38	-	-	Shadow price of hospitalized injuries	Boardman et al. 2016 ²³⁶	-
P(no hosp)	0.9440	-	-	P(no hosp) — probability of not being hospitalized	Sivam et al. 2013 ²³⁷	-

²³⁰ United States Energy Information Administration, “2015 RECS Survey Data”; United States Energy Information Administration, “2020 RECS Survey Data.”

²³¹ United States Energy Information Administration, “2015 RECS Survey Data”; United States Energy Information Administration, “2020 RECS Survey Data.”

²³² National Electronic Injury Surveillance System, “National Estimate of Injuries Treated in Emergency Departments by PROD, Treatment Dates: 2016, 2017, 2018, 2019, 2020.”

²³³ National Electronic Injury Surveillance System, “National Estimate of Injuries Treated in Emergency Departments by PROD, Treatment Dates: 2016, 2017, 2018, 2019, 2020.”

²³⁴ National Electronic Injury Surveillance System, “National Estimate of Injuries Treated in Emergency Departments by PROD, Treatment Dates: 2016, 2017, 2018, 2019, 2020.”

²³⁵ Sivam, Rochette, and Smith, “Stove-Related Injuries Treated in EDs in the United States, 1990-2010.”

²³⁶ Boardman et al., *Cost-Benefit Analysis: Concepts and Practice*.

²³⁷ Sivam, Rochette, and Smith, “Stove-Related Injuries Treated in EDs in the United States, 1990-2010.”

				from a stove-related injury	
Shadow price(no hosp)	\$ 1,337.82	-	-	Shadow price of non-hospitalized injuries	Boardman et al. 2016 ²³⁸ -

1.3 Expected cost of stove-related injuries per household with an induction stoves

The estimated average value of stove-related injuries in a household with an induction stove was calculated using the following formula:

$$\begin{aligned}
 & \text{Injuries(induction)} \\
 &= [P(\text{injury}|\text{induction}) \times P(\text{hosp}) \times \text{Shadow price}(\text{hosp})] \\
 &+ [P(\text{injury}|\text{induction}) \times P(\text{no hosp}) \times \text{Shadow price}(\text{no hosp})]
 \end{aligned}$$

Where:

- $P(\text{injury}|\text{induction})$ is the probability of a stove-related burn or soft tissue injury given the presence of an induction stove,
- $P(\text{hosp})$ is the probability of hospitalization from a stove-related injury,
- $\text{Shadow price}(\text{hosp})$ is the shadow price of hospitalized injuries,
- $P(\text{no hosp})$ is the probability of not being hospitalized from a stove-related injury, and
- $\text{Shadow price}(\text{no hosp})$ is the shadow price of non-hospitalized injuries.

Induction stoves are not detailed in NEISS injury data or U.S. Energy Information Administration stove data. However, according to Sivam and colleagues, 37.5 percent of burns and soft tissue injuries are caused by contact with stove parts.²³⁹ Induction stoves would eliminate that risk because they generate heat through a magnetic field. Therefore, $P(\text{injury}|\text{induction})$ was calculated using the following formula:

$$P(\text{injury}|\text{induction}) = (1 - \text{Injury}(\text{contact})) \times P(\text{injury}|\text{electric})$$

Where:

- $\text{Injury}(\text{contact})$ is the proportion of stove related injuries caused by contact with stove types.

Because of the lack of injury and stove-related data for induction stoves, and because induction stoves can be classified as electric stoves, we keep the other values that make up $P(\text{injury}|\text{induction})$ constant — namely, $P(\text{injury})$ and $P(\text{electric})$.

Boardman and colleagues estimated a \$75,020.00 shadow price of hospitalized injuries and a \$1,337.82 shadow price of non-hospitalized injuries in 2016 dollars. This value was converted to 2023 dollars using the 2016 CPI-

²³⁸ Boardman et al., *Cost-Benefit Analysis: Concepts and Practice*.

²³⁹ Sivam, Rochette, and Smith, “Stove-Related Injuries Treated in EDs in the United States, 1990-2010.”

U annual value and the 2023 CPI-U half1 value. The CPI-U values were based on the U.S. city average for all medical care items.

The values and sources for each variable — as well as the ranges and distributions for uncertain estimates — are presented in Table H.1.3.

Table H.1.3: Variables for Stove-Related Injuries per Household with Induction Stove

Variable	Estimate	Lower Bound	Upper Bound	Description	Source	Distribution
P(injury electric)	See Section H.1.2.	See Section H.1.2.	See Section H.1.2.	See Section H.1.2.		
Injury(contact)	0.375	-	-	Proportion of stove-related injuries caused by contact with stove types	Sivam et al. 2013 ²⁴⁰	-
P(hosp)	0.0560	-	-	Probability of hospitalization from a stove-related injury	Sivam et al. 2013 ²⁴¹	-
Shadow price(hosp)	\$88,738.38	-	-	Shadow price of hospitalized injuries	Boardman et al. 2016 ²⁴²	-
P(no hosp)	0.9440	-	-	P(no hosp) - probability of not being hospitalized from a stove-related injury	Sivam et al. 2013 ²⁴³	-
Shadow price(no hosp)	\$ 1,337.82	-	-	Shadow price of non-hospitalized injuries	Boardman et al. 2016 ²⁴⁴	-

2. Deaths from stove-related fires (annual)

2.1 Expected cost of deaths from stove-related fires per household with a gas stove

We calculated the average value of deaths from stove-related fires in a household with a gas stove using the following formula:

²⁴⁰ Sivam, Rochette, and Smith, “Stove-Related Injuries Treated in EDs in the United States, 1990-2010.”

²⁴¹ Sivam, Rochette, and Smith, “Stove-Related Injuries Treated in EDs in the United States, 1990-2010.”

²⁴² Boardman et al., *Cost-Benefit Analysis: Concepts and Practice*.

²⁴³ Sivam, Rochette, and Smith, “Stove-Related Injuries Treated in EDs in the United States, 1990-2010.”

²⁴⁴ Boardman et al., *Cost-Benefit Analysis: Concepts and Practice*.

$$Deaths(gas) = P(death|gas) \times VSL$$

Where:

- $P(death|gas)$ is the probability of a stove fire-related death given the presence of a gas stove, and
- VSL is the value of a statistical life.

$P(death|gas)$ was calculated using Bayes' Theorem:

$$P(death | gas) = \frac{P(gas | death) P(death)}{P(gas)}$$

Where:

- $P(gas | death)$ is the probability of the presence of a gas stove given a stove fire-related death, or the probability that a stove-related death involves a gas stove,
- $P(death)$ is the probability of a stove fire-related death occurring in a household with a stove, and
- $P(gas)$ is the probability of a household having a gas stove.

$P(gas | death)$, $P(death)$, and $P(gas)$ are calculated using the following formulas:

$$P(gas|death) = \frac{Deaths(gas)}{Deaths(all stoves)}$$

Where:

- $Deaths(gas)$ is the mean annual deaths from gas stove-related fires from 2017–2021, and
- $Deaths(all stoves)$ is the mean annual deaths from all stove-related fires, 2017–2021.

$$P(death) = \frac{Deaths(all stoves)}{NFPA Households(all stoves)}$$

Where:

- $Deaths(all stoves)$ is the mean annual deaths from all stove-related fires, 2017–2021, and
- $Households(all stoves)$ is the number of households with any kind of stove.

$$P(gas) = \frac{NFPA Households(gas)}{NFPA Households(all stoves)}$$

Where:

- $NFPA Households(gas)$ is the number of households with gas stoves, and
- $Households(all stoves)$ is the number of households with any kind of stove.

For stove-related injuries, households with different types of stoves are estimated using estimates from the U.S. EIA. However, in this section, we estimate households with different types of stoves using the same source

that estimates the stove fire-related deaths data.²⁴⁵ We use the same source, instead of the EIA, to improve the accuracy of the probabilities by maintaining internal methodological consistency.

The Environmental Protection Agency estimates the Value of a Statistical Life (VSL) at \$7.4 million in 2006 dollars.²⁴⁶ We convert this value into 2023 dollars using the CPI-U annual average for 2006 and the CPI-U half average for 2023.

We present the values and sources for each variable — as well as the ranges and distributions for uncertain estimates — in Table H.2.1.

Table H.2.1: Variables for Stove-Related Fire Deaths per Household with Natural Gas/Propane Stove

Variable	Estimate	Lower Bound	Upper Bound	Description	Source	Distribution
NFPA Households(gas)	46,700,000	-	-	The number of households with gas stoves	Hall and McGree 2023 ²⁴⁷	-
NFPA Households(all stoves)	130,500,000	-	-	The number of households with stoves (all)	Hall and McGree 2023 ²⁴⁸	-
Deaths(gas)	92	-	-	Mean annual deaths from gas stove-related fires, 2017–2021	Hall and McGree 2023 ²⁴⁹	-
Deaths(all stoves)	414	-	-	Mean annual deaths from all stove related fires, 2017–2021	Hall and McGree 2023 ²⁵⁰	-
VSL	\$10,792,889.04	-	-	Value of a statistical life (VSL) in 2023 dollars	United States Environmental Protection Agency n.d. ²⁵¹	-

²⁴⁵ Shelby Hall and Tucker McGree, “Home Cooking Fires: Supporting Tables” (National Fire Protection Association, September 2023).

²⁴⁶ United States Environmental Protection Agency, “Mortality Risk Valuation.”

²⁴⁷ Shelby Hall and Tucker McGree, “Home Cooking Fires: Supporting Tables” (National Fire Protection Association, September 2023).

²⁴⁸ Hall and McGree, “Home Cooking Fires: Supporting Tables.”

²⁴⁹ Hall and McGree, “Home Cooking Fires: Supporting Tables.”

²⁵⁰ Hall and McGree, “Home Cooking Fires: Supporting Tables.”

²⁵¹ United States Environmental Protection Agency, “Mortality Risk Valuation.”

2.2 Expected cost of deaths from stove-related fires per household with an electric/induction stove

The estimated average value of stove-related injuries in a household with an electric or induction stove was calculated using the following formula:

$$Deaths(electric) = P(death|electric) \times VSL$$

Where:

- $P(death|electric)$ is the probability of a stove fire-related death given the presence of an electric stove, and
- VSL is the value of a statistical life.

We calculate $P(death|electric)$ using Bayes' Theorem:

$$P(death|electric) = \frac{P(electric|death)P(death)}{P(electric)}$$

Where:

- $P(electric|death)$ is the probability of the presence of an electric stove given a stove fire-related death, or the probability that a stove-related death involves an electric stove,
- $P(death)$ is the probability of a stove fire-related death occurring in a household with a stove, and
- $P(electric)$ is the probability of a household having an electric stove.

We calculate $P(electric|death)$, $P(death)$, and $P(electric)$ using the following formulas:

$$P(electric|death) = \frac{Deaths(electric)}{Deaths(all\ stoves)}$$

Where:

- $Deaths(electric)$ is the mean annual deaths from electric stove-related fires from 2017–2021, and
- $Deaths(all\ stoves)$ is the mean annual deaths from all stove-related fires, 2017–2021.

$$P(death) = \frac{Deaths(all\ stoves)}{NFPA\ Households(all\ stoves)}$$

Where:

- $Deaths(all\ stoves)$ is the mean annual deaths from all stove-related fires, 2017–2021, and
- $Households(all\ stoves)$ is the number of households with any kind of stove.

$$P(electric) = \frac{NFPA\ Households(electric)}{NFPA\ Households(all\ stoves)}$$

Where:

- $NFPA\ Households(electric)$ is the number of households with electric stoves, and

- *Households(all stoves)* is the number of households with any kind of stove.

We estimated the stove-related injuries for households with different types of stoves using estimates from the United States Energy Information Administration (U.S. EIA). However, in this section, we estimate households with different types of stoves using the same source that estimates the stove fire-related deaths data.²⁵² We use the same source, instead of the U.S. EIA, to improve the accuracy of the probabilities by maintaining internal methodological consistency.

The Environmental Protection Agency estimates the Value of a Statistical Life (VSL) at \$7.4 million in 2006 dollars.²⁵³ We convert this value into 2023 dollars using the CPI-U annual average for 2006 and the CPI-U half1 average for 2023.

Induction stoves are expected to fall within the category of electric stoves, and the probability of a stove fire-related death given the presence of an induction stove is assumed to be the same as the probability of a stove fire-related death given the presence of an electric stove. This is because there is no evidence suggesting that induction stoves reduce the probability of stove-related fires; on the contrary, one study suggests that induction stoves present a significant fire hazard and that their safety features are insufficient.²⁵⁴ However, we could not find any studies indicating that induction stoves increase the risk of fire, either. Therefore, since induction stoves run on electricity, we assume they incur similar property damage costs per household as electric stoves.

The values and sources for each variable — as well as the ranges and distributions for uncertain estimates — are presented in Table H.2.1.

Table H.2.2: Variables for Stove-Related Fire Deaths per Household with an Electric/Induction Stove

Variable	Estimate	Lower Bound	Upper Bound	Description	Source	Distribution
NFPA Households(electric)	83,800,000	-	-	The number of households with electric stoves	Hall and McGree 2023 ²⁵⁵	-
NFPA Households(all stoves)	130,500,000	-	-	The number of households with stoves (all)	Hall and McGree 2023 ²⁵⁶	-
Deaths(electric)	322	-	-	Mean annual deaths from electric stove-	Hall and McGree	-

²⁵² Hall and McGree, “Home Cooking Fires: Supporting Tables.”

²⁵³ United States Environmental Protection Agency, “Mortality Risk Valuation.”

²⁵⁴ Arthur K. K. Wong and N. K. Fong, “Experimental Study of Induction Cooker Fire Hazard,” *Procedia Engineering* 52 (2013): 13–22, <https://doi.org/10.1016/j.proeng.2013.02.098>.

²⁵⁵ Hall and McGree, “Home Cooking Fires: Supporting Tables.”

²⁵⁶ Hall and McGree, “Home Cooking Fires: Supporting Tables.”

				related fires, 2017–2021	2023 ²⁵⁷	
Deaths(all stoves)	414	-	-	Mean annual deaths from all stove related fires, 2017–2021	Hall and McGree 2023 ²⁵⁸	-
VSL	\$10,792,889.04	-	-	Value of a statistical life (VSL) in 2023 dollars	United States Environmental Protection Agency n.d. ²⁵⁹	-

3. Property damage from stove-related fires (annual)

3.1 Expected stove fire-related property damage costs per household with a gas stove

We calculated the value of property damage from stove-related fires in a household with a gas stove using the following formula:

$$\text{Property damage}(gas) = P(\text{fire}|gas) \times \frac{\text{Total Property Damage}(gas)}{\text{Fires}(gas)}$$

Where:

- $P(\text{fire}|gas)$ is the probability of a stove-related fire in a home with a gas stove,
- $\text{Total Property Damage}(gas)$ is the average cumulative annual property damage caused by gas stove-related fires, and
- $\text{Fires}(gas)$ is the mean annual gas-stove related fires.

We calculated $P(\text{fire}|gas)$ using Bayes' Theorem:

$$P(\text{fire}|gas) = \frac{P(gas|\text{fire}) \times P(\text{fire})}{P(gas)}$$

Where:

- $P(gas|\text{fire})$ is the probability of the presence of a gas stove given a stove-related fire, of the probability of a gas stove being involved in a stove related fire,
- $P(\text{fire})$ is the probability of a stove-related fire across all households with a stove, and
- $P(gas)$ is the probability of a gas stove being in a household with a stove.

²⁵⁷ Hall and McGree, “Home Cooking Fires: Supporting Tables.”

²⁵⁸ Hall and McGree, “Home Cooking Fires: Supporting Tables.”

²⁵⁹ United States Environmental Protection Agency, “Mortality Risk Valuation.”

We calculated $P(\text{gas}|\text{fire})$, $P(\text{fire})$, and $P(\text{gas})$ using the following formulas:

$$P(\text{gas}|\text{fire}) = \frac{\text{Fires}(\text{gas})}{\text{Fires}(\text{all stoves})}$$

Where:

- $\text{Fires}(\text{gas})$ is the mean annual number of gas stove-related fires, and
- $\text{Fires}(\text{all stoves})$ is the mean annual number of all stove-related fires.

$$P(\text{fire}) = \frac{\text{Fire}(\text{all stoves})}{\text{NFPA Households}(\text{all stoves})}$$

Where:

- $\text{Fires}(\text{all stoves})$ is the mean annual number of all stove-related fires, and
- $\text{NFPA Households}(\text{all stoves})$ is the number of households with any kind of stove.

$$P(\text{gas}) = \frac{\text{NFPA Households}(\text{gas})}{\text{NFPA Households}(\text{all stoves})}$$

Where:

- $\text{NFPA Households}(\text{gas})$ is the number of households with gas stoves, and
- $\text{NFPA Households}(\text{all stoves})$ is the number of households with any kind of stove.

We estimated the stove-related injuries for households with different types of stoves using estimates from the United States Energy Information Administration (U.S. EIA). However, in this section, we estimate households with different types of stoves using the same source that estimates the stove fire-related deaths data.²⁶⁰ We use the same source, instead of the EIA, to improve the accuracy of the probabilities by maintaining internal methodological consistency.

Hall and McGree estimated a \$109 million in mean annual direct property damages for gas stove-related fires in 2018 dollars. We converted this value to 2023 dollars using the 2018 CPI-U annual value and the 2023 CPI-U half1 value.²⁶¹ The CPI-U values were based on the U.S. city average for all items.

We present the values and sources for each variable — as well as the ranges and distributions for uncertain estimates — in Table H.3.1.

Table H.3.1: Variables for Stove Fire Property Damage per Household with Natural Gas/Propane Stove

Variable	Estimate	Lower Bound	Upper Bound	Description	Source	Distribution
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²⁶⁰ Hall and McGree, “Home Cooking Fires: Supporting Tables.”

²⁶¹ The 2023 CPI-U half1 value was used because, at the time of the report, the 2023 annual value had not been released.

NFPA Households(all stoves)	130,500,000	-	-	The number of households with stoves (all)	Hall and McGree 2023 ²⁶²	-
NFPA Households(gas)	46,700,000	-	-	The number of households with gas stoves	Hall and McGree 2023 ²⁶³	-
Fires(all stoves)	84,394	-	-	Annual stove-related fires	Hall and McGree 2023 ²⁶⁴	-
Fires(gas)	16,104	-	-	Annual gas stove-related fires	Hall and McGree 2023 ²⁶⁵	-
Total Property Damage(gas)	\$131,268,630.50	-	-	Mean annual property damage caused by gas stove-related fires	Hall and McGree 2023 ²⁶⁶	-

3.2 Expected stove fire-related property damage costs per household with an electric/induction stove

The estimated value of property damage from stove-related fires in a household with an electric stove was calculated using the following formula:

$$\text{Property damage}(\text{electric}) = P(\text{fire}|\text{electric}) \times \frac{\text{Total Property Damage}(\text{electric})}{\text{Fires}(\text{electric})}$$

Where:

- $P(\text{fire}|\text{electric})$ is the probability of a stove-related fire in a home with an electric stove,
- $\text{Total Property Damage}(\text{electric})$ is the average cumulative annual property damage caused by electric stove-related fires, and
- $\text{Fires}(\text{electric})$ is the mean annual number of electric-stove related fires.

$P(\text{fire}|\text{electric})$ was calculated using Bayes' Theorem:

²⁶² Hall and McGree, "Home Cooking Fires: Supporting Tables."

²⁶³ Hall and McGree, "Home Cooking Fires: Supporting Tables."

²⁶⁴ Hall and McGree, "Home Cooking Fires: Supporting Tables."

²⁶⁵ Hall and McGree, "Home Cooking Fires: Supporting Tables."

²⁶⁶ Hall and McGree, "Home Cooking Fires: Supporting Tables."

$$P(\text{fire}|\text{electric}) = \frac{P(\text{electric}|\text{fire}) \times P(\text{fire})}{P(\text{electric})}$$

Where:

- $P(\text{electric}|\text{fire})$ is the probability of the presence of an electric stove given a stove-related fire, of the probability of an electric stove being involved in a stove related fire,
- $P(\text{fire})$ is the probability of a stove-related fire across all households with a stove, and
- $P(\text{electric})$ is the probability of an electric stove being in a household with a stove.

$P(\text{electric}|\text{fire})$, $P(\text{fire})$, and $P(\text{electric})$ were calculated using the following formulas:

$$P(\text{electric}|\text{fire}) = \frac{\text{Fires}(\text{electric})}{\text{Fires}(\text{all stoves})}$$

Where:

- $\text{Fires}(\text{electric})$ is the mean annual number of electric stove-related fires, and
- $\text{Fires}(\text{all stoves})$ is the mean annual number of all stove-related fires.

$$P(\text{fire}) = \frac{\text{Fire}(\text{all stoves})}{\text{NFPA Households}(\text{all stoves})}$$

Where:

- $\text{Fires}(\text{all stoves})$ is the mean annual number of all stove-related fires, and
- $\text{NFPA Households}(\text{all stoves})$ is the number of households with any kind of stove.

$$P(\text{electric}) = \frac{\text{NFPA Households}(\text{electric})}{\text{NFPA Households}(\text{all stoves})}$$

Where:

- $\text{NFPA Households}(\text{electric})$ is the number of households with electric stoves, and
- $\text{NFPA Households}(\text{all stoves})$ is the number of households with any kind of stove.

We estimated the stove-related injuries for households with different types of stoves using estimates from the United States Energy Information Administration (U.S. EIA). However, in this section, we estimate households with different types of stoves using the same source that estimates the stove fire-related deaths data.²⁶⁷ We use the same source, instead of the EIA, to improve the accuracy of the probabilities by maintaining internal methodological consistency.

²⁶⁷ Hall and McGree, “Home Cooking Fires: Supporting Tables.”

Hall and McGree estimated a \$630 million in mean annual direct property damages for gas stove-related fires in 2018 dollars. We converted this value to 2023 dollars using the 2018 CPI-U annual value and the 2023 CPI-U half1 value.²⁶⁸ The CPI-U values were based on the U.S. city average for all items.

We calculated the expected property damage costs for both induction and electric stoves using data about electric stoves. In other words, we assumed the probability of electric and induction stoves causing fire to be the same. This is because there is no evidence suggesting that induction stoves reduce the probability of stove-related fires; on the contrary, one study suggests that induction stoves present a significant fire hazard and that their safety features are insufficient.²⁶⁹ However, we could not find any studies indicating that induction stoves increase the risk of fire, either. Therefore, since induction stoves run on electricity, we assume they incur similar property damage costs per household as electric stoves.

We present the values and sources for each variable — as well as the ranges and distributions for uncertain estimates — in Table H.3.2.

Table H.3.2: Variables for Stove Fire Property Damage per Household with an Electric/Induction Stove

Variable	Estimate	Lower Bound	Upper Bound	Description	Source	Distribution
NFPA Households(all stoves)	130,500,000	-	-	The number of households with stoves (all)	Hall and McGree 2023 ²⁷⁰	-
NFPA Households(electric)	83,800,000	-	-	The number of households with electric stoves	Hall and McGree 2023 ²⁷¹	-
Fires(all stoves)	84,394	-	-	Annual stove-related fires	Hall and McGree 2023 ²⁷²	-
Fires(electric)	68,289	-	-	Annual electric stove-related fires	Hall and McGree 2023 ²⁷³	-
Total Property Damage(electric)	\$758,708,598.33	-	-	Mean annual property damage caused by electric	Hall and McGree	-

²⁶⁸ The 2023 CPI-U half1 value was used because, at the time of the report, the 2023 annual value had not been released.

²⁶⁹ Wong and Fong, “Experimental Study of Induction Cooker Fire Hazard.”

²⁷⁰ Hall and McGree, “Home Cooking Fires: Supporting Tables.”

²⁷¹ Hall and McGree, “Home Cooking Fires: Supporting Tables.”

²⁷² Hall and McGree, “Home Cooking Fires: Supporting Tables.”

²⁷³ Hall and McGree, “Home Cooking Fires: Supporting Tables.”

²⁷⁴ Hall and McGree, “Home Cooking Fires: Supporting Tables.”

Appendix I: Maintenance and cleaning monetization methodology

Return to the [Maintenance and cleaning](#) section.

For gas, electric resistance, and induction range, we are considering the time to clean after cooking, cost of cleaning product, price of replacement parts, price of repairing labor, and lifespan of the cooking range.

1. Time to Clean After Cooking

Definition: The time required to clean the cooking range after use.

Importance: Quick and efficient cleaning processes contribute to maintaining the appliance's appearance, hygiene, and overall functionality.

Considerations: Different cooktop materials may have varying cleaning requirements, and the ease of cleaning can impact user satisfaction.

2. Cost of Cleaning Product

Definition: The monetary expense associated with purchasing cleaning products for maintaining the cooking range.

Importance: Choosing appropriate cleaning products is essential for preserving the appearance and functionality of the appliance.

Considerations: Using recommended cleaning solutions can influence long term range conditions.

3. Price of Replacement Parts

Definition: The cost of purchasing components that may need replacement during the lifespan of the cooking range.

Importance: Understanding replacement part costs is crucial for budgeting and assessing the long-term affordability of maintaining the appliance.

Considerations: Replacement part costs can vary by brand, model, and the complexity of the component.

4. Cost of Repairing Labor

Definition: The monetary expense associated with hiring labor for repairing or servicing the cooking range.

Importance: Professional repairs can extend the lifespan of the appliance and ensure safe and efficient operation.

Considerations: Repair labor costs may vary based on the complexity of the issue and the rates charged by service providers.

5. Lifespan of the Cooking Range

Definition: The expected duration for which the cooking range is designed to function optimally.

Importance: Lifespan influences the overall cost of ownership and can impact the decision between repair and replacement.

Considerations: Lifespan may be influenced by build quality, usage patterns, and adherence to maintenance practices

Maintenance cost of gas range

Table I.1: Maintenance Factors for Gas Range

Cost factors (unit)	Value	Source
Time to clean (hr)	0.33	Frontier Energy (2019) ²⁷⁵
Michigan minimum hourly wage as opportunity cost of time (\$/hr)	10.33	Michigan Labor and Economic Opportunity ²⁷⁶
Annual cooking days	260	Frontier Energy (2019)
Annual Cleaning product (\$/year)	170.28	verve ²⁷⁷
Price of replacement parts (\$)	170 (year 5) / 206 (year 10)	Department of Energy (2015) ²⁷⁸
Price of repairing labor (\$/hr)	19.10	Zippia ²⁷⁹
Time to repair (hr)	2	puls ²⁸⁰
Lifespan (years)	15	Department of Energy (2015)
Discount rate	2%	Office of Management and Budget 2023 ²⁸¹

²⁷⁵ Frontier Energy. 2019. “Residential Cooktop Performance and Energy Comparison Study.” <https://cao-94612.s3.amazonaws.com/documents/Induction-Range-Final-Report-July-2019.pdf>.

²⁷⁶ Labor and Economic Opportunity. 2022. “Michigan Minimum Wage Set to Increase on January 1 2023.” [Www.michigan.gov](https://www.michigan.gov/leo/news/2022/12/05/michigan-minimum-wage-set-to-increase-on-january-1-2023). December 5, 2022. <https://www.michigan.gov/leo/news/2022/12/05/michigan-minimum-wage-set-to-increase-on-january-1-2023>.

²⁷⁷ Petrack, Mindy. 2022. “Cleaning Supplies Costs: How to Save Money While Keeping Your Home Clean.” Verve, a Credit Union. February 3, 2022. <https://verveacu.com/2022/02/03/cleaning-supplies-costs-how-to-save-money-while-keeping-your-home-clean/>.

²⁷⁸ Department of Energy. 2015. “Energy Conservation Program: Energy Conservation Standards for Residential Conventional Ovens.” Department of Energy. May 29, 2015. <https://www.energy.gov/eere/buildings/articles/issuance-2015-05-29-energy-conservation-program-energy-conservation>.

²⁷⁹ Zippia. 2023. “Repair Technician Salaries in Michigan.” [Www.zippia.com](https://www.zippia.com). September 14, 2023. <https://www.zippia.com/repair-technician-jobs/salary/michigan/>.

²⁸⁰ H., Natalie. n.d. “Oven and Stove Repair vs. Replacement: Understanding the Cost Breakdown.” [Blog.puls.com](https://blog.puls.com). Accessed December 15, 2023. <https://blog.puls.com/oven-stove-repair-vs-replacement>.

²⁸¹ “Circular No. A-4.”

Maintenance cost of induction range

Table I.2: Maintenance Factors for Induction Range

Cost factors (unit)	Value	Source
Time to clean (hr)	0.083	Frontier Energy (2019)
Michigan minimum hourly wage as opportunity cost of time (\$/hr)	10.33	Michigan Labor and Economic Opportunity
Cleaning product (\$/year)	170.28	verve
Price of replacement parts (\$)	200-800 avg:350	Department of Energy (2015)
Price of repairing labor (\$/hr)	19.10	Zippia
Time to repair (hr)	2.5	puls
Lifespan (years)	10	USAtoday (2022)
Discount rate	2%	Office of Management and Budget 2023 ²⁸²

Maintenance cost of electric range

Table I.3: Maintenance Cost of Electric Resistance Coil/Ceramic Glass Top Resistance Range

Cost factors (unit)	Value	Source
Cleaning time (hr)	0.17 (resistance coil) 0.083 (ceramic top)	Frontier Energy (2019)
Michigan minimum hourly wage as opportunity cost of time (\$/hr)	10.33	Michigan Labor and Economic Opportunity
Cleaning product (\$/year)	170.28	verve
Price of replacement parts (\$)	29.77 – 39.88 (resistance coil) avg: 35.41 300 – 750 (glass top)	Amazon (search by best sellers)
Price of repairing labor (\$/hr)	19.10	Zippia

²⁸² “Circular No. A-4.”

Repair time (hr)	0.083 (coil) 2.5 (glass top)	puls
Lifespan (years)	14	USAtoday (2022) ²⁸³
Discount rate	2%	Office of Management and Budget 2023 ²⁸⁴

Annuity Factor:

$$A = \frac{1-(1+r)^{-n}}{r}$$

PV cooking range maintenance over lifespan (of 2023)

Gas stove:

Maintenance cost over product lifespan:

$$\sum_{t=1}^{15} \frac{(Time\ to\ clean * hourly\ wage) * annual\ cooking\ days + Cleaning\ product}{(1 + discount\ rate)^{t-0.5}} + \frac{Replacement\ parts + Labor * repair\ time}{(1 + discount\ rate)^5} + \frac{Replacement\ parts + Labor * repair\ time}{(1 + discount\ rate)^{10}}$$

$$Annuity(gas) = Gas\ stove\ maintenance\ cost\ over\ product\ lifespan / Annuity\ Factor$$

Induction stove:

Maintenance cost over product lifespan:

$$\sum_{t=1}^{10} \frac{(Time\ to\ clean * hourly\ wage) * annual\ cooking\ days + Cleaning\ product}{(1 + discount\ rate)^{t-0.5}} + \frac{Replacement\ parts + Labor * repair\ time}{(1 + discount\ rate)^{t-0.5}}$$

$$Annuity(induction) = Induction\ stove\ maintenance\ cost\ over\ product\ lifespan / Annuity\ Factor$$

Electric resistance stove:

Maintenance cost over product lifespan:

$$\sum_{t=1}^{14} \frac{(Time\ to\ clean * hourly\ wage) * annual\ cooking\ days + Cleaning\ product}{(1 + discount\ rate)^{t-0.5}} + \frac{Replacement\ parts + Labor * repair\ time}{(1 + discount\ rate)^{t-0.5}}$$

$$Annuity(electric) = Electric\ resistance\ stove\ maintenance\ cost\ over\ product\ lifespan / Annuity\ Factor$$

²⁸³ DeSiato, Danielle. 2022. "Extend the Life Expectancy of Your Cooking Appliances." Reviewed. October 3, 2022. <https://reviewed.usatoday.com/ovens/features/how-long-do-kitchen-appliances-last>.

²⁸⁴ "Circular No. A-4."

Maintenance cost(gas) = Annuity(gas)-Annuity(induction) (annual benefit of transitioning from gas to induction)

Maintenance cost(electric) = Annuity(electric)-Annuity(induction) (annual benefit of transitioning from electric to induction)

Appendix J: Energy consumption monetization methodology

Return to the [Energy consumption](#) section.

To estimate the benefits for cooking performance, we assume the following scenario based on the Frontier Energy report in 2019:

Table J.1: Household Cooking Scenario Assumption

Days cooking per week	5
Number of 12 lb pot boiled per day	1
12 lb simmer time	15 min
Number of sauté dishes cooked per day	2
Days cooking per year	260

Although a 12-pound pot is large, we use the pot information to give an upper bound estimation about the daily energy use for each stove type.

Annual energy bill = annual energy * Michigan electricity/gas rate

Table J.2: Annual Energy Consumption and Rate

Cooktop	Gas	Induction	Resistance (ceramic glass)	Resistance (coil)
Total energy per day	8150 Btu	996 Wh	1050Wh	1088 Wh
Annual energy	2119 kBtu/21.19therm	259 kWh	273 kWh	283 kWh
Annual energy bill	\$29.68	\$71.38	\$75.24	\$77.99

Michigan electricity rate: \$0.27560/kWh (on peak from 9am to 9pm) ([Upper Michigan Energy Resources, 2023](#))²⁸⁵

Michigan gas rate: \$1.40070/CCF (= 100kBtu = 1 therm) ([Michigan Gas Utilities](#))²⁸⁶

²⁸⁵ Upper Michigan Energy Resources. n.d. “2023 Electric Rates for Michigan Customers.” Accessed December 16, 2023. <https://www.uppermichiganenergy.com/rates/insert/umerc-electric-rates-insert.pdf>.

²⁸⁶ Michigan Gas Utilities. n.d. “Michigan Natural Gas Rates.” [Www.michigangasutilities.com](http://www.michigangasutilities.com). Accessed December 16, 2023. <https://www.michigangasutilities.com/payment-bill/business/mi-rates>.

Annual energy bill (gas) = Annual energy (gas) * Michigan gas rate

Annual energy bill (Induction) = Annual energy (Induction) * Michigan electricity rate

Annual energy bill (Resistance) = Annual energy (Resistance) * Michigan electricity rate

Energy efficiency(gas) = Annual energy bill (gas) - Annual energy bill (Induction)

Energy efficiency(electric) = Annual energy bill (Resistance) - Annual energy bill (Induction)

Appendix K: Greenhouse gas and other life cycle impacts monetization methodology

Return to the [Greenhouse gas and other life cycle impacts](#) section.

The cradle-to-grave life cycle environmental impacts of Induction Hob, Electric Plate, and Gas Hob are evaluated following the methodology employed by Sanglard et al. in 2023, albeit adjusted for product usage in Michigan. Sanglard et al. in 2023 use a plate (not coil) as a representative of resistance/conduction electric cooktops. We assume coils and plates have similar efficiencies to calculate the life cycle impacts of the use phase of cooktops.

It is assumed that Induction Hob and Electric Plate have a lifespan of 10 years due to the presence of electronic elements, whereas the Gas Hob is presumed to last for 20 years.

The functional unit adopted for this evaluation is defined as “the production, utilization, and disposal of a cooking device that heats 2 liters of water from 25°C to 90°C, three times per day, every day, over a 40-year period.” Consequently, the associated impacts arising from energy utilization per functional unit for each cooktop type have been adjusted to accommodate the use of electricity or natural gas in Michigan.

The efficiency (η) of each cooktop is defined as the ratio of the actual amount of energy used (E_{exp}) with the amount of energy theoretically needed (E_{th}) to heat 2 liters of water from 25 degrees Celsius to 90 degrees Celsius. E_{th} is calculated using the equation: $E_{th} = m \times C_p \times \Delta T$. Here, “m” stands for the mass of the water, “ C_p ” is the specific heat of water, and “ ΔT ” is the change in temperature. We calculated the total energy requirement (E_{th}) for cooking as approximately 6832.8 kWh. To evaluate the efficiency of different cooktops, we assume the efficiency of induction, electric, and gas cooktops to be 76%, 65%, and 53%, respectively. However, recognizing the importance of accounting for variations in efficiency, the assumed efficiencies are subject to a variation of $\pm 10\%$ in the sensitivity analysis. The calculated E_{th} , along with these efficiency values, are used to determine the quantity of fuel consumed. For induction and electric stoves, this quantity is expressed in kilowatt-hours (kWh). In the case of gas stoves, the energy requirement is converted to cubic meters of natural gas to ensure uniformity with the life cycle inventory units used in EcoInvent.²⁸⁷

Furthermore, we analyze three distinct scenarios to assess the environmental impact of each cooktop. These scenarios represent the electricity grid mix of Michigan in 2022, 2040, and a 2040 scenario without coal usage. These are input into the SimaPro software (Ecoinvent database) to calculate the environmental impact across 14 distinct categories, as outlined in Table K.2. The physical impacts derived from this analysis are then monetized using the shadow prices obtained from the Environmental Price Book, providing a comprehensive economic assessment of the environmental impacts.

Table K.1: Description of the Energy Mix for Scenarios 2022, 2040 and 2040 (No Coal)

Energy Sources	Units	Michigan Electricity Mix 2022	Michigan Electricity Mix 2040	Michigan Electricity Mix 2040 (No Coal)
Coal	%	19.6	16	0

²⁸⁷ Ecoinvent. (2023, November 28). Ecoinvent Database <https://ecoinvent.org/the-ecoinvent-database/>

Oil	%	0.4	0.1	0.1
Natural gas	%	40.1	8.1	24.1
Nuclear	%	18.2	19.4	19.4
Hydropower	%	6	0.6	0.6
Biomass	%	0	1.5	1.5
Coke	%	0.6	0	0
Wind	%	11.9	34.3	34.3
Solar PV	%	3	19.3	19.3

Sources: EIA and World Energy Outlook 2023.²⁸⁸

Table K.2: The Total Life Cycle Impacts (T) of Induction, Electric Plate and Gas Hob, Broken Down into Construction I, Use (U) and End of Life(E) Stages across Considered Impact Categories for Michigan (Scenario 2022)

Impact Category	Unit	Induction hob				Electric plate				Gas hob			
		U	E	T	C	U	E	T	C	U	E	T	
Climate change	kg CO2 eq	85	4984	0	5070	201	5828	-8	6021	462	2812	-3	3271
Ozone depletion	kg CFC-11 eq	0	12	0	12	0	15	0	15	0	0	0	0
Human toxicity	kg 1,4-DB eq	140	77	0	217	234	90	-2	321	143	41	-2	182
Photochemical oxidant formation	kg NMVOC	0	151	0	151	1	176	0	177	2	2	0	4

²⁸⁸ “U.S. Energy Information Administration - EIA - Independent Statistics and Analysis.” <https://www.eia.gov/outlooks/aeo/data/browser/#/?id=67-AEO2023>

Particulate matter formation	kg PM10 eq	0	17	0	17	1	20	0	21	1	1	0	2
Ionizing radiation	kBq U235 eq	6	1784	0	1789	10	2086	0	2096	10	11	0	21
Freshwater eutrophication	kg P eq	1	14	0	14	1	16	0	17	2	0	0	2
Marine eutrophication	kg N eq	0	13	0	13	0	15	0	15	0	0	0	0
Terrestrial acidification	kg SO2 eq	0	30	0	30	0	35	0	35	1	3	0	3
Terrestrial ecotoxicity	kg 1,4-DB eq	0	13	0	13	0	15	0	15	0	0	0	0
Freshwater ecotoxicity	kg 1,4-DB eq	40	16	12	182	42	18	0	60	7	23	1	31
Marine ecotoxicity	kg 1,4-DB eq	35	23	10	167	37	27	0	64	7	6	1	13
Land use	m ² -year	6	361	0	367	13	422	0	435	15	3	0	18

These impacts are monetized using the shadow prices calculated in the Environmental Price Handbook,²⁸⁹ as shown in Table K.3.

$$Cost (\$) = \sum_i Monetization\ factor_{category\ i} \times \frac{Theoretical\ energy\ required}{Cooktop\ efficiency} \times Impact_{category\ i}$$

²⁸⁹ de Bruyn, Sander, Marijn Bijleveld, Lonneke de Graaff, Ellen Schep, Arno Schrotten, Robert Vergeer, and Saliha Ahdour. "Environmental Prices Handbook." CE Delft: Delft, The Netherlands (2018), https://cedelft.eu/wp-content/uploads/sites/2/2021/04/CE_Delft_7N54_Environmental_Prices_Handbook_EU28_version_Def_VS2020.pdf.

Table K.3: Overall Cost of Switching Cooktops for 2022, 2040 and 2040 (No Coal) Scenarios with In-State Standing

		Units (per household)	2022	2040	2040 no coal
New induction after end of life of previous cooktop	Construction and end of life (C & EOL): 2 induction Usage: 2 induction	\$ ₂₀₂₃ /year	28	16	12
New resistance after end of life of previous cooktop	C and EOL: 2 resistance Usage: 2 resistance	\$ ₂₀₂₃ /year	33	19	15
New gas after end of life of previous cooktop	C and EOL: 1 Gas Use: 1 gas	\$ ₂₀₂₃ /year	8	8	8

Marginal costs / benefits from switching cooktops for 2022 and 2040 scenarios at different stage of the cooktop of the replaced cooktop.

$$GHG \text{ and Energy}_{2022}(\text{gas to induction EOL change}) = -20 \text{ } \$_{2023}/\text{year}$$

$$GHG \text{ and Energy}_{2022}(\text{electric to induction EOL change}) = 5 \text{ } \$_{2023}/\text{year}$$

$$GHG \text{ and Energy}_{2040}(\text{gas to induction EOL change}) = -8 \text{ } \$_{2023}/\text{year}$$

$$GHG \text{ and Energy}_{2040}(\text{electric to induction EOL change}) = 3 \text{ } \$_{2023}/\text{year}$$

$$GHG \text{ and Energy}_{2040 \text{ no coal}}(\text{gas to induction EOL change}) = -4 \text{ } \$_{2023}/\text{year}$$

$$GHG \text{ and Energy}_{2040 \text{ no coal}}(\text{electric to induction EOL change}) = 3 \text{ } \$_{2023}/\text{year}$$

*The final cost/benefits are reported for EOL switches.

Table K.4: Overall Cost of Switching Cooktops for 2022, 2040 and 2040 (No Coal) Scenarios with Global Standing

		Units (per household)	2022	2040	2040 no coal
New induction after end of life of previous cooktop	C and EOL: 2 induction Usage: 2 induction	\$ ₂₀₂₃ /year	29	17	13

New resistance after end of life of previous cooktop	C and EOL: 2 resistance Usage: 2 resistance	\$ ₂₀₂₃ /year	35	20	15
New gas after end of life of previous cooktop	C and EOL: 1 Gas Use: 1 gas	\$ ₂₀₂₃ /year	10	10	10

Appendix L: Primary analysis

Return to the [Primary analysis](#) section.

Gas to induction

To calculate the present value of net benefits (PVNB) of transitioning from gas to induction, we use the following formula:

$$\begin{aligned} & PVNB(\text{Gas to Induction}) \\ &= \text{Households}(\text{NG and propane}) \times [-\text{Upfront Costs}(\text{gas}) \\ &+ \sum_{t=1}^{10} \frac{\text{NO}_2(\text{gas}) + \text{CO}(\text{gas}) + \text{PM}_{2.5}(\text{gas}) + \text{Safety}(\text{gas}) + \text{Maintenance cost}(\text{gas}) \\ &+ \text{Energy efficiency}(\text{gas}) + \text{GHG and Energy}_{2022}(\text{gas})}{(1 + r)^{t-0.5}}] \end{aligned}$$

Where:

- *Households(NG and propane)* is the number of households in Michigan with natural gas and propane stoves,
- *Upfront Costs(gas)* is the sum of the costs accrued when obtaining an induction stove in a household with a gas stove,
- *NO₂(gas)* is the benefits accrued from NO₂ reductions when transitioning to an induction stove from a gas stove (see [Appendix E](#)),
- *CO(gas)* is the benefits accrued from CO reductions when transitioning to an induction stove from a gas stove (see [Appendix E](#)),
- *PM_{2.5}(gas)* is the benefits accrued from PM_{2.5} reductions when transitioning to an induction stove (see [Appendix G](#)),
- *Safety(gas)* is the change in safety-related costs when transitioning to an induction stove from a gas stove (see [Appendix H](#)),
- *Maintenance cost(gas)* is the change in maintenance costs when transitioning to an induction stove from a gas stove (see [Appendix I](#)),
- *Energy efficiency(gas)* is the change in energy efficiency costs associated with cooking performance when transitioning to an induction stove from a gas stove (see [Appendix J](#)),
- *GHG and Energy₂₀₂₂(gas)* is the change in greenhouse gas and energy costs when transitioning from a gas to an induction stove (see [Appendix K](#)),
- *t* is the year when the benefits occur, ranging from 1 to 10, and
- *r* is the discount rate, 2 percent.²⁹⁰

²⁹⁰ “Circular No. A-4.”

t ranges from 1 to 10 because an induction stove has a life of 10 years.²⁹¹ We use $t - 0.5$ to indicate that benefits accrue throughout the year.

Upfront Costs(gas) can be calculated using the following formula:

$$\text{Upfront Costs(gas)} = \text{Induction Stove(gas)} + 240 \text{ Volt} + \text{Cookware}$$

Where:

- *Induction Stove(gas)* is the average per-household cost of purchasing and installing an induction stove for households with gas stoves (see [Appendix A](#)),
- *240 Volt* is the estimated cost for purchasing and installing a 240 Volt circuit (see [Appendix B](#)), and
- *Cookware* is the estimated cost of purchasing induction-stove friendly cookware (see [Appendix C](#)).

The variables for calculating PVNB(Gas to Induction) are in Table L.1.

Table L.1: Variables for Gas-to-Induction Transition

Variable	Estimate	Lower Bound	Upper Bound	Description	Source	Distribution
Households(NG and propane)	2,193,950	-	-	Households in Michigan with natural gas and propane stoves	Brossman et al. 2013 ²⁹²	-
r	0.02	-	-	Discount rate for a 10-year project	Office of Management and Budget 2023 ²⁹³	-

Electric to induction

To calculate the present value of net benefits (PVNB) of transitioning from electric to induction, we use the following formula:

²⁹¹ B. Sanglard et al., “Life Cycle Assessment of a Parabolic Solar Cooker and Comparison with Conventional Cooking Appliances,” *Sustainable Production and Consumption* 42 (November 2023): 211–33, <https://doi.org/10.1016/j.spc.2023.09.018>.

²⁹² Brossman et al., “State Level Residential Building Stock and Energy Efficiency & Electrification Packages Analysis.”

²⁹³ “Circular No. A-4.”

$$\begin{aligned}
& PVNB(\text{Electric to Induction}) \\
& = \text{Households}(\text{electric}_{no\ ind}) \times [-\text{Upfront Costs}(\text{electric}) \\
& \quad \text{Safety}(\text{electric}) + \text{Maintenance cost}(\text{electric}) + \text{Energy efficiency}(\text{electric}) \\
& \quad + \text{GHG and Energy}_{2022}(\text{electric})] \\
& + \sum_{t=1}^{10} \frac{\quad}{(1 + r)^{t-0.5}}
\end{aligned}$$

Where:

- *Households(electric_no ind)* is the number of households in Michigan with non-induction electric stoves,
- *Upfront Costs(electric)* is the sum of the costs accrued when obtaining an induction stove in a household with an electric stove,
- *Safety(electric)* is the change in safety-related costs when transitioning to an induction stove from an electric stove (see [Appendix H](#)),
- *Maintenance cost(electric)* is the change in maintenance costs when transitioning to an induction stove from an electric stove (see [Appendix I](#)),
- *Energy efficiency(electric)* is the change in energy efficiency costs associated with cooking performance when transitioning to an induction stove from an electric stove (see [Appendix J](#)),
- *GHG and Energy_2022(electric)* is the change in greenhouse gas and energy costs when transitioning from an electric to an induction stove (see [Appendix K](#)),
- *t* is the year when the benefits occur, ranging from 1 to 10, and
- *r* is the Office of Management and Budget (OMB) discount rate for a 10-year project.

t ranges from 1 to 10 because an induction stove has a life of 10 years.²⁹⁴ We use *t – 0.5* to indicate that benefits accrue throughout the year.

Upfront Costs(electric) can be calculated using the following formula:

$$\text{Upfront Costs}(\text{electric}) = \text{Induction Stove}(\text{electric}) + \text{Cookware}$$

Where:

- *Induction Stove(electric)* is the average per-household cost of purchasing and installing an induction stove for households with electric stoves (see [Appendix A](#)), and
- *Cookware* is the estimated cost of purchasing induction stove-friendly cookware (see [Appendix C](#)).

Households(electric_no ind) can be calculated using the following formula:

$$\text{Households}(\text{electric}_{no\ ind}) = (1 - p(\text{induction})) \times \text{Households}(\text{electric})$$

Where:

- *p(induction)* is the proportion of electric stoves that have induction cooktops.

The variables for calculating PVNB(Electric to Induction) are in Table L.2.

²⁹⁴ Sanglard et al., “Life Cycle Assessment of a Parabolic Solar Cooker and Comparison with Conventional Cooking Appliances.”

Table L.2: Variables for Electric-to-Induction Transition

Variable	Estimate	Lower Bound	Upper Bound	Description	Source	Distribution
p(induction)	0.04168	-	-	Proportion of electric stoves that have induction cooktops.	U.S. EIA 2020 ²⁹⁵	
Households(electric)	2,291,527.00	-	-	Households in Michigan with electric stoves	Brossman et al. 2013 ²⁹⁶	-
r	0.02	-	-	Discount rate for a 10-year project	Office of Management and Budget 2023 ²⁹⁷	-

Comprehensive transition to induction

To calculate the present value of net benefits (PVNB) of transitioning all stoves to induction stoves, we use the following formula:

$$PVNB(\text{Comprehensive}) = PVNB(\text{Gas to Induction}) + PVNB(\text{Electric to Induction})$$

²⁹⁵ United States Energy Information Administration, “2020 RECS Survey Data.”

²⁹⁶ Brossman et al., “State Level Residential Building Stock and Energy Efficiency & Electrification Packages Analysis.”

²⁹⁷ “Circular No. A-4.”

Appendix M: General health impacts sensitivity analysis

Return to [General health impacts sensitivity analysis](#) section.

Gas to induction

To calculate the present value of net benefits (PVNB) of transitioning from gas to induction, substituting measures of general health impacts of replacing gas stoves with induction stoves instead of air pollutant-specific health impacts, we use the following formula:

$$\begin{aligned} PVNB(\text{Gas to Induction}_{GH}) &= \text{Households}(\text{NG and propane}) \times [-\text{Upfront Costs}(\text{gas}) \\ &+ \sum_{t=1}^{10} \frac{\text{saved cost from asthma} + \text{saved cost from LRT} + \text{saved cost from COPD} + \text{saved cost from ASD}}{(1 + r)^{t-0.5}} \\ &+ \sum_{t=1}^{10} \frac{\text{Safety}(\text{gas}) + \text{Maintenance cost}(\text{gas}) + \text{Energy efficiency}(\text{gas}) + \text{GHG and Energy}_{2022}(\text{gas})}{(1 + r)^{t-0.5}}] \end{aligned}$$

Where $NO_2(\text{gas})$, $CO(\text{gas})$, and $PM_{2.5}(\text{gas})$ are replaced with *saved cost from asthma*, *saved cost from LRT*, *saved cost from COPD*, and *saved cost from ASD*. These latter variables are the saved cost from asthma, LRT, COPD, and ASD, respectively, when transitioning from a gas to an induction stove.²⁹⁸

See [Appendix D](#) for the saved cost from asthma, saved cost from LRT, saved cost from COPD, and saved cost from ASD methodologies. See Section 1 of [Appendix L](#) to see how we defined and calculated the other variables in this formula.

²⁹⁸ See [Appendix D](#) for the *saved cost from asthma*, *saved cost from LRT*, *saved cost from COPD*, and *saved cost from ASD* methodologies. See section 1 of [Appendix L](#) to see how we defined and calculated the other variables in this formula.

Appendix N: 2040 greenhouse gas and life cycle sensitivity analysis

Return to the [2022 vs. 2040 vs. coal-free 2040 greenhouse gas and life cycle sensitivity analysis](#) section.

Gas to induction

To calculate the present value of net benefits (PVNB) of transitioning gas stoves to induction stoves with 2040 greenhouse gas and life cycle impacts, we use the following formula:

$$\begin{aligned} & PVNB(\text{Gas to Induction}_{2040}) \\ &= \text{Households}(\text{NG and propane}) \times [-\text{Upfront Costs}(\text{gas}) \\ &+ \sum_{t=1}^{10} \frac{\text{N02}(\text{gas}) + \text{CO}(\text{gas}) + \text{PM2.5}(\text{gas}) + \text{Safety}(\text{gas}) + \text{Maintenance cost}(\text{gas}) \\ &\quad + \text{Energy efficiency}(\text{gas}) + \text{GHG and Energy}_{2040}(\text{gas})}{(1 + r)^{t-0.5}}] \end{aligned}$$

Where the only variable changed from our primary analysis is *GHG and Energy₂₀₄₀(gas)*, or the change in greenhouse gas and energy costs, using the greenhouse gas and energy values expected in Michigan in 2040, when transitioning from a gas to an induction stove. See [Appendix K](#) for *GHG and Energy₂₀₄₀(gas)* methodology. See Section 1 of [Appendix L](#) to see how we defined and calculated the other variables in this formula.

Electric to induction

To calculate the present value of net benefits (PVNB) of transitioning electric stoves to induction stoves with 2040 greenhouse gas and life cycle impacts, we use the following formula:

$$\begin{aligned} & PVNB(\text{Electric to Induction}_{2040}) \\ &= \text{Households}(\text{electric}_{\text{no ind}}) \times [-\text{Upfront Costs}(\text{electric}) \\ &+ \sum_{t=1}^{10} \frac{\text{Safety}(\text{electric}) + \text{Maintenance cost}(\text{electric}) + \text{Energy efficiency}(\text{electric}) \\ &\quad + \text{GHG and Energy}_{2040}(\text{electric})}{(1 + r)^{t-0.5}}] \end{aligned}$$

Where the only variable changed from our primary analysis is *GHG and Energy₂₀₄₀(electric)*, or the change in greenhouse gas and energy costs, using the greenhouse gas and energy values expected in Michigan in 2040, when transitioning from an electric to an induction stove. See [Appendix K](#) for *GHG and Energy₂₀₄₀(electric)* methodology. See Section 1 of [Appendix L](#) to see how we defined and calculated the other variables in this formula.

Comprehensive transition to induction

To calculate the present value of net benefits (PVNB) of transitioning all stoves to induction stoves, using the greenhouse gas and energy values expected in Michigan in 2040, we use the following formula:

$$PVNB(\text{Comprehensive}_{2040}) = PVNB(\text{Gas to Induction}_{2040}) + PVNB(\text{Electric to Induction}_{2040})$$

Appendix O: Coal-free 2040 greenhouse gas and life cycle sensitivity analysis

Return to the [2022 vs. 2040 vs. coal-free 2040 greenhouse gas and life cycle sensitivity analysis](#) section.

Gas to induction

To calculate the present value of net benefits (PVNB) of transitioning gas stoves to induction stoves with 2040 greenhouse gas and life cycle impacts that do not include coal, we use the following formula:

$$\begin{aligned} & PVNB(\text{Gas to Induction}_{2040 \text{ no coal}}) \\ &= \text{Households}(\text{NG and propane}) \times [-\text{Upfront Costs}(\text{gas}) \\ & \quad \text{N02}(\text{gas}) + \text{CO}(\text{gas}) + \text{PM2.5}(\text{gas}) + \text{Safety}(\text{gas}) + \text{Maintenance cost}(\text{gas}) \\ & \quad + \text{Energy efficiency}(\text{gas}) + \text{GHG and Energy}_{2040 \text{ no coal}}(\text{gas})] \\ & + \sum_{t=1}^{10} \frac{\text{N02}(\text{gas}) + \text{CO}(\text{gas}) + \text{PM2.5}(\text{gas}) + \text{Safety}(\text{gas}) + \text{Maintenance cost}(\text{gas}) \\ & \quad + \text{Energy efficiency}(\text{gas}) + \text{GHG and Energy}_{2040 \text{ no coal}}(\text{gas})}{(1 + r)^{t-0.5}} \end{aligned}$$

Where the only variable changed from our primary analysis is *GHG and Energy_2040 no coal(gas)*, or the change in greenhouse gas and energy costs, using the greenhouse gas and energy values expected in Michigan in 2040 and assuming coal is not a source of energy, when transitioning from a gas to an induction stove. See [Appendix K](#) for *GHG and Energy_2040(gas)* methodology. See Section 1 of [Appendix L](#) to see how we defined and calculated the other variables in this formula.

Electric to induction

To calculate the present value of net benefits (PVNB) of transitioning electric stoves to induction stoves with 2040 greenhouse gas and life cycle impacts that do not include coal, we use the following formula:

$$\begin{aligned} & PVNB(\text{Electric to Induction}_{2040 \text{ no coal}}) \\ &= \text{Households}(\text{electric}_{\text{no ind}}) \times [-\text{Upfront Costs}(\text{electric}) \\ & \quad \text{Safety}(\text{electric}) + \text{Maintenance cost}(\text{electric}) + \text{Energy efficiency}(\text{electric}) \\ & \quad + \text{GHG and Energy}_{2040 \text{ no coal}}(\text{electric})] \\ & + \sum_{t=1}^{10} \frac{\text{Safety}(\text{electric}) + \text{Maintenance cost}(\text{electric}) + \text{Energy efficiency}(\text{electric}) \\ & \quad + \text{GHG and Energy}_{2040 \text{ no coal}}(\text{electric})}{(1 + r)^{t-0.5}} \end{aligned}$$

Where the only variable changed from our primary analysis is *GHG and Energy_2040 no coal (electric)*, or the change in greenhouse gas and energy costs, using the greenhouse gas and energy values expected in Michigan in 2040 and assuming coal is not a source of energy, when transitioning from an electric to an induction stove. See [Appendix K](#) for *GHG and Energy_2040(electric)* methodology. See Section 1 of [Appendix L](#) to see how we defined and calculated the other variables in this formula.

Comprehensive transition to induction

To calculate the present value of net benefits (PVNB) of transitioning all stoves to induction stoves, using the greenhouse gas and energy values expected in Michigan in 2040 and assuming coal is not a source of energy, we use the following formula:

$$\begin{aligned} &PVNB(\textit{Comprehensive}_{2040 \textit{ no coal}}) \\ &= PVNB(\textit{Gas to Induction}_{2040 \textit{ no coal}}) + PVNB(\textit{Electric to Induction}_{2040 \textit{ no coal}}) \end{aligned}$$

Appendix P: Discount rate sensitivity analysis

Return to the [Discount rate sensitivity analysis](#) section.

This analysis uses the same formula as our primary analysis but varies the discount rate from 2 percent to 3 and 7 percent.

Gas to induction

3 percent discount rate

To calculate the present value of net benefits (PVNB) of transitioning from gas to induction using a 3 percent discount rate, we use the following formula:

$$\begin{aligned} & PVNB(\text{Gas to Induction}_3) \\ &= \text{Households}(\text{NG and propane}) \times [-\text{Upfront Costs}(\text{gas}) \\ &+ \sum_{t=1}^{10} \frac{\text{N02}(\text{gas}) + \text{CO}(\text{gas}) + \text{PM2.5}(\text{gas}) + \text{Safety}(\text{gas}) + \text{Maintenance cost}(\text{gas}) \\ &+ \text{Energy efficiency}(\text{gas}) + \text{GHG and energy}_{2022}(\text{gas})}{(1 + r_3)^{t-0.5}}] \end{aligned}$$

Where the only variable that changes from our primary analysis is the discount rate, which changes to r_3 , or 0.03. See Section 1 of [Appendix L](#) to see how we defined and calculated the other variables in this formula.

7 percent discount rate

To calculate the present value of net benefits (PVNB) of transitioning from gas to induction using a 7 percent discount rate, we use the following formula:

$$\begin{aligned} & PVNB(\text{Gas to Induction}_7) \\ &= \text{Households}(\text{NG and propane}) \times [-\text{Upfront Costs}(\text{gas}) \\ &+ \sum_{t=1}^{10} \frac{\text{N02}(\text{gas}) + \text{CO}(\text{gas}) + \text{PM2.5}(\text{gas}) + \text{Safety}(\text{gas}) + \text{Maintenance cost}(\text{gas}) \\ &+ \text{Energy efficiency}(\text{gas}) + \text{GHG and energy}_{2022}(\text{gas})}{(1 + r_7)^{t-0.5}}] \end{aligned}$$

Where the only variable that changes from our primary analysis is the discount rate, which changes to r_7 , or 0.07. See Section 1 of [Appendix L](#) to see how we defined and calculated the other variables in this formula.

Electric to induction

3 percent discount rate

To calculate the present value of net benefits (PVNB) of transitioning from electric to induction using a 3 percent discount rate, we use the following formula:

$$PVNB(\text{Electric to Induction}_3) = \text{Households}(\text{electric}_{no\ ind}) \times [-\text{Upfront Costs}(\text{electric})$$

$$+ \sum_{t=1}^{10} \frac{\text{Safety}(\text{electric}) + \text{Maintenance cost}(\text{electric}) + \text{Energy efficiency}(\text{electric}) + \text{GHG and Energy}_{2022}(\text{electric})}{(1 + r_3)^{t-0.5}}]$$

Where the only variable that changes from our primary analysis is the discount rate, which changes to r_3 , or 0.03. See Section 1 of [Appendix L](#) to see how we defined and calculated the other variables in this formula.

7 percent discount rate

To calculate the present value of net benefits (PVNB) of transitioning from electric to induction using a 7 percent discount rate, we use the following formula:

$$\begin{aligned} &PVNB(\text{Electric to Induction}_7) \\ &= \text{Households}(\text{electric}_{no\ ind}) \times [-\text{Upfront Costs}(\text{electric}) \\ &+ \sum_{t=1}^{10} \frac{\text{Safety}(\text{electric}) + \text{Maintenance cost}(\text{electric}) + \text{Energy efficiency}(\text{electric}) + \text{GHG and Energy}_{2022}(\text{electric})}{(1 + r_7)^{t-0.5}}] \end{aligned}$$

Where the only variable that changes from our primary analysis is the discount rate, which changes to r_7 , or 0.07. See Section 1 of [Appendix L](#) to see how we defined and calculated the other variables in this formula.

Comprehensive transition to induction

3 percent discount rate

To calculate the present value of net benefits (PVNB) of transitioning all stoves to induction stoves using a 3 percent discount rate, we use the following formula:

$$PVNB(\text{Comprehensive}_3) = PVNB(\text{Gas to Induction}_3) + PVNB(\text{Electric to Induction}_3)$$

7 percent discount rate

To calculate the present value of net benefits (PVNB) of transitioning all stoves to induction stoves using a 7 percent discount rate, we use the following formula:

$$PVNB(\text{Comprehensive}_7) = PVNB(\text{Gas to Induction}_7) + PVNB(\text{Electric to Induction}_7)$$

Appendix Q: Stata code

* Induction Stove CBA Monte Carlo Simulation

```
set obs 10000
```

```
set seed 2500
```

```
***** General Values *****
```

* Upfront Costs

```
gen prob_income_med = 0.308 // Proportion of Michigan households between 80% and  
150% of the state median income
```

```
gen prob_income_below = 0.374 // Proportion of Michigan households below 80% of the state  
median income
```

```
gen prob_income_above = 1 - prob_income_below - prob_income_med // Proportion of Michigan  
households above 150% of the state median income
```

```
gen rebate_med = 0.5 // Proportion of stove price covered by the IRA rebate for  
households with 80% to 150% of the median income
```

```
gen rebate_below = 1 // Proportion of stove price covered by the IRA rebate for  
households below 80% of the median income
```

```
gen cost_induction = 1500 // Purchase & installation of induction stove
```

```
gen cost_electric = 718.65 // Purchase & installation of electric stove
```

```
gen cost_gas = 631.54 // Purchase & installation of gas stove
```

```
gen cost_switch_gas = prob_income_med * (1 - rebate_med) * cost_induction + prob_income_below * (1 -  
rebate_below) * cost_induction + prob_income_above * cost_induction - cost_gas // Purchase & installation  
cost of switching to induction stove given current gas stove
```

```
gen cost_switch_electric = cost_induction - cost_electric // Purchase & installation of switching to induction  
stove given current electric stove
```

```
gen cost_circuit = runiform(150,1000) // 240 Volt circuit purchase&installation
```

```
gen cost_replacement = 288.84 // Cookware replacement
```

```
gen cost_upfront_gas = cost_switch_gas + cost_circuit + cost_replacement // Total upfront costs from gas  
to induction stove
```

```
gen cost_upfront_electric = cost_switch_electric + cost_replacement // Total upfront costs from electric to  
induction stove
```

* Demographics in Michigan State

```
gen population = 9892533 // Population in MI
```

```
gen person_per_hh = 2.48 // Persons per household in MI
```

```
gen prob_adult = 0.79 // Proportion of adults in Michigan
```

```
gen prob_child = 0.21 // Proportion of children in Michigan
```

```
gen adults_per_hh = person_per_hh * prob_adult // Adults per household in MI
```

```

* Monetary values of wage and life
gen wage_school = 113.55 // Mean daily wage for school day lost
gen wage_work = 153.11 // Mean daily wage for work day lost
gen wage_hourly = 10.33 // MI minimum hourly wage as opportunity cost of time
gen VLY = 516552.2 // Value of a life year in 2023 USD
gen VLY_adult = 784317.03 // Value of an adult life year in 2023 USD
gen VSL = 10792889.04 // Value of a statistical life in 2023 USD

```

```

* Discount rates
gen discount_rate = 0.02 // Discount rate for 10 years

```

```

***** General Health Impacts *****

```

```

***** (1/4) Saved asthma costs

```

```

gen prob_US_asthma = rnormal(0.077,0.0018) // Proportion of US population with asthma
gen prob_MI_asthma = rnormal(0.115,0.0045) // MI rate of asthma among US adults
gen OR_asthma_gas = runiform(1.42,1.54) // Odds ratio of current asthma and gas cooking exposure
gen RR_asthma_gas = OR_asthma_gas / (1 - prob_MI_asthma + prob_MI_asthma * OR_asthma_gas) //
Risk ratio of current asthma and gas cooking exposure

```

```

gen prob_asthma_con_child = rnormal(0.065,0.0032) // Proportion of children with asthma
gen prob_child_con_asthma = prob_asthma_con_child * prob_child / prob_MI_asthma // Proportion of
being a child given asthma
gen cost_asthma_medical = rnormal(4009.57,710) // Annual medical cost of asthma per person
gen lostdays_school_asthma = rnormal(2.3,0.4) // Incremental school days lost due to asthma per person per
year

```

```

gen prob_asthma_con_adult = rnormal(0.08,0.002) // Proportion of adults with asthma
gen prob_adult_con_asthma = prob_asthma_con_adult * prob_adult / prob_US_asthma // Proportion of
being an adult given asthma
gen lostdays_work_asthma = rnormal(1.8, 0.6) // Incremental work days lost due to asthma per person per
year

```

```

* Total saved costs

```

```

gen cost_general_asthma = prob_MI_asthma * (RR_asthma_gas - 1)* ( prob_child_con_asthma *
person_per_hh * prob_child * (cost_asthma_medical + wage_school * lostdays_school_asthma) +
prob_adult_con_asthma * person_per_hh * prob_adult * (cost_asthma_medical + wage_work *
lostdays_work_asthma)) // Total saved cost from asthma

```

```

***** (2/4) Saved LRT symptom costs

```

```

gen prob_US_LRT = 0.0046 // Rate of LRT among the US population
gen prob_MI_LRT = rnormal(0.2483,0.0197) // Rate of LRT among the MI population

```

```

gen OR_LRT_gas = 1.23 // Odds ratio of LRT given the presence of gas
stoves
gen RR_LRT_gas = OR_LRT_gas / (1 - prob_MI_LRT + prob_MI_LRT * OR_LRT_gas) // Risk ratio of
current LRT and gas cooking exposure

gen prob_LRT_con_adult = runiform(0.00179,0.08256) // Proportion of adults with LRT in the US
gen prob_adult_con_LRT = prob_LRT_con_adult * prob_adult / prob_MI_LRT // Proportion of being an
adult given LRT
gen lostdays_work_LRT = 3 // Incremental work days lost due to LRT per person per
year

gen prob_child_con_LRT = 1 - prob_adult_con_LRT // Proportion of being a child given LRT
gen cost_LRT_medical = 305.83 // Annual per person incremental medical cost of LRT
gen lostdays_school_LRT = 0.8 // Incremental school days lost due to LRT per person per year

* Total saved costs
gen cost_general_LRT = prob_MI_LRT * (RR_LRT_gas - 1) * (prob_child_con_LRT * person_per_hh *
prob_child * (cost_LRT_medical + wage_school * lostdays_school_LRT) + prob_adult_con_LRT *
person_per_hh * prob_adult * (cost_LRT_medical + wage_work * lostdays_work_LRT)) // Total saved cost
from LRT

***** (3/4) Saved COPD costs
gen prob_decrease_COPD = 0.046 // Percent reduction in COPD from removal of gas stove
gen prob_COPD = rnormal(0.075, 0.008) // MI rate of COPD among US adults
gen cost_COPD_medical = 12440 // Annual per person incremental medical cost of COPD
gen cost_COPD_hospitalization = 6852 // Annual per person hospitalization cost of COPD
gen lostdays_work_COPD = 5 // Estimated days of absenteeism days per employed adult
with COPD in MI

* Total saved costs
gen cost_general_COPD = prob_decrease_COPD * prob_COPD * person_per_hh * (cost_COPD_medical
+ cost_COPD_hospitalization + lostdays_work_COPD * wage_work) // Total saved cost from COPD

***** (4/4) Saved children ASD costs
gen OR_ASD_electric = 0.98 // Odds ratio of children ASD given electric/induction
stoves
gen OR_ASD_gas = 0.66 // Odds ratio of children ASD given NG/propane
stoves
gen prob_decrease_ASD = OR_ASD_electric / (1 + OR_ASD_electric) - OR_ASD_gas / (1 + OR_ASD_gas)
// Percentage decrease of ASD from switching
gen prob_ASD_con_child = 0.04 // Probability of children been identified with ASD
gen cost_ASD_medical = rnormal(5876.7, 1191.3) // Annual per person medical cost of child ASD
gen prob_SRB = 0.43 // Probability of SRB for ASD child

```

gen lostdays_school_ASD = rnormal(76.5,58.5) // Incremental school days lost due to SRB annually per ASD child

* Total saved costs

gen cost_general_ASD = prob_decrease_ASD * prob_ASD_con_child * person_per_hh * prob_child * (cost_ASD_medical + prob_SRB * lostdays_school_ASD + wage_school) // Total saved cost from children ASD

***** Air Pollutant Health Impacts *****

***** (1/3) NO2

* Asthma

gen concentration_decrease_NO2 = 7.19 // Concentration decrease in NO2 from NG/propane to electric/induction

gen OR_asthma_15ppb = runiform(1.09,1.31) // Odds ratio of asthma per 15ppb decrease

gen RR_asthma_15ppb = OR_asthma_15ppb / (1 - prob_MI_asthma + prob_MI_asthma * OR_asthma_15ppb) // Risk ratio of asthma

gen adjustedRR_asthma_NO2 = (concentration_decrease_NO2/15) * (RR_asthma_15ppb - 1) + 1 // Adjusted decreased risk of asthma

gen asthma_YLD = 362.13 // Asthma YLDs per 100,000 population in Michigan

gen prob_MI_gas = 0.49 // Proportion of households with gas stoves in Michigan

gen PAF_morbidity_NO2_asthma = (prob_MI_gas * (adjustedRR_asthma_NO2 - 1)) / (prob_MI_gas * (adjustedRR_asthma_NO2 - 1) + 1) // Population attributable fraction of asthma morbidity attributed to the higher NO2 concentrations that are present in homes with gas stoves

gen asthma_YLD_NO2 = (asthma_YLD/100000) * PAF_morbidity_NO2_asthma * VLY * person_per_hh // Saved asthma DALY

gen cost_asthma_medical_NO2 = prob_MI_asthma * PAF_morbidity_NO2_asthma * person_per_hh * cost_asthma_medical // Saved asthma medical costs

gen cost_asthma_productivity_NO2 = prob_MI_asthma * PAF_morbidity_NO2_asthma * person_per_hh * prob_adult_con_asthma * lostdays_work_asthma * wage_work + prob_MI_asthma * PAF_morbidity_NO2_asthma * person_per_hh * prob_child_con_asthma * lostdays_school_asthma * wage_school // Saved asthma productivity costs

* COPD

gen COPD_DALY = 1797.32 // DALY per 100000 population in MI for COPD

gen COPD_YLD = 677.45 // COPD YLDs per 100,000 population in Michigan

gen COPD_YLL = COPD_DALY - COPD_YLD // COPD YLLs per 100,000 population in Michigan

gen RR_morbidity_NO2_COPD = runiform(1.046,1.308) // Decreased risk of COPD prevalence per 5.31 ppb decrease in NO2

gen RR_mortality_NO2_COPD = runiform(1.017,1.035) // Decreased risk of COPD mortality per 5.31 ppb decrease in NO2.

gen adjustedRR_COPD_mbd_NO2 = (concentration_decrease_NO2/5.31) * (RR_morbidity_NO2_COPD - 1) + 1 // Decreased risk of COPD morbidity

gen adjustedRR_COPD_mtl_NO2 = (concentration_decrease_NO2/5.31) * (RR_mortality_NO2_COPD - 1) + 1 // Decreased risk of COPD mortality

gen PAF_morbidity_NO2_COPD = (prob_MI_gas * (adjustedRR_COPD_mbd_NO2 - 1)) / (prob_MI_gas * (adjustedRR_COPD_mbd_NO2 - 1) + 1) // Population attributable fraction of COPD morbidity attributed to the higher NO2 concentrations that are present in homes with gas stoves

gen PAF_mortality_NO2_COPD = (prob_MI_gas * (adjustedRR_COPD_mtl_NO2 - 1)) / (prob_MI_gas * (adjustedRR_COPD_mtl_NO2 - 1) + 1) // Population attributable fraction of COPD mortality attributed to the higher NO2 concentrations that are present in homes with gas stoves

gen COPD_DALY_NO2 = ((COPD_YLD/100000) * PAF_morbidity_NO2_COPD + (COPD_YLL/100000) * PAF_mortality_NO2_COPD) * VLY_adult * adults_per_hh // Saved COPD DALY

gen cost_COPD_medical_NO2 = prob_COPD * PAF_morbidity_NO2_COPD * adults_per_hh * cost_COPD_medical // Saved COPD medical costs

gen cost_COPD_productivity_NO2 = prob_COPD * PAF_morbidity_NO2_COPD * adults_per_hh * lostdays_work_COPD * wage_work // Saved COPD productivity costs

* Total saved costs

gen cost_air_total_NO2 = asthma_YLD_NO2 + cost_asthma_medical_NO2 + cost_asthma_productivity_NO2 + COPD_DALY_NO2 + cost_COPD_medical_NO2 + cost_COPD_productivity_NO2 // Total saved costs from NO2

***** (2/3) CO

gen poisoning_DALY = 16.15 // CO poisoning DALYs per 10,000 in high-income North America

gen prob_poisoning = 0.0405 // Proportion of CO poisoning attributable to gas stoves in MI

gen poisoning_DALY_CO = poisoning_DALY / 10000 * prob_poisoning * VLY * person_per_hh // Saved poisoning DALY

gen num_poisoning_case = 877 // Annual Michigan CO poisoning cases

gen num_poisoning_death = 26 // Annual Michigan CO poisoning deaths

gen prob_poisoning_ED = 0.54 // Proportion of non-fatal CO poisonings that result in ED visits

gen prob_poisoning_ED_hosp = runiform(0.08,0.11) // Proportion of ED visits that result in hospitalizations

gen cost_poisoning_medical = rnormal(17780.94,3940.21) // Average cost per CO poisoning hospitalization

gen cost_poisoning_medical_CO = ((num_poisoning_case - num_poisoning_death) * prob_poisoning / population) * prob_poisoning_ED * prob_poisoning_ED_hosp * cost_poisoning_medical * person_per_hh // Saved poisoning medical costs

```

gen prob_child_con_COhosp = 0.079 // Proportion of people hospitalized for CO poisoning that are children
gen days_CO_hosp = 4.9 // Mean length of stay (days)
gen prob_adult_con_COhosp = 0.921 // Proportion of people hospitalized for CO poisoning that are adults
gen cost_poisoning_productivity_CO = ((num_poisoning_case - num_poisoning_death) * prob_poisoning /
population) * prob_poisoning_ED * prob_poisoning_ED_hosp * (prob_child_con_COhosp *
days_CO_hosp * wage_school + prob_adult_con_COhosp * days_CO_hosp * wage_work) * person_per_hh
// Saved poisoning productivity costs

```

* Total saved costs

```

gen cost_air_total_CO = poisoning_DALY_CO + cost_poisoning_medical_CO +
cost_poisoning_productivity_CO // Total saved costs from CO

```

***** (3/3) PM2.5

```

gen concentration_decrease_PM25 = runiform(0,17.5) // Concentration reduction for PM2.5 in MI

```

* DALY saved from respiratory diseases

```

gen RR_mortality_PM25_RD = runiform(1.0057,1.0096) // Relative risk of mortality associated with each 10
µg/m3 increase in indoor PM2.5

```

```

gen adjustedRR_mortality_PM25_RD = 1 + (concentration_decrease_PM25 / 10) *
(RR_mortality_PM25_RD - 1) // Adjusted relative risk of mortality

```

```

gen PAF_mortality_PM25_RD = prob_MI_gas * (adjustedRR_mortality_PM25_RD - 1) / (prob_MI_gas *
(adjustedRR_mortality_PM25_RD - 1) + 1) // Population attributable fraction of mortality to gas stoves

```

```

gen RR_morbidity_PM25_RD = runiform(1.001,1.05) // Relative risk of morbidity associated with each 10
µg/m3 increase in indoor PM2.5

```

```

gen adjustedRR_morbidity_PM25_RD = 1 + (concentration_decrease_PM25 / 10) *
(RR_morbidity_PM25_RD - 1) // Adjusted relative risk of morbidity

```

```

gen PAF_morbidity_PM25_RD = prob_MI_gas * (adjustedRR_morbidity_PM25_RD - 1) / (prob_MI_gas *
(adjustedRR_morbidity_PM25_RD - 1) + 1) // Population attributable fraction of morbidity to gas stoves

```

```

gen RD_DALY = 2468 // Respiratory diseases DALY

```

```

gen RD_YLD = 1161 // Respiratory diseases year lived with disability

```

```

gen RD_YLL = RD_DALY - RD_YLD // Respiratory diseases year of life lost

```

```

gen RD_DALY_PM25 = RD_YLL * PAF_mortality_PM25_RD + RD_YLD * PAF_morbidity_PM25_RD
// Saved DALY from RD if shift from gas to induction

```

* DALY saved from cardiovascular diseases

```

gen RR_mortality_PM25_CVD = runiform(1.13,1.44) // Relative risk of mortality associated with each 10
µg/m3 increase in indoor PM2.5

```

```

gen adjustedRR_mortality_PM25_CVD = 1 + (concentration_decrease_PM25 / 10) *
(RR_mortality_PM25_CVD - 1) // Adjusted relative risk of mortality

```

gen PAF_mortality_PM25_CVD = prob_MI_gas * (adjustedRR_mortality_PM25_CVD - 1) / (prob_MI_gas * (adjustedRR_mortality_PM25_CVD - 1) + 1) // Population attributable fraction of mortality to gas stoves

gen RR_morbidity_PM25_CVD = runiform(1.01,1.042) // Relative risk of morbidity associated with each 10 µg/m3 increase in indoor PM2.5

gen adjustedRR_morbidity_PM25_CVD = 1 + (concentration_decrease_PM25 / 10) * (RR_morbidity_PM25_CVD - 1) // Adjusted relative risk of morbidity

gen PAF_morbidity_PM25_CVD = prob_MI_gas * (adjustedRR_morbidity_PM25_CVD - 1) / (prob_MI_gas * (adjustedRR_morbidity_PM25_CVD - 1) + 1) // Population attributable fraction of morbidity to gas stoves

gen CVD_DALY = 6516 // Cardiovascular diseases DALY

gen CVD_YLD = 876 // Cardiovascular diseases year lived with disability

gen CVD_YLL = CVD_DALY - CVD_YLD // Cardiovascular diseases year of life lost

gen CVD_DALY_PM25 = CVD_YLL * PAF_mortality_PM25_CVD + CVD_YLD * PAF_morbidity_PM25_CVD // Saved DALY from CVD if shift from gas to induction

* Productivity costs saved

gen num_hosp_RD = 3340 // Number of hospital visits due to respiratory diseases

gen num_hosp_CVD = 28090 // Number of hospital visits due to cardiovascular diseases

gen days_hosp_RD = 3.7 // Average length of hospital visit for respiratory diseases

gen days_hosp_CVD = 5.4 // Average length of hospital visit for cardiovascular diseases

gen cost_hosp_RD = 9000 // Average cost of hospitalization for respiratory diseases

gen cost_hosp_CVD = 15000 // Average cost of hospitalization for cardiovascular diseases

gen cost_PM25_productivity = (num_hosp_RD * PAF_morbidity_PM25_RD * days_hosp_RD + num_hosp_CVD * PAF_morbidity_PM25_CVD * days_hosp_CVD) * wage_work // Saved productivity cost from RD and CVD if shift from gas to induction

* Medical costs saved

gen cost_PM25_medical = num_hosp_RD * PAF_morbidity_PM25_RD * cost_hosp_RD + num_hosp_CVD * PAF_morbidity_PM25_CVD * cost_hosp_CVD // Saved medical cost from RD and CVD if shift from gas to induction

* Total cost saved from PM2.5

gen cost_air_total_PM25 = (cost_PM25_medical + cost_PM25_productivity + (RD_DALY_PM25 + CVD_DALY_PM25) * VLY) * person_per_hh / 100000 // Total saved costs from PM2.5

***** Safety Impacts *****

***** Injuries cost

* Injuries (1/3 gas and propane)

gen number_household_with_gas = 40250000 // Number of households in the US with gas/ propane stoves

gen number_household_with_stove = 109160000 // Number of households with stoves

gen prob_gas = number_household_with_gas / number_household_with_stove // Probability of a household having a gas stove

gen number_injury_allstoves = rnormal(136999,31372) // Number of U.S. annual stove-related burns and soft tissue injuries

gen prob_injury = number_injury_allstoves / number_household_with_stove // Probability of an injury with households with stoves

gen number_injury_gas = rnormal(4554,1535) // U.S. annual burns and soft tissue injuries specified as involving gas stoves

gen number_injury_stovespecified = rnormal(19862,8797) // Number of U.S. annual burns and soft tissue injuries where the stove was specified

gen prob_gas_con_injury = number_injury_gas / number_injury_stovespecified // Probability of gas stove conditional on stove specified injuries

gen prob_injury_con_gas = prob_gas_con_injury * prob_injury / prob_gas // Probability of a injury given a gas stove

gen prob_hosp_injury = 0.0560 // Probability of hospitalization from a stove-related injury

gen cost_hosp_injury = 88738.38 // Shadow price of hospitalized injuries

gen prob_nohosp_injury = 0.9440 // Probability of not being hospitalized from a stove-related injury

gen cost_nohosp_injury = 1337.82 // Shadow price of non-hospitalized injuries

gen cost_injuries_gas = prob_injury_con_gas * prob_hosp_injury * cost_hosp_injury + prob_injury_con_gas * prob_nohosp_injury * cost_nohosp_injury // Costs of injuries from gas and propane

* Injuries (2/3 electric)

gen number_household_with_electric = 65980000 // U.S. households with electric stoves (average of 2015 and 2020 national estimates)

gen prob_electric = number_household_with_electric / number_household_with_stove // Probability of a household having an electric stove

gen number_injury_electric = rnormal(13560,6227) // U.S. annual burns and soft tissue injuries specified as involving electric

gen prob_electric_con_injury = number_injury_electric / number_injury_stovespecified // Probability of an electric stove being associated with a stove-related burn or soft tissue injury

gen prob_injury_con_electric = prob_electric_con_injury * prob_injury / prob_electric // Probability of a stove-related burn or soft tissue injury given the presence of an electric stove

gen cost_injuries_electric = prob_injury_con_electric * prob_hosp_injury * cost_hosp_injury +
prob_injury_con_electric * prob_nohosp_injury * cost_nohosp_injury // Costs of injuries from electric

* Injuries (3/3 induction)

gen prob_injury_contact = 0.375 // Proportion of stove-related injuries

gen prob_injury_con_induction = (1 - prob_injury_contact) * prob_injury_con_electric // Probability of a
stove-related burn or soft tissue injury given the presence of an induction stove,

gen cost_injuries_induction = prob_injury_con_induction * prob_hosp_injury * cost_hosp_injury +
prob_injury_con_induction * prob_nohosp_injury * cost_nohosp_injury // Costs of injuries from induction

***** Death cost

* Death from gas and propane

gen number_NFPAhh_with_gas = 46700000 // The number of households with gas stoves

gen number_NFPAhh_with_stove = 130500000 // The number of households with stoves (all)

gen number_death_stove = 414 // Mean annual deaths from all stove related fires, 2017-2021

gen number_death_gas = 92 // Mean annual deaths from gas stove-related fires

gen prob_gas_NFPA = number_NFPAhh_with_gas / number_NFPAhh_with_stove // Probability of a
household having a gas stove

gen prob_death = number_death_stove / number_NFPAhh_with_stove // Probability of a stove fire-related
death occurring in a household with a stove

gen prob_gas_con_death = number_death_gas / number_death_stove // Probability of the presence of a gas
stove given a stove fire-related death

gen prob_death_con_gas = prob_gas_con_death * prob_death / prob_gas_NFPA // Probability of a stove
fire-related death given the presence of a gas stove

gen cost_death_gas = prob_death_con_gas * VSL // Costs of death from gas and propane

* Death from electric and induction

gen number_NFPAhh_with_electric = 83800000 // The number of households with electric stoves

gen number_death_electric = 322 // Mean annual deaths from electric stove-related fires, 2017-2021

gen prob_electric_NFPA = number_NFPAhh_with_electric / number_NFPAhh_with_stove // Probability
of a household having an electric stove

gen prob_electric_con_death = number_death_electric / number_death_stove // Probability of the presence
of an electric stove given a stove fire-related death

gen prob_death_con_electric = prob_electric_con_death * prob_death / prob_electric_NFPA // //
Probability of a stove fire-related death given the presence of an electric stove

gen cost_death_electric = prob_death_con_electric * VSL // Costs of death from electric and induction

***** Property damage cost

* Property damage from gas and propane

```

gen total_damage_gas = 131268630.50 // Mean annual property damage caused by gas stove-related fires
gen number_fire_stove = 84394 // Annual stove-related fires
gen number_fire_gas = 16104 // Annual gas stove-related fires

gen prob_fire = number_fire_stove / number_NFPAhh_with_stove // Probability of a stove-related fire
across all households with a stove
gen prob_gas_con_fire = number_fire_gas / number_fire_stove // Probability of the presence of a gas stove
given a stove-related fire
gen prob_fire_con_gas = prob_gas_con_fire * prob_fire / prob_gas_NFPA // Probability of a stove-related
fire in a home with a gas stove

gen cost_damage_gas = prob_fire_con_gas * total_damage_gas / number_fire_gas // Costs of property
damage from gas and propane

* Property damage from electric and induction
gen total_damage_electric = 758708598.33 // Mean annual property damage caused by electric stove-related
fires
gen number_fire_electric = 68289 // Annual electric stove-related fires

gen prob_electric_con_fire = number_fire_electric / number_fire_stove // // Probability of the presence of
an electric stove given a stove-related fire
gen prob_fire_con_electric = prob_electric_con_fire * prob_fire / prob_gas_NFPA // Probability of a stove-
related fire in a home with an electric stove

gen cost_damage_electric = prob_fire_con_electric * total_damage_electric / number_fire_electric // Costs
of property damage from electric and propane

***** Total safety costs
* from gas and propane
gen cost_safety_gas = ( cost_injuries_gas - cost_injuries_induction ) + (cost_death_gas - cost_death_electric)
+ (cost_damage_gas - cost_damage_electric) // Total safety cost from gas/propane stoves

* from electric
gen cost_safety_electric = cost_injuries_electric - cost_injuries_induction // Total safety cost from electric
stoves

***** Maintenance and Cleaning Impacts *****
gen days_cooking = 260 // Annual cooking days
gen cost_clean_product = 170.28 // Annual cleaning product
gen cost_repair_labor = 19.10 // Price of repairing labor

***** (1/3) Gas and propane
gen time_clean_gas = 0.33 // Time to clean

```

```

gen cost_replacement_gas_yr5 = 170 // Price of replacement parts in year 5
gen cost_replacement_gas_yr10 = 206 // Price of replacement parts in year 10
gen time_repair_gas = 2 // Time to repair gas stove
gen lifespan_gas = 15 // Lifespan

```

* Lifetime maintenance cost for gas and propane

```

gen cost_maintenance_gas1 = ((time_clean_gas * wage_hourly) * days_cooking + cost_clean_product)/((1 + discount_rate)^0.5) // Year 1 real maintenance cost for gas and propane
gen cost_maintenance_gas2 = ((time_clean_gas * wage_hourly) * days_cooking + cost_clean_product)/((1 + discount_rate)^1.5) // Year 2 real maintenance cost for gas and propane
gen cost_maintenance_gas3 = ((time_clean_gas * wage_hourly) * days_cooking + cost_clean_product)/((1 + discount_rate)^2.5) // Year 3 real maintenance cost for gas and propane
gen cost_maintenance_gas4 = ((time_clean_gas * wage_hourly) * days_cooking + cost_clean_product)/((1 + discount_rate)^3.5) // Year 4 real maintenance cost for gas and propane
gen cost_maintenance_gas5 = ((time_clean_gas * wage_hourly) * days_cooking + cost_clean_product)/((1 + discount_rate)^4.5) // Year 5 real maintenance cost for gas and propane
gen cost_maintenance_gas6 = ((time_clean_gas * wage_hourly) * days_cooking + cost_clean_product)/((1 + discount_rate)^5.5) // Year 6 real maintenance cost for gas and propane
gen cost_maintenance_gas7 = ((time_clean_gas * wage_hourly) * days_cooking + cost_clean_product)/((1 + discount_rate)^6.5) // Year 7 real maintenance cost for gas and propane
gen cost_maintenance_gas8 = ((time_clean_gas * wage_hourly) * days_cooking + cost_clean_product)/((1 + discount_rate)^7.5) // Year 8 real maintenance cost for gas and propane
gen cost_maintenance_gas9 = ((time_clean_gas * wage_hourly) * days_cooking + cost_clean_product)/((1 + discount_rate)^8.5) // Year 9 real maintenance cost for gas and propane
gen cost_maintenance_gas10 = ((time_clean_gas * wage_hourly) * days_cooking + cost_clean_product)/((1 + discount_rate)^9.5) // Year 10 real maintenance cost for gas and propane
gen cost_maintenance_gas11 = ((time_clean_gas * wage_hourly) * days_cooking + cost_clean_product)/((1 + discount_rate)^10.5) // Year 11 real maintenance cost for gas and propane
gen cost_maintenance_gas12 = ((time_clean_gas * wage_hourly) * days_cooking + cost_clean_product)/((1 + discount_rate)^11.5) // Year 12 real maintenance cost for gas and propane
gen cost_maintenance_gas13 = ((time_clean_gas * wage_hourly) * days_cooking + cost_clean_product)/((1 + discount_rate)^12.5) // Year 13 real maintenance cost for gas and propane
gen cost_maintenance_gas14 = ((time_clean_gas * wage_hourly) * days_cooking + cost_clean_product)/((1 + discount_rate)^13.5) // Year 14 real maintenance cost for gas and propane
gen cost_maintenance_gas15 = ((time_clean_gas * wage_hourly) * days_cooking + cost_clean_product)/((1 + discount_rate)^14.5) // Year 15 real maintenance cost for gas and propane

```

```

gen lifespan_maintenance_gas = cost_maintenance_gas1 + cost_maintenance_gas2 + cost_maintenance_gas3 + cost_maintenance_gas4 + cost_maintenance_gas5 + cost_maintenance_gas6 + cost_maintenance_gas7 + cost_maintenance_gas8 + cost_maintenance_gas9 + cost_maintenance_gas10 + cost_maintenance_gas11 + cost_maintenance_gas12 + cost_maintenance_gas13 + cost_maintenance_gas14 + cost_maintenance_gas15 + (cost_replacement_gas_yr5 + cost_repair_labor * time_repair_gas)/((1 + discount_rate)^5) + (cost_replacement_gas_yr10 + cost_repair_labor * time_repair_gas)/((1 + discount_rate)^10) // Lifetime maintenance cost for gas and propane

```

* Annual maintenance cost for gas and propane

```
gen af_maintenance_gas = (1 - (1 + discount_rate)^(-15))/discount_rate // Annuity factor for gas and propane
gen annual_maintenance_gas = lifespan_maintenance_gas / af_maintenance_gas // Annual maintenance cost
for gas and propane
```

***** (2/3) Induction

```
gen time_clean_induction = 0.083 // Time to clean
gen cost_replacement_induction = runiform(200,800) // Price of replacement parts
gen time_repair_induction = 2.5 // Time to repair induction stove
gen lifespan_induction = 10 // Lifespan
```

* Lifetime maintenance cost for induction

```
gen cost_maintenance_induction1 = ((time_clean_induction * wage_hourly) * days_cooking +
cost_clean_product + cost_replacement_induction + cost_repair_labor * time_repair_induction)/((1 +
discount_rate)^0.5) // Year 1 real maintenance cost for induction
gen cost_maintenance_induction2 = ((time_clean_induction * wage_hourly) * days_cooking +
cost_clean_product + cost_replacement_induction + cost_repair_labor * time_repair_induction)/((1 +
discount_rate)^1.5) // Year 2 real maintenance cost for induction
gen cost_maintenance_induction3 = ((time_clean_induction * wage_hourly) * days_cooking +
cost_clean_product + cost_replacement_induction + cost_repair_labor * time_repair_induction)/((1 +
discount_rate)^2.5) // Year 3 real maintenance cost for induction
gen cost_maintenance_induction4 = ((time_clean_induction * wage_hourly) * days_cooking +
cost_clean_product + cost_replacement_induction + cost_repair_labor * time_repair_induction)/((1 +
discount_rate)^3.5) // Year 4 real maintenance cost for induction
gen cost_maintenance_induction5 = ((time_clean_induction * wage_hourly) * days_cooking +
cost_clean_product + cost_replacement_induction + cost_repair_labor * time_repair_induction)/((1 +
discount_rate)^4.5) // Year 5 real maintenance cost for induction
gen cost_maintenance_induction6 = ((time_clean_induction * wage_hourly) * days_cooking +
cost_clean_product + cost_replacement_induction + cost_repair_labor * time_repair_induction)/((1 +
discount_rate)^5.5) // Year 6 real maintenance cost for induction
gen cost_maintenance_induction7 = ((time_clean_induction * wage_hourly) * days_cooking +
cost_clean_product + cost_replacement_induction + cost_repair_labor * time_repair_induction)/((1 +
discount_rate)^6.5) // Year 7 real maintenance cost for induction
gen cost_maintenance_induction8 = ((time_clean_induction * wage_hourly) * days_cooking +
cost_clean_product + cost_replacement_induction + cost_repair_labor * time_repair_induction)/((1 +
discount_rate)^7.5) // Year 8 real maintenance cost for induction
gen cost_maintenance_induction9 = ((time_clean_induction * wage_hourly) * days_cooking +
cost_clean_product + cost_replacement_induction + cost_repair_labor * time_repair_induction)/((1 +
discount_rate)^8.5) // Year 9 real maintenance cost for induction
gen cost_maintenance_induction10 = ((time_clean_induction * wage_hourly) * days_cooking +
cost_clean_product + cost_replacement_induction + cost_repair_labor * time_repair_induction)/((1 +
discount_rate)^9.5) // Year 10 real maintenance cost for induction
```

```

gen lifespan_maintenance_induction = cost_maintenance_induction1 + cost_maintenance_induction2 +
cost_maintenance_induction3 + cost_maintenance_induction4 + cost_maintenance_induction5 +
cost_maintenance_induction6 + cost_maintenance_induction7 + cost_maintenance_induction8 +
cost_maintenance_induction9 + cost_maintenance_induction10 // Lifetime maintenance cost for induction

```

* Annual maintenance cost for induction

```

gen af_maintenance_induction = (1 - (1 + discount_rate)^(-10))/discount_rate // Annuity factor for induction
gen annual_maintenance_induction = lifespan_maintenance_induction / af_maintenance_induction //
Annual maintenance cost for induction

```

***** (3/3) Electric

```

gen time_clean_electric = 0.17 // Time to clean
gen cost_replacement_electric = runiform(29.77,39.88) // Price of replacement parts
gen time_repair_electric = 0.083 // Time to repair electric stove
gen lifespan_electric = 14 // Lifespan

```

* Lifetime maintenance cost for electric

```

gen cost_maintenance_electric1 = ((time_clean_electric * wage_hourly) * days_cooking + cost_clean_product
+ cost_replacement_electric + cost_repair_labor * time_repair_electric)/((1 + discount_rate)^0.5) // Year 1
real maintenance cost for electric
gen cost_maintenance_electric2 = ((time_clean_electric * wage_hourly) * days_cooking + cost_clean_product
+ cost_replacement_electric + cost_repair_labor * time_repair_electric)/((1 + discount_rate)^1.5) // Year 2
real maintenance cost for electric
gen cost_maintenance_electric3 = ((time_clean_electric * wage_hourly) * days_cooking + cost_clean_product
+ cost_replacement_electric + cost_repair_labor * time_repair_electric)/((1 + discount_rate)^2.5) // Year 3
real maintenance cost for electric
gen cost_maintenance_electric4 = ((time_clean_electric * wage_hourly) * days_cooking + cost_clean_product
+ cost_replacement_electric + cost_repair_labor * time_repair_electric)/((1 + discount_rate)^3.5) // Year 4
real maintenance cost for electric
gen cost_maintenance_electric5 = ((time_clean_electric * wage_hourly) * days_cooking + cost_clean_product
+ cost_replacement_electric + cost_repair_labor * time_repair_electric)/((1 + discount_rate)^4.5) // Year 5
real maintenance cost for electric
gen cost_maintenance_electric6 = ((time_clean_electric * wage_hourly) * days_cooking + cost_clean_product
+ cost_replacement_electric + cost_repair_labor * time_repair_electric)/((1 + discount_rate)^5.5) // Year 6
real maintenance cost for electric
gen cost_maintenance_electric7 = ((time_clean_electric * wage_hourly) * days_cooking + cost_clean_product
+ cost_replacement_electric + cost_repair_labor * time_repair_electric)/((1 + discount_rate)^6.5) // Year 7
real maintenance cost for electric
gen cost_maintenance_electric8 = ((time_clean_electric * wage_hourly) * days_cooking + cost_clean_product
+ cost_replacement_electric + cost_repair_labor * time_repair_electric)/((1 + discount_rate)^7.5) // Year 8
real maintenance cost for electric
gen cost_maintenance_electric9 = ((time_clean_electric * wage_hourly) * days_cooking + cost_clean_product
+ cost_replacement_electric + cost_repair_labor * time_repair_electric)/((1 + discount_rate)^8.5) // Year 9
real maintenance cost for electric

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gen cost_maintenance_electric10 = ((time_clean_electric * wage_hourly) * days_cooking + cost_clean_product + cost_replacement_electric + cost_repair_labor * time_repair_electric)/((1 + discount_rate)^9.5) // Year 10 real maintenance cost for electric

gen cost_maintenance_electric11 = ((time_clean_electric * wage_hourly) * days_cooking + cost_clean_product + cost_replacement_electric + cost_repair_labor * time_repair_electric)/((1 + discount_rate)^10.5) // Year 11 real maintenance cost for electric

gen cost_maintenance_electric12 = ((time_clean_electric * wage_hourly) * days_cooking + cost_clean_product + cost_replacement_electric + cost_repair_labor * time_repair_electric)/((1 + discount_rate)^11.5) // Year 12 real maintenance cost for electric

gen cost_maintenance_electric13 = ((time_clean_electric * wage_hourly) * days_cooking + cost_clean_product + cost_replacement_electric + cost_repair_labor * time_repair_electric)/((1 + discount_rate)^12.5) // Year 13 real maintenance cost for electric

gen cost_maintenance_electric14 = ((time_clean_electric * wage_hourly) * days_cooking + cost_clean_product + cost_replacement_electric + cost_repair_labor * time_repair_electric)/((1 + discount_rate)^13.5) // Year 14 real maintenance cost for electric

gen lifespan_maintenance_electric = cost_maintenance_electric1 + cost_maintenance_electric2 + cost_maintenance_electric3 + cost_maintenance_electric4 + cost_maintenance_electric5 + cost_maintenance_electric6 + cost_maintenance_electric7 + cost_maintenance_electric8 + cost_maintenance_electric9 + cost_maintenance_electric10 + cost_maintenance_electric11 + cost_maintenance_electric12 + cost_maintenance_electric13 + cost_maintenance_electric14 // Lifetime maintenance cost for electric

* Annual maintenance cost for electric

gen af_maintenance_electric = (1 - (1 + discount_rate)^(-14))/discount_rate // Annuity factor for electric

gen annual_maintenance_electric = lifespan_maintenance_electric / af_maintenance_electric // Annual maintenance cost for electric

***** Annual costs saved from switching

gen cost_maintenance_electric = annual_maintenance_electric - annual_maintenance_induction // Annual maintenance costs saved from switching to electric stove

gen cost_maintenance_gas = annual_maintenance_gas - annual_maintenance_induction // Annual maintenance costs saved from switching to induction stove

***** Energy Efficiency Impacts *****

gen cost_gas_bill = 29.68 // Annual energy bill from gas stove

gen cost_induction_bill = 71.38 // Annual energy bill from induction stove

gen cost_electric_bill = 77.99 // Annual energy bill from electric stove

gen cost_efficiency_electric = cost_electric_bill - cost_induction_bill // Annual energy efficiency saving from switching to electric stove

gen cost_efficiency_gas = cost_gas_bill - cost_induction_bill // Annual energy efficiency saving from switching to induction stove

***** GHG Impacts *****

gen cost_GHG_gas_2022 = -20 // Marginal benefits saved from switching from gas to induction in 2022
gen cost_GHG_electric_2022 = 5 // Marginal benefits saved from switching from electric to induction in 2022

gen cost_GHG_gas_2040 = -8 // Marginal benefits saved from switching from gas to induction in 2040
gen cost_GHG_electric_2040 = 3 // Marginal benefits saved from switching from electric to induction in 2040

gen cost_GHG_gas_nocoal = -4 // Marginal benefits saved from switching from gas to induction in 2040
without coal electricy
gen cost_GHG_electric_nocoal = 3 // Marginal benefits saved from switching from electric to induction in
2040 without coal electricy

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***** Primary Analysis *****

* Gas to induction (1/3)

gen hh_gas_propane = 2193950 // Households in MI with natural gas and propane stoves

gen primary_gas1 = (cost_air_total_NO2 + cost_air_total_CO + cost_air_total_PM25 + cost_safety_gas +
cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2022) / ((1 + discount_rate)^0.5) // Total
saved cost present value of year 1

gen primary_gas2 = (cost_air_total_NO2 + cost_air_total_CO + cost_air_total_PM25 + cost_safety_gas +
cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2022) / ((1 + discount_rate)^1.5) // Total
saved cost present value of year 2

gen primary_gas3 = (cost_air_total_NO2 + cost_air_total_CO + cost_air_total_PM25 + cost_safety_gas +
cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2022) / ((1 + discount_rate)^2.5) // Total
saved cost present value of year 3

gen primary_gas4 = (cost_air_total_NO2 + cost_air_total_CO + cost_air_total_PM25 + cost_safety_gas +
cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2022) / ((1 + discount_rate)^3.5) // Total
saved cost present value of year 4

gen primary_gas5 = (cost_air_total_NO2 + cost_air_total_CO + cost_air_total_PM25 + cost_safety_gas +
cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2022) / ((1 + discount_rate)^4.5) // Total
saved cost present value of year 5

gen primary_gas6 = (cost_air_total_NO2 + cost_air_total_CO + cost_air_total_PM25 + cost_safety_gas +
cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2022) / ((1 + discount_rate)^5.5) // Total
saved cost present value of year 6

gen primary_gas7 = (cost_air_total_NO2 + cost_air_total_CO + cost_air_total_PM25 + cost_safety_gas +
cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2022) / ((1 + discount_rate)^6.5) // Total
saved cost present value of year 7

gen primary_gas8 = (cost_air_total_NO2 + cost_air_total_CO + cost_air_total_PM25 + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2022) / ((1 + discount_rate)^7.5) // Total saved cost present value of year 8

gen primary_gas9 = (cost_air_total_NO2 + cost_air_total_CO + cost_air_total_PM25 + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2022) / ((1 + discount_rate)^8.5) // Total saved cost present value of year 9

gen primary_gas10 = (cost_air_total_NO2 + cost_air_total_CO + cost_air_total_PM25 + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2022) / ((1 + discount_rate)^9.5) // Total saved cost present value of year 10

gen PVNB_primary_gas = hh_gas_propane * (- cost_upfront_gas + primary_gas1 + primary_gas2 + primary_gas3 + primary_gas4 + primary_gas5 + primary_gas6 + primary_gas7 + primary_gas8 + primary_gas9 + primary_gas10) // Present value of net benefits of transition from gas and propane to induction

* Electric to induction (2/3)

gen prob_induction = 0.04168 // Proportion of electric stoves that have induction cooktops

gen hh_electric = 2291527 // Households in MI with electric stoves

gen hh_electric_nound = (1 - prob_induction) * hh_electric // Number of households in MI with non-induction electric stoves

gen primary_electric1 = (cost_safety_electric + cost_maintenance_electric + cost_efficiency_electric + cost_GHG_electric_2022) / ((1 + discount_rate)^0.5) // Total saved cost present value of year 1

gen primary_electric2 = (cost_safety_electric + cost_maintenance_electric + cost_efficiency_electric + cost_GHG_electric_2022) / ((1 + discount_rate)^1.5) // Total saved cost present value of year 2

gen primary_electric3 = (cost_safety_electric + cost_maintenance_electric + cost_efficiency_electric + cost_GHG_electric_2022) / ((1 + discount_rate)^2.5) // Total saved cost present value of year 3

gen primary_electric4 = (cost_safety_electric + cost_maintenance_electric + cost_efficiency_electric + cost_GHG_electric_2022) / ((1 + discount_rate)^3.5) // Total saved cost present value of year 4

gen primary_electric5 = (cost_safety_electric + cost_maintenance_electric + cost_efficiency_electric + cost_GHG_electric_2022) / ((1 + discount_rate)^4.5) // Total saved cost present value of year 5

gen primary_electric6 = (cost_safety_electric + cost_maintenance_electric + cost_efficiency_electric + cost_GHG_electric_2022) / ((1 + discount_rate)^5.5) // Total saved cost present value of year 6

gen primary_electric7 = (cost_safety_electric + cost_maintenance_electric + cost_efficiency_electric + cost_GHG_electric_2022) / ((1 + discount_rate)^6.5) // Total saved cost present value of year 7

gen primary_electric8 = (cost_safety_electric + cost_maintenance_electric + cost_efficiency_electric + cost_GHG_electric_2022) / ((1 + discount_rate)^7.5) // Total saved cost present value of year 8

gen primary_electric9 = (cost_safety_electric + cost_maintenance_electric + cost_efficiency_electric + cost_GHG_electric_2022) / ((1 + discount_rate)^8.5) // Total saved cost present value of year 9

gen primary_electric10 = (cost_safety_electric + cost_maintenance_electric + cost_efficiency_electric + cost_GHG_electric_2022) / ((1 + discount_rate)^9.5) // Total saved cost present value of year 10

gen PVNB_primary_electric = hh_electric_noind * (- cost_upfront_electric + primary_electric1 + primary_electric2 + primary_electric3 + primary_electric4 + primary_electric5 + primary_electric6 + primary_electric7 + primary_electric8 + primary_electric9 + primary_electric10) // Present value of net benefits of transition from electric to induction

* Comprehensive transition to induction (3/3)

gen PVNB_primary_all = PVNB_primary_gas + PVNB_primary_electric // Present value of net benefits of transitioning all stoves to induction

***** General Health Impacts Sensitivity Analysis *****

* Gas/propane to induction

gen general_gas1 = (cost_general_asthma + cost_general_LRT + cost_general_COPD + cost_general_ASD + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2022) / ((1 + discount_rate)^0.5) // Total saved cost present value of year 1

gen general_gas2 = (cost_general_asthma + cost_general_LRT + cost_general_COPD + cost_general_ASD + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2022) / ((1 + discount_rate)^1.5) // Total saved cost present value of year 2

gen general_gas3 = (cost_general_asthma + cost_general_LRT + cost_general_COPD + cost_general_ASD + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2022) / ((1 + discount_rate)^2.5) // Total saved cost present value of year 3

gen general_gas4 = (cost_general_asthma + cost_general_LRT + cost_general_COPD + cost_general_ASD + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2022) / ((1 + discount_rate)^3.5) // Total saved cost present value of year 4

gen general_gas5 = (cost_general_asthma + cost_general_LRT + cost_general_COPD + cost_general_ASD + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2022) / ((1 + discount_rate)^4.5) // Total saved cost present value of year 5

gen general_gas6 = (cost_general_asthma + cost_general_LRT + cost_general_COPD + cost_general_ASD + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2022) / ((1 + discount_rate)^5.5) // Total saved cost present value of year 6

gen general_gas7 = (cost_general_asthma + cost_general_LRT + cost_general_COPD + cost_general_ASD + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2022) / ((1 + discount_rate)^6.5) // Total saved cost present value of year 7

gen general_gas8 = (cost_general_asthma + cost_general_LRT + cost_general_COPD + cost_general_ASD + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2022) / ((1 + discount_rate)^7.5) // Total saved cost present value of year 8

gen general_gas9 = (cost_general_asthma + cost_general_LRT + cost_general_COPD + cost_general_ASD + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2022) / ((1 + discount_rate)^8.5) // Total saved cost present value of year 9

gen general_gas10 = (cost_general_asthma + cost_general_LRT + cost_general_COPD + cost_general_ASD + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2022) / ((1 + discount_rate)^9.5) // Total saved cost present value of year 10

gen PVNB_general = hh_gas_propane * (- cost_upfront_gas + general_gas1 + general_gas2 + general_gas3 + general_gas4 + general_gas5 + general_gas6 + general_gas7 + general_gas8 + general_gas9 + general_gas10) // Present value of net benefits of transition from gas and propane to induction

***** 2040 Energy and Greenhouse Gas Sensitivity Analysis *****

* Gas to induction (1/3)

gen primary_gas2040_1 = (cost_air_total_NO2 + cost_air_total_CO + cost_air_total_PM25 + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2040) / ((1 + discount_rate)^0.5) // Total saved cost present value of year 1

gen primary_gas2040_2 = (cost_air_total_NO2 + cost_air_total_CO + cost_air_total_PM25 + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2040) / ((1 + discount_rate)^1.5) // Total saved cost present value of year 2

gen primary_gas2040_3 = (cost_air_total_NO2 + cost_air_total_CO + cost_air_total_PM25 + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2040) / ((1 + discount_rate)^2.5) // Total saved cost present value of year 3

gen primary_gas2040_4 = (cost_air_total_NO2 + cost_air_total_CO + cost_air_total_PM25 + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2040) / ((1 + discount_rate)^3.5) // Total saved cost present value of year 4

gen primary_gas2040_5 = (cost_air_total_NO2 + cost_air_total_CO + cost_air_total_PM25 + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2040) / ((1 + discount_rate)^4.5) // Total saved cost present value of year 5

gen primary_gas2040_6 = (cost_air_total_NO2 + cost_air_total_CO + cost_air_total_PM25 + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2040) / ((1 + discount_rate)^5.5) // Total saved cost present value of year 6

gen primary_gas2040_7 = (cost_air_total_NO2 + cost_air_total_CO + cost_air_total_PM25 + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2040) / ((1 + discount_rate)^6.5) // Total saved cost present value of year 7

gen primary_gas2040_8 = (cost_air_total_NO2 + cost_air_total_CO + cost_air_total_PM25 + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2040) / ((1 + discount_rate)^7.5) // Total saved cost present value of year 8

gen primary_gas2040_9 = (cost_air_total_NO2 + cost_air_total_CO + cost_air_total_PM25 + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2040) / ((1 + discount_rate)^8.5) // Total saved cost present value of year 9

gen primary_gas2040_10 = (cost_air_total_NO2 + cost_air_total_CO + cost_air_total_PM25 + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_2040) / ((1 + discount_rate)^9.5) // Total saved cost present value of year 10

gen PVNB_primary_gas2040 = hh_gas_propane * (- cost_upfront_gas + primary_gas2040_1 + primary_gas2040_2 + primary_gas2040_3 + primary_gas2040_4 + primary_gas2040_5 + primary_gas2040_6 + primary_gas2040_7 + primary_gas2040_8 + primary_gas2040_9 + primary_gas2040_10) // Present value of net benefits of transition from gas and propane to induction

* Electric to induction (2/3)

$$\text{gen primary_electric2040_1} = (\text{cost_safety_electric} + \text{cost_maintenance_electric} + \text{cost_efficiency_electric} + \text{cost_GHG_electric_2040}) / ((1 + \text{discount_rate})^{0.5}) // \text{ Total saved cost present value of year 1}$$

$$\text{gen primary_electric2040_2} = (\text{cost_safety_electric} + \text{cost_maintenance_electric} + \text{cost_efficiency_electric} + \text{cost_GHG_electric_2040}) / ((1 + \text{discount_rate})^{1.5}) // \text{ Total saved cost present value of year 2}$$

$$\text{gen primary_electric2040_3} = (\text{cost_safety_electric} + \text{cost_maintenance_electric} + \text{cost_efficiency_electric} + \text{cost_GHG_electric_2040}) / ((1 + \text{discount_rate})^{2.5}) // \text{ Total saved cost present value of year 3}$$

$$\text{gen primary_electric2040_4} = (\text{cost_safety_electric} + \text{cost_maintenance_electric} + \text{cost_efficiency_electric} + \text{cost_GHG_electric_2040}) / ((1 + \text{discount_rate})^{3.5}) // \text{ Total saved cost present value of year 4}$$

$$\text{gen primary_electric2040_5} = (\text{cost_safety_electric} + \text{cost_maintenance_electric} + \text{cost_efficiency_electric} + \text{cost_GHG_electric_2040}) / ((1 + \text{discount_rate})^{4.5}) // \text{ Total saved cost present value of year 5}$$

$$\text{gen primary_electric2040_6} = (\text{cost_safety_electric} + \text{cost_maintenance_electric} + \text{cost_efficiency_electric} + \text{cost_GHG_electric_2040}) / ((1 + \text{discount_rate})^{5.5}) // \text{ Total saved cost present value of year 6}$$

$$\text{gen primary_electric2040_7} = (\text{cost_safety_electric} + \text{cost_maintenance_electric} + \text{cost_efficiency_electric} + \text{cost_GHG_electric_2040}) / ((1 + \text{discount_rate})^{6.5}) // \text{ Total saved cost present value of year 7}$$

$$\text{gen primary_electric2040_8} = (\text{cost_safety_electric} + \text{cost_maintenance_electric} + \text{cost_efficiency_electric} + \text{cost_GHG_electric_2040}) / ((1 + \text{discount_rate})^{7.5}) // \text{ Total saved cost present value of year 8}$$

$$\text{gen primary_electric2040_9} = (\text{cost_safety_electric} + \text{cost_maintenance_electric} + \text{cost_efficiency_electric} + \text{cost_GHG_electric_2040}) / ((1 + \text{discount_rate})^{8.5}) // \text{ Total saved cost present value of year 9}$$

$$\text{gen primary_electric2040_10} = (\text{cost_safety_electric} + \text{cost_maintenance_electric} + \text{cost_efficiency_electric} + \text{cost_GHG_electric_2040}) / ((1 + \text{discount_rate})^{9.5}) // \text{ Total saved cost present value of year 10}$$

$$\text{gen PVNB_primary_electric2040} = \text{hh_electric_noind} * (- \text{cost_upfront_electric} + \text{primary_electric2040_1} + \text{primary_electric2040_2} + \text{primary_electric2040_3} + \text{primary_electric2040_4} + \text{primary_electric2040_5} + \text{primary_electric2040_6} + \text{primary_electric2040_7} + \text{primary_electric2040_8} + \text{primary_electric2040_9} + \text{primary_electric2040_10}) // \text{ Present value of net benefits of transition from electric to induction}$$

* Comprehensive transition to induction (3/3)

$$\text{gen PVNB_primary_all2040} = \text{PVNB_primary_gas2040} + \text{PVNB_primary_electric2040} // \text{ Present value of net benefits of transitioning all stoves to induction}$$

***** 2040 Without Coal Energy and Greenhouse Gas Sensitivity Analysis *****

* Gas to induction (1/3)

$$\text{gen nocoal_gas2040_1} = (\text{cost_air_total_NO2} + \text{cost_air_total_CO} + \text{cost_air_total_PM25} + \text{cost_safety_gas} + \text{cost_maintenance_gas} + \text{cost_efficiency_gas} + \text{cost_GHG_gas_nocoal}) / ((1 + \text{discount_rate})^{0.5}) // \text{ Total saved cost present value of year 1}$$

$$\text{gen nocoal_gas2040_2} = (\text{cost_air_total_NO2} + \text{cost_air_total_CO} + \text{cost_air_total_PM25} + \text{cost_safety_gas} + \text{cost_maintenance_gas} + \text{cost_efficiency_gas} + \text{cost_GHG_gas_nocoal}) / ((1 + \text{discount_rate})^{1.5}) // \text{ Total saved cost present value of year 2}$$

$$\text{gen nocoal_gas2040_3} = (\text{cost_air_total_NO2} + \text{cost_air_total_CO} + \text{cost_air_total_PM25} + \text{cost_safety_gas} + \text{cost_maintenance_gas} + \text{cost_efficiency_gas} + \text{cost_GHG_gas_nocoal}) / ((1 + \text{discount_rate})^{2.5}) // \text{ Total saved cost present value of year 3}$$

gen nocoal_gas2040_4 = (cost_air_total_NO2 + cost_air_total_CO + cost_air_total_PM25 + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_nocoal) / ((1 + discount_rate)^3.5) // Total saved cost present value of year 4

gen nocoal_gas2040_5 = (cost_air_total_NO2 + cost_air_total_CO + cost_air_total_PM25 + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_nocoal) / ((1 + discount_rate)^4.5) // Total saved cost present value of year 5

gen nocoal_gas2040_6 = (cost_air_total_NO2 + cost_air_total_CO + cost_air_total_PM25 + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_nocoal) / ((1 + discount_rate)^5.5) // Total saved cost present value of year 6

gen nocoal_gas2040_7 = (cost_air_total_NO2 + cost_air_total_CO + cost_air_total_PM25 + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_nocoal) / ((1 + discount_rate)^6.5) // Total saved cost present value of year 7

gen nocoal_gas2040_8 = (cost_air_total_NO2 + cost_air_total_CO + cost_air_total_PM25 + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_nocoal) / ((1 + discount_rate)^7.5) // Total saved cost present value of year 8

gen nocoal_gas2040_9 = (cost_air_total_NO2 + cost_air_total_CO + cost_air_total_PM25 + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_nocoal) / ((1 + discount_rate)^8.5) // Total saved cost present value of year 9

gen nocoal_gas2040_10 = (cost_air_total_NO2 + cost_air_total_CO + cost_air_total_PM25 + cost_safety_gas + cost_maintenance_gas + cost_efficiency_gas + cost_GHG_gas_nocoal) / ((1 + discount_rate)^9.5) // Total saved cost present value of year 10

gen PVNB_nocoal_gas2040 = hh_gas_propane * (- cost_upfront_gas + nocoal_gas2040_1 + nocoal_gas2040_2 + nocoal_gas2040_3 + nocoal_gas2040_4 + nocoal_gas2040_5 + nocoal_gas2040_6 + nocoal_gas2040_7 + nocoal_gas2040_8 + nocoal_gas2040_9 + nocoal_gas2040_10) // Present value of net benefits of transition from gas and propane to induction

* Electric to induction (2/3)

gen nocoal_electric2040_1 = (cost_safety_electric + cost_maintenance_electric + cost_efficiency_electric + cost_GHG_electric_nocoal) / ((1 + discount_rate)^0.5) // Total saved cost present value of year 1

gen nocoal_electric2040_2 = (cost_safety_electric + cost_maintenance_electric + cost_efficiency_electric + cost_GHG_electric_nocoal) / ((1 + discount_rate)^1.5) // Total saved cost present value of year 2

gen nocoal_electric2040_3 = (cost_safety_electric + cost_maintenance_electric + cost_efficiency_electric + cost_GHG_electric_nocoal) / ((1 + discount_rate)^2.5) // Total saved cost present value of year 3

gen nocoal_electric2040_4 = (cost_safety_electric + cost_maintenance_electric + cost_efficiency_electric + cost_GHG_electric_nocoal) / ((1 + discount_rate)^3.5) // Total saved cost present value of year 4

gen nocoal_electric2040_5 = (cost_safety_electric + cost_maintenance_electric + cost_efficiency_electric + cost_GHG_electric_nocoal) / ((1 + discount_rate)^4.5) // Total saved cost present value of year 5

gen nocoal_electric2040_6 = (cost_safety_electric + cost_maintenance_electric + cost_efficiency_electric + cost_GHG_electric_nocoal) / ((1 + discount_rate)^5.5) // Total saved cost present value of year 6

gen nocoal_electric2040_7 = (cost_safety_electric + cost_maintenance_electric + cost_efficiency_electric + cost_GHG_electric_nocoal) / ((1 + discount_rate)^6.5) // Total saved cost present value of year 7

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gen nocoal_electric2040_8 = (cost_safety_electric + cost_maintenance_electric + cost_efficiency_electric +
cost_GHG_electric_nocoal) / ((1 + discount_rate)^7.5) // Total saved cost present value of year 8
gen nocoal_electric2040_9 = (cost_safety_electric + cost_maintenance_electric + cost_efficiency_electric +
cost_GHG_electric_nocoal) / ((1 + discount_rate)^8.5) // Total saved cost present value of year 9
gen nocoal_electric2040_10 = (cost_safety_electric + cost_maintenance_electric + cost_efficiency_electric +
cost_GHG_electric_nocoal) / ((1 + discount_rate)^9.5) // Total saved cost present value of year 10

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```

gen PVNB_nocoal_electric2040 = hh_electric_noind * (- cost_upfront_electric + nocoal_electric2040_1 +
nocoal_electric2040_2 + nocoal_electric2040_3 + nocoal_electric2040_4 + nocoal_electric2040_5 +
nocoal_electric2040_6 + nocoal_electric2040_7 + nocoal_electric2040_8 + nocoal_electric2040_9 +
nocoal_electric2040_10) // Present value of net benefits of transition from electric and propane to induction

```

* Comprehensive transition to induction (3/3)

```

gen PVNB_nocoal_all2040 = PVNB_nocoal_gas2040 + PVNB_nocoal_electric2040 // Present value of net
benefits of transitioning all stoves to induction

```

***** Histograms *****

* State Level

```

gen small_primary_gas = PVNB_primary_gas / 1000000000
gen small_primary_electric = PVNB_primary_electric / 1000000000
gen small_primary_all = PVNB_primary_all / 1000000000
gen small_general = PVNB_general / 1000000000
gen small_2040_gas = PVNB_primary_gas2040 / 1000000000
gen small_2040_electric = PVNB_primary_electric2040 / 1000000000
gen small_2040_all = PVNB_primary_all2040 / 1000000000
gen small_nocoal_gas = PVNB_nocoal_gas2040 / 1000000000
gen small_nocoal_electric = PVNB_nocoal_electric2040 / 1000000000
gen small_nocoal_all = PVNB_nocoal_all2040 / 1000000000

```

```

histogram small_primary_gas, title("PVNB of Michigan Gas/Propane Stoves Transition in 2022 (State Level)",
size(medium)) xtitle("PVNB (Billion 2023 USD)") fcolor(none) lcolor(red)
graph export "/Users/yulianchen/Desktop/881/PVNB/Primary_gas.png", replace

```

```

histogram small_primary_electric, title("PVNB of Michigan Electric Stoves Transition in 2022 (State Level)",
size(medium)) xtitle("PVNB (Billion 2023 USD)") fcolor(none) lcolor(red)
graph export "/Users/yulianchen/Desktop/881/PVNB/Primary_electric.png", replace

```

```

histogram small_primary_all, title("PVNB of All Michigan Stoves Transition in 2022 (State Level)",
size(medium)) xtitle("PVNB (Billion 2023 USD)") fcolor(none) lcolor(red)
graph export "/Users/yulianchen/Desktop/881/PVNB/Primary_all.png", replace

```

```
histogram small_general, title("PVNB of Michigan Gas/Propane Stoves Transition in 2022 (State Level)",
size(medium)) xtitle("PVNB (Billion 2023 USD)") fcolor(none) lcolor(red)
graph export "/Users/yulianchen/Desktop/881/PVNB/General_all.png", replace
```

```
histogram small_2040_gas, title("PVNB of Michigan Gas/Propane Stoves Transition in 2040 (State Level)",
size(medium)) xtitle("PVNB (Billion 2023 USD)") fcolor(none) lcolor(red)
graph export "/Users/yulianchen/Desktop/881/PVNB/2040_gas.png", replace
```

```
histogram small_2040_electric, title("PVNB of Michigan Electric Stoves Transition in 2040 (State Level)",
size(medium)) xtitle("PVNB (Billion 2023 USD)") fcolor(none) lcolor(red)
graph export "/Users/yulianchen/Desktop/881/PVNB/2040_electric.png", replace
```

```
histogram small_2040_all, title("PVNB of All Michigan Stoves Transition in 2040 (State Level)", size(medium))
xtitle("PVNB (Billion 2023 USD)") fcolor(none) lcolor(red)
graph export "/Users/yulianchen/Desktop/881/PVNB/2040_all.png", replace
```

```
histogram small_nocoal_gas, title("PVNB of Michigan Gas/Propane Stoves Transition in Clean 2040 (State
Level)", size(medium)) xtitle("PVNB (Billion 2023 USD)") fcolor(none) lcolor(red)
graph export "/Users/yulianchen/Desktop/881/PVNB/nocoal_gas.png", replace
```

```
histogram small_nocoal_electric, title("PVNB of Michigan Electric Stoves Transition in 2040 (State Level)",
size(medium)) xtitle("PVNB (Billion 2023 USD)") fcolor(none) lcolor(red)
graph export "/Users/yulianchen/Desktop/881/PVNB/nocoal_electric.png", replace
```

```
histogram small_nocoal_all, title("PVNB of All Michigan Stoves Transition in 2040 (State Level)",
size(medium)) xtitle("PVNB (Billion 2023 USD)") fcolor(none) lcolor(red)
graph export "/Users/yulianchen/Desktop/881/PVNB/nocoal_all.png", replace
```

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Line	(a) Energy Waste Reduction Plan	(b) Plan UCT Score	(c) 2026		(e) Budget (\$)		(f) 2027		(g) Savings (kWh)		(h) Budget (\$)		(i) 2028		(j) Savings (kWh)		(k) Budget (\$)		(l) 2029		(m) Savings (kWh)		(n) Budget (\$)		
			1st Year	Lifetime	1st Year	Lifetime	1st Year	Lifetime	1st Year	Lifetime	1st Year	Lifetime	1st Year	Lifetime	1st Year	Lifetime	1st Year	Lifetime	1st Year	Lifetime	1st Year	Lifetime	1st Year	Lifetime	
1	Low Income																								
2	Empower - Single Family	2.90	1,471,907	16,336,667	489,612	1,585,707	17,019,467	520,213	1,467,946	18,960,657	604,987	1,500,817	19,390,248	640,156											
3	Empower - Multi-Family	1.80	218,607	2,489,656	116,636	231,582	2,619,406	127,129	239,367	2,697,256	134,665	239,367	2,697,256	137,359											
4	Low Income Evaluation				100,272			100,236			121,307			124,917											
5	Low Income Administration				101,703			103,724			106,836			110,041											
6	Low Income Health and Safety	3.35	215,208	2,560,973	60,975	215,208	2,560,973	64,205	215,208	2,560,973	74,622	215,208	2,560,973	77,559											
7	Subtotal - Low Income	2.14	1,905,722	21,387,296	\$ 869,198	2,032,497	22,199,846	\$ 915,507	1,922,521	24,218,886	\$ 1,042,417	1,955,392	24,648,477	\$ 1,090,032											
8																									
9	Residential																								
10	Appliance Recycling	7.85	631,092	5,000,992	71,240	631,092	5,000,992	72,665	631,092	5,000,992	74,118	631,092	5,000,992	75,600											
11	ENERGY STAR®	3.77	595,748	5,189,688	129,190	595,748	5,189,688	131,774	654,135	5,773,563	160,419	665,813	5,890,338	168,934											
12	Home Performance - Single Family	3.52	1,604,952	19,519,552	489,874	1,607,178	23,559,253	560,188	2,342,848	32,575,705	776,748	2,303,087	35,263,832	820,091											
13	Home Performance - Multi-Family	2.03	28,392	262,011	11,658	28,392	262,011	11,891	37,734	355,431	16,291	37,734	355,431	16,616											
14	New Construction	2.72	76,104	1,226,002	42,472	76,104	1,226,002	43,321	76,104	1,226,002	44,188	76,104	1,226,002	45,072											
15	Evaluation				109,471			114,945			156,653			162,815											
16	Administration				139,067			143,239			147,536			151,962											
17	Subtotal - Residential	2.96	2,936,288	31,198,245	\$ 992,972	2,938,514	35,237,946	\$ 1,078,023	3,741,913	44,931,693	\$ 1,375,953	3,713,830	47,736,595	\$ 1,441,090											
18																									
19	Business																								
20	Prescriptive	6.28	2,923,133	35,714,667	510,783	2,929,824	35,796,671	522,345	3,222,822	38,848,367	582,939	3,229,750	38,941,268	595,485											
21	Custom	7.38	1,200,012	17,400,000	232,000	1,200,012	17,400,000	236,640	1,200,012	17,400,000	241,373	1,200,012	17,400,000	246,200											
22	Small Business	6.01	349,450	4,985,870	47,266	349,450	4,985,870	48,212	349,450	4,985,870	49,176	349,450	4,985,870	50,159											
23	Small Business Finance				25,000			25,000			25,000			25,000											
24	Self-Direct		2,026,665	2,026,665		2,026,665	2,026,665		2,026,665	2,026,665		2,026,665	2,026,665												
25	Evaluation				188,743			198,181			230,219			241,256											
26	Administration				239,770			246,963			254,372			262,003											
27	Subtotal - Business	4.27	6,499,260	60,127,202	\$ 1,243,562	6,505,951	60,209,206	\$ 1,277,341	6,798,949	63,260,902	\$ 1,383,079	6,805,877	63,353,803	\$ 1,420,103											
28																									
29	Portfolio																								
30	Pilot Programs	3.38	753,227	8,963,406	213,413	753,227	8,963,406	224,718	538,020	6,402,433	186,555	538,020	6,402,433	193,897											
31	Educational Services	5.56	258,549	3,076,735	73,387	258,995	3,082,045	77,370	268,152	3,191,010	92,980	263,241	3,132,564	94,870											
32	Think! Energy		334,000	2,672,000	18,076	336,672	2,693,376	18,938	348,696	2,789,568	18,953	348,696	2,789,568	21,469											
33	Renewable Energy Certificates		1,000,000		4,000	900,000		3,600	1,070,000		4,280	1,070,000		4,280											
34	Workforce Development				60,975			64,205			37,311			38,779											
35	Performance Incentive				695,117			731,940			875,105			919,015											
36	Subtotal - Portfolio	0.66	2,345,776	14,712,141	1,064,968	2,248,894	14,738,827	1,120,771	2,224,868	12,383,011	1,215,184	2,219,957	12,324,565	1,272,310											
37																									
38	Total EWR Plan	2.70	13,687,046	127,424,884	4,170,700	13,725,856	132,385,825	4,391,642	14,688,251	144,794,492	5,016,633	14,695,056	148,063,440	5,223,535											

	(a)	(b)	(c)	(d)	(e)	(f)
Line	<u>Energy Waste Reduction Plan</u>	UCT Score	TRC Score	RIM Score	Societal Score	Participant Score
1	Low Income ("LI")					
2	Empower - Single Family	2.90	1.61	0.40	1.61	7.90
3	Empower - Multi-Family	1.80	0.99	0.37	0.99	4.83
4	Low Income Evaluation					
5	Low Income Administration					
6	Low Income Health and Safety	3.35	3.35	0.36	3.35	
7	Subtotal - Low Income	2.14	1.37	0.37	1.37	7.32
8						
9	Residential					
10	Appliance Recycling	7.85	5.86	0.43	5.86	20.95
11	ENERGY STAR®	3.77	2.01	0.39	2.06	6.93
12	Home Performance - Single Family	3.52	1.83	0.42	1.88	5.69
13	Home Performance - Multi-Family	2.03	1.28	0.38	1.32	4.70
14	New Construction	2.72	0.85	0.40	0.89	2.42
15	Evaluation					
16	Administration					
17	Subtotal - Residential	2.96	1.72	0.40	1.76	6.15
18						
19	Business					
20	Prescriptive	6.28	3.29	0.35	3.38	12.85
21	Custom	7.38	2.52	0.38	2.52	7.85
22	Small Business	6.01	4.20	0.33	4.20	39.40
23	Small Business Finance					
24	Self-Direct					
25	Evaluation					
26	Administration					
27	Subtotal - Business	4.27	2.44	0.35	2.47	11.43
28						
29	Portfolio					
30	Pilot Programs	3.38	3.38	0.36	3.38	
31	Educational Services	5.56	5.56	0.39	5.56	
32	Renewable Energy Certificates					
33	Workforce Development					
34	Performance Incentive					
35	Subtotal - Portfolio	0.66	0.66	0.25	0.66	
36						
37	Total including LI and PI	2.70	1.78	0.36	1.80	9.61
38	Total excluding LI and PI	3.63	2.21	0.37	2.25	9.86
39	Total including LI and excluding PI	3.25	2.01	0.37	2.03	9.61
40	Total excluding LI and including PI	2.84	1.89	0.36	1.92	9.86

Line	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
	COMPONENT #1				COMPONENT #2				
	Annual Energy Savings Goal (MWh) ^{1,5}				Lifetime Savings Goal (MWh) (Weighed 60%) ²	8	Annual Low Income Spend (\$) (Weighed 50%) ³		
1	Goal	10,760			86,083		\$ 868,896	25%	Budget \$ ⁴
2	Target	13,672			109,373				
3	Plan	13,687			127,425		\$ 869,198		
4	2026 Incentive ⁵	191%	20.00%	148%	12.76%		25.01%	7.50%	695,117
5	Tier 1	1.50%	150%	15.00%	100%	9.00%	25.00%	7.50%	
6		1.51%	151%	15.00%	101%	9.09%	25.06%	7.57%	
7		1.52%	152%	15.00%	102%	9.18%	25.12%	7.65%	
8		1.53%	153%	15.00%	103%	9.27%	25.18%	7.72%	
9		1.54%	154%	15.00%	104%	9.36%	25.24%	7.80%	
10		1.55%	155%	15.00%	106%	9.45%	25.30%	7.87%	
11		1.56%	156%	15.00%	107%	9.54%	25.36%	7.95%	
12		1.57%	157%	15.00%	108%	9.63%	25.42%	8.02%	
13		1.58%	158%	15.00%	109%	9.72%	25.48%	8.10%	
14		1.59%	159%	15.00%	110%	9.81%	25.54%	8.17%	
15		1.60%	160%	15.00%	111%	9.90%	25.60%	8.25%	
16		1.61%	161%	15.00%	112%	9.99%	25.66%	8.32%	
17		1.62%	162%	15.00%	113%	10.07%	25.72%	8.40%	
18		1.63%	163%	15.00%	115%	10.16%	25.78%	8.47%	
19		1.64%	164%	15.00%	116%	10.25%	25.84%	8.54%	
20		1.65%	165%	15.00%	117%	10.34%	25.90%	8.62%	
21	Tier 2	1.66%	166%	17.50%	118%	10.43%	25.96%	8.69%	
22		1.67%	167%	17.50%	119%	10.52%	26.01%	8.77%	
23		1.68%	168%	17.50%	120%	10.61%	26.07%	8.84%	
24		1.69%	169%	17.50%	121%	10.70%	26.13%	8.92%	
25		1.70%	170%	17.50%	122%	10.79%	26.19%	8.99%	
26		1.71%	171%	17.50%	124%	10.88%	26.25%	9.07%	
27		1.72%	172%	17.50%	125%	10.97%	26.31%	9.14%	
28		1.73%	173%	17.50%	126%	11.06%	26.37%	9.22%	
29		1.74%	174%	17.50%	127%	11.15%	26.43%	9.29%	
30		1.75%	175%	17.50%	128%	11.24%	26.49%	9.37%	
31		1.76%	176%	17.50%	129%	11.33%	26.55%	9.44%	
32		1.77%	177%	17.50%	130%	11.42%	26.61%	9.51%	
33		1.78%	178%	17.50%	131%	11.51%	26.67%	9.59%	
34		1.79%	179%	17.50%	132%	11.60%	26.73%	9.66%	
35		1.80%	180%	17.50%	134%	11.69%	26.79%	9.74%	
36		1.81%	181%	17.50%	135%	11.78%	26.85%	9.81%	
37		1.82%	182%	17.50%	136%	11.87%	26.91%	9.89%	
38	Tier 3	1.83%	183%	20.00%	137%	11.96%	26.97%	9.96%	
39		1.84%	184%	20.00%	138%	12.04%	27.03%	10.04%	
40		1.85%	185%	20.00%	139%	12.13%	27.09%	10.11%	
41		1.86%	186%	20.00%	140%	12.22%	27.15%	10.19%	
42		1.87%	187%	20.00%	141%	12.31%	27.21%	10.26%	
43		1.88%	188%	20.00%	143%	12.40%	27.27%	10.34%	
44		1.89%	189%	20.00%	144%	12.49%	27.33%	10.41%	
45		1.90%	190%	20.00%	145%	12.58%	27.39%	10.49%	
46		1.91%	191%	20.00%	146%	12.67%	27.45%	10.56%	
47		1.92%	192%	20.00%	147%	12.76%	27.51%	10.63%	
48		1.93%	193%	20.00%	148%	12.85%	27.57%	10.71%	
49		1.94%	194%	20.00%	149%	12.94%	27.63%	10.78%	
50		1.95%	195%	20.00%	150%	13.03%	27.69%	10.86%	
51		1.96%	196%	20.00%	151%	13.12%	27.75%	10.93%	
52		1.97%	197%	20.00%	153%	13.21%	27.81%	11.01%	
53		1.98%	198%	20.00%	154%	13.30%	27.87%	11.08%	
54		1.99%	199%	20.00%	155%	13.39%	27.93%	11.16%	
55	Tier 4	2.00%	200%	22.50%	156%	13.48%	27.99%	11.23%	
56		2.01%	201%	22.50%	157%	13.57%	28.04%	11.31%	
57		2.02%	202%	22.50%	158%	13.66%	28.10%	11.38%	
58		2.03%	203%	22.50%	159%	13.75%	28.16%	11.46%	
59		2.04%	204%	22.50%	160%	13.84%	28.22%	11.53%	
60		2.05%	205%	22.50%	162%	13.93%	28.28%	11.60%	
61		2.06%	206%	22.50%	163%	14.01%	28.34%	11.68%	
62		2.07%	207%	22.50%	164%	14.10%	28.40%	11.75%	
63		2.08%	208%	22.50%	165%	14.19%	28.46%	11.83%	
64		2.09%	209%	22.50%	166%	14.28%	28.52%	11.90%	
65		2.10%	210%	22.50%	167%	14.37%	28.58%	11.98%	
66		2.11%	211%	22.50%	168%	14.46%	28.64%	12.05%	
67		2.12%	212%	22.50%	169%	14.55%	28.70%	12.13%	
68		2.13%	213%	22.50%	171%	14.64%	28.76%	12.20%	
69		2.14%	214%	22.50%	172%	14.73%	28.82%	12.28%	
70		2.15%	215%	22.50%	173%	14.82%	28.88%	12.35%	
71		2.16%	216%	22.50%	174%	14.91%	28.94%	12.43%	
72		2.17%	217%	25.00%	175%	15.00%	29.00%	12.50%	

(1) 1st Year Savings Goal calculated using prior 3-year retail sales average.
 (2) Lifetime Savings Goal is 1st Year Savings Goal multiplied by Average Measure Life.
 (3) Low Income Spend Goal is 25% of Budget and 150% target equal to 29% of Budget
 (4) UPPCO's EWR Plan Costs
 (5) Goals and Targets are anticipated EWR Plan results.
 (6) Incentive is for illustrative purposes based on anticipated EWR Plan results.

Line	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
	COMPONENT #1				COMPONENT #2				
	Annual Energy Savings Goal (MWh) ^{1,5}				Lifetime Savings Goal (MWh) (Weighed 60%) ²	8	Annual Low Income Spend (\$) (Weighed 50%) ³		
1	Goal	10,760			86,083		\$ 914,926	25%	Budget \$ ⁴
2	Target	13,672			109,373				
3	Plan	13,726			132,386		\$ 915,507		
4	2027 Incentive ⁵	191%	20.00%	154%	13.30%		25.02%	7.50%	3,659,702
5	Tier 1	1.50%	150%	15.00%	100%	9.00%	25.00%	7.50%	731,940
6		1.51%	151%	15.00%	101%	9.09%	25.06%	7.57%	
7		1.52%	152%	15.00%	102%	9.18%	25.12%	7.65%	
8		1.53%	153%	15.00%	103%	9.27%	25.18%	7.72%	
9		1.54%	154%	15.00%	104%	9.36%	25.24%	7.80%	
10		1.55%	155%	15.00%	106%	9.45%	25.30%	7.87%	
11		1.56%	156%	15.00%	107%	9.54%	25.36%	7.95%	
12		1.57%	157%	15.00%	108%	9.63%	25.42%	8.02%	
13		1.58%	158%	15.00%	109%	9.72%	25.48%	8.10%	
14		1.59%	159%	15.00%	110%	9.81%	25.54%	8.17%	
15		1.60%	160%	15.00%	111%	9.90%	25.60%	8.25%	
16		1.61%	161%	15.00%	112%	9.99%	25.66%	8.32%	
17		1.62%	162%	15.00%	113%	10.07%	25.72%	8.40%	
18		1.63%	163%	15.00%	115%	10.16%	25.78%	8.47%	
19		1.64%	164%	15.00%	116%	10.25%	25.84%	8.54%	
20		1.65%	165%	15.00%	117%	10.34%	25.90%	8.62%	
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22		1.67%	167%	17.50%	119%	10.52%	26.01%	8.77%	
23		1.68%	168%	17.50%	120%	10.61%	26.07%	8.84%	
24		1.69%	169%	17.50%	121%	10.70%	26.13%	8.92%	
25		1.70%	170%	17.50%	122%	10.79%	26.19%	8.99%	
26		1.71%	171%	17.50%	124%	10.88%	26.25%	9.07%	
27		1.72%	172%	17.50%	125%	10.97%	26.31%	9.14%	
28		1.73%	173%	17.50%	126%	11.06%	26.37%	9.22%	
29		1.74%	174%	17.50%	127%	11.15%	26.43%	9.29%	
30		1.75%	175%	17.50%	128%	11.24%	26.49%	9.37%	
31		1.76%	176%	17.50%	129%	11.33%	26.55%	9.44%	
32		1.77%	177%	17.50%	130%	11.42%	26.61%	9.51%	
33		1.78%	178%	17.50%	131%	11.51%	26.67%	9.59%	
34		1.79%	179%	17.50%	132%	11.60%	26.73%	9.66%	
35		1.80%	180%	17.50%	134%	11.69%	26.79%	9.74%	
36		1.81%	181%	17.50%	135%	11.78%	26.85%	9.81%	
37		1.82%	182%	17.50%	136%	11.87%	26.91%	9.89%	
38	Tier 3	1.83%	183%	20.00%	137%	11.96%	26.97%	9.96%	
39		1.84%	184%	20.00%	138%	12.04%	27.03%	10.04%	
40		1.85%	185%	20.00%	139%	12.13%	27.09%	10.11%	
41		1.86%	186%	20.00%	140%	12.22%	27.15%	10.19%	
42		1.87%	187%	20.00%	141%	12.31%	27.21%	10.26%	
43		1.88%	188%	20.00%	143%	12.40%	27.27%	10.34%	
44		1.89%	189%	20.00%	144%	12.49%	27.33%	10.41%	
45		1.90%	190%	20.00%	145%	12.58%	27.39%	10.49%	
46		1.91%	191%	20.00%	146%	12.67%	27.45%	10.56%	
47		1.92%	192%	20.00%	147%	12.76%	27.51%	10.63%	
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49		1.94%	194%	20.00%	149%	12.94%	27.63%	10.78%	
50		1.95%	195%	20.00%	150%	13.03%	27.69%	10.86%	
51		1.96%	196%	20.00%	151%	13.12%	27.75%	10.93%	
52		1.97%	197%	20.00%	153%	13.21%	27.81%	11.01%	
53		1.98%	198%	20.00%	154%	13.30%	27.87%	11.08%	
54		1.99%	199%	20.00%	155%	13.39%	27.93%	11.16%	
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Line	Goal	10,760			86,083	8	\$ 1,035,382	25%	Budget \$ ⁴
	Target	14,661			117,292				
	Plan	14,688			144,794		\$ 1,042,417		4,141,528
	2028 Incentive ⁵	205%	22.50%	168%	13.48%		25.17%	7.65%	875,105
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7		1.52%	152%	15.00%	102%	9.18%	25.12%	7.65%	
8		1.53%	153%	15.00%	103%	9.27%	25.18%	7.72%	
9		1.54%	154%	15.00%	104%	9.36%	25.24%	7.80%	
10		1.55%	155%	15.00%	106%	9.45%	25.30%	7.87%	
11		1.56%	156%	15.00%	107%	9.54%	25.36%	7.95%	
12		1.57%	157%	15.00%	108%	9.63%	25.42%	8.02%	
13		1.58%	158%	15.00%	109%	9.72%	25.48%	8.10%	
14		1.59%	159%	15.00%	110%	9.81%	25.54%	8.17%	
15		1.60%	160%	15.00%	111%	9.90%	25.60%	8.25%	
16		1.61%	161%	15.00%	112%	9.99%	25.66%	8.32%	
17		1.62%	162%	15.00%	113%	10.07%	25.72%	8.40%	
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	Annual Energy Savings Goal (MWh) ^{1,5}				Lifetime Savings Goal (MWh) (Weighed 60%) ²	Annual Low Income Spend (\$) (Weighed 50%) ³			
Line	Goal	10,760			86,083	8	\$ 1,076,130	25%	Budget \$ ⁴
	Target	14,661			117,292				
	Plan	14,695			148,063		\$ 1,090,032		4,304,520
	2029 Incentive ⁵	205%	22.50%	172%	13.48%		25.32%	7.87%	919,015
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**2026 – 2029 Energy Optimization Plan
 Energy Waste Reduction (EWR)
 Financial Incentive Mechanism**

The performance incentive will be calculated at the individual achievement of lifetime savings achieved incentive percentage plus low income dollar spend incentive percentage. Lifetime savings account for 60% of the weighting and the Low Income Spend accounts for 50% of the weighting. The performance incentive award percentage will not exceed the percentage earned for first year savings achieved.

Example Calculations

	First Year	Lifetime	Low-Income	<i>Incentive Earned</i>
Scenario 1:	1.50%	100.0%	25.00%	
Incentive -	15.00%	9.00%	7.50%	15.00%
Formula -	Incentive = the lesser of 15% or (9.00% + 7.50%)			
Scenario 2:	2.0%	150.0%	25.60%	
Incentive -	22.50%	13.03%	8.25%	21.28%
Formula -	Incentive = the lesser of 22.500% or (13.03% + 8.25%)			
Scenario 3:	2.17%	175.0%	29.00%	
Incentive -	25.00%	15.00%	12.50%	25.00%
Formula -	Incentive = the lesser of 25% or (15.00% + 12.50%)			

The Company cannot earn an incentive without at least reaching Tier 1 of the Annual 1st Year Savings Goal. If lifetime falls short, low income must achieve even higher to maximize the incentive, or vice versa.

Upper Peninsula Power Company (UPPCO)
 2026 - 2029 Energy Optimization (EO) Plan
 Energy Waste Reduction (EWR) Revenue Requirement

Case No. U-21684
 Exhibit A-5 (AHM-5)
 Witness: Andrew McNeally

	(a)	(b)	(c)	(d)	(e)	(f)
Line	Energy Waste Reduction Revenue Requirement	Low Income	Residential	Business	Portfolio	Total
1	2026 EWR Plan Costs	\$ 869,198	\$ 992,972	\$ 1,243,562	\$ 1,064,968	\$ 4,170,700
2	2027 EWR Plan Costs	\$ 915,507	\$ 1,078,023	\$ 1,277,341	\$ 1,120,771	\$ 4,391,642
3	2028 EWR Plan Costs	\$ 1,042,417	\$ 1,375,953	\$ 1,383,079	\$ 1,215,184	\$ 5,016,633
4	2029 EWR Plan Costs	\$ 1,090,032	\$ 1,441,090	\$ 1,420,103	\$ 1,272,310	\$ 5,223,535
5						
6	Proposed Revenue Requirement	\$ 3,917,154	\$ 4,888,038	\$ 5,324,085	\$ 4,673,233	\$ 18,802,510

STATE OF MICHIGAN

BEFORE THE MICHIGAN PUBLIC SERVICE COMMISSION

* * * * *

In the matter, on the Commission's own motion,)
regarding the regulatory reviews, revisions,)
determinations, and/or approvals necessary for) Case No. U-21684
UPPER PENINSULA POWER COMPANY to)
fully comply with Public Act 295 of 2008, as)
amended.)

DIRECT TESTIMONY AND EXHIBITS

OF NICOLE E. BELL

ON BEHALF OF UPPER PENINSULA POWER COMPANY

July 1, 2025

DIRECT TESTIMONY AND EXHIBITS

OF NICOLE E. BELL

1 Q. PLEASE STATE YOUR NAME, BUSINESS ADDRESS, AND NAME OF YOUR
2 EMPLOYER.

3 A. My name is Nicole E. Bell. My business address is 18494 Canal Road, Houghton, Michigan
4 49931. I am employed by Upper Peninsula Power Company (“UPPCO” or the “Company”).
5

6 Q. PLEASE PROVIDE YOUR TITLE AND DESCRIBE YOUR JOB RESPONSIBILITIES.

7 A. My title is Manager of Rates and Power Supply within the Regulatory Affairs department. My
8 responsibilities in this role include a wide variety of issues touching several aspects of UPPCO’s
9 business, including tariff administration, Renewable Portfolio Standard (“RPS”) compliance
10 analysis, sales and peak demand forecasting, rate design and revenue analysis, among other
11 related duties.
12

13 Q. BRIEFLY DESCRIBE YOUR EDUCATIONAL BACKGROUND AND APPLICABLE
14 PROFESSIONAL EXPERIENCE.

15 A. I graduated from the Community College of the Air Force in 2013 with an Associate of Applied
16 Science in Weather Technology. I graduated from American Military University in 2016 with a
17 Bachelor of Science in Environmental Science. I graduated from Grand Canyon University in
18 2021 with a Master’s in Business Administration. In January 2011, I entered employment with
19 the United States Air Force (“USAF”) as a Weather Specialist, tasked with the observing,
20 recording, forecasting, and dissemination of weather data and information to military installations
21 throughout the United States. In January 2015, I completed my enlistment in the USAF and began
22 employment with the Tucson Electric Power Company (“TEPC”) as a Renewable Energy
23 Forecaster and Trading Analyst in the Wholesale Marketing and Renewables departments of
24 TEPC. My responsibilities in this position included the forecasting and analysis of renewable
25 resource output and availability, the updating and maintaining of TEPC’s renewable resource

DIRECT TESTIMONY AND EXHIBITS

OF NICOLE E. BELL

1 forecasting models, and other analysis of the department's generation resources, including
2 analysis of transactions between TEPC and its counterparties. I cross-trained in several different
3 positions throughout the Wholesale Marketing department, where I completed tasks related to the
4 scheduling of power purchases and sales, creation and monitoring of transaction tags, creation
5 and monitoring of transmission reservations, and the conducting of daily communication between
6 counterparties. In January 2020, I left my employment with TEPC. I began employment with
7 UPPCO in March 2020 as a Regulatory Analyst within the Regulatory Affairs department.

8
9 Q. HAVE YOU PREVIOUSLY TESTIFIED IN ANY REGULATORY PROCEEDINGS?

10 A. Yes. I have provided testimony in several cases before the Commission. Recent notable
11 examples include the following proceedings on behalf of UPPCO: Case No. U-21833 (2024
12 Renewable Energy reconciliation), Case No. U-21809 (2025 Integrated Resource Plan), Case No.
13 U-21555 (General Rate Case), Case No. U-21602 (2025 PSCR Plan), and Case No. U-21268
14 (2023 PSCR reconciliation)

15
16 Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY?

17 A. The purpose of my testimony is to present support of UPPCO's Energy Optimization Plan for the
18 2026 through 2029 plan years, specifically related to the identification of UPPCO's Energy Waste
19 Reduction (EWR) energy savings target, revenue requirement allocation, rate design, and tariff
20 sheets.

21
22 Q. ARE YOU SPONSORING ANY EXHIBITS IN YOUR DIRECT TESTIMONY?

23 A. Yes, I am sponsoring the following exhibits, which were prepared by me:

- 24 • Exhibit A-6 (NEB-1) – EWR Rate Class Sales, Energy Savings Goals and Targets
25 • Exhibit A-7 (NEB-2) – EWR Rate Class Revenues

DIRECT TESTIMONY AND EXHIBITS

OF NICOLE E. BELL

- 1 • Exhibit A-8 (NEB-3) – EWR Allocation Factors
- 2 • Exhibit A-9 (NEB-4) – EWR Revenue Requirement Allocation
- 3 • Exhibit A-10 (NEB-5) – EWR Rate Design – Surcharges & Self-direct Surcharges
- 4 • Exhibit A-11 (NEB-6) – EWR Tariff Sheet

5

6 Q. HOW IS YOUR TESTIMONY ORGANIZED?

7 A. My testimony is organized into the following sections:

- 8 1. EWR 3-year Energy Savings Goals and Targets
- 9 2. EWR Plan Revenue Allocation and Surcharges
- 10 3. EWR Tariff Sheet Update

11

12 **I. EWR 3-YEAR ENERGY SAVINGS GOALS**

13

14 Q. WHAT ARE THE PLAN STATUTORY SAVINGS GOALS?

15 A. The UPPCO 2026-2029 EWR plan was developed to exceed the statutory goals of 1.5% as set
16 forth in 2008 PA 295, as amended by 2016 PA 342 and 2023 PA 229, Sec 77(1). The energy
17 savings goal required by statute for the current plan cycle is 10,760 MWh, as shown in Exhibit A-
18 6 (NEB-1) EWR Rate Class Sales, Energy Savings, Goals and Targets.

19

20 Q. PLEASE DESCRIBE THE SAVINGS GOALS INCLUDED IN UPPCO'S 2026-2029 PLAN.

21 A. The calculation of UPPCO's EWR Plan savings goals and targets are included for each rate class
22 in columns (f) and (g) of Exhibit A-6 (NEB-1) EWR Rate Class Sales, Energy Savings, Goals and
23 Targets.

24

DIRECT TESTIMONY AND EXHIBITS

OF NICOLE E. BELL

1 Q. PLEASE DESCRIBE HOW THE SAVINGS CONTRIBUTION OF SELF-DIRECT
2 CUSTOMERS IS ACCOUNTED FOR IN THE CALCULATION OF UPPCO'S 2026-2029
3 PLAN SAVINGS GOALS.

4 A. Customers who have opted to self-direct their EWR Plan are assumed to deliver the 1.5%
5 statutory minimum savings goal in contribution to UPPCO's overall EWR plan savings target.

6

7 **II. EWR PLAN REVENUE ALLOCATION AND SURCHARGES**

8

9 Q. PLEASE DESCRIBE UPPCO'S 2026-2029 EWR PLAN BUDGETS?

10 A. As described by Witness McNeally in Exhibit A-2 (AHM-2), UPPCO is proposing a self-
11 administered EWR Plan for 2026 through 2029 plan years with a total budget of \$18,802,510.

12

13 Q. HOW HAS UPPCO CALCULATED THE RATE CLASS REVENUE REQUIREMENTS FOR
14 ITS PROPOSED EWR SURCHARGE RATES?

15 A. The total revenue requirements are based on the forecasted 2026 through 2029 EWR Plan costs as
16 identified by Witness McNeally in Exhibit A-2 (AHM-2). The energy and meter counts are based
17 on 2026 forecast data. The rate class revenue requirements for 2026 through 2029 are developed
18 through the application of allocation factors derived using rate class revenues. As evidenced in
19 Exhibit A-7 (NEB-2) Rate Class Revenues and Exhibit A-8 (NEB-3) Allocation Factors, the
20 allocation factors are derived based on the 3-year average of UPPCO's filed P-521 Reports. The
21 program allocation factors assign the residential and business revenue requirements to the
22 individual rates classes within the residential or business sectors, respectively. The rate class
23 allocation factors assign the portfolio and low-income related costs to the individual rate
24 categories. For the large business and industrial customers, the rate class allocation factors also

DIRECT TESTIMONY AND EXHIBITS

OF NICOLE E. BELL

1 assign the low-income revenue requirement to be collected via Self-Direct surcharges, if a
2 customer opts to Self-Direct.

3

4 Q. HOW HAS UPPCO PERFORMED RATE DESIGN FOR ITS PROPOSED EWR SURCHARGE
5 RATES?

6 A. The rate class revenue requirements calculated in Exhibit A-9 (NEB-4) Revenue Requirement
7 Allocation serves as the basis for calculating the proposed EWR surcharges for 2026 through
8 2029. To calculate the proposed surcharge rate, each rate class revenue requirement was divided
9 by the respective number of energy volume or meters listed in Exhibit A-10 (NEB-5) Rate Design
10 – Surcharges & Self-Direct Surcharges.

11

12 **III. TARIFF SHEET UPDATE**

13

14 Q. WHAT EXHIBIT REPRESENTS UPPCO'S TARIFF UPDATE?

15 A. UPPCO's proposed tariff sheet incorporating the attributes of the 2026-2029 EWR plan are
16 included Exhibit A-11 (NEB-6) Tariff Sheet.

17

18 Q. DOES THIS CONCLUDE YOUR TESTIMONY?

19 A. Yes.

Line	(a) Rate Class	(b) 2022 P-521 Rate Class Sales ¹	(c) 2023 P-521 Rate Class Sales ¹	(d) 2024 P-521 Rate Class Sales ¹	(e) 3-Year Average Sales	(f) Statutory 1.5% Savings Goal	(g) EWR Plan 2.0% Savings Target	(h) EWR Plan 2.17% Savings Target
1	Residential							
2	A-1	237,191	228,191	225,396	230,259	3,454	4,605	4,997
3	AH-1	23,892	22,492	21,218	22,534	338	451	489
4	Residential Total	261,083	250,683	246,614	252,793	3,792	5,056	5,486
5								
6	Business							
7	Small							
8	C-1	65,423	70,792	62,498	66,238	994	1,325	1,437
9	H-1	7,153	6,381	5,992	6,509	98	130	141
10								
11	Medium							
12	P-1	67,979	66,579	67,012	67,190	1,008	1,344	1,458
13								
14	Large							
15	CP-U	124,935	121,450	125,140	123,842	1,858	2,477	2,687
16	CP-I	-	-	-	-	-	-	-
17								
18	Industrial							
19	RTMP ³	129,528	92,767	99,929	107,408	1,611	1,611	1,611
20	RTMP-D	-	-	-	-	-	-	-
21								
22	Special Contract ^{2 3}	28,203	28,247	26,659	27,703	416	416	416
23								
24	WP-3	70,548	64,918	60,555	65,340	980	1,307	1,418
25								
26	Lighting							
27	SL-3	370	347	293	337	5	7	7
28								
29	Business Total	494,139	451,481	448,078	464,566	6,968	8,616	9,176
30								
31	Total	755,222	702,164	694,692	717,359	10,760	13,672	14,661

(1) - UPPCO P-521 Report for year ending December 31st, page 304 , column (b)

(2) - Special Contract Sales from non-utility monthly invoices

(3) - Current EWR Self-Direct Customer with 1.5% Savings Target

	(a)	(b)	(c)	(d)	(e)
		2022 P-521	2023 P-521	2024 P-521	3-Year
Line	Rate Class	Rate Class	Rate Class	Rate Class	Average
		Revenues ¹	Revenues ¹	Revenues ¹	Revenues
1	<u>Residential</u>				
2	A-1	55,116,375	58,180,362	61,243,788	58,180,175
3	AH-1	4,681,710	4,862,156	4,854,221	4,799,362
4	Residential Total	59,798,085	63,042,518	66,098,009	62,979,537
5					
6	<u>Business</u>				
7	<u>Small</u>				
8	C-1	12,247,659	14,824,019	16,687,234	14,586,304
9	H-1	1,062,401	1,146,855	1,198,929	1,136,061
10					
11	<u>Medium</u>				
12	P-1	12,271,183	12,709,620	12,662,451	12,547,751
13					
14	<u>Large</u>				
15	CP-U	11,446,246	13,775,168	14,416,247	13,212,553
16	CP-I	-	-	-	-
17					
18	<u>Industrial</u>				
19	RTMP ³	10,178,938	4,579,363	4,157,403	6,305,235
20	RTMP-D	-	-	-	-
21					
22	Special Contract ^{2 3}	1,472,489	1,459,286	1,456,372	1,462,715
23					
24	WP-3	4,164,594	4,376,602	5,523,867	4,688,354
25					
26	<u>Lighting</u>				
27	SL-3	78,379	75,885	63,676	72,647
28					
29	Business Total	52,921,888	52,946,798	56,166,177	54,011,621
30					
31	Total	112,719,973	115,989,315	122,264,186	116,991,158

(1) - UPPCO P-521 Report for year ending December 31st, page 304 , column (c)

(2) - Special Contract Sales from non-utility monthly invoices

(3) - Current EWR Self-Direct Customer

	(a)	(b)	(c)	(d)
		3-year Average P-521 Rate Class Revenues ¹	Program Allocation Factor	Rate Class Allocation Factor
Line	Rate Class			
1	<u>Residential</u>			
2	A-1	58,180,175	0.9238	0.4973
3	AH-1	4,799,362	0.0762	0.0410
4	Residential Total	62,979,537	1.0000	
5				
6	<u>Commercial</u>			
7	<u>Small</u>			
8	C-1	14,586,304	0.2701	0.1247
9	H-1	1,136,061	0.0210	0.0097
10				
11	<u>Medium</u>			
12	P-1	12,547,751	0.2323	0.1073
13				
14	<u>Large</u>			
15	CP-U	13,212,553	0.2446	0.1129
16	CP-I	-	-	-
17				
18	<u>Industrial</u>			
19	RTMP ²	6,305,235	0.1167	0.0539
20	RTMP-D	-	-	-
21				
22	Special Contract ²	1,462,715	0.0271	0.0125
23				
24	WP-3	4,688,354	0.0868	0.0401
25				
26	<u>Lighting</u>			
27	SL-3	72,647	0.0013	0.0006
28				
29	Commercial Total	54,011,621	1.0000	
30				
31	Total	116,991,158		1.0000

(1) - U-21684 Exhibit A-7 (NEB-2), Page 2, Column (e)

(2) - Current EWR Self-Direct Customer

	(a)	(b)	(c)	(d)	(e)
Line	Rate Class	Program Revenue Allocation	Portfolio Revenue Allocation	Low Income Revenue Allocation	EWR Plan Revenue Requirement
1	<u>Residential</u>				
2	A-1	4,515,545	2,324,018	1,948,016	\$ 8,787,579
3	AH-1	372,493	191,711	160,695	\$ 724,899
4	Residential Subtotal	4,888,038			
5					
6	<u>Commercial</u>				
7	<u>Small</u>				
8	C-1	1,437,815	582,653	488,386	\$ 2,508,853
9	H-1	111,985	45,380	38,038	\$ 195,403
10					
11	<u>Medium</u>				
12	P-1	1,236,869	501,222	420,130	\$ 2,158,221
13					
14	<u>Large</u>				
15	CP-U	1,302,400	527,778	442,389	\$ 2,272,567
16	CP-I	-	-	-	\$ -
17					
18	<u>Industrial</u>				
19	RTMP ¹	621,526	251,864	211,115	\$ 1,084,504
20	RTMP-D	-	-	-	\$ -
21					
22	Special Contract ¹	144,184	58,428	48,975	\$ 251,588
23					
24	WP-3	462,145	187,277	156,978	\$ 806,400
25					
26	<u>Lighting</u>				
27	SL-3	7,161	2,902	2,432	\$ 12,495
28					
29	Commercial Subtotal	5,324,085			
30					
31	Portfolio Subtotal		\$ 4,673,233		
32					
33	Low Income Subtotal			\$ 3,917,154	
34					
35	Total	10,212,123	4,673,233	3,917,154	18,802,510

(1) - Current EWR Self-Direct Customer

(a)	(b)	(c)	(d)	(e)	(f)	
Line	Rate Class	EWR Plan Revenue Requirement	Forecasted Volumes In MWh 2026 ¹	Current EWR Surcharge	Proposed EWR Surcharge	Units
1	Residential					
2	A-1	8,787,579	229,188			
3	AH-1	724,899	18,906			
4	Subtotal	9,512,478	248,094	0.0064	0.0096	per kWh
5						
6	Commercial		Number of			
7	Small		Customers/Meters			
8	C-1	2,508,853	5,221			
9	H-1	195,403	200			
10	Subtotal	2,704,256	5,421	0.2264	0.3464	per meter/day
11						
12	Medium					
13	P-1	2,158,221	493			
14	Subtotal	2,158,221	493	1.9869	3.0401	per meter/day
15						
16	Large					
17	CP-U	2,272,567	53			
18	CP-I	-	0			
19	Subtotal	2,272,567	53	19.4615	29.7768	per meter/day
20						
21	Industrial					
22	RTMP ²	1,084,504	1			
23	RTMP-D	-	0			
24	Subtotal	1,084,504	1	492.2273	753.1279	per meter/day
25						
26	Special Contract ²	251,588	1			
27	Subtotal	251,588	1	114.1890	174.7139	per meter/day
28						
29	WP-3	806,400	3			
30	Subtotal	806,400	3	122.0011	186.6666	per meter/day
31						
32	Lighting					
33	SL-3	12,495	70			
34	Subtotal	12,495	70	0.0810	0.1240	per meter/day
35						
36						
37	Total ³	\$ 18,802,510				

(1) - Forecast Annual Sales from U-21602, Exhibit A-2(NEB-2), Page 1

(2) - Current EWR Self-Direct Customer

(3) - Total in this exhibit does not included assumed Self-Direct revenues.

(a)	(b)	(c)	(d)	(e)	(f)	
Line	Rate Class	Self-Direct Revenue Requirement	Forecasted Volumes In MWh 2024 ¹	Current EWR Surcharge	U-21561 Proposed Surcharge	Units
1	Residential					
2	A-1	1,948,016	229,188			
3	AH-1	160,695	18,906			
4	Subtotal	2,108,711	248,094	N/A	N/A	
5						
6	Commercial		Number of			
7	Small		Customers/Meters			
8	C-1	488,386	5,221			
9	H-1	38,038	200			
10	Subtotal	526,424	5,421	N/A	N/A	
11						
12	Medium					
13	P-1	420,130	493			
14	Subtotal	420,130	493	N/A	N/A	
15						
16	Large					
17	CP-U	442,389	53			
18	CP-I	-	0			
19	Subtotal	442,389	53	3.8247	5.7965	per meter/day
20						
21	Industrial					
22	RTMP	211,115	1			
23	RTMP-D	-	0			
24	Subtotal	211,115	1	96.7348	146.6076	per meter/day
25						
26	Special Contract	48,975	1			
27	Subtotal	48,975	1	22.4409	34.0107	per meter/day
28						
29	WP-3	156,978	3			
30	Subtotal	156,978	3	23.9762	36.3374	per meter/day
31						
32	Lighting					
33	SL-3	2,432	70			
34	Subtotal	2,432	70	N/A	N/A	
35						
36						
37	Total	\$ 3,917,154				

(1) - Forecast Annual Sales from U-21602, Exhibit A-2(NEB-2), Page 1

MPSC Vol No 8-ELECTRIC

Replaces ~~23rd22nd~~ Rev. Sheet No. D-73.00
~~22nd21st~~ Rev. Sheet No. D-73.00

D2. Energy Waste Reduction (EWR)

EWR

Energy Waste Reduction Surcharge

This surcharge permits, pursuant to Section 91(4) of 2008 Pa 295, and as amended in 2016 PA 342, the adjustment of distribution rates, via the application of an Energy Waste Reduction Surcharge, to allow recovery of the energy waste reduction alternative compliance payment made by the Company in compliance with Section 91(1) of 2008 Pa 295 as amended in 2016 PA 342.

All customer bills subject to the provisions of this tariff, including any bills rendered under special contract, shall be adjusted by the Energy Waste Reduction Surcharge per kWh or per meter, per day as follows:

Rates per kWh

RATE SCHEDULE	EWR Rate	+	Distribution Charge	=	TOTAL Distribution Charge
A-1	\$0. 0064 <u>0096</u>	+	0.13567	=	0. 142071 <u>14530</u>
AH-1	\$0. 0064 <u>0096</u>	+	0.13567	=	0. 142071 <u>14527</u>
AH-1, 0-500 kWh, Oct-May	\$0. 0064 <u>0096</u>	+	0.13567	=	0. 142071 <u>14527</u>
AH-1, 500+ kWh, Oct-May	\$0. 0064 <u>0096</u>	+	0.06783	=	0. 074230 <u>07743</u>

Rates per meter, per day

RATE SCHEDULE	Customers without Self-Directed Plan EWR Rate	OR	Customers with Self-Directed Plan EWR Rate	+	Service/ Customer Charge	=	Customers without Self-Directed Plan TOTAL Service/ Customer Charge	OR	Customers with Self-Directed Plan TOTAL Service/ Customer Charge
C-1	0. 2264346 4	OR		+	0.6247	=	0. 8510971 1	OR	
H-1	0. 2264346 4	OR		+	0.6247	=	0. 8510971 1	OR	
P-1	1.98693.0 401	OR		+	1.2164	=	3.20234.2 565	OR	
CP-U Secondary	19.461529 .7768	OR	3.82475.7 965	+	16.4383	=	35.899846 .2151	OR	20.263022 .2348
CP-U Primary	19.461529 .7768	OR	3.82475.7 965	+	21.3698	=	40.831351 .1466	OR	25.194527 .1663
CP-U Transmission	19.461529 .7768	OR	3.82475.7 965	+	49.3150	=	68.777657 9.0918	OR	53.139755 .1115
RTMP	492.22735 73.1279	OR	96.734814 6.6076	+	32.8767	=	525.10407 86.0046	OR	129.61151 79.4843
RTMP-D	492.22737 53.1279	OR	96.734814 6.6076	+	32.8767	=	525.10407 86.0046	OR	129.61151 79.4843
Special Contract	114.18901 74.7139	OR	22.440934 .0107	+		=	114.18901 74.7139	OR	22.440934 .0107
WP-3	122.00111 86.6666	OR	23.976236 .3374	+	49.3150	=	171.31612 35.9816	OR	73.291285 .6524
SL-3	0. 0810124 0	OR		+	0.6247	=	0. 7057748 7	OR	

Issued: XX-XX-XXXX
By G R Haehnel
Chief Executive Officer
Marquette, Michigan

Effective for Service
On and After: XX-XX-XXXX
Issued Under Auth. of
Mich Public Serv Comm
Dated: XX-XX-XXXX
In Case No: U-2168421675

MICHIGAN DEPARTMENT OF LICENSING AND REGULATORY AFFAIRS
PUBLIC SERVICE COMMISSION

ENTRY OF APPEARANCE IN AN ADMINISTRATIVE HEARING

This form is issued as provided for by 1939 PA 3, as amended, and by 1933 PA 254, as amended. The filing of this form, or an acceptable alternative, is necessary to ensure subsequent service of any hearing notices, Commission orders, and related hearing documents.

General Instructions:

Type or print legibly in ink. For assistance or clarification, please contact the Public Service Commission at 517-284-8090.

*Please Note: The Commission will provide **electronic** service of documents to all parties in this proceeding.*

THIS APPEARANCE TO BE ENTERED IN ASSOCIATION WITH THE ADMINISTRATIVE HEARING:

Case / Company Name: _____ Docket No. U-_____

Please enter my appearance in the above-entitled matter on behalf of:

1. (Name)
2. (Name)
3. (Name)
4. (Name)
5. (Name)
6. (Name)
7. (Name)

Name _____

Address _____

City _____ State _____

Zip _____ Phone _____

Email _____

Date _____

Signature: _____

I am not an attorney

I am an attorney whose:

Michigan Bar # is P-_____

_____ Bar # is: _____
(state)