STATE OF MICHIGAN

BEFORE THE MICHIGAN PUBLIC SERVICE COMMISSION

In the matter of the application of CONSUMERS ENERGY COMPANY for approval of a Power Supply Cost Recovery Plan and for Authorization of Monthly Power Supply Cost Recovery Factors for the Year 2014.
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Case No. **U-17317**

DIRECT TESTIMONY AND EXHIBITS OF GEOFFREY C. CRANDALL

On Behalf of The

Great Lakes Renewable Energy Association

August 12, 2014

I. QUALIFICATIONS

Q. What is your name and business address?

A. My name is Geoffrey C. Crandall. My business address is MSB Energy Associates, Inc., University Avenue 6907 University Avenue #162, Middleton, Wisconsin 53562.

Q. On whose behalf are you testifying today?

A. I am testifying on behalf of Great Lakes Renewable Energy Association.

Q. Please describe your background and experience in the field of gas and electric utility regulation.

A. I am a principal and the Vice President of MSB Energy Associates, Inc. I have over 40 years of experience in utility regulatory issues, including resource planning, restructuring, mergers, fuel, purchase power and gas cost recovery and planning analysis, energy efficiency, conservation and load management impacts, program design and other issues. I have provided expert testimony before more than a dozen public utility regulatory bodies throughout the United States. I have provided expert testimony before the United States Congress on several occasions and have previously filed testimony in numerous cases before the Michigan Public Service Commission.

My experience includes over 15 years of service on the Staff of the Michigan Public Service Commission (Commission). In my tenure at the Commission, I served as an analyst in the Electric Division (Rates and Tariff section) involving rate as well as fuel and purchase power cases. I also served as the Technical Assistant to the Chief of Staff, supervisor of the energy conservation section (involving residential and commercial

energy efficiency programs). I also served as the Division Director of the Industrial, Commercial and Institutional Division. In that capacity, I was Director of the Division that had responsibility for the energy efficiency and conservation program design, funding, and implementation of Michigan utility and DOE-funded private company implemented programs and initiatives involving Industrial, Commercial and Institutional gas and electric customers throughout Michigan.

In 1990, I became employed by MSB Energy Associates, Inc. and have served clients throughout the United States on numerous projects related to system planning, fuel, purchase power and gas cost recovery assessments, energy efficiency and load management program development, electric restructuring, customer impact analyses, and other issues. My vita is attached as **GLREA Exhibit 1 (GCC-1)**.

II. DIRECT TESTIMONY

Q. What is the purpose of your testimony in this case?

A. The primary purpose of my testimony is to focus upon the 5-year forecast that Consumers Energy Company (CECO) has filed in this case, and to make recommendations to the Administrative Law Judge and the Commission concerning the forecast.

Q. What have you concluded based upon a review of CECO's testimony and Exhibits concerning its 5-year forecast?

A. CECO's 5-year forecast is incomplete and flawed with respect to its presentation of the contribution of solar energy resources over the five years presented. The witnesses for CECO present no discussion, analysis of, or support for CECO's projections of solar

energy contributions through 2018. CECO witness Sara Walz, in her direct testimony (prefiled page 3, lines 9-11) does state:

> This 2014 forecast was produced using up-to-date assumptions and data that were reviewed by the responsible departments before they were input to the program. The results have been reviewed for reasonableness and for consistency with input and assumptions.

CECo witness Walz, in a discovery response (17317-GLREA-CE-97) also indicated that "(T)he forecast of solar generation production and costs align with the assumptions included in the 2013 Biennial Renewable Energy Plan, MPSC Case No. U-17301." According to the information provided by CECO (See Exhibits A-3 and Exhibit A-4 of the U-17301 filing) CECO is projecting that for E.A.R.P. Phase 1 and Phase 2 solar contributions are expected to decline for both on and off peak periods. For E.A.R.P. Phase 3 solar contributions, the projections increase from 2014-2016, then decrease from 2016-2018 and beyond through 2029. The total renewable energy in the forecast for on and off peak contributions is slightly declining during the PSCR forecast period. This forecast generally embraces an assumption that essentially a flat or declining solar energy resources contribution will occur in the five-year forecast period (2014-2018). The testimony of this and other CECO witnesses in this proceeding present no evidentiary basis or other discussion whatsoever to support these numbers and the generally declining multi-year solar forecast. CECO has not offered justification in this PSCR Plan proceeding for its unstated basis for its PSCR related solar resource projections. As a result, CECO's PSCR forecast is flawed, deficient, and incomplete.

Q. What concerns do you have regarding this flawed resource planning approach?

A. This PSCR Plan case is the major docket in which CECO examines its energy resource forecasts and costs for the upcoming five years. Michigan does not have a robust integrated resource planning or least cost planning process in contrast to other states. Act 304 thus provides an important mechanism via PSCR plan and forecast cases to review the future mix of resources that will be financially supported by CECO's ratepayers. In this filing CECO has proposed reliance on a five-year forecast that constrains consideration of and reliance on renewable resources. Increased use of renewable resources would reduce the need for the purchase power and fuels to directly serve CECO PSCR customers. Renewable resources are underutilized in CECO's proposed forecast, which in turn would unnecessarily impede and constrain renewable resource application resulting in higher levels of fuel and purchased power than would otherwise be the case.

Q. Why do you take issue with the assumptions regarding the magnitude of renewable resources included in the PSCR Plan and forecast?

A. A very significant driver of renewable resource adoption levels is the installed cost of renewable systems. We are now experiencing an era of declining costs for renewable energy technologies. As demand increases in this country for more renewable equipment, costs are declining as well. My concern is that given the declining costs of renewable technologies, the CECO PSCR plan underestimated the magnitude of renewable energy systems in its service territory and therefore understated the likely impact on the five-year PSCR forecast. This flaw in the forecast would result in higher electricity costs to CECO PSCR consumers than would otherwise be the case.

Q. Aside from the absence of justification and support for CECO's forecast concerning solar resource, why do you conclude that CECO's solar resource forecasts are flawed?

A. CECO's forecast of a generally declining or flat contribution from solar resources for the years 2014-2018 contrasts significantly from extrinsic information that is available nationally, regionally and specifically with respect to Michigan and MPSC regulation, that establishes that significant growth in solar capacity and energy resources should come into operation in CECO's service territory over the 5-year forecast period.

The national experience in recent years has been that there has been a very sizeable increase in solar resources, and a maturing of the industry. This is contributing to significant reductions in the cost of solar development and implementation, which is adding to the economic attractiveness of solar energy.

In Michigan, there appears to be increasing interest in solar resource development, both with respect to customer owned resources and community solar projects. Also, there have been significant increases in net-metering participation under Michigan's net - metering program. For example, a formal Commission report confirms a 55% increase in this program in 2012 over 2011 (*Michigan Public Service Commission's Net Metering and Solar Pilot Program Report for Calendar Year 2012*, August 2013, p3). Also, there is room for further increases in net metering with current statutory ceilings. As of mid-2014, the amount of energy supplied to utilities under net metering under Category I, most applicable to residential customers, was still limited with much room to expand based upon present caps. For CECO, the net metering capacity limit was 45 MW, while the then current use was 1.2 MW (less than 3 %). As of mid-2014, the amount of

capacity available for the net metering purposes for Category II under Act 295 and the Commission's program (applicable to larger facilities of 20-150 KW) was 22 MW for CECO, while the current use for that category was .8 MW's (less than 4%). (*Michigan Public Service Commission's Staff Report August 2014* pp 4-5). The level of enrollment in CECO's net metering program for both Category I and II are woefully inadequate in comparison to the legislatively prescribed levels identified in the Clean, Renewable and Efficient Energy Act 295 of 2008.

The Legislature in 2008 PA 195 has also established public policies to encourage the development of renewable energy resources, including solar, and to thereby assist with the diversification of Michigan's energy resources and to encourage the furthering of an in-state renewable energy industry.

The Governor has also shown an interest in furthering the encouragement of a renewable energy industry in Michigan and has encouraged or directed the formulation of formal reports and increased focus on this strategy.

The MPSC has also reviewed considerable evidence concerning renewable energy, including solar resources, in its biennial renewable energy plan cases, including the CECO U-17301 and DTE Electric U-17302 cases. In those cases, extensive evidence was submitted by intervenor parties to support increases in renewable energy resources, including specifically solar energy. Notable, the MPSC in that case in its December 19, 2013 order (pp 18-20) required the establishment of a collaborative workgroup process to focus on solar energy program resource issues. This process, which included participation by CECO, is likely to be a forerunner of future MPSC orders and policies to

promote increased development and implementation of renewable energy resources, including specifically solar resources, in the near future, well ahead of the 5-year forecast period ending in 2018. In the June 19, 2014 Commission Order U-17301, the Commission noted that the program is not offered continuously, rather the company offers contracts through a periodic lottery. Customer and trade-allies complications and hassles result with a stop-start, on-again, off-again implementation of renewable energy, energy efficiency, rate offerings and other services offered to CECO customers. CECO needs to remedy this programmatic flaw and erratic offering of services. This will enhance the program and reduce customer resistance, hassles and impediments to active and vibrant customer participation in CECO's solar resources program.

Another factor suggesting that solar resources will increase in CECO's service territory is public pressure and interest in this subject. An increasing number of customers, communities, and community groups are actively pursuing proposals to install or implement solar facilities, including residential, commercial, institutional and industrial customers. Increased focus on community solar PV projects is also occurring. This public pressure, along with public regulation and policy as noted earlier, can be expected to require CECO to implement or accommodate increased solar resources. In addition, with increased pubic awareness and public pressure, more solar will be installed irrespective of CECO's programs, resulting in further implementation of solar resources and increasing solar contribution forecasts, in contrast to CECo's flat or declining forecast in this case.

Q. What additional factors support your view that CECO's 5-year forecast of solar resources is faulty and deficient, and significantly understates this resource during the forecast years through 2018?

A. CECO's forecast of (and failure to include) increased levels of solar resources appears to disregard the value of, and benefits to be derived from, increased utilization of solar resources, and also appears to disregard the statutory purposes and policies set forth in both 1982 PA 304 (Act 304) and 2008 PA 195 (Act 195) which should be recognized in a complementary and consistent fashion.

Act 295 requires the Commission to ensure that CECO takes steps to pursue the following course of action; a) diversification of resources to meet future energy needs, b) increased use of indigenous energy resources within the state, c) encourage private investments in renewable energy and energy efficiency and d) provide improved air quality and other benefits to energy consumers. The Commission's December 19, 2013 Order in U-17302 (p 16) specifically states:

> Pursuant to MCL 460.1001(2), the purpose of Act 295 is:
>
> . . . to promote the development of clean energy, renewable energy, and energy optimization through the implementation of a clean, renewable, and energy efficient standard that will cost-effectively do all of the following:
>
> (a) Diversify the resources used to reliably meet the energy needs of consumers in this state.
>
> (b) Provide greater energy security through the use of indigenous energy resources available within the state.
>
> (c) Encourage private investment in renewable energy and energy efficiency.
>
> (d) Provide improved air quality and other benefits to energy consumers and citizens of this state.

Greater use of PV resources advances these public policy objectives. PV offers a multitude of positive benefits including providing: a hedge against volatile fuel and purchase power costs, a hedge against the risk of resource availability, and a hedge against new environmental pollution reduction requirements. Increased use of PV in CECO's service territory also provides a means to mitigate exposure to MISO congestion charges, transmission charges, and emission reduction credits, while enhancing economic development.

A key benefit of solar power is the impact that these resources can have in mitigating CECO's peak loads and high peak power costs during the summer months. These summer months are also the months during which solar power has the greatest output and the value of generation is typically the highest. These are also the months when the air-conditioning loads of residential customers are significantly contributing to utility peaks and higher energy costs. This means that enhanced solar development by residential customers can favorably align with CECO's most expensive summer peak periods. This provides the opportunity for a win-win situation whereby utilities can ameliorate their summer peak and energy while customers who are enrolled in the net metering program or other solar programs or arrangements can similarly benefit.

Significant PSCR benefits derived from increased growth in solar power include: (1) reducing CECO's PSCR costs, particularly during peak periods when costs are highest; (2) reducing customer costs for those customers implementing net metering or deploying solar resources, by empowering customers to directly reduce their energy costs; and (3) by engendering progress toward diversifying Michigan's energy industry and promoting the generation of more efficient, less costly energy, directly from Michigan customers.

Several studies have been undertaken or are ongoing which support the premise that the use of renewable energy including solar facilities derive positive benefits. For example, the draft paper issued by the National Renewable Energy Laboratory (NREL), entitled "*White Paper: The Value of Grid-Connected Photovoltaics in Michigan*," dated January 23, 2012, attached as attached as **GLREA Exhibit 2 (GCC-2)** includes significant findings, such as (page iii):

- Photovoltaic (PV) value is consistently higher than average electricity prices due to favorable correlation with peak prices.
- Over 75% of PV value in Michigan is realized in energy and generation capacity benefits and environmental benefits.

The NREL study states (pp 1-3) that "PV installations can provide value across several categories" including:

- Energy and Generation ("reduce[ing] the need to generate electricity from other sources, thus saving operating and fuel costs");
- Capacity ("…to reduce the need for construction of future generation capacity and also reduce the need to run certain power plants during peak load.");
- Transmission and Distribution ("it can help offset the need to build or upgrade future T&D infrastructure");
- Loss Savings (avoidance of transmission and distribution losses, or "loss savings");
- Reactive Power Support ("to provide reactive power for utilities");
- Environmental Benefits ("PV systems help offset pollutant emissions and greenhouse gas emissions"); and
- Other Benefits ("… hedge value, disaster recovery benefits, and other ancillary services help support a secure and reliable electric power system"), p 2, including relieving "severe congestion in the power lines" (p 3).

The NREL study, pp 3-4, presents charts demonstrating that (p 3): "Michigan's summer electricity market prices are well correlated with the solar resource. The PV system's

peak generation typically occurs within 3 hours of when prices are at their peak." The NREL study provides additional charts and discussions, and then states in Section 4 "Conclusions," p 7, as follows:

> This study explores the value of PV generation in Michigan's wholesale electricity market and finds that PV value is consistently higher than average electricity prices due to favorable correlation with peak prices. Additional value components were also estimated, bringing the total value of PV in Michigan to four times that of its generation on the wholesale market. Over 75% of the PV value is realized in the energy and generation capacity benefits and the environmental benefits.
>
> Suggestions for further analysis include a thorough investigation of PV value in Michigan, taking into account the various system constraints and infrastructure considerations for the state's local utilities.

Act 304 should be viewed as compatible with Act 295. Commission reviews and exercise of authority under each Act can dovetail or complement the scope, objectives, and purposes of both Acts. The issues raised in this testimony are directly relevant and within the scope of Act 304's provisions governing the requirement for the filing of a 5-year forecast with each annual plan. For example Section 6j(4) and (7), MCL 460.6j(4) and (7) state:

> (4) In order to implement the power supply cost recovery clause established pursuant to subsection (2), a utility shall file, contemporaneously with the power supply cost recovery plan required by subsection (3), a 5-year forecast of the power supply requirements of its customers, its anticipated sources of supply, and projections of power supply cost in light of its existing sources of electrical generation and sources of electrical generation under construction. The forecast shall include a description of all relevant major contracts and power supply arrangements entered into or contemplated by the utility, and such other information as the commission may require.
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> * * * *

> (7) In its final order in a power supply and cost review, the commission shall evaluate the decisions underlying the 5-year forecast filed by a utility pursuant to subsection (4). The commission may also indicate any cost items in the 5-year forecast that, on the basis of present evidence, the commission would be unlikely to permit the utility to recover from its customers in rates, rate schedules, or power supply cost recovery factors established in the future.

Under these provisions, the 5-year forecast must include "its anticipated sources of supply" . . . "and power supply arrangements entered into or contemplated by the utility, and such other information as the Commission may require." The Commission in Section 6j (7) is also required to "evaluate the decisions underlying the 5-year forecast filed by a utility pursuant to subsection 4." Under the provisions, CECO is obligated to file adequate information concerning the 5-year forecast. The scope of the forecast filing must be a forward looking forecast whereby CECO in an open and transparent way reveals and analyzes contemplated and/or forward looking sources and cost impacts of existing sources or categories of generation and power. Solar resources are an existing source and resource for energy generation. Act 295 statutory provisions recognize or contemplate higher limits and use of this resource compared to present levels. An adequate 5-year forecast under Act 304 therefore should include forward-looking plans and forecasts including increasing availability and utilization of solar resources or other renewable sources of energy. CECO's filing does not satisfy that requirement.

Act 304 places a heavy burden on CECO to present a reasonable PSCR plan and 5-year forecast. CECO also has a duty and burden to minimize the fuel and purchase power cost of electricity, as stated in Sections 6j(3) and 6j(6) of Act 304.

This 5-year forecast planning case for CECO is the proceeding where the Commission as well as interested PSCR customers and interveners are afforded the opportunity to examine the many resource choices that are available in constructing a five-year resource plan. This review includes consideration of and the weight given to resource options regarding diversity of supply, risk mitigation, costs, and other factors. Energy and capacity forecasts are an essential element of the plan and reflect the expected contribution from numerous supply resources as well as forecast energy and demand levels.

Q. What additional concerns do you have regarding CECO's proposed resource acquisition plan and forecast in this proceeding?

A. CECO's 5-year forecast underestimates the impact of renewable resources. Increased use of renewable resources would reduce the need for the purchase power and fuels to directly serve CECO metered jurisdictional customers. Yet, renewable resources are underutilized in CECO's proposed forecast resource mix. CECO has significantly underestimated the magnitude of solar resources available in its service territory for this PSCR forecast period.

Q. Why do you take issue with CECO's assumptions regarding the magnitude of renewable resources included in the PSCR Plan and forecast?

A. There are several reasons. First, a very significant driver of renewable resource adoption levels is the installed cost of renewable systems. We are in a period of declining costs for renewable energy technologies. As demand for renewable energy increases in Michigan as well as throughout this country, renewable equipment costs are declining. Because of the operational characteristics of solar systems and the declining costs of renewable

technologies, the CECO PSCR plan and forecast has underestimated the magnitude of renewable energy systems in its service territory for the 2014-2018 period. Leaving this error unchecked will result in an underestimation/underutilization of solar resource impacts on the resource needs identified in the five-year PSCR plan.

Q. Do you have other concerns regarding the methodology for valuation of Solar PV resources that CECO relied on in formulating its PSCR forecast?

A. Yes. Based on review of the PSCR Plan filing, testimony, exhibits, work papers, etc. and responses to discovery questions in this proceeding from GLREA and other parties, CECO failed to adequately quantify the capacity and energy benefits of PV solar resources and include this resource in its PSCR forecast.

Q. Why do you believe there are unrecognized and therefore untapped capacity benefits from solar PV resources that CECO failed to include in the PSCR forecast?

A. In preparation for this testimony, GLREA posed a number of discovery questions to CECO regarding hour-by-hour costs and loads in the CECO service territory to compare them to the costs of PV. CECO provided the load information GLREA requested. See 17317-GLREA-CE-250 and 17317-GLREA-CE-253.

Q. From the above information, was GLREA able to quantify the potential impact of solar resources on fuel and purchase power costs?

A. Yes. We prepared an analysis quantifying the peak impact of solar PV using CECO's system load information and the local cost and operational data. See **GLREA Exhibit 3 (GCC-3)**.

Q. Please explain what this analysis shows.

A. This analysis demonstrates the likely impact of solar resources on fuel and purchase power in CECO's service territory. In this analysis the hour-by-hour loads on CECO service territory were compiled (using 2013 hourly load data provided in CECo responses 250 and 253, referenced more fully above). The hourly loads were then compared to the hourly PV output. Since this is correlated to peak reduction and potential capacity savings, the focus was on the months of June, July, August and September. For each month, an average daily load shape was derived, consisting of the average load for the hour ending 1:00 for every day of the month, the average load for the hour ending 2:00, for 3:00 and so on. This was then normalized, so that each average hour was reflected as a percentage of the maximum average hour for the month. In **GLREA Exhibit 3 (GCC-3)**, which includes graphs, the load information is presented as the blue line.

This was also done exactly the same way for PV generation output, starting with the distribution depicted by day and hour. This was then calculated to determine the average hourly output for each month, which was normalized to develop a typical daily solar output profile. In **Exhibit GLREA-3 (GCC-3)** the PV output information is presented as the red line.

Comparing the red and blue lines for each month shows that the solar output occurs over a narrower period than the load peak. Then for illustrative purposes, we assumed that solar output was at a maximum of 10% of the load. The impact of the PV on the load shape was then determined to create a new (after-PV) load shape. This value is plotted as the green line in **GLREA Exhibit 3 (GCC-3)**. This demonstrates the impact the assumed magnitude of PV would have on CECO's system need for capacity, given the

assumptions. It would narrow the system peak in all cases. It would reduce the monthly peak demand in some cases. This demonstrates that in Michigan for CECO, there is considerable peak mitigation value available from use of PV solar, and if utilized, would result in a reduced system peak as well as making the system peak more manageable.

Q. Why do you believe there are unrecognized and therefore untapped PSCR economic benefits from solar PV resources that CECO failed to include in the PSCR forecast?

A. In preparation for this testimony we reviewed and compared the estimated energy costs of solar PV to other resource options and operational characteristics that CECO included in the plan e.g., acquisition costs and operational costs and related data.

Q. What did you conclude from this review and why do you believe there are unrecognized benefits from solar PV resources that CECO did not include in the PSCR forecast that are important for the Commission to consider in this proceeding?

A. I reviewed the MPSC Order U-17301 and U-17302 and other background materials related to the formulation of the PSCR forecast and plan. As noted earlier, Act 295 sets forward the public policy and purposes of the reforms adopted by that Act. Solar resources have the potential to advance Act 295's public policy purposes and objectives, as well as the purposes and objectives of Act 304. Solar resources offer a multitude of positive PSCR related benefits including providing: a hedge against volatile fuel and purchase power costs, a hedge against the risk of resource availability, and a hedge against new environmental pollution reduction requirements. Increased use of PV in CECO's service territory also provides a means to mitigate exposure to MISO congestion

charges, transmission charges, emission reduction credits, while also enhancing economic development.

Q. Please explain why increased solar resources would benefit PSCR customers in this planning period.

A. Generally, electric utilities, and now MISO, dispatch their generation resources in order of increasing production costs, i.e., the generation resources with lower production costs are dispatched before more expensive generation resources in order to minimize the total production costs. Since fixed costs are sunk costs, minimizing the production costs minimizes the total cost of service.

Economic dispatch provides economic benefits to customers in Michigan. Economic dispatch is done by tracking and comparing variable production costs. The fundamental criteria MISO embraces for resource selection is the cost of the next available resource compared to all other available resource options. Therefore, if CECO needs additional power to serve its customer's it would be required to pay the cost of electricity assigned to the next highest cost of resource that is available and dispatchable by MISO. Moving up the loading order to meet increased load means employing resources with increasing incremental costs. It follows that the average production cost increases as the loads increase.

In the context of the Act 304 PSCR process, it also follows that decreasing the load: 1) decreases the cost of the marginal resource serving the load, 2) decreases the average cost to serve the load, and 3) reduces the PSCR factor. Underestimating the amount of customer-owned solar resources on the system overestimates the load and thus

overestimates the PSCR factor. Adding PV will reduce the PSCR cost and the PSCR factor.

Solar resources bring value in that they reduce the need for capacity and energy particularly during high cost periods e.g., system peak periods during the summer months. Hot, sunny, high-moisture periods in Michigan are generally when electric system strain is the most acute. These are the conditions that are optimal for solar system production and output. The more solar resources that are in place and providing production output the greater the reduction in customer demand and ultimately greater the reduction in the reliance on more expensive generating plants and purchased power. Again, this is a result of MISO economic dispatch of available resources priced at the next least-expensive variable production cost above the prevailing price, at that point in time.

The PSCR regulatory mechanism and the supply resource selection process are predicated on optimizing economic opportunity by minimizing variable production costs. Since solar systems operation does not consume fossil fuels the variable production costs are minimal to non-existent. In the context of the Act 304 PSCR process, solar resources are an economically superior resource choice. There is a natural synergy here for solar technology, which matches electric system peak load stress with the operational prime time and conditions for the operation and contribution from solar systems. PSCR related purchase power costs would be reduced by increased reliance and customer use of solar systems.

Q. Would the Commission's acceptance of CECO's PSCR plan and forecast as proposed in this filing represent a lost opportunity for CECO'S customers and citizens of the State of Michigan?

A. Yes. Michigan is an energy importing state using more fossil energy than it exports. Therefore, the less cost incurred to import coal, oil, natural gas, or nuclear fuel for the generation of electricity or to acquire purchased power, the fewer dollars are exported outside of Michigan's boundaries. Dollars leaving the state for fuel and purchase power consumption represent an adverse impact and economic drain on citizens of the State of Michigan.

Q. Please summarize your recommendations.

A. 1) The Commission in its Order in this case should order CECO in its upcoming PSCR Plan and forecast cases to submit discussion and analysis of the basis for its proposed 5 year forecast of solar energy resources, including a full explanation of the basis of its forecast numbers for this resource;

2) The Commission in its Order in this and future PSCR plan and forecast cases should require the utility to align its forecasts of solar resources to the results of Commission-ordered workgroup collaboratives and to Commission orders implementing Act 295 policies to increase utilization of renewable energy, including solar energy resources;

3) The Commission should require CECO to further analyze and correct its valuation of solar energy resources and forecast methodology to include solar resource related capacity, energy, and cost reduction impacts in subsequent PSCR plan and forecast filings.

Q. Does this complete your testimony?

A. Yes.

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Case No. **U-17317**
E-File/Paperless

GLREA EXHIBIT 1 (GCC-1) TO DIRECT TESTIMONY OF GEOFFREY C. CRANDALL

August 12, 2014

Geoffrey C. Crandall

Vice President and Principal

EDUCATION

B.S. in Business and Pre-Law, Western Michigan University, 1974.

Mr. Crandall has also completed courses at Michigan State University Graduate School, the University of Wisconsin-Madison and Wayne State University, in areas of federal taxation, accounting, management and the economics of utility regulation. Mr. Crandall also completed the examination for the National Conference of States on Building Codes and Standards Energy Auditor.

EXPERIENCE

Mr. Crandall joined MSB in January 1990. Mr. Crandall has addressed issues related to fuel and purchase power, natural gas, re-regulation, planning, regulatory issues, residential and low-income issues, energy efficiency and impacts of utility restructuring on customers in California, New York, Colorado, Iowa, and Michigan. He has analyzed and/or designed energy efficiency programs for residential customers in Michigan, Georgia, Wisconsin, Arizona, and New Orleans, and has conducted workshops on system planning, energy efficiency, low-income restructuring and energy efficiency issues in over 20 states, including Washington, Hawaii, Nevada, Kansas, Michigan, Rhode Island, California, Virginia, and New Orleans. Mr. Crandall has analyzed integrated resource plan and or energy efficiency programs in the states of Arizona, Georgia, Hawaii, Illinois, Maine, Michigan, Minnesota, North Carolina, Ohio, Pennsylvania, Utah, Washington State, California, Iowa, Montana, Colorado, Missouri, Virginia, Wisconsin, and Washington D.C.

Prior to joining MSB, Mr. Crandall was employed by the Michigan Public Service Commission from 1974 through 1989, where he served in several capacities including analyst in the rates and tariff section, Technical Assistant to the Chief of Staff, and as the Director of the Demand-Side Management Division. He had responsibilities that included rate and tariff review, rate cases, utilities uncollectible and bad debts, integrated resource planning, the development, implementation and monitoring of government- and utility-sponsored demand-side management, energy-efficiency and load response policies and programs. These activities involved customers in the residential, commercial, industrial and institutional sectors.

Mr. Crandall has dealt with a wide variety of regulatory issues beyond energy efficiency, including utility diversification, incentive regulation, utility billing practices, utility power plant maintenance and management of plant outages.

Mr. Crandall served as Chair of the NARUC Energy Conservation Staff Subcommittee from 1986-1989. He has lectured and made presentations to many groups on demand-side programs and least-cost planning, including two NARUC-sponsored least-cost planning conferences; the 1990 NARUC Regional Workshops on Least-Cost Utility Planning in Newport, Rhode Island and Little Rock, Arkansas; the Wisconsin Public Service Commission's Integrated Resource Planning Workshop; the 1988, 1989, and 1990 Michigan State University Graduate School of Public Utilities and the U.S. Department of Energy.

Mr. Crandall has testified before the: United States Congress, Michigan Legislature, Michigan Public Service Commission, North Carolina Utilities Commission, Public Service Commission of the District of Columbia, Illinois Commerce Commission, Maine Public Utilities Commission, Massachusetts Department of Public Utilities, Public Service Commission of Hawaii, Minnesota Public Service Commission, Iowa Public Service Commission, Georgia Public Service Commission, Public Utility Commission of Ohio, Virginia Public Service Commission, Wisconsin Public Service Commission, and the City Council of the City of New Orleans, Louisiana.

Mr. Crandall has written several articles published in the Public Utilities Fortnightly and Electricity Journal, Natural Gas Magazine, and a number of proceedings for the Biennial Regulatory Information Conference and the American Council for an Energy-Efficient Economy.

TESTIMONY

Case No. U-5531, (8/77), Consumers' Power Company electric rate increase application. Mr. Crandall served as the Staff Witness and recommended that the Applicant initiate the Residential Electric Customers' Information program.

Case No. U-6743, (3/81), Michigan Consolidated Gas Company. Mr. Crandall served as the Staff policy witness and recommended that the Commission approve a surcharge to cover all reasonable and prudent costs associated with Applicant's implementation of the Michigan Residential Conservation Services Program.

Case No. U-6819, (6/81), Michigan Power Company-Gas. Mr. Crandall served as the Staff policy witness and described the basis for the program and the expected level of activity, recommending that the Commission approve a surcharge to cover all reasonable and prudent costs associated with Applicant's implementation of the Michigan Residential Conservation Service Program.

Case No. U-6787, (6/81), Michigan Gas Utilities Company. Served as the Staff policy witness and described the basis for the program and the expected level of activity, recommending that the Commission approve a surcharge to cover all reasonable and prudent costs associated with the implementation of the Michigan Residential Conservation Service Program.

Case No. U-6820, (6/81), Michigan Power Company-Electric. Served as the Staff policy witness and reviewed the Applicant's request to operate the Michigan Residential Conservation Service Program. Although not mandated by federal law, Applicant chose to operate the program in conjunction with its other services offered to residential gas customers. Recommended the establishment of a surcharge to cover all reasonable and prudent costs associated with the operation of that program.

Case No. U-5451-R, (10/82), Michigan Consolidated Gas Company. Served as the Staff policy witness and described the Staff's position regarding Applicant's proposed adjustment of surcharge level. Recommended that the eligibility criteria for customers be adjusted to more accurately reflect proper fuel consumption and to include customers who would be likely to realize a seven-year return on their investment by installing flue-modification devices in conjunction with Applicant's financing program.

Case No. U-6743-R, (10/82), Michigan Consolidated Gas Company. Served as the Staff policy witness regarding the Applicant's proposed expenses and revenues, as well as the reasonableness of activity and expense levels in the company's projected period.

Case No. U-7341, (12/84), Detroit Edison Company, Request for Authority for Certain Non-Utility Business Activities. Represented the Staff's position during settlement discussions and sponsored the settlement agreement.

Case No. U-6787-R, (3/84), Michigan Gas Utilities Company. Served as the Staff witness regarding the Applicant's proposed expenses and revenues. This also included a review of the company's future expenses associated with the Energy Assurance Program, the Specialized Unemployed Energy Analyses, and the Michigan Business Energy Efficiency Program expenses.

Case No. U-8528, (3/87), Commission's Own Motion on the Costs, Benefits, Goals and Objectives of Michigan's Utility Conservation Programs. Represented the Staff on the costs and savings of conservation programs and the other benefits of existing programs, and described alternative actions available to the Commission relative to future energy-conservation programs and services and other conservation policy matters.

Case No. U-8871, et al., (4/88), Midland Cogeneration Venture Limited Partnership. For approval of capacity charges contained in a power-purchase agreement with Consumers' Power Company. Served as the Staff witness on Michigan conservation potential and reasonably achievable programs that could be operated by Consumers' Power Company, and testified to the potential impact of these conservation programs on the Company's request for use of its converted nuclear plant cogeneration project. Also recommended levels of demand-side management potential for the commercial, industrial and institutional sectors in Consumers' Power service territory.

Case No. U-9172, (1/89), Consumers' Power Company, Power-Supply Cost-Recovery Plan and Authorization of Monthly Power-Supply Cost-Recovery Factors for 1989. Served as Staff witness on the conservation potential and reasonably achievable programs that could be operated by Consumers' Power Company. Testified to the potential impact of these conservation programs on the Company's fuel and purchase practices, its five-year forecast and the fuel factor. Recommended levels of demand-side management potential for the commercial, industrial and institutional sectors in Consumers' Power service territory as an offset to its more-expensive outside and internally generated power. Suggested that CPCO vigorously pursue conservation, demand-side management research, and planning and program implementation.

Case No. U-9263, (4/89), Consumers' Power Company Request to Amend its Gas Rate Schedule to Modify its Rule on Central Metering. Served as a Staff witness on the conservation effect of converting from individual metered apartments to a master meter. Suggested that the Commission continue its moratorium on the master meters, due to the adverse energy-conservation and efficiency impact.

Case No. E-100, (1/90), North Carolina Public Service Commission proceeding on review of the Duke Power Company's least-cost utility plan. Testified on behalf of the North Carolina Consumers' Council regarding utility energy-efficiency and demand-side management programs and the concept of profitability and implementation of demand-side management programs.

Case No. 889, (1/90), Public Service Commission of the District of Columbia. Testified on behalf of the Government of the District of Columbia in the Potomac Electric Power Company's application for an increase in its retail rates (general rate case). Sponsored testimony regarding the design and implementation and overall appropriateness of PEPCO's existing and proposed energy-efficiency and conservation programs.

Case No. 889, (4/90), Public Service Commission of the District of Columbia. Provided supplemental direct testimony and testified on behalf of the Government of the District of Columbia in the Potomac Electric Power Company's application for an increase in its retail rates (general rate case). Offered supplemental testimony regarding a more detailed review of PEPCO's existing pilot and full-scale energy-efficiency and conservation programs. Offered suggestions and recommendations for a future direction for PEPCO to pursue in order to implement more cost-effective and higher-impact energy-efficiency and conservation programs.

Case No. ICC Docket 90-004 and 90-0041, (6/90), Illinois Commerce Commission proceeding to adopt an electric-energy plan for Central Illinois Light Company (CILCO). Testified on behalf of the State of Illinois, Office of Public Counsel and the Small-Business Utility Advocate. Reviewed the CILCO electric least-cost plan filing and the conservation and load-management programs proposed in its filing. Sponsored testimony regarding my analysis of the proposed programs, and offered alternative programs for the Company's and the Commission's consideration.

Case No. D.P.U. 90-55, (6/90), Commonwealth of Massachusetts Department of Public Utilities. Testified on behalf of the Commonwealth of Massachusetts, Division of Energy Resources. Reviewed and analyzed Boston Gas' proposed energy-conservation programs that were submitted for pre-approval in its main rate case. In addition, suggested that it might consider implementation of other natural-gas energy- efficiency programs, and not award an economic incentive for energy-efficiency and conservation programs until minimum program-implementation standards are satisfied.

Case No. U-9346, (6/90), Michigan Public Service Commission. Testified on behalf of the Michigan Community Action Agency Association. Reviewed and analyzed the Consumers' Power Company rate-case filing related to energy-efficiency and demand-side management programs. Proposed alternative energy-efficiency programs and recommended program budgets and a cost-recovery mechanism.

Case No. 89-193; 89-194; 89-195; and 90-001, (6/90), Maine Public Utilities Commission. Testified on behalf of the Maine Public Advocate's Office. Reviewed the appropriateness of Bangor Hydro-Electric Company's existing energy-efficiency and demand-side management programs in the context of BHE's main rate case and request for approval to construct the Basin Mills Hydro-Electric dam. Reviewed the overall resource plan and suggested alternative programs to strengthen the energy-efficiency and demand-side management resource efforts.

Case No. 6617, (4/91), Hawaii Public Utility Commission. Testified on behalf of the Hawaii Division of Consumer Advocacy. Described what demand-side management resources are, why they should be included in the integrated resource planning process, and proposed the implementation of several pilot projects in Hawaii along with guidelines for the pilot programs.

Case No. E002/GR-91-001, (5/91), Minnesota Public Utilities Commission. Testified on behalf of Minnesotans for an Energy Efficient Economy. Assessed the DSM programs being operated or proposed by Northern States Power Company and made recommendations as to ways in which NSP could improve its DSM efforts.

Case No. 905, (6/91), Public Service Commission of the District of Columbia. Testified on behalf of the District of Columbia Energy Office. Responded to the energy-efficiency and load management aspects of Potomac Electric Company's filing and made several recommendations for DC-PSC action.

Case No. 6690-UR-106, (9/91), Public Service Commission of Wisconsin. Testified on behalf of The Citizens' Utility Board of Wisconsin. Assessed the DSM programs being operated or proposed by the Wisconsin Public Service Corporation, made recommendations as to the WPSCO energy efficiency programs, and suggested ways the company could improve its DSM efforts.

Case No. E002/CN-91-19, (12/91), Minnesota Public Utilities Commission. Testified on behalf of Minnesota Department of Public Service. Assessed the DSM potential and programs being

operated or proposed by Northern States Power Company and made recommendations as to the potential for energy efficiency in the NSP service territory and ways in which NSP could improve its DSM efforts.

Case No. 912, (4/92), Public Service Commission of the District of Columbia. Testified on behalf of the Government of the District of Columbia in the Potomac Electric Power Company's application for an increase in its retail rates for the sale of electric energy. Testified regarding the reasonableness of DSM and EUM policy changes, the cost allocation of the DSM and EUM expenses, an examination of the prudence of management regarding the energy-efficiency programs, and an examination of the appropriateness of the costs associated with energy-efficiency programs.

Case No. PUE 910050, (5/92), Virginia State Corporation Commission. Testified on behalf of the Citizens for the Preservation of Craig County regarding the need for the Wyoming-Cloverdale 765 kV transmission line. Specifically, addressed the adequacy of the DSM planning of Appalachian Power Company and Virginia Power/North Carolina Power. Made recommendations as to APCO and VEPCO's energy efficiency programs, and suggested ways the company could improve its DSM efforts.

Case No. EEP-91-8, (5/92), Iowa Utilities Board. Testified on behalf of the Izaak Walton League concerning the adequacy of Iowa Public Service Company's Energy Efficiency Plan. Reviewed the plan and suggested modifications to it.

Case No. 4131-U and 4134-U, (5/92), Georgia Public Service Commission. Testified on behalf of the Georgia Public Service Commission staff regarding the demand-side management portions of Georgia Power Company's and Savannah Electric and Power Company's Integrated Resource Plans. Testimony demonstrated that it is reasonable for the Commission to expect that the utilities can successfully secure substantial amounts of demand-side management resources by working effectively with customers.

Case No. 917, (8/92), Public Service Commission of the District of Columbia. Testified on behalf of the District of Columbia Energy Office in hearings on Potomac Electric Power Company's Integrated Resource Planning process. Addressed a number of program-specific issues related to PEPCO's demand-side management efforts.

Case No. 4132-U, 4133-U, 4135-U, 4136-U, (10/92), Georgia Public Service Commission. Testified on behalf of the Staff Adversary IRP Team of the Georgia PSC. Provided a critique of Georgia Power Company's and Savannah Electric and Power Company's proposed residential and small commercial DSM programs.

Case No. 4135-U, (3/93), Georgia Public Service Commission. Testified on behalf of the Staff Adversary IRP Team of the Georgia PSC. Provided a critique of Savannah Electric and Power Company's proposed Commercial and Industrial DSM programs.

Case No. R-0000-93-052, (12/93), Arizona Corporation Commission. Testified on behalf of the Arizona Community Action Association. Critiqued and made recommendations regarding the integrated resource plans and demand-side management programs of Arizona Public Service Company and Tucson Electric Power Company.

Case No. 934, (4/94), Public Service Commission of the District of Columbia. Filed testimony on behalf of the District of Columbia Energy Office in hearings concerning the Washington Gas Light Company (WGL) general rate case application to increase existing rates and charges for gas service. Testimony involved critiquing and reviewing WGL's least cost planning efforts and integration of DSM, marketing and gas supply efforts.

Case No. U-10640, (10/94), Michigan Public Service Commission. Testified on behalf of the Michigan Community Action Agency Association concerning the need to integrate DSM and load promotion analysis into MichCon's GCR planning process.

Case No. 05-EP-7, (3/95), Wisconsin Public Service Commission. Testified on behalf of the Citizens' Utility Board on level of utility DSM and program designs and strategies.

Case No. 05-EP-7, (3/95), Wisconsin Public Service Commission. Testified on behalf of the Wisconsin Community Action Program Association on low-income customers and utility DSM programs.

Case No. TVA 2020-IRP, (9/95), Tennessee Valley Authority. Testified on behalf of the Tennessee Valley Energy Reform Coalition. Assessed, critiqued and made recommendations regarding the integrated resource plans and demand-side management programs proposed by the Tennessee Valley Authority.

Case No. R-96-1, (10/95), Alaska Public Utilities Commission. Testified on behalf of the Alaska Weatherization Directors Association regarding the proposed standards and guidelines for integrated resource planning and energy efficiency initiatives under consideration in Alaska.

Case No. D95.9.128, (2/96), Montana Public Service Commission. Testified on behalf of the District XI Human Resources Council concerning the low-income energy efficiency programs offered by the Montana Power Company.

Case No. DPSC Docket No. 95-172, (5/96), Delaware Public Service Commission. Prepared draft testimony on behalf of the Low-Income Energy Consumer Interest Group regarding Delmarva Power & Light Company's application to revise its demand-side programs. The case was settled, with LIECIG obtaining funding for low-income energy efficiency programs, prior to testimony.

Case No. U-11076, (8/96), Michigan Public Service Commission. Testified on behalf of the Michigan Community Action Agency regarding the Michigan Jobs Commission's recommendations regarding electric and gas reform. Discussed the implications of utility

restructuring and the needs of residential and low-income households, and proposed regulatory and industry solutions.

Case No. 96-E-0897, (3/97), New York Public Service Commission. Prepared draft testimony for New York's Association for Energy Affordability regarding the impact of proposed utility restructuring plans on low-income customers. The case was settled in Spring 1997.

Case No. R-00973954, (7/97), Pennsylvania Public Utilities Commission. Testified on behalf of the Commission on Economic Opportunity regarding the economics of demand-side measures and programs proposed for implementation by Pennsylvania Power & Light Company.

Case No. 98-07-037, (7/98), California Public Utilities Commission. Testified on the California Alternative Rates for Energy and the Low Income Energy Efficiency programs regarding the implementation and adoption of revisions to these programs necessitated by the AB 1890 and the Low Income Governing Board.

Case No. U-12613, (3/01), Michigan Public Service Commission. Testified on behalf of the Michigan Community Action Agency regarding the Wisconsin Public Service Corporation application to implement PA 141 the electricity deregulation law. I reviewed the portions of the filing related to their provision of electric energy efficiency and load management.

Case No. U-12649, (3/01), Michigan Public Service Commission. Testified on behalf of the Michigan Community Action Agency regarding the Wisconsin Electric Power Company and the Edison Sault Electric Company application to implement PA 141 Michigan's electricity deregulation law. I reviewed the portions of the filing related to their provision of electric energy efficiency and load management.

Case No. U-12651, (3/01), Michigan Public Service Commission. Testified on behalf of the Michigan Community Action Agency regarding the Northern States Power Company – Wisconsin application to implement PA 141 the electricity deregulation law. I reviewed the portions of the filing related to their provision of electric energy efficiency and load management.

Case No. U-12652. (3/01), Michigan Public Service Commission. Testified on behalf of the Michigan Community Action Agency regarding the Indiana Michigan Power Company d/b/a American Electric Power application to implement PA 141 the electricity deregulation law. I reviewed the portions of the filing related to their provision of electric energy efficiency and load management.

Case No. U-12725, (4/01), Michigan Public Service Commission. Testified on behalf of the Michigan Community Action Agency regarding the Wisconsin Electric Power Company and the Edison Sault Electric Company application to increase its residential rates. I reviewed the portions of the filing related to their provision of electric energy efficiency and load management and recommended a significant increase in these activities.

Case No. U-13060, (12/01), Michigan Public Service Commission. Testified on behalf of the Michigan Community Action Agency regarding the Michigan Consolidated Gas Company application for Approval of their Gas Cost Recovery Plan and Five-Year gas Forecast. I reviewed the filing and recommended the Commission reject the proposed GCR factor and suggested continuation of the existing GCR factor or adopt an adjusted MCAAA sponsored GCR factor. I also suggested a set-aside allocation be designated for low-income customers to ensure access to alternative gas providers under the applicant's customer choice program.

Case No. 6690-UR-114, (9/02), Wisconsin Public Service Commission. Testified on behalf of the Citizens Utility Board regarding the Wisconsin Public Service Corporation application to increase its electric and natural gas rates. I reviewed the portions of the filing related to their low-income assistance/weatherization and the proposed executive compensation incentive plan.

Case No. U-14401, (04/05), Michigan Public Service Commission. Testified on behalf of the Michigan Community Action Agency regarding the Michigan Consolidated Gas Company application for Approval of their Gas Cost Recovery Plan and Five-Year gas Forecast. I reviewed the filing and recommended the Commission reject the proposed plan and suggested initiation of strategies that would lower the need to acquire expensive and unnecessary gas supplies.

Case No. U-14401-R, (10/05), Michigan Public Service Commission. Testified on behalf of the Michigan Community Action Agency regarding the Michigan Consolidated Gas Company application re-opener Approval of their Gas Cost Recovery Plan and Five-Year gas Forecast. I reviewed the filing and recommended the Commission reject the proposed plan and suggested initiation of strategies that would lower the need to acquire expensive and unnecessary gas supplies.

Case No. U-14701, (02/06), Michigan Public Service Commission. Testified on behalf of the Michigan Environmental Council and The Public Interest Group In Michigan regarding the Consumers Energy Company application for Approval of a Power Supply Cost Recovery Plan and for Authorization of Monthly Power Supply Cost Recovery Factors for Calendar Year 2006. I reviewed the filing including the application, testimony, exhibits, discovery responses and submitted testimony recommending that the Commission not approve the five-year PSCR plan as filed due to the impacts related to the Palisades sale and the absence of alternative resources in the projected five-year resource portfolio.

Case No. U-14702, (02/06), Michigan Public Service Commission. Testified on behalf of the Michigan Environmental Council and The Public Interest Group In Michigan regarding The Detroit Edison Company application for authority to implement a Power Supply Cost Recovery Plan in its rate schedules for 2006-metered jurisdictional sales of electricity. I reviewed the application, testimony, exhibits and submitted testimony that recommended that the Commission

not approve the proposed five-year PSCR plan as filed due because it was deficient in its selection of alternative resources in the projected five-year resource portfolio.

Case No. U-14992, (12/06), Michigan Public Service Commission. Testified on behalf of the Michigan Environmental Council and The Public Interest Group In Michigan regarding The Consumers Energy Company application for approval of the proposed Power Purchase Agreement in connection with the sale of the Palisades Nuclear Power Plant and other assets. The purpose of my testimony was to address the overall soundness of this application and proposal. I reviewed the application, testimony, exhibits and submitted testimony that recommended that the Commission not approve the proposed purchase power agreement and transfer the ownership of the nuclear plant and other assets.

Case No. 06-0800, (3/07), Illinois Commerce Commission. Provided testimony on behalf of the Illinois Citizens Utility Board regarding the Illinois electricity resource auction process. I assessed the existing resource/power supply auction based bidding process and recommended modifications and improvements to the Illinois resource acquisition mechanism.

Case No. 24505-U, (5/07), Georgia Public Service Commission. Testified on behalf of the Georgia Public Service Commission Advocacy staff regarding the demand-side management portions of Georgia Power Company's Integrated Resource Plans. Testimony demonstrated that it is reasonable for the Commission to approve the five proposed DSM programs and expect that Georgia Power can successfully secure considerably more demand-side management resources by working effectively with its customers.

Case No. U-14992, (11/07), Michigan Public Service Commission. Testified on behalf of the Michigan Environmental Council and The Public Interest Group In Michigan regarding The Consumers Energy Company rate application for approval of a rate increase and the recovery of energy efficiency programs and certain costs in connection with the sale of the Palisades Nuclear Power Plant and other assets. I reviewed the application, testimony, exhibits and submitted testimony that recommended that the Commission not approve the recovery of transaction costs involving the transfer the ownership of the nuclear plant and other assets and on various aspects of its proposed energy efficiency programs and proposed incentives.

Case No. 07-0540, (12/07), Illinois Commerce Commission. Provided testimony on behalf of the Environmental Law and Policy Center regarding the Commonwealth Edison Company application for approval of its proposed Energy Efficiency and Demand Response Plan. I assessed the proposed energy efficiency and demand response plan and recommended modifications and improvements to the proposed plan filing.

Case No. 07-0539, (12/07), Illinois Commerce Commission. Provided testimony on behalf of the Environmental Law and Policy Center regarding the Central Illinois Light Company d/b/a and Ameren CIPS CENTRAL ILLINOIS PUBLIC SERVICE COMPANY and Ameren CIPS ILLINOIS POWER COMPANY d/b/a Ameren IP application for approval of its proposed Energy Efficiency and Demand Response Plan. I assessed the proposed energy efficiency and

demand response plan and recommended modifications and improvements to the proposed plan filing.

Case No. U-15415, (2/08), Michigan Public Service Commission. Testified on behalf of the American Association of Retired People regarding The Consumers Power Company application for approval for authority to implement a Purchase Power recovery plan, 5-year forecast, and monthly PSCR factors for the 12-month period calendar year 2008. I reviewed the application, testimony, exhibits and submitted testimony that recommended that the Commission adopt a more effective and less expensive resource acquisition procedure to help keep the cost of energy down in Michigan.

Case No. U-15417, (4/08), Michigan Public Service Commission. Provided testimony on behalf of the American Association of Retired People regarding The Detroit Edison Company for Authority to Implement a Power Supply Cost Recovery Plan in its Rate Schedule for 2008 Metered Jurisdictional Sales of Electricity. I reviewed the application, testimony, exhibits and submitted testimony that recommended that the Commission adopt a more effective and less expensive resource acquisition procedure to help keep the cost of energy down in Michigan.

Case No. U-15244, (7/08), Michigan Public Service Commission. Provided testimony on behalf of the Michigan Environmental Council and The Public Interest Group In Michigan regarding The Detroit Edison Company request for Authority to increase rates, amend its rate schedules and rules governing the distribution and supply of electric energy, and for miscellaneous accounting authority. I reviewed the application, testimony, exhibits and submitted testimony that recommended that the Commission direct DECO to make modifications to its Integrate Resource Planning analysis.

Case No. EEP-08-2, (7-08), Iowa Public Utilities Board. Provided testimony on behalf of the environmental interveners regarding the request of the Mid American Energy Company for approval of an Energy Efficiency Plan. I made an assessment of the proposed energy efficiency and demand response plan and recommended modifications and improvements to the implementation strategy and proposed programs.

Case No. EEP-08-1, (8-08), Iowa Public Utilities Board. Provided testimony on behalf of the environmental interveners regarding the Interstate Power and Light Company request for approval of an Energy Efficiency Plan. I made an assessment of the proposed energy efficiency and demand response plan and recommended modifications and improvements to the proposed programs and implementation strategy.

Case No. 137-CE-147, (2-09), Public Service Commission of Wisconsin. Provided testimony on behalf of PRESERVE OUR RURAL LANDS regarding the Application of American Transmission Company, as an Electric Public Utility, to Construct a new 345 kV Line from the Rockdale Substation to the West Middleton Substation, Dane County, Wisconsin. I suggested modifications of the proposal and rejection of the approval of the line.

Case No. M2009-2093218, (8-09), Pennsylvania Public Utility Commission. Provided testimony on behalf of The Office Of Consumer Advocate regarding the West Penn Power Company d/b/a Allegheny Power Energy Efficiency and Conservation Plan request for plan approval. I analyzed the proposed plan and made an assessment of the proposed energy efficiency and demand response and cost recovery plan. I suggested modifications and improvements to the proposed programs as well as the proposed implementation strategy.

Case No. 09-1947-EL-POR, 09-1948-EL-POR, 09-1949-EL-POR, 09-1942-EL-EEC, 09-1943-EL-EEC, 09-1944-EL-EEC, POR, 09-580-EL-EEC, 09-580-EL-EEC, 09-580-EL-EEC, Public Utilities Commission of Ohio. Provided testimony on behalf of The Office Of The Environmental Law and Policy Center regarding the Ohio Edison Company, The Cleveland Electric Illuminating Company and the Toledo Edison Company for approval of their energy efficiency and peak demand reduction program portfolio and associated cost recovery mechanism and approval of their initial benchmark reports and in the matter of the energy efficiency and peak demand reduction programs. I reviewed, analyzed and assessed the appropriateness of the proposed plans, benchmark reports and proposed peak reduction program portfolio. I suggested modifications and improvements to the proposed programs. I also made recommendations regarding the proposed implementation strategy as well as accounting and program cost tracking.

Case No. U-16412, (10/10), Michigan Public Service Commission. Provided testimony on behalf of the Natural Resources Defense Council, Michigan Environmental Council and The Environmental Law and Policy Center regarding the Consumers Energy Company request to amend its natural gas & energy efficiency Energy Optimization Plan. I reviewed the application, testimony, exhibits, discovery responses and submitted testimony that recommended modifications to the proposed Energy Optimization Plan.

Case No. 10-0570, (11/10), Illinois Commerce Commission. Provided testimony on behalf of the Environmental Law and Policy Center regarding the Commonwealth Edison Company application for approval of its proposed Energy Efficiency and Demand Response Plan. Assessed the proposed energy efficiency and demand response plan and recommended modifications and improvements to the proposed plan filing.

Case No. 10-0568, (11/10), Illinois Commerce Commission. Provided testimony on behalf of the Environmental Law and Policy Center regarding the Central Illinois Light Company d/b/a and Ameren CIPS CENTRAL ILLINOIS PUBLIC SERVICE COMPANY and Ameren CIPS ILLINOIS POWER COMPANY d/b/a Ameren IP application for approval of its proposed Energy Efficiency and Demand Response Plan. Assessed the proposed energy efficiency and demand response plan and recommended modifications and improvements to the proposed plan filing.

Case No. 10-0564, (11/10), Illinois Commerce Commission. Provided testimony on behalf of the Environmental Law and Policy Center regarding the People's Gas Light and Coke Company and North Shore Gas Company request for approval of its proposed Energy Efficiency Plan.

Assessed the proposed energy efficiency and demand response plan and recommended modifications and improvements to the proposed plan filing.

Case No. 10-0567, (11/10), Illinois Commerce Commission. Provided testimony on behalf of the Environmental Law and Policy Center regarding the Northern Illinois Gas Company application for approval of its proposed Energy Efficiency Plan and approval of Rider 30, Energy Efficiency Plan Cost recovery and related changes to Nicor tariffs. Assessed the proposed energy efficiency and demand response plan and recommended modifications and improvements to the proposed plan filing.

Case No. M-2010-2210316, (3/11), Pennsylvania Public Utility Commission. I provided testimony on behalf of The Office Of Consumer Advocate regarding the UGI Utilities, Inc. Electric Division (UGI-Electric) request for Efficiency and Conservation Plan approval. I analyzed the proposed plan and made an assessment of the proposed energy efficiency and demand response and cost recovery plan. I suggested modifications and improvements to the proposed programs and implementation strategy.

Case No. 11-07026 and 11-07027, (11/11), Public Utilities Commission of Nevada. I provided testimony on behalf of the Bureau of Consumer Protection regarding both the Sierra Pacific Power Company and Nevada Power Company 2011 Annual Demand Side Management Update reports. I reviewed the filings and made recommendations regarding various aspects of demand response resources and demand side management portfolios.

Case No., U-16671 (01/12), Michigan Public Service Commission. I provided testimony on behalf of the Environmental Law and Policy Center regarding the reasonableness of the Detroit Edison Company's filing and assertions made by a witness regarding a net-to-gross factor relative to the 2010 and 2011 energy efficiency programs implemented in response to Public Act 295 of 2008.

Case Nos. P-2012-2320468, P-2012-2320480, P-2012-2320484, P-2012-2320450, (10/12), Pennsylvania Public Utility Commission. I provided testimony on behalf of The Office Of the Consumer Advocate regarding the application of Metropolitan Edison Company, Pennsylvania Electric Company, West Penn Power, Pennsylvania Power Company on the Energy Efficiency regarding the benchmarks established for the period June 1, 2013 through May 31, 2016. I analyzed the proposed adjustments of Phase II Energy Efficiency and Conservation target levels and energy efficiency acquisition costs.

Case No. Case Nos. 12-2190-EL-POR, 12-2191-EL-POR, 12-2192-EL-POR, (10/12) Application of Ohio Edison Company, The Cleveland Electric Illuminating Company and the Toledo Edison Company for Approval of their energy efficiency and peak demand reduction program portfolio plan for 2013-2015. I provided testimony on behalf of Ohio Environmental

Council and The Environmental Law and Policy Center regarding the Ohio Edison Company, The Cleveland Electric Illuminating Company and the Toledo Edison Company for approval of their 2013-2015 energy efficiency and peak demand reduction program portfolio. I reviewed, analyzed and assessed the appropriateness of the proposed plans, benchmark reports and proposed peak reduction program portfolio. I suggested modifications and improvements to the proposed programs and made recommendations and proposed new approaches to the proposed implementation strategy.

Case No., 12-06052 and 12-06053 (10/12), Public Utilities Commission of Nevada, I provided testimony on behalf of the Attorney General of the State of Nevada, Bureau of Consumer Protection regarding both the Sierra Pacific Power Company and Nevada Power Company 2013-2015 Triennial Integrated Resource Plan covering the period 2013-2032 and Approval of its Energy Supply Plan for the period 2013-2015. I reviewed, analyzed and assessed the appropriateness of the proposed plans and proposed peak reduction portfolio. I suggested modifications and improvements to the proposed programs and made recommendations and proposed new approaches to the implementation strategy.

Case No. U-16434-R, (10/12), Michigan Public Service Commission. Provided testimony on behalf of the Michigan Community Action Agency Association regarding The Detroit Edison Company for Reconciliation of its Power Supply Cost Recovery Plan for 12-month Period Ending December 31, 2011. I reviewed the application, testimony, exhibits and submitted testimony that recommended that the Commission adopt a remedy in regards to several aspects of the Reduced Emission Fuels projects that Detroit Edison was involved in.

Case No. Docket No. M-2012-2334388 (12/12), Pennsylvania Public Utility Commission. I provided testimony on behalf of The Office of the Consumer Advocate regarding the Petition of PPL Electric Utilities Corporation for Approval of an Energy Efficiency and Conservation Plan. I analyzed the proposed plan and made an assessment of the proposed energy efficiency and demand response and cost recovery plan. I suggested modifications to the proposed programs and implementation strategy to enhance its effectiveness.

Case No. U-17097, (03/13) Michigan Public Service Commission. Provided testimony on behalf of the Michigan Community Action Agency Association regarding The Detroit Edison Company filing for Reconciliation of its Power Supply Cost Recovery Plan for 12-month Period Ending December 31, 2013. I reviewed the application, testimony, exhibits and submitted testimony recommending that the Commission adopt a remedy regarding the Reduced Emission Fuels projects that Detroit Edison was participating in.

Case No. U-17095, (04/13) Michigan Public Service Commission. Provided testimony on behalf of the Michigan Community Action Agency Association regarding The Consumers Electric

Company Application for Approval of A Power Supply Cost Recovery Plan and for Authorization of Monthly Power Supply Cost Recovery Factors for 2013. I reviewed the application, testimony, exhibits and submitted testimony recommending that the Commission reject the proposed five year resource plan. I also recommend that the Commission prohibit CECO from collecting capital related investments for a pipeline in Zeeland, Michigan. I also recommended that CECO demonstrate to the Commission that the Palisades and MCV generation plants purchase power agreements are cost-effective, being complied with and are in the public interest.

Case No. EEP-2012-0001, (4-13), Iowa Public Utilities Board. Provided testimony on behalf of the environmental interveners regarding the Interstate Power and Light Company 2014-2018 Energy Efficiency Plan. I made an assessment of IPL's proposed resource planning as well their energy efficiency, renewable energy and demand response resources. I recommended modifications and improvements to the proposed programs, implementation and resource measurement strategy.

Case No. U-17131, (04/13), Michigan Public Service Commission. Testified on behalf of the Michigan Community Action Agency regarding the Michigan Consolidated Gas Company application for Approval of their Gas Cost Recovery Plan and Five-Year gas Forecast and approval to implement a reservation charge. I reviewed the filing and recommended the Commission require MichCon to initiate procurement strategies that would reduce the heavy reliance that is being placed on the 75% VCA gas procurement strategy.

Case No. U-17133, (04/13), Michigan Public Service Commission. Testified on behalf of the Michigan Community Action Agency regarding the Consumers Energy Company application for approval of its gas cost recovery plan and authorization of a gas cost recovery factor from April 2013- March 2014. I reviewed the filing and made recommendations regarding the Quartile Fixed Price Purchases Gas purchasing strategy used by CECO.

Case No. EEP-2012-0002, (6/13), Iowa Public Utilities Board. Provided testimony on behalf of the environmental interveners regarding the Mid American Energy Company 2014-2018 Energy Efficiency Plan. I made an assessment of MidAm's proposed resource planning as well their energy efficiency, renewable energy and demand response resources. I recommended modifications and improvements to the proposed programs, implementation and resource measurement strategy.

Case No. 13-0431-EL-POR (08/13) regarding the Application of Duke Energy Ohio, Inc. for Approval of its Energy Efficiency and Peak Demand Reduction Portfolio of Programs.
I provided testimony on behalf of Ohio Environmental Council and The Environmental Law and Policy Center regarding Duke Energy Ohio, Inc. for approval of their revised energy efficiency and peak demand reduction program portfolio. I analyzed and reviewed the appropriateness of the revised plan and proposed peak reduction program portfolio. I suggested that significant additions and modifications be made before the proposed programs were approved. I offered

specific program recommendations and new elements be added to their programs and implementation strategy.

Case No. 13-0498, (10/13), Illinois Commerce Commission. Provided testimony on behalf of the Environmental Law and Policy Center regarding the request by Ameren Illinois for approval of its proposed Energy Efficiency and Demand Response Plan 3. Assessed the proposed energy efficiency and demand response plan and recommended modifications and improvements to the proposed plan filing.

Case No. 13-0499 (10/13), Illinois Commerce Commission. Provided testimony on behalf of the Environmental Law and Policy Center regarding the request by The Illinois Department of Commerce and Economic Opportunity for approval of its proposed Energy Efficiency Plan 3. Assessed the proposed energy efficiency plan and recommended modifications and improvements to the proposed plan filing.

Case No. 13-0495 (11/13), Illinois Commerce Commission. Provided testimony on behalf of the Environmental Law and Policy Center regarding the request by Commonwealth Edison application for approval of its proposed third Energy Efficiency Plan. I assessed the proposed energy efficiency plan and recommended modifications and enhancements to the proposed plan.

Case No. 13-0550 (12/13), Illinois Commerce Commission. Provided testimony on behalf of the Environmental Law and Policy Center regarding the request by North Shore Gas Company and The Peoples Gas Light and Coke Company for approval of its proposed second Energy Efficiency Plan. I assessed the proposed energy efficiency plan and recommended modifications and enhancements to the proposed plan.

Case No. U-17319, (06/14) Michigan Public Service Commission. Provided testimony on behalf of the Great Lakes Renewable Association regarding The Detroit Edison Company filing for Authority to implement a Power Supply Cost Recovery Plan in its rate schedules for 2014. I reviewed the application, testimony, exhibits and submitted direct testimony recommending that the Commission adopt a remedy regarding the reasonableness and completeness of its proposed plan.

In addition, I have served the following public sector clients since 1990.

Client	**Nature of Service**
Alaska Housing Finance Corporation	Analysis of energy efficiency, system planning and applicability of Energy Policy Act standards to Alaska resource selection process.

California Low Income Governing Board	In conjunction with AB 1890 the state's restructuring statute provided analyses of options to deliver energy efficiency and assistance programs to low-income households in a restructured utility environment. Assisted the CPUC and Low Income Governing Board in developing low-income energy assistance and energy efficiency programs, implementation methods and procedures under interim utility administration.
Conservation Law Foundation of New England	Provided technical support to the collaborative working groups with Boston Edison, United Illuminating, Eastern Utilities Association, and Nantucket Electric regarding system planning approaches, energy efficiency programs and resource screening.
District of Columbia Public Service Commission	Testimony regarding demand-side management, least cost planning principles.
Germantown Settlement, Philadelphia	Analysis and technical support regarding business structure and market to aggregate load and/or provide energy efficiency and energy assistance services to low-income households.
City of New Orleans	Developed least cost planning rules, guided a public working group to develop demand-side programs, and developed a low income, senior citizens energy efficiency program.
Oak Ridge National Laboratory	Prepared an economic analysis of the customer impact from various electricity restructuring configurations for the State of Ohio
Ohio Office of Consumer Council	Analyzed two utilities' long-range plans and energy efficiency resource options. Analyzed the Dominion East Gas Company application to be relieved of the merchant function.
Ontario Energy Board	Developed demand-side management programs and evaluated need for natural gas integrated resource planning rules.
U.S. Environmental Protection Agency	Developed handbook, "Energy Efficiency and Renewable Energy: Opportunities from Title IV of the Clean Air Act", which focuses on how energy efficiency and renewables relate to acid rain compliance strategies.
U.S. Environmental Protection Agency and U.S.	Analyzed and compared utility supply- and demand-side resource selection for Clean Air Act compliance on the

Department of Energy	Pennsylvania-New Jersey-Maryland (PJM) interconnection.
Washington State Weatherization Directors	Natural Gas energy conservation program design involving Cascade Natural Gas Company

STATE OF MICHIGAN

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Case No. **U-17317**
E-File/Paperless

GLREA EXHIBIT 2 (GCC-2) TO DIRECT TESTIMONY OF GEOFFREY C. CRANDALL

August 12, 2014

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

White Paper: The Value of Grid-Connected Photovoltaics in Michigan

Author: Sean Ong

MICHIGAN REVIEW DRAFT 1/23/12

Purpose/Background

This report is a deliverable of the U.S. Department of Energy's (DOE) Solar Energy Technologies Program Public Utilities Commission Technical Assistance Program. This program provides technical assistance to state policymakers and public utilities commissions in support of overcoming market barriers to the broad deployment of solar technologies.

Acknowledgments

The author thanks the DOE sponsorship and direction of this work, especially Jennifer DeCesaro at DOE and John Miller with SRA International. The author also thanks Elizabeth Doris, Paul Denholm, Easan Drury, and Robert Margolis of the National Renewable Energy Laboratory (NREL) for reviewing various versions of the document and Mary Lukkonen of NREL's Communications Office for a thorough technical edit of the document. Finally, and naturally, any remaining errors are the fault of the author.

Major Findings

- Photovoltaic (PV) value is consistently higher than average electricity prices due to favorable correlation with peak prices.
- Over 75% of PV value in Michigan is realized in energy and generation capacity benefits and environmental benefits.
- On an annual basis, PV production in Michigan is valued at $0.138/kWh.

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1 Introduction

In recent years, Michigan has seen an increase in grid-connected photovoltaics (PV), with 1.9 MW installed in 2010, bringing the total grid-connected PV capacity to 2.6 MW (Sherwood 2011). As solar technologies become more prominent in Michigan's electric generation portfolio, it is increasingly important to understand the value it provides to the state's electric utilities and citizens. This study estimates the value of PV generation in Michigan by comparing hourly solar generation with hourly electricity prices from specific years. This study also considers other value components that have been quantified in previous PV valuation studies and uses these to estimate similar value components for PV installed in Michigan.

2 Data and Methodology

2.1 PV Value Components

PV installations can provide value across several categories. These value components are often difficult to quantify because they are either external benefits (such as environmental benefits) or indirect benefits (such as future transmission or distribution capacity deferrals). Several studies have explored the value that PV installations can provide. A literature review was conducted to explore the range of values estimated by these studies. Over 30 unique categories have been identified where PV systems can provide value to a variety of stakeholders (Hoff and Margolis 2005). This study consolidates the various categories into seven main components:

- **Energy and Generation** – The electricity generated by a PV system helps reduce the need to generate electricity from other sources, thus saving operating and fuel costs. This category is typically quantified using marginal wholesale electricity prices [locational marginal pricing (LMP)] and the fuel and operation and maintenance (O&M) costs of natural gas plants.
- **Capacity** – PV systems help to reduce the need for construction of future generation capacity and also reduce the need to run certain power plants during peak load. This category is typically quantified using the price of new natural gas peaking plants and the effective load carrying capacity[1] (ELCC) of solar plants.
- **Transmission and Distribution** – As electricity consumption increases, additional transmission and distribution (T&D) infrastructure is needed to facilitate the movement of electricity from the power plants to consumers. Since distributed PV is placed at or near where electricity is consumed, it can help offset the need to build or upgrade future T&D infrastructure. T&D deferrals are typically quantified using the ELCC of power plants and the cost of new T&D capacity.
- **Loss Savings** – Some energy is lost when transmitting electricity over long distances and through multiple transformers. Because distributed PV is placed near where

[1] The ELCC is the portion of the PV plant's rated capacity that can be relied upon to reduce the power grid's peak load. For a complete discussion of ELCC, see Perez et al. (2006).

electricity is consumed, it avoids much of these losses.[2] The value of avoiding these losses is typically quantified on a marginal basis.

- **Reactive Power Support** – PV inverters have the ability to provide reactive power for utilities. This helps avoid installing additional power quality equipment, such as capacitors.
- **Environmental Benefits** – PV systems help offset pollutant emissions and greenhouse gas emissions. Greenhouse benefits are typically quantified using renewable energy certificates (RECs), other premiums paid for green power, and estimates on possible carbon tax enactments.
- **Other** – PV benefits, such as hedge value, disaster recovery benefits, and other ancillary services help support a secure and reliable electric power system.

Data was collected from four studies: the Austin Energy study (Hoff et al. 2006), the WE Energies study (Norris et al. 2009), the Navigant study (Contreras et al. 2008), and the Arizona Public Service study (R.W. Beck 2009). The data collected expressed PV value in terms of dollars per kilowatt-hour, allowing for the analysis to abstract from system size and relative solar resource. Table 1 lists the four studies that were reviewed. In each of the studies, a range of values were typically given for each benefit component (high-end estimate and low-end estimate). The median value of the range was used in this analysis and is represented in Table 1.

Table 1. Summary of Select PV Valuation Studies

Study	Location	Energy/Generation Value Only ($/kWh)	Total PV Value ($/kWh)
Austin Energy	Austin, Texas	$0.070	$0.11
WE Energies	Milwaukee, Wisconsin	$0.063	$0.12
Navigant	Madison, Wisconsin[3]	$0.068	$0.23
Arizona Public Service	Phoenix, Arizona	$0.097	$0.11

Variations in the studies' values exist because of methodology differences. For example, the WE Energies study (Norris et al. 2009) does not quantify any capacity benefits and states: "Capacity benefits are considered to be small and were not included in the study even though PV also provides generation capacity benefits." (page ES-6)

For contrast, the Navigant study (Contreras et al. 2008) (having the highest quantified capacity benefit) provides a high-end estimate for capacity value at $0.108/kWh. Variations between values can also occur because of local considerations. For instance, some locations may have a

[2] Distributed PV systems not only offset the energy that conventional power plants produce but also the losses associated with delivering that energy. It is these offset losses that are attributed as "loss savings."

[3] The Navigant study was a national study but included PV value estimates for select locations around the United States. This analysis used data from the Wisconsin location due to its proximity to Michigan.

greater T&D value than other locations due to severe congestion in the power lines. Some locations may have a greater energy and generation value component due to a greater use of expensive fuels for power plants in that region.

The estimate for PV value in Michigan was obtained by averaging the various value components from these four PV valuation studies with exception to the energy value component. This value component was quantified by evaluating the market value of PV generation. Quantifying the market value of PV energy is the most direct way to measure the value of a PV system's generation. The market value is determined by overlaying the hourly PV energy output with the hourly wholesale electricity prices from the same time period. The PV energy output is valued and compensated at the market price. The wholesale electricity price data used was LMP data from the Midwest Independent System Operator (MISO 2011). Data was collected for the Michigan Hub. Hourly price data was collected for 2006–2009.

The PV production data used in this analysis were simulated using hourly meteorological data from SolarAnywhere (CPR 2011). Meteorological data for 2006–2009 was collected for the Michigan Hub, located near Grand Rapids, Michigan (MISO 2011). The data were used as an input for the System Advisor Model (SAM) (NREL 2011), which simulated hourly PV production. The PV system simulated had a fixed tilt of 25 degrees and faced due-south (180-degree azimuth). The PV production data was aligned and evaluated with the corresponding LMP data from the same year in order to determine the market value of PV generation in Michigan. This is illustrated in Figure 1, where the 2006–2009 average hourly PV production is compared with the 2006–2009 average LMP data for the first week in August.

As seen in Figure 1, Michigan's summer electricity market prices are well correlated with the solar resource. The PV system's peak generation typically occurs within 3 hours of when prices are at their peak. Figure 2 illustrates the PV production and wholesale electricity price comparison during the week of December 10. In December, electricity prices typically peak during the evening hours when there is little or no PV output.

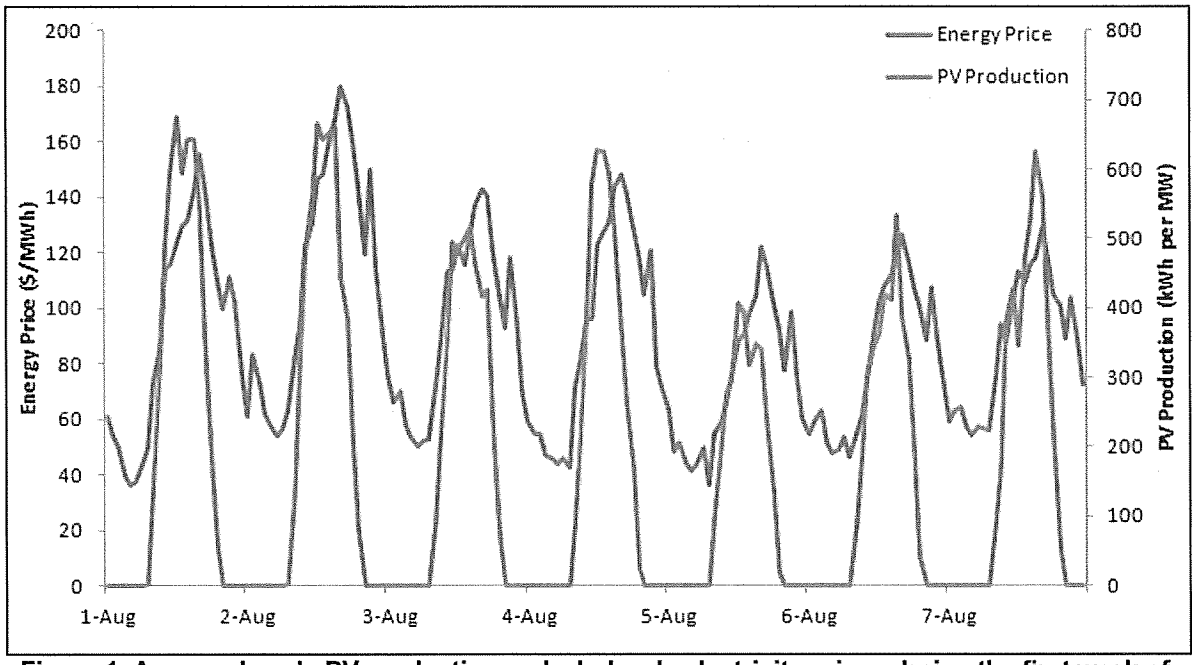

Figure 1. Average hourly PV production and wholesale electricity prices during the first week of August, 2006–2009

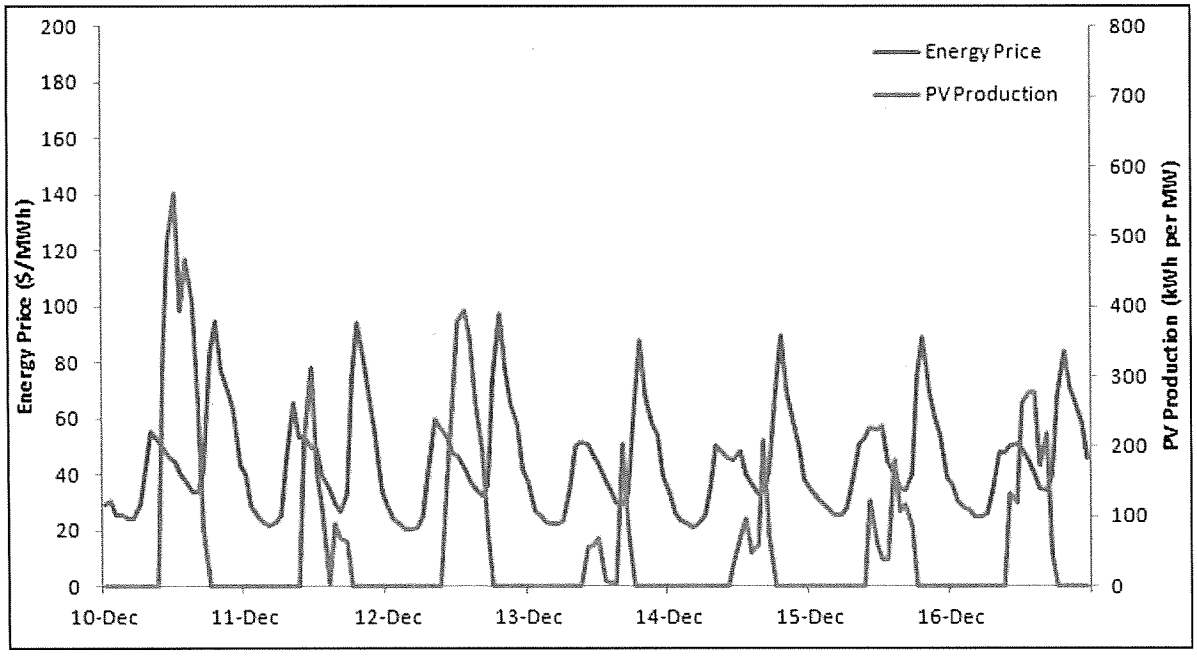

Figure 2. Average hourly PV production and wholesale electricity prices during the week of December 10, 2006–2009

The value of PV generation was evaluated on an hourly basis. The monthly and annual weighted average values (in $/MWh) was determined by dividing the total revenue of the PV generation by the total energy output of the PV system during the time period in question. Figure 3 shows the calculated energy value component stacked alongside the other values estimated for

Michigan. The other PV value components for Michigan were determined by taking the average of each value component from the four studies evaluated.

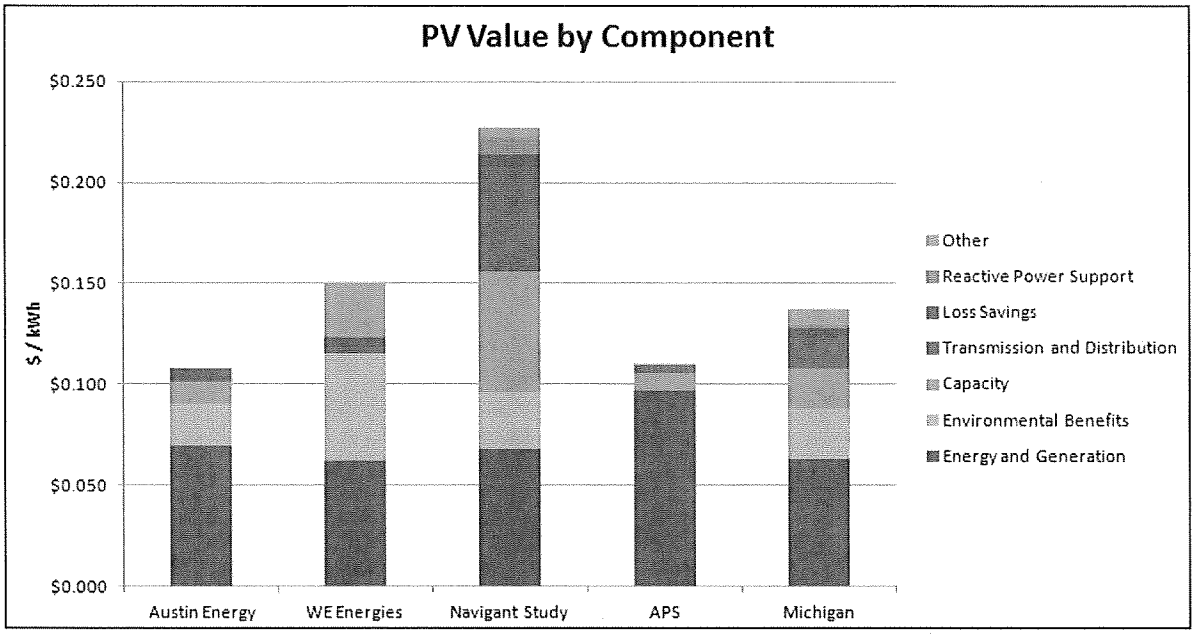

Figure 3. Value components quantified in various PV valuation studies

3 Results

PV production in Michigan coincides well with hourly wholesale electricity prices. Figure 4 illustrates the average PV value in Michigan by month. PV value remains above $70/MWh from June through August and peaks in August at $93/MWh. PV value is at a minimum from November through January, not only because grid prices are lower during this time but because the PV output is less correlated with peak prices than other months of the year. As a result, December is the only month when the average PV value is less than the average electricity price. The top 20% of electricity prices are also shown for comparison. Although PV value is consistently higher than average electricity prices, it is still less than the highest grid prices due to the time difference (2–4 hours) between peak solar production and peak grid prices. On an annual basis, PV production in Michigan is valued at $63/MWh ($0.063/kWh) on the wholesale electricity market.

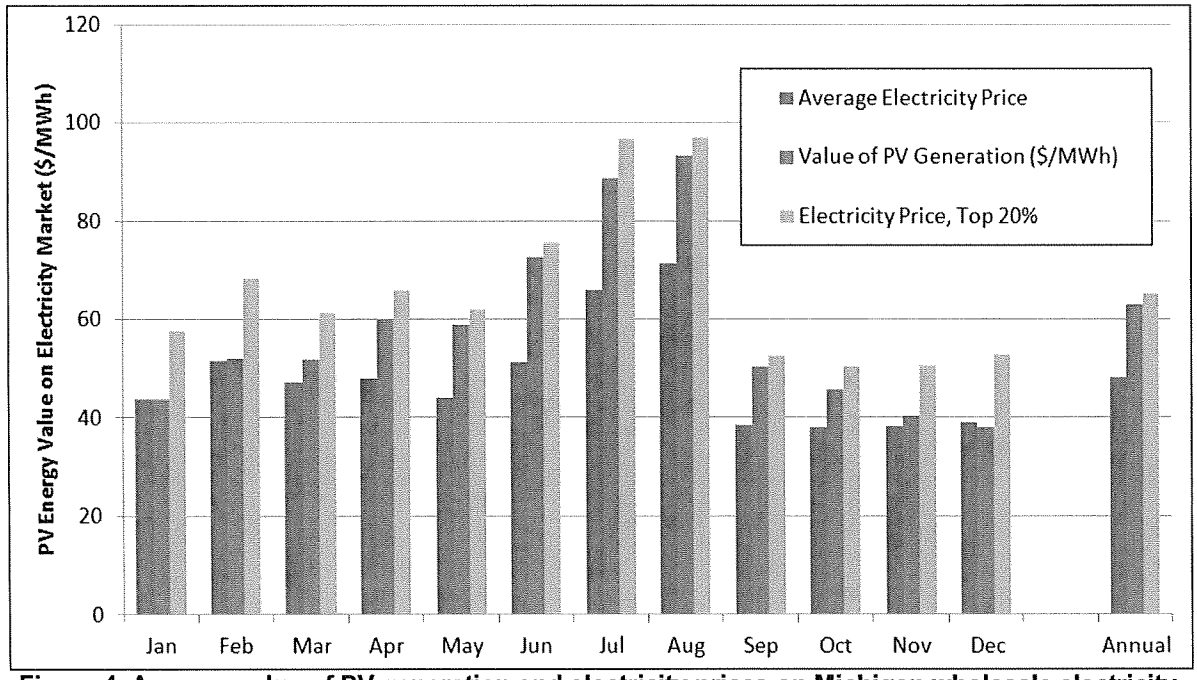

Figure 4. Average value of PV generation and electricity prices on Michigan wholesale electricity market

Figure 5 shows the estimated value of each component for PV in Michigan. The energy and generation value represents the largest component at $0.063/kWh, or 46% of the total value. The second largest component is the environmental benefits value at $0.025/kWh. Since Michigan is under a renewable portfolio standard, requiring a certain amount of its electricity to come from renewable resources, this value represents the price that utilities can avoid paying for RECs from other sources. Infrastructure support and deferrals make up the next $0.04/kWh, comprising T&D benefits, capacity benefits, and reactive power support. The combined value of all components is $0.138/kWh.

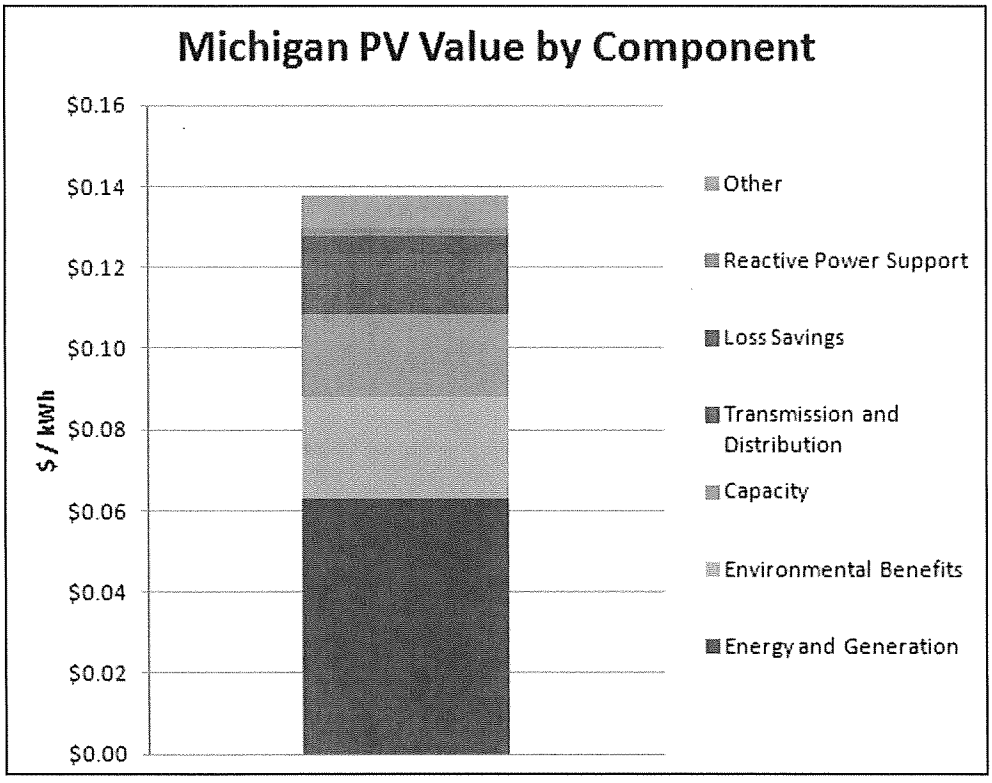

Figure 5. Estimated value of PV in Michigan

4 Conclusions

This study explores the value of PV generation in Michigan's wholesale electricity market and finds that PV value is consistently higher than average electricity prices due to favorable correlation with peak prices. Additional value components were also estimated, bringing the total value of PV in Michigan to four times that of its generation on the wholesale market. Over 75% of the PV value is realized in the energy and generation capacity benefits and the environmental benefits.

Suggestions for further analysis include a thorough investigation of PV value in Michigan, taking into account the various system constraints and infrastructure considerations for the state's local utilities.

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STATE OF MICHIGAN

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Case No. **U-17317**
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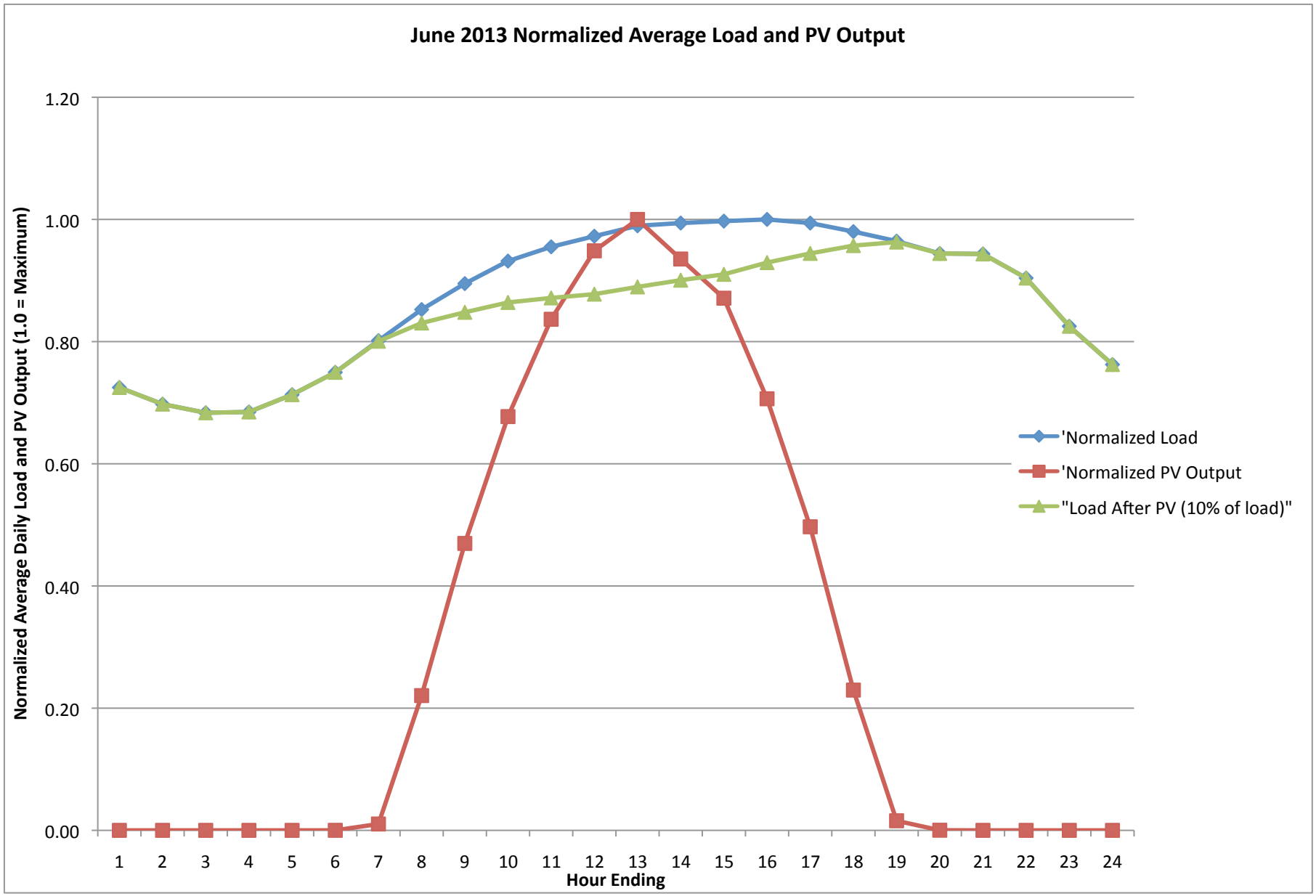
GLREA EXHIBIT 3 (GCC-3) TO DIRECT TESTIMONY OF GEOFFREY C. CRANDALL

August 12, 2014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Normalized Average Daily Load and PV Output (1.0 = Maximum)
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1.00
0.80
0.60
0.40
0.20
0.00
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Hour Ending
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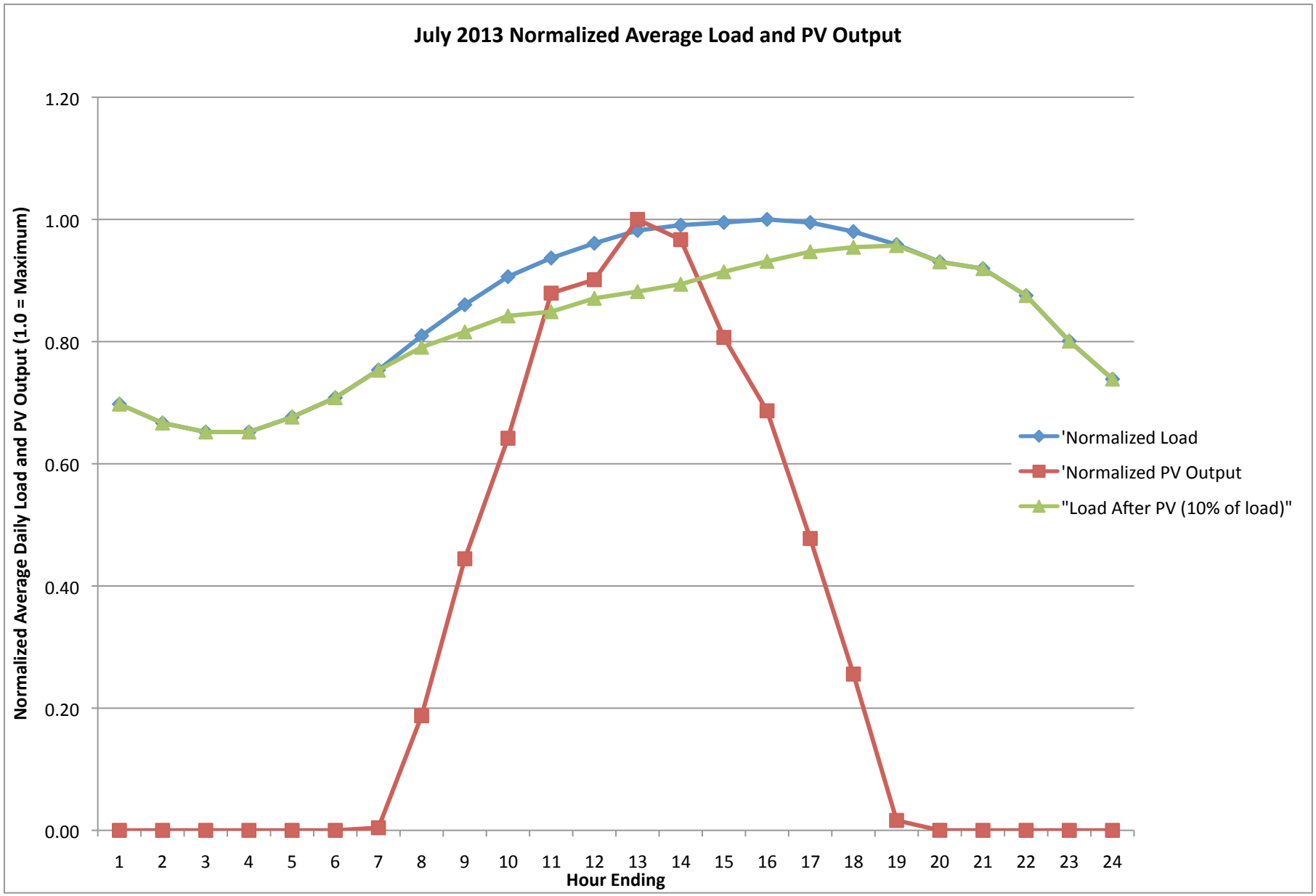
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Hour Ending
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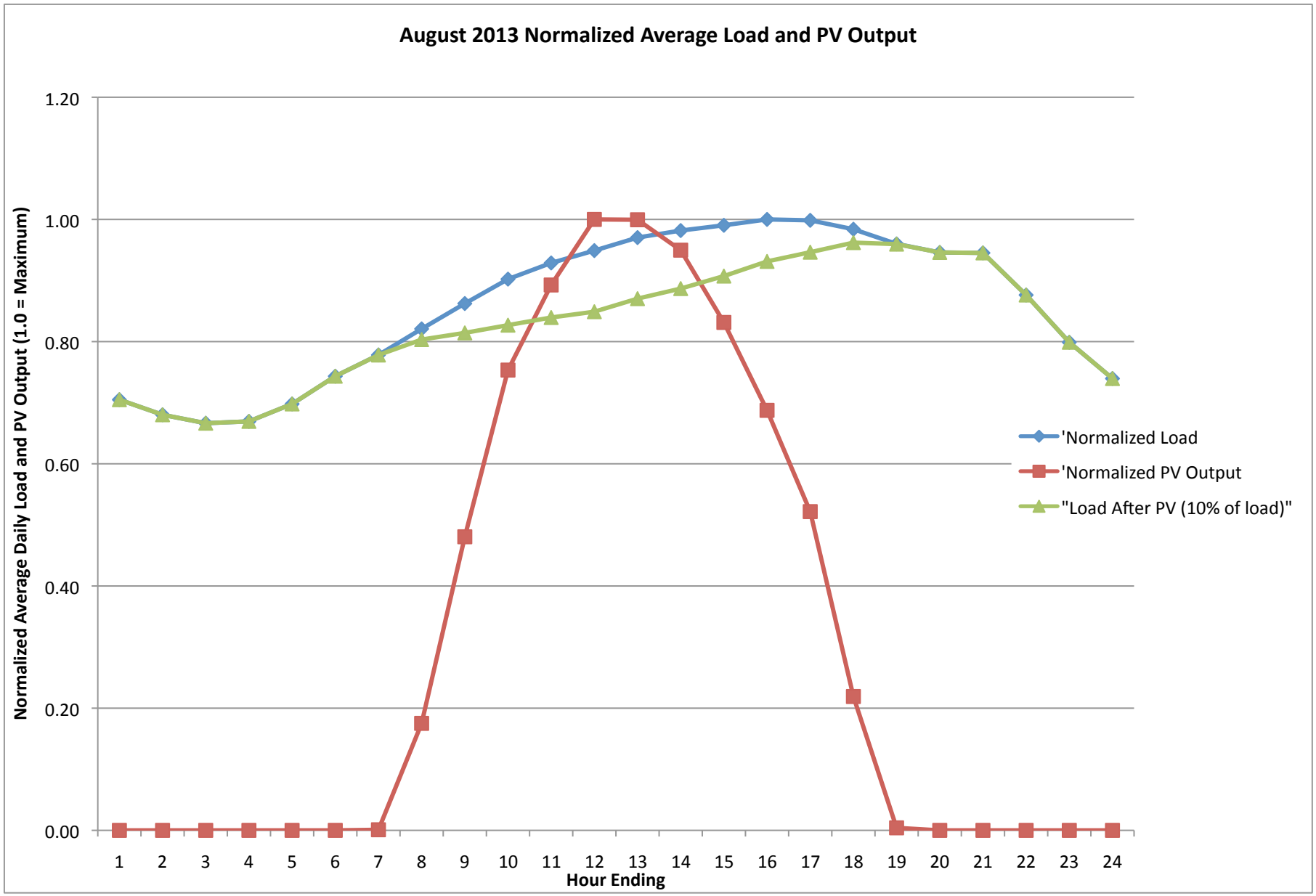
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0.60
0.40
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Hour Ending
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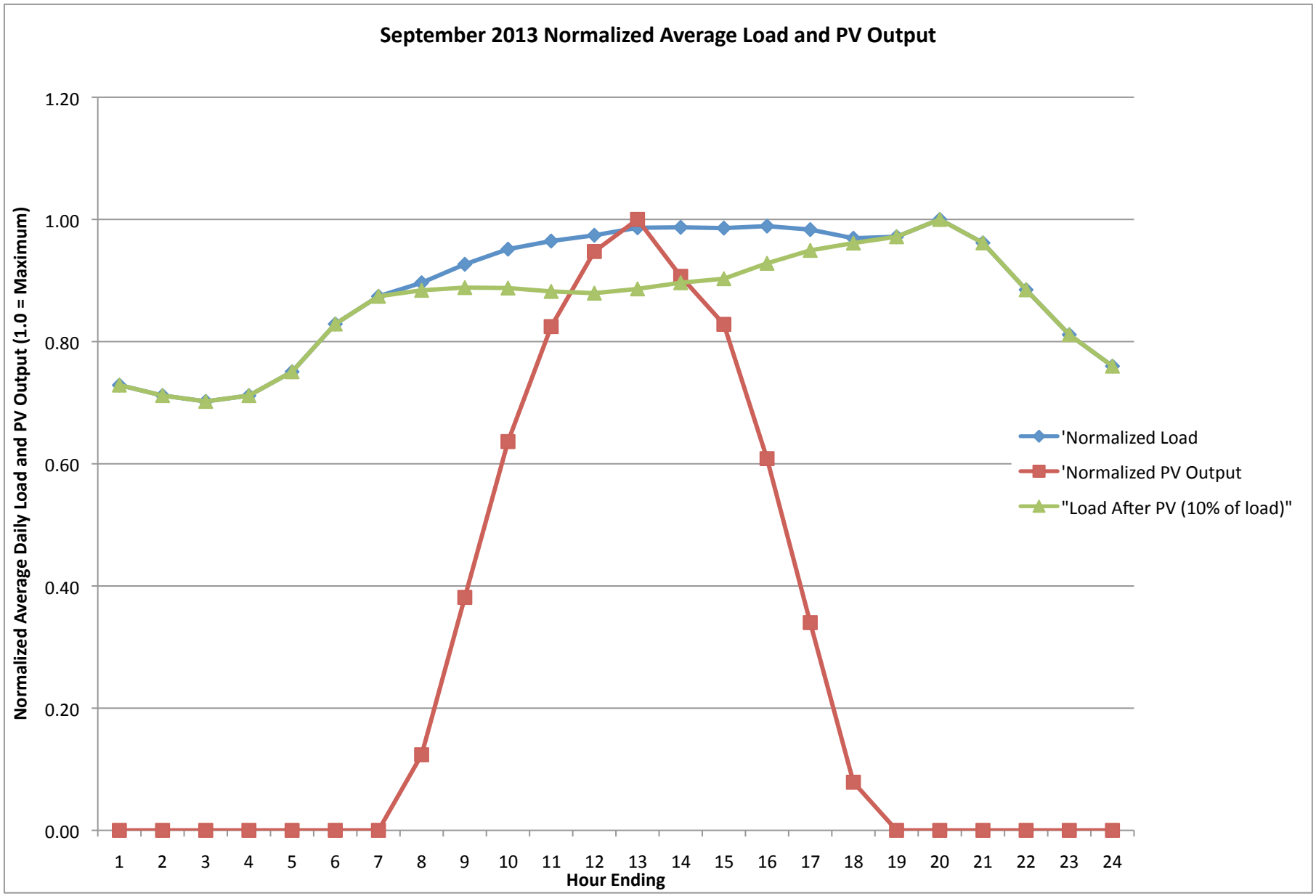
"Load After PV (10% of load)"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Normalized Average Daily Load and PV Output (1.0 = Maximum)
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0.40
0.20
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour Ending
'Normalized Load
'Normalized PV Output
"Load After PV (10% of load)"

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ELECTRONIC SERVICE LIST

On the date below, an electronic copy of the **Direct Testimony and Exhibits of Geoffrey C. Crandall on behalf of The Great Lakes Renewable Energy Association** was served on the following:

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The statements above are true to the best of my knowledge, information and belief.

Respectfully submitted,

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Date: August 12, 2014