ENVIRONMENTAL LAW & POLICY CENTER
Protecting the Midwest's Environment and Natural Heritage

August 29, 2013

Ms. Mary Jo. Kunkle
Michigan Public Service Commission
6545 Mercantile Way
P. O. Box 30221
Lansing, MI 48909

RE: MPSC Case No. U-17302

Dear Ms. Kunkle:

Attached for electronic filing in Case No. U-17302, please find:

- Direct Testimony of Karl Rabago;
- Exhibits KRR-1 through KRR-6; and
- Proof of Service

Please do not hesitate to contact me with any questions.

Sincerely,

Digitally signed by Bradley Klein
DN: cn=Bradley Klein, o, ou, email=bklein@elpc.org, c=US
Date: 2013.08.29 15:06:54 -05'00'

Bradley Klein
Environmental Law & Policy Center
BKlein@elpc.org

CC: Service List, Case No. U-17302

35 East Wacker Drive, Suite 1600 • Chicago, Illinois 60601
(312) 673-6500 • www.ELPC.org
Nancy Loeb, Chairperson • Howard A. Learner, Executive Director
Columbus, OH • Des Moines, IA • Jamestown, ND • Madison, WI • Minneapolis, MN • Sioux Falls, SD • Washington, D.C.

STATE OF MICHIGAN
MICHIGAN PUBLIC SERVICE COMMISSION

In the matter, on the Commission's own motion, regarding the regulatory reviews, revisions, determinations and/or approvals necessary for the DTE ELECTRIC COMPANY (f/k/a The Detroit Edison Company) to fully comply with Public Acts 286 and 295 of 2008.	**)))))))**	**Case No. U-17302**

QUALIFICATIONS

AND

DIRECT TESTIMONY

OF

KARL R. RÁBAGO

Q. State your name, business name and address.

A. My name is Karl R. Rábago. I am the principal of Rábago Energy LLC, a Texas limited liability corporation, located at 8904 Granada Hills, Austin, Texas.

Q. On whose behalf are you appearing in this case?

A. I am appearing here as an expert witness on behalf of the Environmental Law and Policy Center. The Environmental Law & Policy Center is the Midwest's leading public interest environmental legal advocacy and eco-business innovation organization, and among the nation's leaders. ELPC develops and leads successful strategic advocacy campaigns to improve environmental quality and protect our natural resources.

Q. Summarize your experience and expertise in the fields of electric utility regulation.

A. I have worked for more than 20 years in the electricity industry and its related fields. My work experience is set forth in detail in my resume, attached as Exhibit KRR-1. My previous government experience includes service as a Commissioner with the Texas Public Utility Commission and Deputy Assistant Secretary with the U.S. Department of Energy. In private industry, I served as Vice President of Austin Energy, and I was a Director of AES Corporation, among others. I also serve as Chairman of the Board of Directors of the Center for Resource Solutions, and as a member of the Board of Directors of the Interstate Renewable Energy Council.

More specifically, my relevant experience includes record decisions in hundreds of rate cases and rulemakings, utility leadership as a vice president for Distributed Energy

Services at Austin Energy, and leadership and execution on major studies of the electric utility sector in Texas, Colorado, and Alaska. At Austin Energy, one of the nation's largest municipal utilities, I managed a highly successful distributed solar program that included incentive and net metering programs for residential and commercial customers, and a capital investment program for municipally-owned distributed solar. I have written and spoken widely on issues facing electric utilities relating to emerging technologies, services, challenges, and opportunities at the distribution edge of the electric utility system. I co-created and co-led the Texas Sustainable Energy Development Council, established by Executive Order of Governor Ann Richards in 2003, which developed a study and strategic plan for how Texas could meet its energy needs entirely from sustainable energy resources. I contributed to the symposium book, "The Virtual Utility" in 1996. I co-authored the seminal study on distributed energy resources, entitled "Small Is Profitable," and published in 2002, while at Rocky Mountain Institute. More recently, I have published articles concerning an innovative and award-winning residential solar tariff, called the "Value of Solar" tariff, which I designed and implemented while at Austin Energy. A list of relevant publications is included with my resume at Exhibit KRR-1.

Q. Have you ever testified before this Commission or as an expert in any other proceeding?

A. I have never testified before the Michigan Public Service Commission before this. In the past year, I have formally testified as expert witness on matters relating to electric utility matters, distributed generation integration, rate innovation, net metering, and other matters before the Minnesota State Senate and House of Representatives, the Georgia Public Service Commission, and the Louisiana Public Service Commission.

Q. What is the Center for Resource Solutions?

A. The Center for Resource Solutions ("CRS") is a not-for-profit California corporation that offers certification services to green pricing and green power products throughout the U.S., under the certification mark "Green-®."

Q. Does Detroit Edison ("The Company") have a green energy program certified by CRS?

A. Yes. The Company's GreenCurrents^{SM} Program is certified under the Green-e Energy program. The Company pays a fee to CRS for use of the Green-e certification mark. I have no direct involvement with the certification of programs under the Green-e Energy program, and I have no involvement with matters directly relating to the Company's certification. Consistent with the conflict of interest policy adopted by the CRS Board, I have notified my fellow board members of my participation in this proceeding as an expert witness.

Q. What is your role in this proceeding?

A. I am testifying on behalf of ELPC to review the Company's Renewable Energy Plan ("REP") as it relates to solar energy. In my testimony, I offer my conclusions and recommendations regarding incorporation of distributed solar energy resources in its plan.

Q. State the purpose of your testimony.

A. In my testimony, I address deficiencies in the Company's REP related to distributed solar. I identify a major analytical weakness underlying the Plan and the Company's approach to distributed solar energy; that is, the Company fails to recognize the value of distributed solar.

I also propose that the Company improve and increase market opportunities for distributed solar technology in its service territory through adoption of improved program approaches, program expansion, improved resource valuation methodologies in the Company's REP, and other processes, as appropriate.

Q. How do you define distributed solar?

A. For purposes of my testimony distributed solar means solar photovoltaic systems producing electrical energy that are imbedded within the distribution system.

Q. What materials did you review in preparing this testimony?

A. Through ELPC counsel, I reviewed relevant portions of the company's filings in this proceeding. I also reviewed laws, rules, reports, and other materials referenced in those documents, as well as a wide range of additional studies, reports, and articles. These additional materials are listed on Exhibit KRR-2. I also reviewed relevant portions of the Company's discovery responses to ELPC as indicated further in my testimony. These discovery responses are included in Exhibit KRR-8.

Q. What are the key points in your testimony?

A. My testimony makes the following key points:

1. The goal of utility operations is ultimately the procurement and operation of the most cost-effective and economically efficient portfolio of resources to meet the demand for electricity services. In order to properly compare alternative resources, each resource must be valued correctly. Under-valuation of resources, like over-valuation, results in suboptimal resource procurement across the portfolio.

2. Valuation techniques for distributed solar energy resources have significantly improved over time and with decades of deployment experience, allowing utilities, regulators, and policy makers to make better-informed decisions about how much distributed solar maximizes benefits to the utility and ratepayers. Though the price paid by utilities to purchase or support solar generated electricity has dropped dramatically over the past ten years—a trend that is expected to continue—this is only part of the equation. The "value" of distributed solar to the Company and ratepayer is now well documented.

3. Numerous published solar valuation studies confirm that distributed solar resources offer cumulative energy, capacity, and ancillary services valued in excess of retail rates. These studies show that in addition to the energy-related value, distributed solar offers financial and security benefits, environmental services benefits, and economic development benefits.

4. Based on research available on the value of solar ("VOS"), the Company should be directed (in the short term) to modify and improve its programs in order to

support and/or procure additional solar resources in its REP beyond the level the Company has set for these resources. The Company can identify and benefit from the true resource potential for distributed solar by supporting and/or purchasing electricity from distributed solar resources at an effective price likely well below its value.

5. Based on experience gained in other regions, the Company should be directed to conduct a full value of solar technology analysis and to use that analysis to inform the development of new goals, programs, and rates and incentives relating to distributed solar technology.

THE IMPORTANCE OF PROPER RESOURCE VALUATION IN THE REP

Q. Is it important to properly value generation resources in the Company's REP?

A. Yes. My understanding is that as the Commission has implemented Act 295, in determining whether a plan is "reasonable and prudent," the Commission should consider the goals and purposes of the Act. These purposes are laid out in Section 1 of the Act, which provides that:

> *The purpose of this act is to promote the development of clean energy, renewable energy, and energy optimization through 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.*
>
> MCL 460.1001(2).

As such, actions that tend to move the State in the direction of these goals are more likely "reasonable and prudent" than actions that move the State away from these goals. Progress toward the goals requires an analytical foundation for understanding the value of the renewable energy generation resources under consideration. Renewable energy does have different operational and value considerations that should be thoughtfully analyzed and thoroughly understood in order to inform programs structure design and operation.

Q. In your opinion, does the Company's filed REP move the State toward the goals of Act 295?

A. In my opinion, the Company plan does not move the State toward the goals of Act 295 in regards to distributed solar generation ("DSG"). My review of the Company's filed testimony and responses to discovery requests leads me to conclude that the Company's proposed REP is deficient in several major regards. These deficiencies are:

1. The Company REP includes a DSG program that is poorly structured, lacks meaningful goals and metrics, and fails to realize the cost-effective potential for DSG development in the Company's service territory.
2. The Company fails to track and analyze key operational data and use such data in a comprehensive analysis of the impact of DSG on the Company system and on

its ratepayers.

3. The Company has set unreasonably low goals for its DSG programs, resulting in program rationing and lost opportunities for greater resource diversity, greater energy security, greater private investment, and greater progress in improving Michigan's environment.

THE COMPANY'S DISTRIBUTED SOLAR PROGRAMS SHOULD BE IMPROVED

Q. Why is program structure so important?

A. Program structure, including the setting of and measurement against meaningful goals and metrics is essential to maximizing the cost-effective use of program funds, which ultimately come from ratepayers.

Q. Have you reviewed the Company's distributed solar programs?

A. Yes, and based on that review, I have several recommendations for improving program design. My recommendations are informed by my own experience in program management as a utility executive, and by my familiarity with many other DSG programs.

Q. What overriding objectives should guide the structure and operation of a DSG program?

A. In my view the primary goals for a strong DSG program should be:

- The Program and incentives should ultimately lead to a self-sustaining rooftop/small scale solar energy market in Michigan.

- The Program should provide fair compensation for solar energy value and additional financial incentives that are economically efficient, i.e., incentives that prompt customers to make solar energy investments they would not otherwise make, without being excessive.

Q. What indicators should the Company track in monitoring its DSG program?

A. The Company should focus not just on numbers of systems, dollars, kilowatts, and kilowatt hours. For a pilot program that should translate into a full program, it is the direction that the numbers are moving that is most important, and whether continued progress is being made toward program objectives designed to achieve program goals. Some of the key indicators of a sound solar program include:

- Progressive reduction in the incentives stimulating customer investment in DSG.
- Progressive and systematic reductions in system and component costs.
- Progressive reduction in the fraction of system cost represented by incentives.
- Progressive increases in DSG capacity per dollar of program budget.
- Progressive increases in the numbers of solar contractors and full-time, year-round employees.

Q. What factors should be tracked to understand statewide and Company-specific solar market conditions?

A. The Company program managers should track several factors on an ongoing basis that could impact local solar market conditions in order to reach a judgment about those market conditions so as to inform the setting of economically efficient solar incentive levels. Factors impacting emerging solar markets are local, regional, national, and even international, and include:

- Local and regional solar installer workloads
- Availability of skilled workforce
- Local and regional economic conditions
- Local customer awareness
- Local markets for solar financing
- Other local economic incentives
- Utility incentive programs in Michigan, especially adjacent utilities
- Regulatory and legislative policy development in Michigan, the Midwest, and the United States
- National solar module prices
- National solar incentive levels and status of programs
- National tax policy and incentives relating to solar energy
- International solar incentive programs (which impact global solar module prices)

In combination, these factors can impact customer demand for incentives and program participation. For example, when prices for modules drop quickly, customer demand for incentives can grow quickly. If such a trend is long-term in nature, adjustments to incentive levels may be warranted. In fact, recent reductions in installed solar costs as well as the availability of substantial federal tax incentives have been drivers of downward adjustments in rebates and incentives across the United States.

Q. What other recommendations do you have for a strong DSG program?

A. I have several other recommendations. These include:

- Good DSG programs feature regular meetings of program staff with solar installation contractors and stakeholders, featuring two-way dialogue about market conditions, program performance, administrative requirements, and other issues. These meetings provide invaluable "ground-truthing" for solar program managers.
- Program managers should continually review the state of the art in solar promotion programs to stay abreast of innovations and opportunities for program improvements.
- While solar programs should be designed to provide predictability regarding incentives and program requirements, it is also appropriate to grant flexibility to program managers to respond to unexpected or sooner-than-expected changes in DSG market conditions. When program adjustments are required they should not be a surprise to the Commission or stakeholders.
- Program managers should also be prepared for increases in the average size of installed systems as solar prices fall. Larger system sizes consume larger incentives per customer, and in a fixed budget environment, potentially reduce the number of systems receiving incentives. On the other hand, per-unit fixed and system costs decline with system size, allowing for more kilowatts per incentive dollar expended.
- Robust DSG programs should account for repeat customers. Distributed solar is modular in nature, meaning customers can install a system one year, and expand

the system in later years as demand or household budget grows. These system expansion investments can be a relatively low cost path to valuable incremental market growth.

The Company Should Conduct a Thorough Value of Solar Analysis

Q. What is the benefit of comprehensive value analysis for DSG?

A. Full and updated evaluation of resource value improves the chance that a forward-looking resource plan will strike the economically efficient balance in crafting a robust and least-cost resource portfolio and meet the objectives of Act 295 in the most cost effective manner possible. If a renewable generation resource is under-valued by the Company, it will be under-selected and under-utilized in the REP. If the plan under-values a resource with greater value and lower cost, there is an unnecessary upward pressure on rates because the next best resource with lower value and/or greater cost will be selected. Likewise if the plan over-values a resource with lower value and higher cost, there is also unnecessary upward pressure on rates. Updating value calculations of generation resources on a frequent basis enables the Commission and the Company to capture changes in technology, performance, costs, and risks. This is especially important in rapidly evolving market segments like the distributed solar market. Stated simply, unless resources are identical, differences in current market price only tell part of the essential value story. It is not enough to say that one resource is “expensive” compared to another unless the benefits of the competing resources are also assessed and compared.

Q. How do utilities typically assess the value of distributed solar resources?

A. Distributed solar resources have historically not fared well in traditional utility ratemaking systems, which often have a financial bias toward large, capital-intensive projects owned by the utility. Historically, these utility-owned projects, if successful, tend to maximize profits at the expense of the lowest cost and highest value for customers. Historically utilized preferences tend to assign higher value to dispatchable generation options with low capacity cost, while undervaluing several increasingly valuable and important components, such as fuel price volatility, regulatory (especially environmental) risk, water supply and availability risk, transmission infrastructure requirements, and others. Traditional avoided cost methodologies, designed to set energy payments based on current costs, can reduce the value of low- or zero-risk resources and long run marginal cost and risk reductions.

Q. Does this traditional process properly address renewable resources?

A. No. This traditional process has not addressed renewable resources properly. Renewable energy resources such as solar and wind power have zero fuel costs and concomitantly high capacity costs. Essentially, the capacity cost of renewable energy "pre-pays" for a lifetime of fuel. Typical avoided cost methodologies do not work well with this kind of resource. More and different data about value is required.

Q. Can you elaborate further?

A. Yes. For example, the Company calculates and reports the "capacity factor" for solar energy. This is simple division of hours during which solar operates into 8760, the number of hours in a year. More important is the coincidence or overlap of solar production with hourly prices, which informs the capacity *credit* that should be recognized for this resource. The Company should also recognize value for the greenhouse gas benefits of solar energy as well as the reduced risk of environmental regulation that solar energy provides—very real economic risks even in the absence of current control costs. Traditional avoided cost calculations tend to ignore all manner of risk, including fuel price and environmental regulation risks. In response to ELPC's efforts to adduce the various value factors considered by the Company for renewable resources, it appears that very few are considered and even fewer are quantified. The factors and the Company's responses to requests for information are discussed in more detail later.

Q. How has distributed solar valuation evolved?

A. As the U.S. Department of Energy reported to Congress in 2007,

> *"Calculating [distributed generation] benefits is complicated, and ultimately requires a complete dataset of site-specific operational characteristics and circumstances. This renders the possibility of utilizing a single, comprehensive analysis tool, model, or methodology to estimate national or regional benefits of [distributed generation] highly improbable. However, methodologies exist for accurately evaluating "local" costs and benefits (such as [distributed generation] to support a distribution feeder). It is also possible to develop comprehensive methods for aggregating local [distributed generation] costs and benefits for substations, local utility service areas, states, regional transmission*

organizations, and the Nation as a whole."[1]

Over the past decades, a number of local studies have been conducted to calculate the benefits of distributed solar. Today, VOS analysis rests on a solid foundation of data that, if applied, can significantly improve the Company's REP development process and the economic efficiency of its proposed resource portfolio through increased reliance on distributed solar energy.

VOS ANALYSIS

Q. What is VOS analysis?

A. Value of Solar (VOS) analysis identifies and characterizes the value attributes of solar energy generation. Numerous VOS studies published over the past decade share a common general approach and fairly common general structure. A representative list of these studies is described in greater detail in attached Exhibit KRR-3, a recent report from the Rocky Mountain Institute's eLab Project entitled "A Review of Solar PV Benefit and Cost Studies."[2] While results vary depending on methodologies, local energy markets and other factors, research consistently demonstrates that distributed solar energy has value that significantly exceeds the Company's and utility ratepayers' costs associated with stimulating distributed solar energy development. That value should be, but is not, reflected in the Company's REP or in its characterization of distributed solar generation. As a consequence, the Company proposes less solar development and support

[1]U.S. DOE, "The Potential Benefits of Distributed Generation and the Rate-Related Issues That May Impede Its Expansion: Report Pursuant to Section 1817 of the Energy Policy Act of 2005," June 2007.
[2] "A Review of Solar PV Benefit and Cost Studies," Rocky Mountain Institute eLab Report, April 2013. ("RMI eLab Report") Available at: http://www.rmi.org/Content/Files/eLab-DER_cost_value_Deck_130722.pdf

than would be economically efficient and misses a valuable opportunity to advance the goals of Act 295.

Q. What are the basic elements of distributed VOS analysis?

A. VOS analysis is an expansion on a full avoided cost approach that adds a long term valuation perspective, including social costs and benefits. There are two basic steps: first, benefits and costs are identified and grouped, then, second, the benefits are quantified. These steps are essentially the same as traditional ratemaking functions inherent in cost of service analysis. The focus is on the net value that distributed resources bring to utility and grid finances and operations.

Q. Is the calculation of VOS market driven?

A. Yes. Solar valuation studies are, at heart, avoided cost calculations that embrace a full range of costs avoided by distributed solar generation, including savings over the life of the solar generation system. So the source of the value of solar is in the market costs avoided and market benefits received. As explained earlier, solar valuation studies offer improved market pricing signals over traditional avoided cost calculations, which ignore long-term risk, especially fuel price and environmental regulatory risk. My own experience with Austin Energy's VOS methodology is that the calculated value of solar better reflects market conditions and the value of solar investments than short-term avoided cost calculations and base rate calculations established in prior years based on historical test year costs.

Q. What are the benefits and costs studied in VOS analysis?

A. The benefits and costs are those that accrue to the utility and its ratepayers as a result of the satisfaction of the demand for electricity services from a distributed solar facility in lieu of the Company's use of its current and planned system resources to meet that demand. The value of solar to the Company, as a renewable distributed generation resource, must be calculated in a very different manner from the historical capital-intensive, remote central station projects that I referenced earlier in my testimony. A value of solar analysis also differs from other cost-effectiveness analysis conducted from a societal perspective in that customer investment and costs are typically omitted.

At a high level, the costs and benefits to the Company and ratepayers associated with distributed solar energy generation systems include:

- Energy: The basic electrical energy created by the distributed solar system, plus a credit for line-loss savings that accrue because distributed solar displaced generation from remote, central station plants.
- Capacity: Also referred to as "demand." Capacity values capture the avoided capital investments in generation, transmission and distribution that flow from distributed solar generation units.
- Grid Support (Interconnected Operations Services): Often referred to as "ancillary services." These benefits include affirmative provision of services and avoidance of costs related to a range of services inherent in maintaining a reliable, functioning grid network. This grid support or ancillary services include, at both the transmission and distribution level, reactive supply and voltage control, regulation and frequency response, energy and generator imbalance, scheduling, forecasting and system control

and dispatch.

- Customer benefits: Customers accrue a number of benefits from hosting and operating distributed solar systems including reputational, community participation, bill management and stability, and efficiency support benefits. While some of these benefits do not accrue to the utility, some do, like reduced bad debt and delayed payment costs that accompany self-generation.
- Financial and security: These benefits generally reduce both the cost and risk associated with maintaining reliable electric service for customers, especially in the face or variable regulatory, economic, and grid security conditions. These benefits include utility fuel price volatility control, and costs associated with emergency customer power and outages, as well as more rapid and less costly recovery from outage events.
- Environment: Distributed solar creates benefits in reducing the supply portfolio costs associated with control of criteria pollutants, greenhouse gas emissions, water use, and land use. Where control regimes exist, these costs may be reflected in the cost of operating polluting resources. Distributed solar valuation goes beyond traditional avoided cost approaches in recognizing that these resources also affirmatively reduce financial risks associated with compliance with future control regimes.
- Social: Distributed solar also generates social benefits associated with net job growth benefits compared to "conventional" generation options, increased local tax revenues, reduced occupational safety costs (such as black lung insurance), and others.

Q. How are these benefits and costs quantified?

A. I provide several examples of quantification studies in at Exhibit KRR-2. My recommendation is that the Company should be directed to develop the quantification methodology and value of solar calculation in consultation with a broadly based group of stakeholders. As of this filing, I am completing a white paper relating to quantification issues and methodologies. With leave of the Commission, I will seek to supplement this testimony with the published version of that paper.

Q. Have any studies quantified the value of solar in the Company's service territory?

A. A strong body of research exists on this topic nationally. I have found and reviewed one study that attempts to characterize the value of grid connected photovoltaic systems in Michigan, entitled "The Value of Grid-Connected Photovoltaics in Michigan."[3] The white paper, written by a researcher at the National Renewable Energy Laboratory, uses Michigan energy price information in the form of LMP data for 2011 for the MISO Michigan hub in combination with data on other value factors from studies conducted in other states. While the study is not an entirely original study using Michigan-specific data, it does provide a strong indication that the cumulative value of grid connected PV significantly exceeds the retail price for electricity in the state. The study summed values for energy and generation, environmental benefits, capacity, transmission and distribution, loss savings, reactive power support, and other factors. The study concludes that PV has a total value of $0.138/kWh, and also recommends "a thorough investigation of PV value in Michigan that would take into account various system constraints and

[3] "The Value of Grid-Connected Photovoltaics in Michigan," S. Ong, National Renewable Energy Laboratory (Michigan Review Draft, Jan. 23, 2012). Available at: http://www.michigan.gov/documents/mpsc/120123_PVvaluation_MI_394661_7.pdf

infrastructure considerations for the state's local utilities."[4]

The RMI eLab Report that I cited earlier and attached to this report characterizes more than a dozen value of solar and other studies addressing DSG costs and benefits. Among the more prominent researchers cited was Richard Perez. Richard Perez led a team that published a study titled "The Value of Distributed Solar Electric Generation to New Jersey and Pennsylvania,"[5] That study modeled the value of a 15% peak load penetration of distributed solar electric generation at seven locations in the region. The model addressed the following values:

- Market Price Reduction
- Environmental Value
- Transmission and Distribution Capacity Value
- Fuel Price Hedge Value
- Generation Capacity Value

The study found that the total value of distributed solar ranged from $0.256 to $0.318 per kWh. A copy of the paper is attached at Exhibit KRR-4 and is offered as an indicator of how a comprehensive distributed VOS study can and should be conducted.

[4] Id. at 7.
[5] "The Value of Distributed Solar Electric Generation to New Jersey and Pennsylvania," Clean Power Research, November 2012. ("CPR NJ & PA Study 2012") Available at: http://mseia.net/site/wp-content/uploads/2012/05/MSEIA-Final-Benefits-of-Solar-Report-2012-11-01.pdf

Q. Can the study results be applied directly to the Company and Michigan's utility systems?

A. These studies were not based on specific data from the Company's service territory or from data for Michigan. Given the diversity of the data sets from which the studies are drawn, and the relatively high importance of energy and local costs in the estimation, it is reasonable to conclude that the value delivered by distributed solar in the Company's service territory will be significant and likely higher than the current retail price for electricity.

Q. How does VOS relate to payments made by the Company (or any utility) when it purchases electricity or renewable energy credits, or incentivizes third party solar generation?

A. The calculated value of solar should serve as a benchmark indicator for payments the utility makes for third-party solar energy. As with the theory behind avoided cost calculation, VOS analysis quantifies the value equal to what it would cost either the utility or a third party to provide solar energy delivered to the point where the energy does its work. It establishes an economic "indifference price." The Company, however, appears to conduct no value-based analysis that underlies the solar payment rate set by the Company.[6]

[6] See Company Witness Conlen's response to ELPC/DE-1.1m, described in detail below.

Q. What is the relationship between the calculation of VOS and the analysis of solar resources as a factor in retail rates paid by the ratepayer?

A. Because the VOS approach improves on the Company's traditional avoided cost methodology, it indicates a compensation level that can be used to ensure net positive benefits to ratepayers. That is, once the value of solar is fully and accurately known, the Company can be assured that distributed solar enabled at a lower payment will generate excess value for the Company and its ratepayers. At volume, these cumulative excess benefits will exert downward pressure on rates, reflecting the value-to-price differential. The Company's practice today is not grounded in value analysis, but rather in strict statutory compliance. Such practice provides no assurance of value in excess of cost. This represents a significant opportunity cost to the Company and its customers. For example, at value of solar of $0.15/kWh and a retail rate averaging $0.13, the Company and its ratepayers could realize $0.02/kWh in value with each unit of energy produced and introduced into the grid. That value accrues to the benefit of the Company and its ratepayers with the ultimate and cumulative impact of reducing future revenue requirements.

Q. Do solar program subscription rates indicate whether the payment level reflects the value of DSG to the Company and its ratepayers?

A. No. Program subscription rates indicate how investor-customers perceive payment levels under current market conditions. The Company's decision to switch to random allocation is concrete evidence that payment rates are not market based. Rather, the "stampede" effect[7] seen by the Company in its solar program is either an indicator of excessive pent up demand, excessive incentives, poor communications, or lack of confidence in program durability—all of which relate to program management and not the value of DSG.

Q. In summation, what should the Commission and the Company reasonably conclude based on the many published distributed VOS studies?

A. From published VOS research, the Commission and the Company can and should reasonably conclude that:

- Distributed solar systems in the Company's service territory likely have value that will exceed the payment required to facilitate wider deployment of solar as a generation resource.
- Because distributed solar value exceeds the cost to facilitate deployment, increased deployment of distributed solar will put downward pressure on rates.
- Value of solar analysis coupled with greater market development can support and confirm the cost-effectiveness of DSG, that is, the availability of distributed solar at costs that are less than value.

In sum, distributed solar value analysis enables the Commission and the Company to benchmark the resource value of the distributed solar option and to conclude that the Company should move forward with a market-based approach to advancing the deployment of distributed solar in the Company's service territory beyond the limits of the Company's current proposals.

[7] ELPC/DE-1.1l, response of Company witness Conlen. "The Company decided to pursue a random selection approach to encourage a controlled pace of applications rather than a "stampede" which might consume the entire 2 MW expansion in a short period of time."

VOS AND AVOIDED COST

Q. Earlier in your testimony, you discussed avoided cost methodology. Can you distinguish between VOS and traditional avoided cost calculations?

A. Yes. Avoided cost analysis differs from VOS analysis in two key ways. First, most avoided cost analysis is not a "full avoided cost" calculation. Second, traditional avoided cost analysis differs from more far-reaching, forward-looking analyses used to evaluate new resource additions.

A major difference between the two approaches relates to risk. Not all resources bear the same risks. Risk is not well addressed even in full avoided cost methodologies. A resource that depends on long-term availability of fuel at an affordable price is very different from distributed solar, which has no fuel cost, now or in the future. This risk of price volatility is not captured in avoided cost calculations. Risk, therefore, is either ignored or undervalued in avoided cost methodologies.

Undervaluing fuel volatility risk means that a resource option like distributed solar is seen to avoid less cost than it actually does. This results from adjustments made to traditional ratemaking and cost recovery decades ago. Utilities increased their dependence on generation run on fuels with volatile pricing patterns. They sought pass-through cost recovery mechanisms for fuel costs in fuel cost reconciliation charges or "fuel charges," as they are often called. Generally, regulations approved the addition of fuel costs recovery riders on customer bills, over and above basic rates for electricity to address potential regulatory lag issues arising from price volatility.

As a result, utility finances were largely immunized from the deleterious impacts of regulatory lag in fuel cost recovery, but also less sensitive to fuel price volatility than even their customers. The typical "peaker" approach to avoided cost calculations confirms this—it is a methodology that essentially gives no value to resources that reduce fuel price volatility and instead affirmatively favors resources with low capacity costs, even if the long-run fuel and capacity costs of the resource are extremely variable. By undervaluing distributed solar, this approach encourages a utility to procure or support solar at a sub-optimal levels in its planning, systematically rejecting resources that reduce portfolio exposure to fuel price volatility risk.

A similar undervaluation arises regarding security risk and vulnerability to disruptions due to natural and man-made events and risks associated with obtaining water at affordable prices, for example. Economic efficiency is maximized by an analysis that quantifies the full future stream of benefits and costs avoided over the full operational life of distributed solar and expressly addresses the volatility associated with all costs over the life of each resource option. There is significant value in a generation resource that has no fuel or water cost over its entire life—a value appears to be largely ignored in the Company's planning process.

Understanding risk reduction value of all types associated with increased deployment of DSG is key to constructing an optimally diverse portfolio of resources.

Q. Are there future costs and/or benefits that should be included in evaluating the value of distributed solar, but which are not finitely quantifiable?

A. Some costs and benefits are not precisely quantifiable. There is an analytical risk in erroneous valuation. Undervaluing one "alternative" option is the same as overvaluing the incumbent or reference unit. Overvaluing an option might impose costs on ratepayers that could inflate rates. It is appropriate to reach a reasonable level of confidence about a value estimate before using it in resource evaluation decision. But, the field is hardly static. Avoided cost and valuation methodologies have improved over the past several decades. There are also some values that, while difficult to quantify, should be reviewed qualitatively as part of the process of resource plan development. For example, while the tax base and job creation benefits of distributed solar market penetration might not yet lend themselves to discrete quantification in a utility resource plan or explicit reflection in utility rates, the relative job creation and other economic development benefits must be expressly reviewed in the planning exercises like the REP. Such factors often have a strong impact on market and regulatory risk. It is important to note that the objective is not just to estimate on and report jobs benefits, but to also estimate whether particular options perform better than others in job creation. The record in this proceeding does not include such information.

Q. How would forward-looking resource evaluation further improve the evaluation of alternatives?

A. Avoided cost methodologies are an appropriate means for comparing the cost avoided when a single unit of energy from a Qualifying Facility is introduced into the grid.

Distributed solar systems, however, are long-lived, with high availability and low output degradation. This is why the REP and distributed solar programs should take a longer view than is taken with traditional avoided cost calculation. Levelized cost of energy calculations and production cost modeling exercises are explicitly focused on a resource's capability to meet the demand for energy over the life of the resource. They are not limited to traditional marginal cost calculations such as are used in setting avoided cost rates. The amount paid to stimulate the construction and operation of a new distributed system will likely yield 30 or more years of continued energy generation and benefit creation. The most common and appropriate way to account for this stream of benefits is to adjust a full avoided cost calculation by iterating it over the entire expected operating life of the system and then calculating a levelized present value of that stream of benefits.

Q. How does a levelized present value of a stream of full avoided costs calculation potentially impact ratepayers?

A. The approach of both conducting a full avoided cost calculation and then adjusting it for the forward looking stream of value puts evaluation of the resource alternative on a level evaluation playing field with other resources and with planned additions to the system. More importantly, it sets a benchmark for the price above which the utility and ratepayers would be adversely impacted, and below which both the utility and its ratepayers would benefit. It sets a fair level for testing for financial indifference. It is important to note that unlike utility-owned assets, distributed solar systems owned and operated by customers and third parties create no long term stranded cost risk for the utility. Performance or production payments at or below the full value of distributed solar are calculated to minimize such risk by only paying when energy is generated.

COMMERCIAL/RESIDENTIAL VOS

Q. Does the VOS have implications for commercial and residential distributed solar deployment?

A. Yes. Most of my testimony to this point addresses the full range of distributed solar systems. However, there are significant implications for application of VOS in a commercial/residential environment. An empirically established VOS would assist the Company in developing reasonable and forward-looking value based rates and incentives.

Q. What is a "value-based" rate?

A. As introduced above, a value-based distributed solar rate uses utility-specific data to calculate the value of solar energy to the utility and to its ratepayers. The approach calculates what a kilowatt-hour of solar energy generated at or near the point of consumption would be worth to the utility. It is a benchmark of the value at which the utility and its ratepayers would be economically indifferent to whether the customer generates the energy or whether the utility provides solar or solar-equivalent energy to the customer. This benchmark can then inform the strategy for optimizing economic efficiency along the road to portfolio diversity and other benefits from renewable energy.

Q. Can the values you describe be used in constructing a distributed solar rate for commercial/residential customers?

A. Yes. Austin Energy used its VOS analysis as the basis for a new residential solar rate that went into effect for existing and future residential solar customers in October 2012. Some key documents related to the Austin Energy's development of its Value of Solar tariff are included in Exhibit KRR-5. ELPC witness Douglas Jester provides detailed testimony on how value of solar analysis can be used in tariffs proposed for consideration by the Commission and the Company.

THE COMPANY'S APPLICATIONS, DATA, AND PROPOSALS

Q. Is there sufficient information in the Company's filings to assess whether the Company has attempted to quantify the value of distributed solar to the Company and its ratepayers?

A. Through review of the application and responses submitted to ELPC requests for information, I attempted to secure information that would demonstrate such analysis. The Company does not possess or has not made this information available.

Q. What is the Company burden in this case as you understand it?

A. I draw on the Commission's guidance in Case Nos. U-16582 (Dec. 10, 2011) and U-16543 (May 10, 2011) decisions in the Company's and Consumers Energy Company's ("Consumers Energy") applications to amend their respective REPs. In those matters, the Company and Consumers Energy had asserted that their proposals were prudent and reasonable because the plans would meet the REC requirements of PA 295, as the

Company has done in the instant matter. In those prior decisions, the Commission found the proposals unreasonable because they failed to comport with the objective of Act 295 to increase the diversity of energy generation sources. As in this case, the Company and Consumers Energy had based assertions of reasonableness on the cost of compliance with the requirements of Act 295. The Commission took a broader view of a utility's obligations under the act. In fact, the Commission pointed out that expansion of the Company's and Consumers Energy's efforts to support the development of distributed generation would provide additional grid support and stability benefits, in addition to increasing resource diversification, and would offer economic development benefits as well.

Q. What did the Commission direct in Case Nos. U-16582 and U-16543?

A. The Commission directed expansion of the Company's and Consumer Energy's renewable energy programs in order to capture additional benefits.

Q. What else did the Commission say in U-16543 about utility solar incentive programs that is relevant in this proceeding?

A. The Commission specifically found that "boom and bust" cycles in solar incentive programs can be detrimental to development of a solar industry. In my opinion, that concern is specifically relevant to the Company's proposal in this matter; a problem not cured by changing the rationing system for program opportunities. The Commission said "the preferred approach is to develop programs that are long term, consistent, and that foster steady growth." The Commission cited its earlier decision in Case No. U-15805 as indicative of the reasons for this preferred approach. Finally, the Commission directed Consumers Energy to design programs to take advantage of the economic benefits of net metering.

Q. In your opinion, does the Company proposal meet the Commission's expectations regarding solar incentive program design and implementation?

A. No. I have previously discussed elements of a strong distributed solar program. These features are notably absent in the Company's proposal in this matter. I believe the proposed program will fail to capture the benefits of distributed solar. One major reason for this failure is that the Company has failed to undertake sufficient effort to discern, analyze, and understand these benefits in a comprehensive fashion.

Q. How does the Company characterize its obligations under Act 295?

A. Based on the testimony of Company witness Conlen and others, the Company appears to have based its REP upon achieving the specific renewable energy capacity targets under Act 295. In response to ELPC/DE-1.1bii, Company witness Conlen states that "[a]ny decision on whether to expand SolarCurrents beyond the pilot phase would primarily be based on whether the Company needs the renewable energy credits (RECs) from an expanded SolarCurrents program to fulfill the compliance requirements of 2008 PA 295, and whether those RECs are cost competitive with RECs from other sources (such as wind or landfill gas) in the Company's portfolio." The Company fails to adequately evaluate distributed solar energy in such a fashion as to support any determination of whether additional cost effective distributed energy resources could advance the diversity, economic development, environmental and other benefits available.

With more than 560 solar systems installed in its service territory, Company witness Conlen asserts in response to ELPC/DE-1.1a that the Company goal for a program still characterized as a "pilot" is to "learn about and gain experience in addressing the construction, interconnection, and operating challenges associated with distributed solar arrays, in order to be better prepared if photovoltaic systems become economic and commercially viable in Michigan."

Witness Conlen also states in response to ELPC/DE-1.1a that the Company "has successfully gained experience." In response to ELPC/DE-1.1d, witness Conlen provides a list of process improvements that go to the SolarCurrents process, none of which addresses support for the economic commercialization of distributed solar.

Q. Does the Company propose an increase in its distributed solar efforts?

A. The Company had added an additional 2 MW of distributed solar support in the last biennial case, but makes so proposal for added solar in this case. There is a notable absence of analysis to demonstrate why no added solar capacity is appropriate. It appears that the Company again underserves demand for this resource, strongly suggesting that even more solar capacity could be supported with better program design and stronger evidence of commitment from the Company to help establish a sustained orderly market for distributed solar in its service territory and to attain the goals established in PA 295.

Q. What does the Company assert about cost effectiveness of renewable energy?

A. The Company offers confused testimony regarding the costs of renewable energy. Company witness Conlen testifies as page CLC-23 in the Company's application that "costs for renewable energy systems and related equipment have fluctuated greatly over the past few years," and that recently the market has been characterized by "excess supply." Then witness Conlen testifies, at p. 24, that renewable energy "capital costs are expected to increase over the next few years due to economic growth and commodity escalation." Witness Conlen supports this latter assertion, in response to ELPC/DE-1.5a & 1.5biv, by pointing to a macro-economic forecast of GDP, CPI, and other very high level factors from Company witness Leuker, at A-22 in the Company's application.

In response to information requests, the Company makes other assertions. In response to ELPC/DE-1.1n, requesting information regarding price trends for solar systems, the Company offers reference to Figure 17 in the "BEW Report" included in ELPC/DE-1.1f-1.pdf, a chart showing little or no pattern in costs. The BEW Report asserts "on average, PV system costs have declined over this period by about 30%," and concludes at page 40 both that "DECo saw PV system costs drop over the two year period and the trend is expected to continue," and "installed system cost was highly variable." Such a price reduction is highly significant, and is consistent with the Company's assertion in response to ELPC DE-1.1o, that renewable energy price trends have followed California and national experience as charted in ELPC/DE-1.1o.pdf, a report from the U.S Department of Energy's SunShot initiative.

Finally, in response to ELPC/DE-1.5biii, the Company asserts the installed capital cost for solar, assumed to be $5,876 per kW in 2013 in witness Conlen's testimony at p. 24, was derived simply from a weighted average calculation for solar systems installed in 2013.

Q. What does the BEW Report provided in response to ELPC/DE-1.1f reveal about the SolarCurrents program?

A. The BEW report, taken as a whole reveals a great deal of data and very little program direction. From the Company's testimony and the BEW Report, it is most notable what is absent from the SolarCurrents program, including any vision or goals concerning supporting successful commercialization of distributed solar, price reduction goals, job creation, customer diversity, geographic diversity, targeted siting to support grid operations, supply chain indicators, or other metrics relating to factors beyond compliance with the REC requirements of Act 295.

Q. Does the Company provide any other information about the value elements of distributed solar?

A. In response to ELPC/DE-1.1h, seeking data regarding "energy production, capacity value, avoided transmission and distribution costs, and other costs or benefits of the systems," the Company reports that it collects data on "energy production and capacity factor." Witness Conlen also provides a list of certain "hidden" costs of solar systems, detailed in response to ELPC/DE-1.1i, including the need for studies on circuits with fast-recloser systems, that distribution system upgrades are "sometimes" necessary, and that it has investigated "several" cases of customer systems frequently tripping offline due to customer-side problems. The Company provided no additional detail in this response.

In its response to ELPC's Second Discovery Request, the Company provided data, under objection, regarding the issue of transmission and distribution system losses from the year 1995. ELPC requested the information in Questions ELPC/DE-1.21 and ELPC/DE-2.27(5). The data was detailed in Company Attachment ELPC/DE-2.27(5). The data is significant in that it shows that transmission and distribution system losses were almost 23% higher in the summer months of June, July, and August than in the rest of the year. During those months, system losses have a simple average of 10.5%. Given the high coincidence of energy generation from solar systems during the summer months, this indicates that distributed solar generation enjoys a 10.5% premium value due to avoided losses that should be accounted for by the Company. The Company continues to assert that this difference is not relevant.

Q. How then does the Company develop its proposed REC price for the SolarCurrents program?

A. Company witness Conlen states in response to ELPC/DE-1.1m that a price of $12 per REC was reached by averaging two numbers—a market referent price of $0.25 derived from a recent reverse auction and the average approved REC price of $16.95 for the years 2013-2029.

Q. Did you find any evidence on how the Company estimates the capacity value of distributed solar?

A. Company witness Conlen, in response to ELPC/DE-1.1c states that the calculated twelve-month capacity factor for all customer-owned solar systems is 12.8%.

Q. Does the Company assign any additional capacity credit due to solar generation occurring during periods of higher demand?

A. No. The issue of capacity credit is a good example of how the Company has not attempted to quantify the value of distributed solar resources. Again, the Company's responses are somewhat confused. In response to ELPC/DE-1.2d, witness Conlen states that he assumes that "capacity credit" means "credit toward the Renewable Energy Capacity standard under 2008 Act 295." In response to ELPC/DE-1.9b, Company witness Conlen states that capacity credit has not yet been assigned in the MISO market, and that the Company "expects to received capacity credit for these resources in the planning year which begins on 6/1/2014." In response to ELPC/DE-1.9c, witness Conlen stated how a MISO capacity credit could be calculated, but offered no data. Company witness Conlen stated in response to ELPC/DE-1.22h that "[t]he Company does store hourly data for customer owned solar generation," though it provided hourly aggregated generation data for Company-owned solar.

In the end, I could find no evidence in the Company testimony or in its responses to requests for information regarding an evaluation by the Company of the capacity benefits of distributed solar generation aside from the calculated capacity factor.

Q. Does the Company quantify any other benefits or costs of distributed solar beyond energy, capacity factor, and the cited instances of "hidden" costs?

A. ELPC submitted a carefully crafted set of information requests designed to adduce information about how the Company quantifies the benefits and costs of distributed solar energy. For example:

In response to ELPC/DE-1.10b, Company witness Conlen stated that the Company does not have any documents that perform quantification of risks cited as potentially impacting the regulatory liability balance on page CLC-32 of his prefiled direct testimony. Witness Conlen also confirmed that the Company has not attempted to quantify the value associated with calculation of renewable energy credit shortfalls, allocation of change-in-law risk, allocation of resource risk, excess supply provisions, credit support, force majeure, energy curtailment, or any of "hundreds" of other matters typically appearing as clauses in purchased power agreements and potentially applicable to distributed solar generators. See Company responses to ELPC/DE-1.13ai-aviii.

RECOMMENDATIONS

Q. In light of your testimony, how should the Commission and the Company move forward?

A. In my opinion, efforts of the Commission and the Company to seed the development of a solar energy market have borne fruit. Coupled with substantial cost reductions experienced in solar generation, the Commission and the Company have tapped an infant, but increasingly viable market for distributed solar in the State of Michigan. For this and other reasons, I propose that the Commission direct the Company to increase its solar program substantially, to revise its program structure and metrics, and to conduct a comprehensive Value of Solar analysis in consultation with a broadly based group of stakeholders, all with a view to supporting the emergence of a sustained orderly market for DSG in Michigan.

Q. Why should the Commission and the Company act on these recommendations at this time?

A. In order to maximize the potential for economically efficient and cost-effective deployment of distributed solar in Michigan over the current planning horizon of the current REP and Act 295, it is essential that the Company understand and fully account for all the impacts—including both costs and benefits—of distributed solar. The many published solar valuation analysis reports now available and the consensus emerging about the value of distributed solar to the utility and its customers enable the Company to launch these market support initiatives at this time.

Q. Will these initiatives impose a management burden on the Company?

A. The actions recommended will require some effort on the part of the Company, but they are not significantly greater than those already required in the proposed REP. Customers and installers bear the greatest burdens in DSG market, and experienced consultants to help manage improved solar support programs. Distributed solar systems are typically owned and operated by third parties or customers, minimizing utility administrative burdens.

Q. What are the advantages of moving forward to support the development of cost-effective distributed solar at this time?

A. Solar markets are largely driven by economies of manufacturing scale. That is, the more systems that are deployed, the faster the market moves to lower prices and greater value. The Company's proposal to barely increase its distributed solar program is headed in precisely the wrong direction at a time when these benefits can be captured and the foundation for self-sustaining solar markets can be laid.

Q. Does this conclude your testimony?

A. Yes.

Karl R. Rábago

8904 Granada Hills, Austin, Texas 78737
t: +1.512.968.7543 e: karl@rabagoenergy.com

Summary

Nationally recognized electricity industry leader and innovator. Experienced as a utility executive leader and manager, public utility regulatory commissioner, research and development program manager, educator, business builder, federal executive, corporate sustainability leader, consultant, and advocate. Thought leader and practice expert in organizational transformation. Highly proficient in advising, managing and interacting with government agencies and committees, the media, citizen groups, and business associations. Successful track record of working with US Congress, state legislatures, governors, regulators, city councils, business leaders, researchers, academia, and community groups. National and international contacts through experience with Austin Energy, AES Corporation, US Department of Energy, Texas Public Utility Commission, Jicarilla Apache Tribal Utility Authority, Cargill Dow LLC (now NatureWorks, LLC), Rocky Mountain Institute, CH2M HILL, Houston Advanced Research Center, Environmental Defense Fund, and others. Expert in development of new energy markets in renewable energy, green power, and tradable credits, and in helping new market entrants shape new products and services. Skilled attorney, negotiator, and advisor with more than twenty years experience working with diverse stakeholder communities in guiding electricity policy and regulation, emerging energy markets development, clean energy technology development, electric utility restructuring, smart grid development, and the implementation of sustainability principles. Nationally recognized speaker on energy, environment and sustainable development matters. Managed staff as large as 250; responsible for operations of research facilities with staff in excess of 600. Developed and managed budgets in excess of $300 million. Law teaching experience at University of Houston Law Center and U.S. Military Academy at West Point. Trial experience as a Judge Advocate. Post doctorate degrees in environmental and military law. Military veteran.

Employment

RÁBAGO ENERGY LLC

Principal: July 2012--Present. Solo consulting practice dedicated to providing strategic advice and support to businesses and organizations in the clean and advanced energy sectors. Services include distributed energy business, project, and product development; energy policy development and advocacy; renewable energy product development and market development; strategic and corporate sustainability planning; and government and regulatory affairs support. Additional activities:

- Chairman of the Board, Center for Resource Solutions (1997-present). CRS is a not-for-profit organization based at the Presidio in California. CRS developed and manages the Green-e Renewable Electricity Brand, a nationally and internationally recognized branding program for green power and green pricing products and programs. Past chair of the Green-e Governance Board (formerly the Green Power Board).
- Director, Interstate Renewable Energy Council (IREC) (2012-present). IREC focuses on issues impacting expanded renewable energy use such as rules that support renewable energy and distributed resources in a restructured market, connecting small-scale renewables to the utility grid, developing quality credentials that indicate a level of knowledge and skills competency for renewable energy professionals.
- Of Counsel, Osha Liang, LLP. Osha Liang is an intellectual property law firm with offices in Texas, California, France, and Japan.

AUSTIN ENERGY – THE CITY OF AUSTIN, TEXAS

Vice President, Distributed Energy Services: April 2009—June 2012. Executive in 8th largest public power electric utility serving more than one million people in central Texas. Responsible for management and oversight of energy efficiency, demand response, and conservation programs; low-income weatherization; distributed solar and other renewable energy technologies; green buildings program; key accounts relationships; electric vehicle infrastructure; and market research and product development. Executive sponsor of Austin Energy's participation in an innovative federally-funded smart grid demonstration project led by the Pecan Street Project. Led teams that successfully secured over $39 million in federal stimulus funds for energy efficiency, smart grid, and advanced electric transportation initiatives. Additional activities included:

- Director, Renewable Energy Markets Association. REMA is a trade association dedicated to maintaining and strengthening renewable energy markets in the United States.
- Membership on Pedernales Electric Cooperative Member Advisory Board. Invited by the Board of Directors to sit on first-ever board to provide formal input and guidance on energy efficiency and renewable energy issues for the nation's largest electric cooperative.

THE AES CORPORATION

Director, Government & Regulatory Affairs: June 2006—December 2008. Government and regulatory affairs manager for AES Wind Generation, one of the largest wind companies in the country. Manage a portfolio of regulatory and legislative initiatives to support wind energy market development in Texas, across the United States, and in many international markets. Active in national policy and the wind industry through work with the American Wind Energy Association as a participant on the organization's leadership council. Also served as Managing Director, Standards and Practices, for Greenhouse Gas Services, LLC, a GE and AES venture committed to generating and marketing greenhouse gas credits to the U.S. voluntary market. Authored and implemented a standard of practice based on ISO 14064 and industry best practices. Commissioned the development of a suite of methodologies and tools for various greenhouse gas credit-producing technologies. Also served as Director, Global Regulatory Affairs, providing regulatory support and group management to AES's international electric utility operations on five continents. Additional activities:

- Director and past Chair, Jicarilla Apache Nation Utility Authority (1998 to 2008). Located in New Mexico, the JAUA is an independent utility developing profitable and autonomous utility services that provides natural gas, water utility services, low income housing, and energy planning for the Nation. Authored "First Steps" renewable energy and energy efficiency strategic plan.

HOUSTON ADVANCED RESEARCH CENTER

Group Director, Energy and Buildings Solutions: December 2003—May 2006. The Houston Advanced Research Center (HARC) is a mission-driven not-for-profit contract research organization based in The Woodlands, Texas. Responsible for developing, maintaining and expanding upon technology development, application, and commercialization support programmatic activities, including the Center for Fuel Cell Research and Applications, an industry-driven testing and evaluation center for near-commercial fuel cell generators; the Gulf Coast Combined Heat and Power Application Center, a state and federally funded initiative; and the High Performance Green Buildings Practice, a consulting and outreach initiative. Secured funding for major new initiative in carbon nanotechnology applications in the energy sector. Developed and launched new and integrated program activities relating to hydrogen energy technologies, combined heat and power, distributed energy resources, renewable energy, energy efficiency, green buildings, and regional clean energy development. Active participant in policy development and regulatory implementation in Texas, the Southwest, and national venues. Frequently engaged with policy, regulatory, and market leaders in the region and internationally. Additional activities:

- President, Texas Renewable Energy Industries Association. As elected president of the statewide business association, leader and manager of successful efforts to secure and implement significant expansion of the state's renewable portfolio standard as well as other policy, regulatory, and market development activities.
- Director, Southwest Biofuels Initiative. Established the Initiative acts as an umbrella structure for a number of biofuels related projects, including emissions evaluation for a stationary biodiesel pilot project, feedstock development, and others.

- Member, Committee to Study the Environmental Impacts of Windpower, National Academies of Science National Research Council. The Committee was chartered by Congress and the Council on Environmental Quality to assess the impacts of wind power on the environment.
- Advisory Board Member, Environmental & Energy Law & Policy Journal, University of Houston Law Center.

CARGILL DOW LLC (NOW NATUREWORKS, LLC)

Sustainability Alliances Leader: April 2002—December 2003. Founded in 1997, NatureWorks, LLC is based in Minnetonka, Minnesota. Integrated sustainability principles into all aspects of a ground-breaking biobased polymer manufacturing venture. Responsible for maintaining, enhancing and building relationships with stakeholders in the worldwide sustainability community, as well as managing corporate and external sustainability initiatives. NatureWorks is the first company to offer its customers a family of polymers (polylactide – “PLA”) derived entirely from annually renewable resources with the cost and performance necessary to compete with packaging materials and traditional fibers; now marketed under the brand name “Ingeo.”

- Successfully completed Minnesota Management Institute at University of Minnesota Carlson School of Management, an alternative to an executive MBA program that surveyed fundamentals and new developments in finance, accounting, operations management, strategic planning, and human resource management.

ROCKY MOUNTAIN INSTITUTE

Managing Director/Principal: October 1999–April 2002. In two years, co-led the team and grew annual revenues from approximately $300,000 to more than $2 million in annual grant and consulting income. Co-authored “Small Is Profitable,” a comprehensive analysis of the benefits of distributed energy resources. Worked to increase market opportunities for clean and distributed energy resources through consulting, research, and publication activities. Provided consulting and advisory services to help business and government clients achieve sustainability through application and incorporation of Natural Capitalism principles. Frequent appearance in media at international, national, regional and local levels. RMI is an independent, non-profit research and educational foundation. Joined the organization to develop the Natural Capitalism research and consulting practice at RMI.

- President of the Board, Texas Ratepayers Organization to Save Energy. Texas R.O.S.E. is a non-profit organization advocating low-income consumer issues and energy efficiency programs.
- Co-Founder and Chair of the Advisory Board, Renewable Energy Policy Project-Center for Renewable Energy and Sustainable Technology. REPP-CREST was a national non-profit research and internet services organization.

CH2M HILL

Vice President, Energy, Environment and Systems Group: July 1998–August 1999. Responsible for providing consulting services to a wide range of energy-related businesses and organizations, and for creating new business opportunities in the energy industry for an established engineering and consulting firm. Completed comprehensive electric utility restructuring studies for the states of Colorado and Alaska.

PLANERGY

Vice President, New Energy Markets: January 1998–July 1998. Responsible for developing and managing new business opportunities for the energy services market. Provided consulting and advisory services to utility and energy service companies.

ENVIRONMENTAL DEFENSE FUND

Energy Program Manager: March 1996–January 1998. Managed renewable energy, energy efficiency, and electric utility restructuring programs for a not-for-profit environmental group with a staff of 160 and over 300,000 members. Led regulatory intervention activities in Texas and

California. In Texas, played a key role in crafting Deliberative Polling processes, which in turn led to electric utility restructuring legislation and the state's Renewable Portfolio Standard. Initiated and managed nationwide collaborative activities aimed at increasing use of renewable energy and energy efficiency technologies in the electric utility industry, including the Green-e Certification Program, Power Scorecard, and others. Participated in national environmental and energy advocacy networks, including the Energy Advocates Network, the National Wind Coordinating Committee, the NCSL Advisory Committee on Energy, and the PV-COMPACT Coordinating Council. Frequently appeared before the Texas Legislature, Austin City Council, and regulatory commissions on electric restructuring issues.

UNITED STATES DEPARTMENT OF ENERGY

Deputy Assistant Secretary, Utility Technologies: January 1995–March 1996. Manager of the Department's programs in renewable energy technologies and systems, electric energy systems, energy efficiency, and integrated resource planning. Supervised technology research, development and deployment activities in photovoltaics, wind energy, geothermal energy, solar thermal energy, biomass energy, high-temperature superconductivity, transmission and distribution, hydrogen, and electric and magnetic fields. Developed, coordinated, and advised on legislation, policy, and renewable energy technology development within the Department, among other agencies, and with Congress. Managed, coordinated, and developed international agreements for cooperative activities in renewable energy and utility sector policy, regulation, and market development between the Department and counterpart foreign national entities. Established and enhanced partnerships with stakeholder groups, including technology firms, electric utility companies, state and local governments, and associations. Supervised development and deployment support activities at national laboratories. Developed, advocated and managed a Congressional budget appropriation of approximately $300 million.

STATE OF TEXAS

Commissioner, Public Utility Commission of Texas. May 1992–December 1994. Appointed by Governor Ann W. Richards. Regulated electric and telephone utilities in Texas. Laid the groundwork for legislative and regulatory adoption of integrated resource planning, electric utility restructuring, and significantly increased use of renewable energy and energy efficiency resources. Appointed by Governor Richards to co-chair and organize the Texas Sustainable Energy Development Council, a public/private council that crafted a blueprint for Texas' development of renewable energy, energy efficiency, and other sustainable energy resources. Served as Vice-Chair of the National Association of Regulatory Utility Commissioners (NARUC) Committee on Energy Conservation. Member and co-creator of the Photovoltaic Collaborative Market Project to Accelerate Commercial Technology (PV-COMPACT), a nationwide program to develop domestic markets for photovoltaics. Member, Southern States Energy Board Integrated Resource Planning Task Force. Member of the University of Houston Environmental Institute Board of Advisors.

LAW TEACHING

Associate Professor of Law: University of Houston Law Center, 1990–1992. Full time, tenure track member of faculty. Courses taught: Criminal Law, Environmental Law, Criminal Procedure, Environmental Crimes Seminar, Wildlife Protection Law. Provided *pro bono* legal services in administrative proceedings and filings at the Texas Public Utility Commission. Launched a student clinical effort that reviewed and made recommendations on utility energy efficiency program plans.

Assistant Professor: United States Military Academy, West Point, New York, 1988–1990. Member of the faculty in the Department of Law. Honorably discharged in August 1990, as Major in the Regular Army. Courses taught: Constitutional Law, Military Law, and Environmental Law Seminar. Greatly expanded the environmental law curriculum and laid foundation for the concentration program in law. While carrying a full time teaching load, earned a Master of Laws degree in Environmental Law. Established a program for subsequent environmental law professors to obtain an LL.M. prior to joining the faculty.

LITIGATION

Trial Defense Attorney and Prosecutor, U.S. Army Judge Advocate General's Corps, Fort Polk, Louisiana, January 1985–July 1987. Assigned to Trial Defense Service and Office of the Staff Judge Advocate. Prosecuted and defended over 150 felony courts-martial. As prosecutor, served as legal officer for two brigade-sized units (approximately 5,000 soldiers), advising commanders on appropriate judicial, non-judicial, separation, and other actions. Pioneered use of psychiatric and scientific testimony in administrative and judicial proceedings.

NON-LEGAL MILITARY SERVICE

Armored Cavalry Officer, 2d Squadron 9th Armored Cavalry, Fort Stewart, Georgia, May 1978–August 1981. Served as Logistics Staff Officer (S-4). Managed budget, supplies, fuel, ammunition, and other support for an Armored Cavalry Squadron. Served as Support Platoon Leader for the Squadron (logistical support), and as line Platoon Leader in an Armored Cavalry Troop. Graduate of Airborne and Ranger Schools. Special training in Air Mobilization Planning and Nuclear, Biological and Chemical Warfare.

Formal Education

LL.M., Environmental Law, Pace University School of Law, 1990: Curriculum designed to provide breadth and depth in study of theoretical and practical aspects of environmental law. Courses included: International and Comparative Environmental Law, Conservation Law, Land Use Law, Seminar in Electric Utility Regulation, Scientific and Technical Issues Affecting Environmental Law, Environmental Regulation of Real Estate, Hazardous Wastes Law. Individual research with Hudson Riverkeeper Fund, Garrison, New York.

LL.M., Military Law, U.S. Army Judge Advocate General's School, 1988: Curriculum designed to prepare Judge Advocates for senior level staff service. Courses included: Administrative Law, Defensive Federal Litigation, Government Information Practices, Advanced Federal Litigation, Federal Tort Claims Act Seminar, Legal Writing and Communications, Comparative International Law.

J.D. with Honors, University of Texas School of Law, 1984: Attended law school under the U.S. Army Funded Legal Education Program, a fully funded scholarship awarded to 25 or fewer officers each year. Served as Editor-in-Chief (1983–84); Articles Editor (1982–83); Member (1982) of the Review of Litigation. Moot Court, Mock Trial, Board of Advocates. Summer internship at Staff Judge Advocate's offices. Prosecuted first cases prior to entering law school.

B.B.A., Business Management, Texas A&M University, 1977: ROTC Scholarship (3–yr). Member: Corps of Cadets, Parson's Mounted Cavalry, Wings & Sabers Scholarship Society, Rudder's Rangers, Town Hall Society, Freshman Honor Society, Alpha Phi Omega service fraternity.

Karl R. Rábago

Selected Publications

“The ‘Value of Solar’ Rate: Designing An Improved Residential Solar Tariff,” Solar Industry, Vol. 6, No. 1 (Feb. 2013)

“A Review of Barriers to Biofuels Market Development in the United States,” 2 Environmental & Energy Law & Policy Journal 179 (2008).

“A Strategy for Developing Stationary Biodiesel Generation,” Cumberland Law Review, Vol. 36, p.461 (2006).

“Evaluating Fuel Cell Performance through Industry Collaboration,” co-author, Fuel Cell Magazine (2005).

“Applications of Life Cycle Assessment to NatureWorks™ Polylactide (PLA) Production,” co-author, Polymer Degradation and Stability 80 (2003) 403-419.

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Documents Reviewed by Karl R. Rabago

Document Name (Close to Title)	Author	Year	URL
AE Residential Rate Descr 2012.pdf	Austin Energy	2012	https://my.austinenergy.com/wps/wcm/connect/d7823b804bcc40c2a049bad6d6106fd0/aeElectricRateScheduleSep212012.pdf?MOD=AJPERES
AE VOS Update 080916.pdf	Austin Energy	2008	http://www.solarfuturearizona.com/AE-VOSUpdate091608%5B2%5D-1.pdf
AE VOS Update 110425.pdf	Austin Energy	2011	http://www.austinenergy.com/about%20us/newsroom/Reports/distributedSolarPVvalueUpdate2011.pdf
Beach Arizona Cost-Benefit 2013.pdf	Beach	2013	http://www.seia.org/sites/default/files/resources/AZ-Distributed-Generation.pdf
Beach Crossborder NEM Eval in CA 1301.pdf	Beach	2013	http://votesolar.org/wp-content/uploads/2013/01/Crossborder-Energy-CA-Net-Metering-Cost-Benefit-Jan-2013-final.pdf
CPR Austin Energy VOS w Nodal 120905.pdf	CPR	2012	http://www.cleanpower.com/wp-content/uploads/090_DesigningAustinEnergysSolarTariff.pdf
CPR Eval Framework for PV 0506.pdf	CPR	2005	http://cleanpower.com/wp-content/uploads/2012/02/011_EvaluationFrameworkForPV.pdf
CPR Federal Tax Rev Protection 2002.pdf	CPR	2002	http://cleanpower.com/wp-content/uploads/2012/02/037_FederalTaxRevenueProtection.pdf
CPR MSEIA Value of Solar NJ & DE 1211.pdf	CPR	2012	http://mseia.net/site/wp-content/uploads/2012/05/MSEIA-Final-Benefits-of-Solar-Report-2012-11-01.pdf
CPR Research Timeline.pdf	CPR		http://www.cleanpower.com/research/research-timeline/
CPR VOS for San Antonio 130313.pdf	CPR	2013	http://www.solarsanantonio.org/wp-content/uploads/2013/04/Value-of-Solar-at-San-Antonio-03-13-2013.pdf
CPR VOS to Austin 2006.pdf	CPR	2006	http://www.cleanpower.com/resources/value-of-distributed-pv-to-austin/
DOE Sec. 1817 Rpt Potential Benefits DG 0702.pdf	DOE	2007	http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/1817_Report_-final.pdf http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/1817_Stu
Doris, et al NREL MN NEM study 0902.pdf	Doris/NREL	2009	http://www.nrel.gov/docs/fy10osti/46670.pdf
Drury, et al NREL Perceived Value of Solar 1110.pdf	Drury/NREL	2011	http://www.nrel.gov/docs/fy12osti/52197.pdf
E3 CSI Cost Effectiveness Eval 1104.pdf	E3	2011	http://www.ethree.com/documents/CSI/CSI%20Report_Complete_E3_Final.pdf
E3 Technical Potential for Local Distributed PV in CA 1203.pdf	E3	2012	http://www.cpuc.ca.gov/NR/rdonlyres/8A822C08-A56C-4674-A5D2-099E48B41160/0/LDPVPotentialReportMarch2012.pdf
Epstein, et al Full Cost Accounting Coal 2011.pdf	Epstein	2011	http://solar.gwu.edu/index_files/Resources_files/epstein_full%20cost%20of%20coal.pdf
Hoke Komor Maximizing Benefit of Dist PV Elec Journal 1204.pdf	Hoke/Komor	2012	http://www.scribd.com/doc/114168547/Hoke-Komor-2012-Maximizing-the-Benefits-of-Distributed-Photovoltaics
Itron CPUC Self-Gen Cost Effectiveness of DG 110209.pdf	Itron	2011	http://www.cpuc.ca.gov/NR/rdonlyres/750FD78D-9E2B-4837-A81A-6146A994CD62/0/ImpactsofDistributedGenerationReport_2010.pdf
IREC KFW Unlocking-DG-Value PURPA 1305.pdf	IREC	2013	http://www.irecusa.org/wp-content/uploads/2013/05/Unlocking-DG-Value.pdf
Keyes Wiedman Solar ABCs Assessing Rate Impact of NEM 1201.pdf	Keyes et al	2012	http://www.solarabcs.org/about/publications/reports/rateimpact/pdfs/rateimpact_full.pdf
LBNL Hedge Value of Wind 1303.pdf	LBNL	2013	http://emp.lbl.gov/sites/all/files/lbnl-6103e.pdf
LBNL Utility Solar Valuation 1212.pdf	LBNL	2012	http://emp.lbl.gov/sites/all/files/lbnl-5933e_0.pdf
LBNL Wide Area Impact on Variability 1009.pdf	LBNL	2010	http://eetd.lbl.gov/ea/emp/reports/lbnl-3884e.pdf
Lowder, et al NREL Sandia PV Risk Mgmt 1302.pdf	Lowder/NREL	2013	http://www.nrel.gov/docs/fy13osti/57143.pdf
Margolis NREL Literature Review Non-Technical Barriers to Solar 0609.pdf	Margolis/NREL	2006	http://www.nrel.gov/docs/fy07osti/40116.pdf
NAS Hidden Costs of Energy 2010.pdf	NAS	2010	http://www.nap.edu/catalog.php?record_id=12794
Navigant NREL PV Value 0802.pdf	Navigant	2008	http://www.nrel.gov/analysis/pdfs/42303.pdf
Navigant NV DG Solar Cost 101230.pdf	Navigant	2010	http://www.navigant.com/~/media/WWW/Site/Insights/NVE_DG_Study_Energy.ashx
NREL Michigan Grid-Connected PV Valuation draft 120123.pdf	NREL	2012	http://www.michigan.gov/documents/mpsc/120123_PVvaluation_MI_394661_7.pdf
Perez, et al. Cost of High PV Penetration 2010.pdf	Perez/CPR	2010	http://cleanpower.com/wp-content/uploads/2012/02/031_CostHighPVPenetration.pdf

Power Pundits AZ Solar Future DE & NEM Conference 130411.pdf	Power Pundits	2013	http://www.solarfuturearizona.com/APSWorkshopIIIFINAL4-11-2013(1).pdf
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Rábago Value of Solar SIM 1302.pdf	Rábago	2013	www.rabagoenergy.com
RW Beck Distrib RE Impacts & Valuation APS 0901.pdf	RW Beck	2009	http://www.solarfuturearizona.com/SolarDEStudy.pdf
SAIC APS APS Value Study 2013.pdf	SAIC	2013	http://azenergyfuture.com/wp-content/uploads/2013/05/2013_updated_solar_pv_value_report.pdf
SCE CREST Contract Pricing 130326.pdf	SCE	2013	https://www.sce.com/NR/sc3/tm2/pdf/2870-E.pdf
EPA Understanding Cost-Effectiveness 0811.pdf	EPA	2008	http://www.epa.gov/cleanenergy/documents/suca/cost-effectiveness.pdf
Smeloff VSI Quantifying the Benefits 0501.pdf	Smeloff	2005	http://votesolar.org/wp-content/uploads/2009/11/tools_QuantifyingSolarsBenefits.pdf
Solar Cities MN Solar Resource Assess 1106.pdf	Solar Cities	2011	http://mn.gov/commerce/energy/images/SolarValueReport.pdf
Stein Sandia RE Integration Studies 2011.pdf	Stein/Sandia	2011	http://energy.sandia.gov/wp/wp-content/gallery/uploads/RE-Integration-Case-Studies_Josh-Stein_VT-2011.pdf
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A REVIEW OF SOLAR PV BENEFIT & COST STUDIES

Contacts:
Lena Hansen, Principal, lhansen@rmi.org
Virginia Lacy, Senior Consultant, vlacy@rmi.org
Devi Glick, Analyst, dglick@rmi.org

1820 Folsom Street | Boulder, CO 80302 | RMI.org

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ABOUT THIS DOCUMENT

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OBJECTIVE AND ACKNOWLEDGEMENTS

The objective of this e-Lab discussion document is to assess what is known and unknown about the categorization, methodological best practices, and gaps around the benefits and costs of distributed photovoltaics (DPV), and to begin to establish a clear foundation from which additional work on benefit/cost assessments and pricing structure development can be built.

e-Lab members and advisors were invited to provide input on this report. The assessment greatly benefited from contributions by the following individuals: Stephen Frantz, Sacramento Municipal Utility District (SMUD); Mason Emnett, Federal Energy Regulatory Commission (FERC); Eran Mahrer, Solar Electric Power Association (SEPA); Sunil Cherian, Spirae; Karl Rabago, Rabago Energy; Tom Brill and Chris Yunker, San Diego Gas & Electric (SDG&E); and Steve Wolford, Sunverge.

This e-Lab work product was prepared by Rocky Mountain Institute to support e-Lab and industry-wide discussions about distributed energy resource valuation. e-Lab is a joint collaboration, convened by RMI, with participation from stakeholders across the electricity industry. e-Lab is not a consensus organization, and the views expressed in this document do not necessarily represent those of any individual e-Lab member or supporting organizations. Any errors are solely the responsibility of RMI.

WHAT IS e-LAB?

The Electricity Innovation Lab (e-Lab) brings together thought leaders and decision makers from across the U.S. electricity sector to address critical institutional, regulatory, business, economic, and technical barriers to the economic deployment of distributed resources.

In particular, e-Lab works to answer three key questions:

- How can we understand and effectively communicate the costs and benefits of distributed resources as part of the electricity system and create greater grid flexibility?
- How can we harmonize regulatory frameworks, pricing structures, and business models of utilities and distributed resource developers for greatest benefit to customers and society as a whole?
- How can we accelerate the pace of economic distributed resource adoption?

A multi-year program, e-Lab regularly convenes its members to identify, test, and spread practical solutions to the challenges inherent in these questions. e-Lab has three annual meetings, coupled with ongoing project work, all facilitated and supported by Rocky Mountain Institute. e-Lab meetings allow members to share learnings, best practices, and analysis results; collaborate around key issues or needs; and conduct deep-dives into research and analysis findings.

EXECUTIVE SUMMARY

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EXECUTIVE SUMMARY

THE NEED

- The addition of distributed energy resources (DERs) onto the grid creates new opportunities and challenges because of their unique siting, operational, and ownership characteristics compared to conventional centralized resources.

- Today, the increasingly rapid adoption of distributed solar photovoltaics (DPV) in particular is driving a heated debate about whether DPV creates benefits or imposes costs to stakeholders within the electricity system. But the wide variation in analysis approaches and quantitative tools used by different parties in different jurisdictions is inconsistent, confusing, and frequently lacks transparency.

- Without increased understanding of the benefits and costs of DERs, there is little ability to make effective tradeoffs between investments.

OBJECTIVE OF THIS DOCUMENT

- The objective of this e-Lab discussion document is to assess what is known and unknown about the categorization, methodological best practices, and gaps around the benefits and costs of DPV, and to begin to establish a clear foundation from which additional work on benefit/cost assessments and pricing structure design can be built.

- This discussion document reviews 15 DPV benefit/cost studies by utilities, national labs, and other organizations. Completed between 2005 and 2013, these studies reflect a significant range of estimated DPV value.

KEY INSIGHTS

- No study comprehensively evaluated the benefits and costs of DPV, although many acknowledge additional sources of benefit or cost and many agree on the broad categories of benefit and cost. There is broad recognition that some benefits and costs may be difficult or impossible to quantify, and some accrue to different stakeholders.

- There is a significant range of estimated value across studies, driven primarily by differences in local context, input assumptions, and methodological approaches.

    - **Local context**: Electricity system characteristics—generation mix, demand projections, investment plans, market structures—vary across utilities, states, and regions.
    - **Input assumptions**: Input assumptions—natural gas price forecasts, solar power production, power plant heat rates—can vary widely.
    - **Methodologies**: Methodological differences that most significantly affect results include (1) resolution of analysis and granularity of data, (2) assumed cost and benefit categories and stakeholder perspectives considered, and (3) approaches to calculating individual values.

- Because of these differences, comparing results across studies can be informative, but should be done with the understanding that results must be normalized for context, assumptions, or methodology.

- While detailed methodological differences abound, there is general agreement on overall approach to estimating energy value and some philosophical agreement on capacity value, although there remain key differences in capacity methodology. There is significantly less agreement on overall approach to estimating grid support services and currently unmonetized values including financial and security risk, environment, and social value.

EXECUTIVE SUMMARY (CONT'D)

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IMPLICATIONS

- Methods for identifying, assessing and quantifying the benefits and costs of distributed resources are advancing rapidly, but important gaps remain to be filled before this type of analysis can provide an adequate foundation for policymakers and regulators engaged in determining levels of incentives, fees, and pricing structures for DPV and other DERs.
- In any benefit/cost study, it is critical to be transparent about assumptions, perspectives, sources and methodologies so that studies can be more readily compared, best practices developed, and drivers of results understood.
- While it may not be feasible to quantify or assess sources of benefit and cost comprehensively, benefit/cost studies must explicitly decide if and how to account for each source of value and state which are included and which are not.
- While individual jurisdictions must adapt approaches based on their local context, standardization of categories, definitions, and methodologies should be possible to some degree and will help ensure accountability and verifiability of benefit and cost estimates that provide a foundation for policymaking.
- The most significant methodological gaps include:
  - **Distribution value:** The benefits or costs that DPV creates in the distribution system are inherently local, so accurately estimating value requires much more analytical granularity and therefore greater difficulty.
  - **Grid support services value:** There continues to be uncertainty around whether and how DPV can provide or require additional grid support services, but this could potentially become an increasingly important value.
  - **Financial, security, environmental, and social values:** These values are largely (though not comprehensively) unmonetized as part of the electricity system and some are very difficult to quantify.

LOOKING AHEAD

- Thus far, studies have made simplifying assumptions that implicitly assume historically low penetrations of DPV. As the penetration of DPV on the electric system increases, more sophisticated, granular analytical approaches will be needed and the total value is likely to change.
- Studies have largely focused on DPV by itself. But a confluence of factors is likely to drive increased adoption of the full spectrum of renewable and distributed resources, requiring a consideration of DPV's benefits and costs in the context of a changing system.
- With better recognition of the costs and benefits that all DERs can create, including PDV, pricing structures and business models can be better aligned, enabling greater economic deployment of DERs and lower overall system costs for ratepayers.

FRAMING THE NEED

01

overview
distributed energy resources
structural misalignments
structural misalignments in practice

FRAMING THE NEED

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- A confluence of factors including rapidly falling solar prices, supportive policies and new approaches to finance are leading to a steadily increasing solar PV market.
  - In 2012, the US added 2 GW of solar PV to the nation's generation mix, of which approximately 50% were customer-sited solar, net-metered projects. [1]
  - Solar penetrations in certain regions are becoming significant. About 80% of customer-sited PV is concentrated in states with either ample solar resource and/ or especially solar-friendly policies: California, New Jersey, Arizona, Hawaii and Massachusetts. [2]
- The addition of DPV onto the grid creates new challenges and opportunities because of its unique siting, operational, and ownership characteristics compared to conventional centralized resources. The value of DPV is temporally, operationally and geographically specific and varies by distribution feeder, transmission line configuration, and composition of the generation fleet.
- Under today's regulatory and pricing structures, multiple misalignments along economic, social and technical dimensions are emerging. For example, pricing mechanisms are not in place to recognize or reward service that is being provided by either the utility or customer.
- Electricity sector stakeholders around the country are recognizing the importance of properly valuing DPV, the current lack of clarity around the costs and benefits that drive DPV's value or how to calculate it.
- To enable better technical integration and economic optimization, it is critical to better understand the services that DPV can provide, and the costs and benefits of those services as a foundation for more accurate pricing and market signals. As the penetration of DPV and other customer-sited resources increases, accurate pricing and market signals can help align stakeholder goals, minimize total system cost, and maximize total net value.

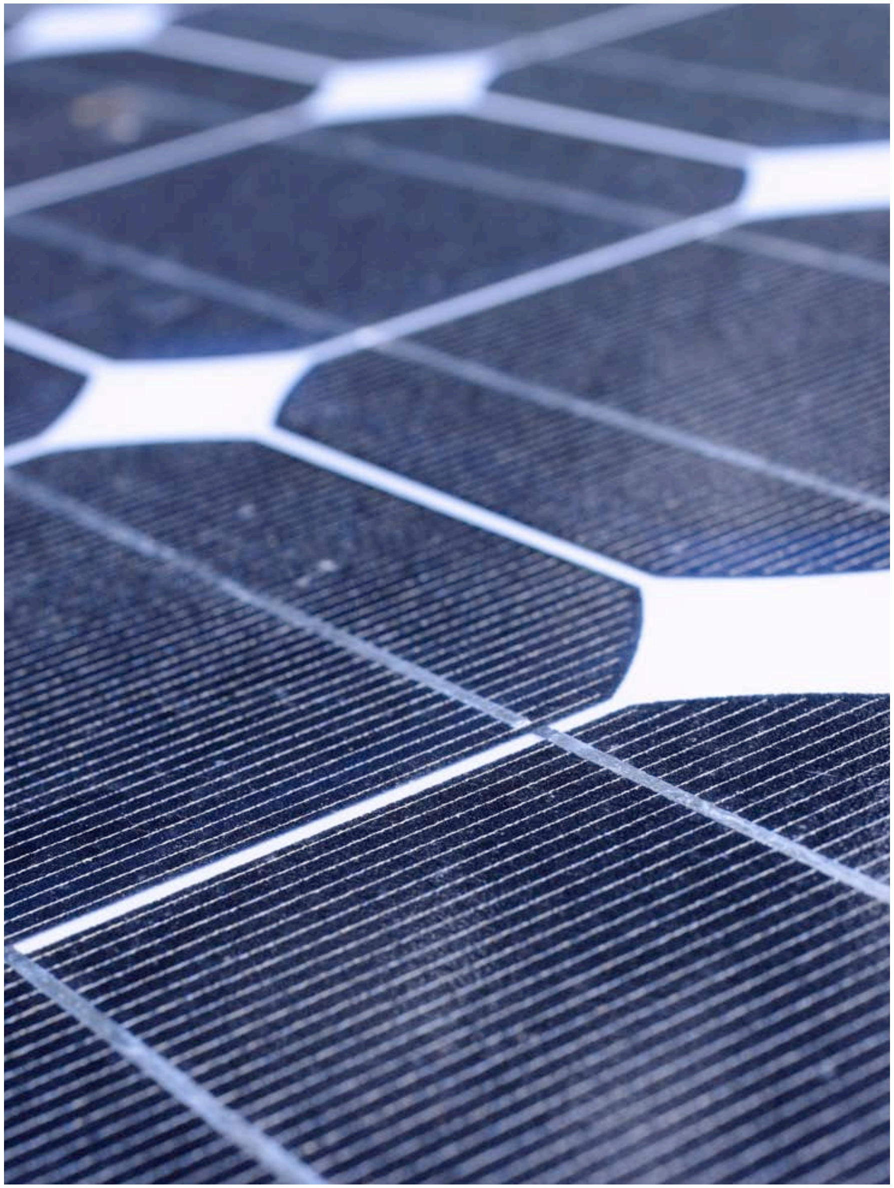

Photo courtesy of Shutterstock

1. Solar Electric Power Association. June 2013. *2012 SEPA Utility Solar Rankings,* Washington, DC.
2. Ibid.

DISTRIBUTED ENERGY RESOURCES (DERs)

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DUE TO UNIQUE CHARACTERISTICS, DERs BEHAVE DIFFERENTLY FROM CONVENTIONAL RESOURCES—**THIS DISCUSSION DOCUMENT FOCUSES ON DISTRIBUTED PHOTOVOLTAICS (DPV)**

DISTRIBUTED ENERGY RESOURCES (DERs): demand- and supply-side resources that can be deployed throughout an electric distribution system to meet the energy and reliability needs of the customers served by that system. DERs can be installed on either the customer side or the utility side of the meter.

TYPES OF DERs:

Efficiency

Technologies and behavioral changes that reduce the quantity of energy that customers need to meet all of their energy-related needs. The main type is:

- end-used efficiency

Distributed generation

Small, self-contained energy sources located near the final point of energy consumption. The main distributed generation sources are:

- Solar PV
- Combined heat & power
- Small-scale wind
- Others (i.e., fuel cells)

Distributed flexibility & storage

A collection of technologies that allows the overall system to use energy smarter and more efficiently by storing it when supply exceeds demand, and prioritizing need when demand exceeds supply. These technologies include:

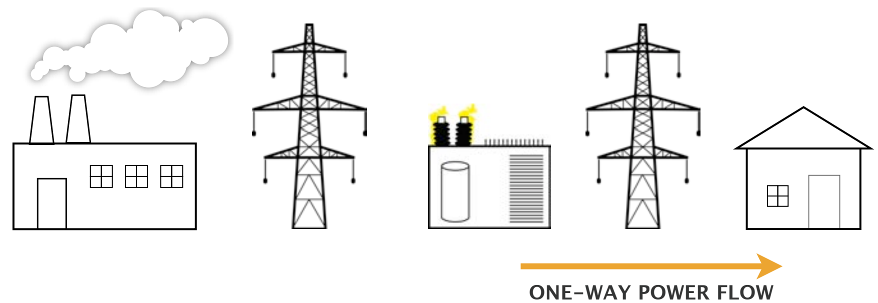
- Demand response
- Electric vehicles
- Thermal storage
- Battery storage

Distributed intelligence

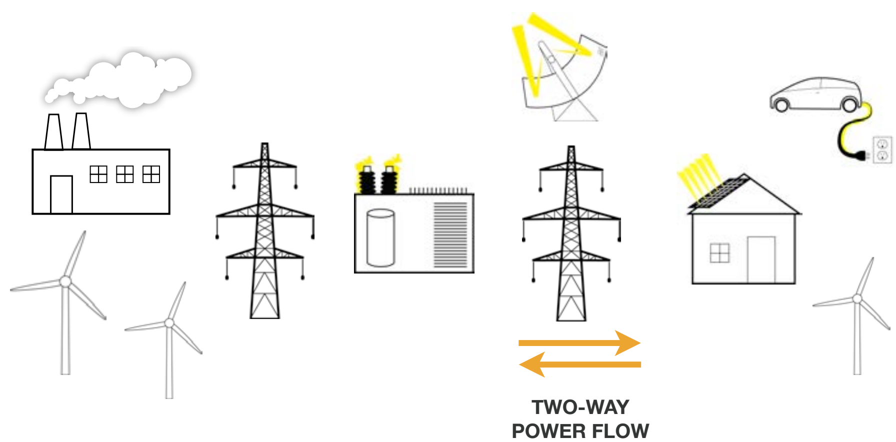
Technologies that combine sensory, communication, and control functions to support the electricity system, and magnify the value of DER system integration. Examples include:

- Smart inverters
- Home-area networks

CURRENT SYSTEM/VALUE CHAIN:



FUTURE SYSTEM/VALUE CONSTELLATION:



WHAT MAKES DERs UNIQUE:

Siting

Smaller, more modular energy resources can be installed by disparate actors outside of the purview of centrally coordinated resource planning.

Operations

Energy resources on the distribution network operate outside of centrally controlled dispatching mechanisms that control the real-time balance of generation and demand.

Ownership

DERs can be financed, installed or owned by the customer or a third party, broadening the typical planning capability and resource integration approach.

U-17302 ELPC/Rabago Exhibit KRR-3

STRUCTURAL MISALIGNMENTS

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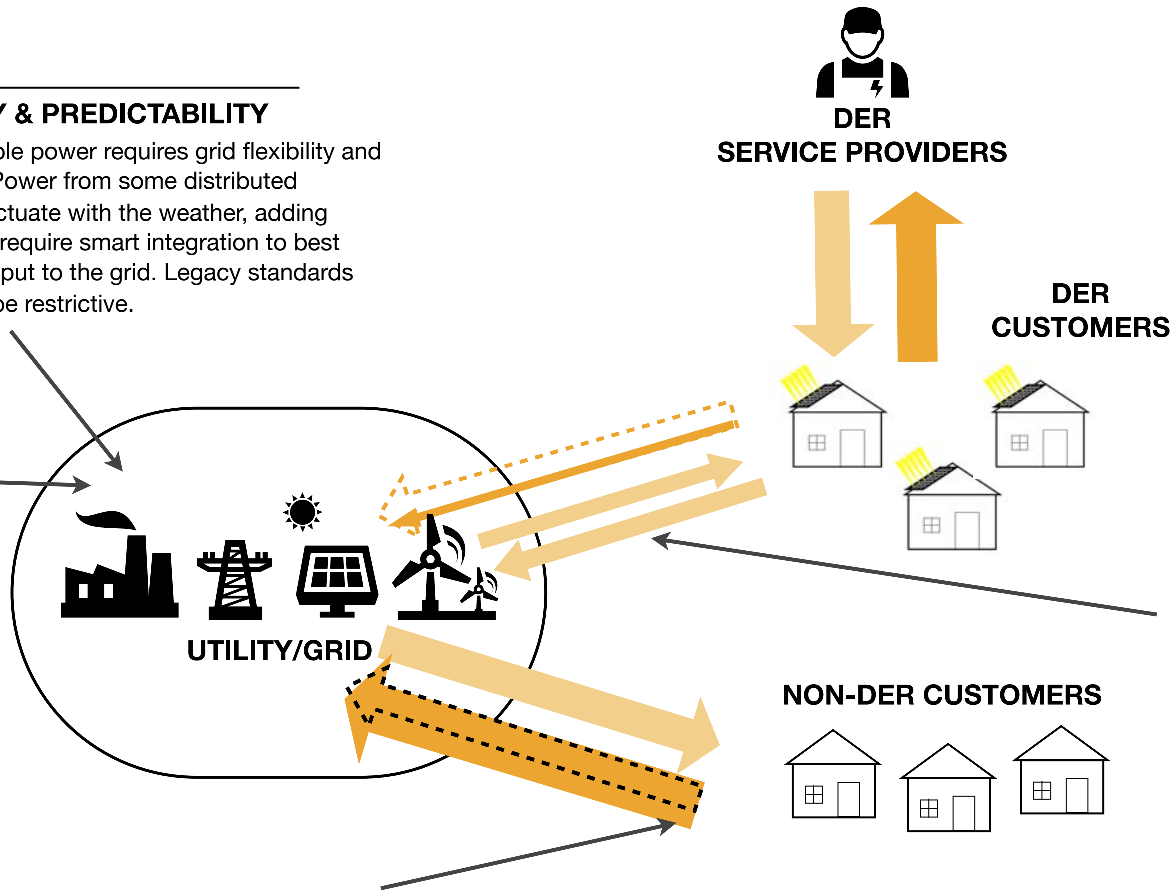
TODAY, OPERATIONAL AND PRICING MECHANISMS DESIGNED FOR AN HISTORICALLY CENTRALIZED ELECTRICITY SYSTEM ARE NOT WELL-ADAPTED TO THE INTEGRATION OF DERS CAUSING FRICTION AND INEFFICIENCY

FLEXIBILITY & PREDICTABILITY

Providing reliable power requires grid flexibility and predictability. Power from some distributed renewables fluctuate with the weather, adding variability, and require smart integration to best shape their output to the grid. Legacy standards and rules can be restrictive.



LOCATION & TIME

Limited feedback loop to customers that the costs or benefit of any electricity resource, especially DERs, vary by location and time.

BENEFIT AND COST RECOGNITION AND ALLOCATION

Mechanisms are not in place to transparently recognize or compensate service (be it monetized grid services like energy, capacity or balancing supply and demand, or less consistently monetized values, such as carbon emissions savings) provided by the utility or the customer. To the utility, revenue from DER customers may not match the cost to serve those customers. To the customer, bill savings or credit may not match the value provided.

SOCIAL PRIORITIES

Society values the environmental and social benefits that DERs could provide, but those benefits are often externalized and unmonetized.

SOCIAL EQUITY

If costs are incurred by DER customers that are not paid for, those costs would be allocated to the rest of customers. Conversely, DER customers also provide provide benefits to other customers and to society.

Adapted from RMI, Net Energy Metering, Zero Net Energy And The Distributed Energy Resource Future: Adapting Electric Utility Business Models For The 21st Century

U-17302 ELPC/Rabago Exhibit KRR-3

STRUCTURAL MISALIGNMENTS IN PRACTICE

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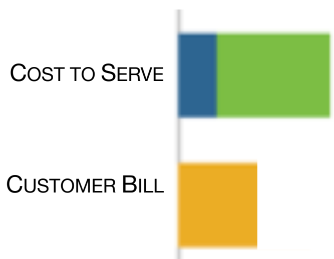
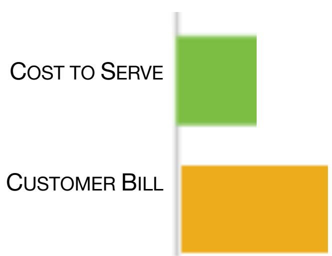
THESE STRUCTURAL MISALIGNMENTS ARE LEADING TO IMPORTANT QUESTIONS, DEBATE, AND CONFLICT

VALUE UNCERTAINTY...

WHAT IF A DPV CUSTOMER DOES NOT PAY FOR THE FULL COST TO SERVE THEIR DEMAND?



WHAT IF A DPV CUSTOMER IS NOT FULLY COMPENSATED FOR THE SERVICE THEY PROVIDE?



...DRIVES HEADLINES...

...RAISING KEY QUESTIONS

- What benefits can customers provide? Is the ability of customers to provide benefits contingent on anything?
- What costs are incurred to support DER customer needs?
- What are the best practice methodologies to assess benefits and costs?
- How should externalized and unmonetized values, such as environmental and social values, be recognized?
- How can benefits and costs be more effectively allocated and priced?

SETTING THE STAGE

defining value
categories of value
stakeholder implications

02

SETTING THE STAGE

- When considering the total value of DPV or any electricity resource, it is critical to consider the types of value, the stakeholder perspective and the flow of benefits and costs–that is, who incurs the costs and who receives the benefits (or avoids the costs).
- For the purposes of this report, value is defined as net value, i.e. benefits minus costs. Depending upon the size of the benefit and the size of the cost, value can be positive or negative.
- A variety of categories of benefits or costs of DPV have been considered or acknowledged in evaluating the value of DPV. Broadly, these categories are: energy, system losses, capacity (generation, transmission and distribution), grid support services, financial risk, security risk, environmental and social.
- These categories of costs and benefits differ significantly by the degree to which they are readily quantifiable or there is a generally accepted methodology for doing so. For example, there is general agreement on overall approach to estimating energy value and some philosophical agreement on capacity value, although there remain key differences in capacity methodology. There is significantly less agreement on overall approach to estimating grid support services and currently unmonetized values including financial and security risk, environment, and social value.
- Equally important, the qualification of whether a factor is a cost or benefit also differs depending upon the perspective of the stakeholder. Similar to the basic framing of testing cost effectiveness for energy efficiency, the primary stakeholders in calculating the value of DPV are: the participant, or in this case, the solar customer; the utility; other customers (also referred to as ratepayers); and society (taxpayers are a subset of society).

BENEFIT & COST CATEGORIES

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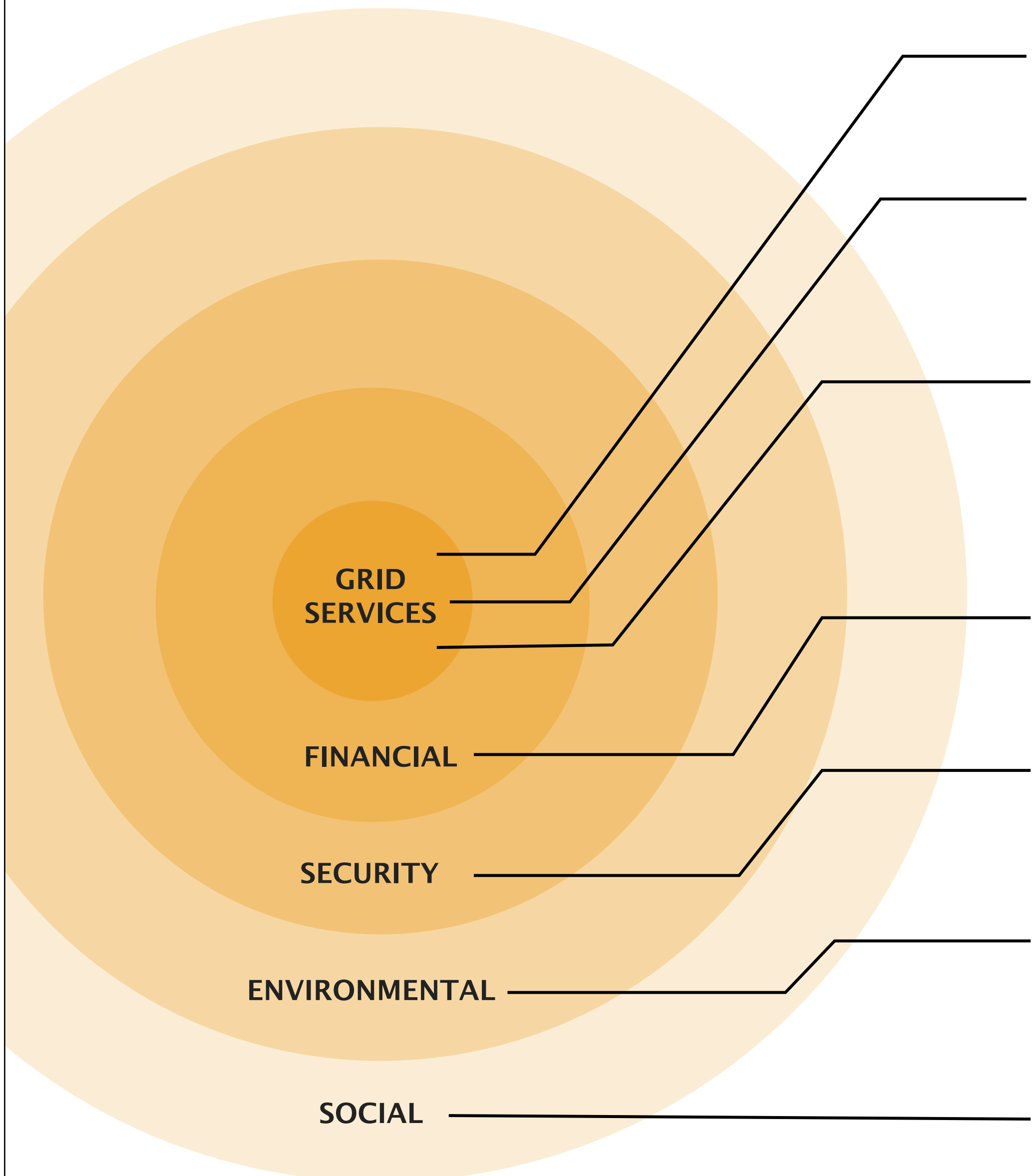
For the purposes of this report, **value is defined as net value, i.e. benefits minus costs.** Depending upon the size of the benefit and the size of the cost, value can be positive or negative. A variety of categories of benefits or costs of DPV have been considered or acknowledged in evaluating the value of DPV. Broadly, these categories are:



ENERGY
- energy
- energy losses

CAPACITY
- generation capacity
- transmission & distribution capacity
- DPV installed capacity

GRID SUPPORT SERVICES
- reactive supply & voltage control
- regulation & frequency response
- energy & generator imbalance
- synchronized & supplemental operating reserves
- scheduling, forecasting, and system control & dispatch

FINANCIAL RISK
- fuel price hedge
- market price response

SECURITY RISK
- reliability & resilience

ENVIRONMENTAL
- carbon emissions
- criteria air pollutants (SOx, NOx, PM10)
- water
- land

SOCIAL
- Economic development (jobs and tax revenues)

BENEFIT & COST CATEGORIES DEFINED

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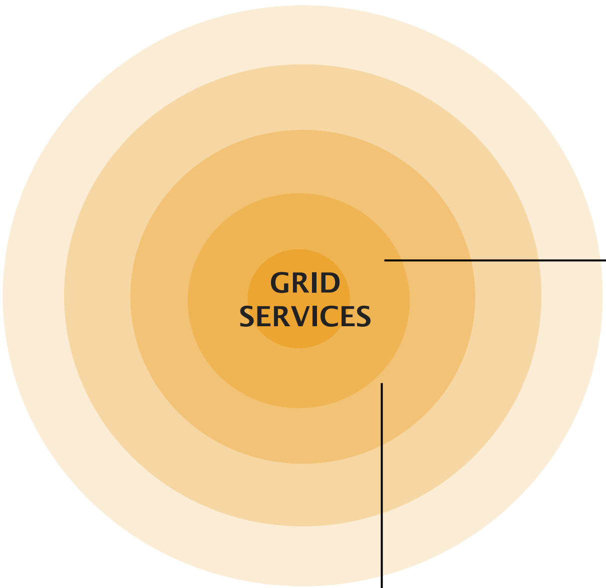


ENERGY

Energy value of DPV is positive when the solar energy generated displaces the need to produce energy from another resource at a net savings. There are two primary components:

- **Avoided Energy** - The cost and amount of energy that would have otherwise been generated to meet customer needs, largely driven by the variable costs of the marginal resource that is displaced. In addition to the coincidence of solar generation with demand and generation, key drivers of avoided energy cost include (1) fuel price forecast, (2) variable operation & maintenance costs, and (3) heat rate.

- **Energy Losses** - The value of the additional energy generated by central plants that would otherwise be lost due to inherent inefficiencies (electrical resistance) in delivering energy to the customer via the transmission and distribution system. Since DPV generates energy at or near the customer, that additional energy is not lost. Losses act as a magnifier of value for capacity and environmental benefits, since avoided energy losses result in lower required capacity and lower emissions.

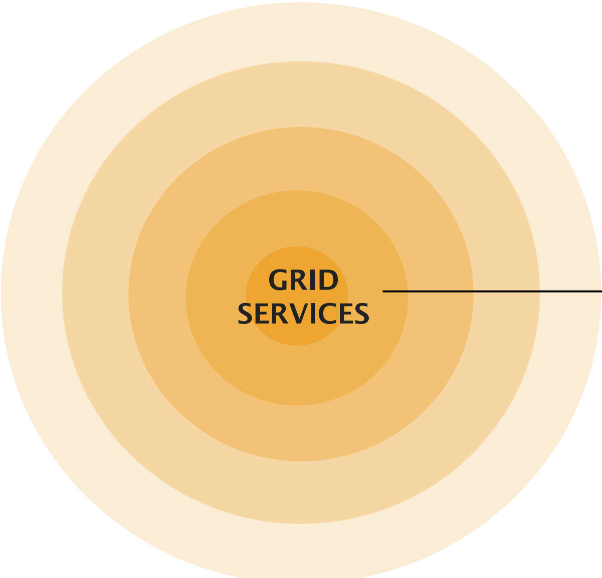
CAPACITY

Capacity value of DPV is positive when the addition of DPV defers or avoids more investment in generation, transmission, and distribution assets than it incurs. There are two drivers primary components:

- **Generation Capacity** - The cost of the amount of central generation capacity that can be deferred of avoided due to DPV. Key drivers of value include (1) DPV's effective capacity and (2) system capacity needs.

- **Transmission & Distribution Capacity** - The value of the net change in T&D infrastructure investment due to DPV. Benefits occur when DPV is able to meet rising demand locally, relieving capacity constraints upstream and deferring or avoiding T&D upgrades. Costs occur when additional T&D investment is needed to support the addition of DPV.

BENEFIT & COST CATEGORIES DEFINED

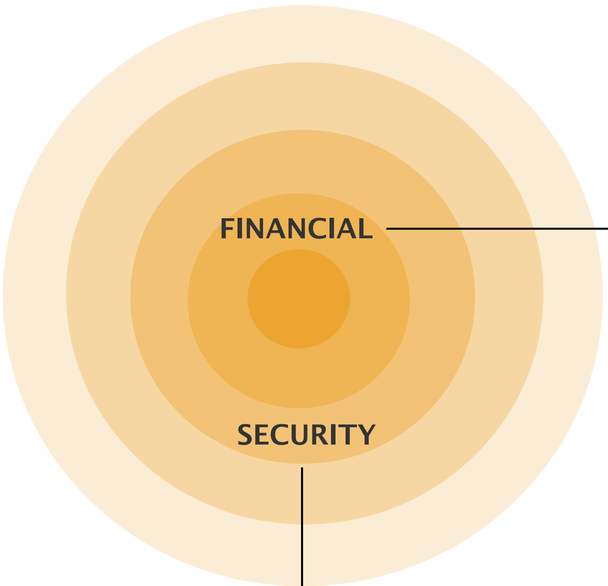


GRID SUPPORT SERVICES

Grid support value of DPV is positive when the net amount and cost of grid support services required to balance supply and demand is decreased than would otherwise have been required. Grid support services, which encompass more narrowly defined ancillary services (AS), are those services required to enable the reliable operation of interconnected electric grid systems. Grid support services include:

- **Reactive supply and voltage control**—Using generating facilities to supply reactive power and voltage control.
- **Frequency regulation**—Control equipment and extra generating capacity necessary to (1) maintain frequency by following the moment-to-moment variations in control area load (supplying power to meet any difference in actual and scheduled generation), and (2) to respond automatically to frequency deviations in their networks. While the services provided by Regulation Service and Frequency Response Service are different, they are complementary services made available using the same equipment and are offered as part of one service.
- **Energy imbalance**—This service supplies any hourly net mismatch between scheduled energy supply and the actual load served.
- **Operating reserves**—Spinning reserve is provided by generating units that are on-line and loaded at less than maximum output, and should be located near the load (typically in the same control area). They are available to serve load immediately in an unexpected contingency. Supplemental reserve is generating capacity used to respond to contingency situations that is not available instantaneously, but rather within a short period, and should be located near the load (typically in the same control area).
- **Scheduling/forecasting**—Interchange schedule confirmation and implementation with other control areas, and actions to ensure operational security during the transaction.

CATEGORIES DEFINED



FINANCIAL RISK

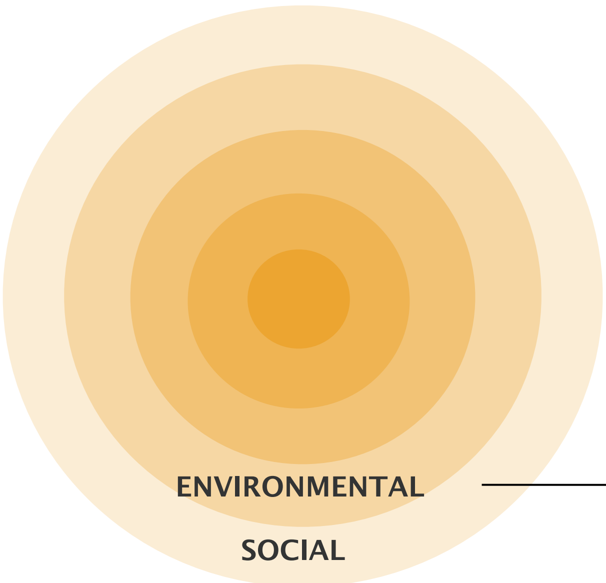
Financial value of DPV is positive when financial risk or overall market price is reduced due to the addition of DPV. There are two components of financial value:

- **Fuel Price Hedge** - The cost that a utility would otherwise incur to guarantee that a portion of electricity supply-costs are fixed.
- **Market Price Response** - The price impact as a result of DPV's reducing demand for centrally-supplied electricity and the fuel power those generators, thereby lowering electricity prices and potentially commodity prices.

SECURITY RISK

Security value of DPV is positive when grid **reliability and resiliency** are increased by (1) reducing outages by reducing congestion along the T&D network, (2) reducing large-scale outages by increasing the diversity of the electricity system's generation portfolio with smaller generators that are geographically dispersed, and (3) providing back-up power sources available during outages through the combination of PV, control technologies, inverters and storage.

CATEGORIES DEFINED



ENVIRONMENTAL

Environmental value of DPV is positive when DPV results in the reduction of environmental or health impacts that would otherwise have been created. Key drivers include primarily the environmental impacts of the marginal resource being displaced. There are four components of environmental value:

- **Carbon** - The value from reducing carbon emissions is driven the emission intensity of displaced marginal resource and the price of emissions.

- **Criteria Air Pollutants** - The value from reducing criteria air pollutant emissions—NOX, SO2, and particulate matter—is driven by the cost of abatement technologies, the market value of pollutant reductions, and/or the cost of human health damages.

- **Water** - The value from reducing water use is driven by the differing water consumption patterns associated with different generation technologies, and can be measured by the price paid for water in competing sectors.

- **Land** - The value associated with land is driven by the difference in the land footprint required for energy generation and any change in property value driven by the addition of DPV.

SOCIAL

Social value of DPV is positive when DPV results in a net increase in jobs and local economic development. Key drivers include the number of jobs created or displaced, as measured by a job multiplier, as well as the value of each job, as measured by average salary and/or tax revenue.

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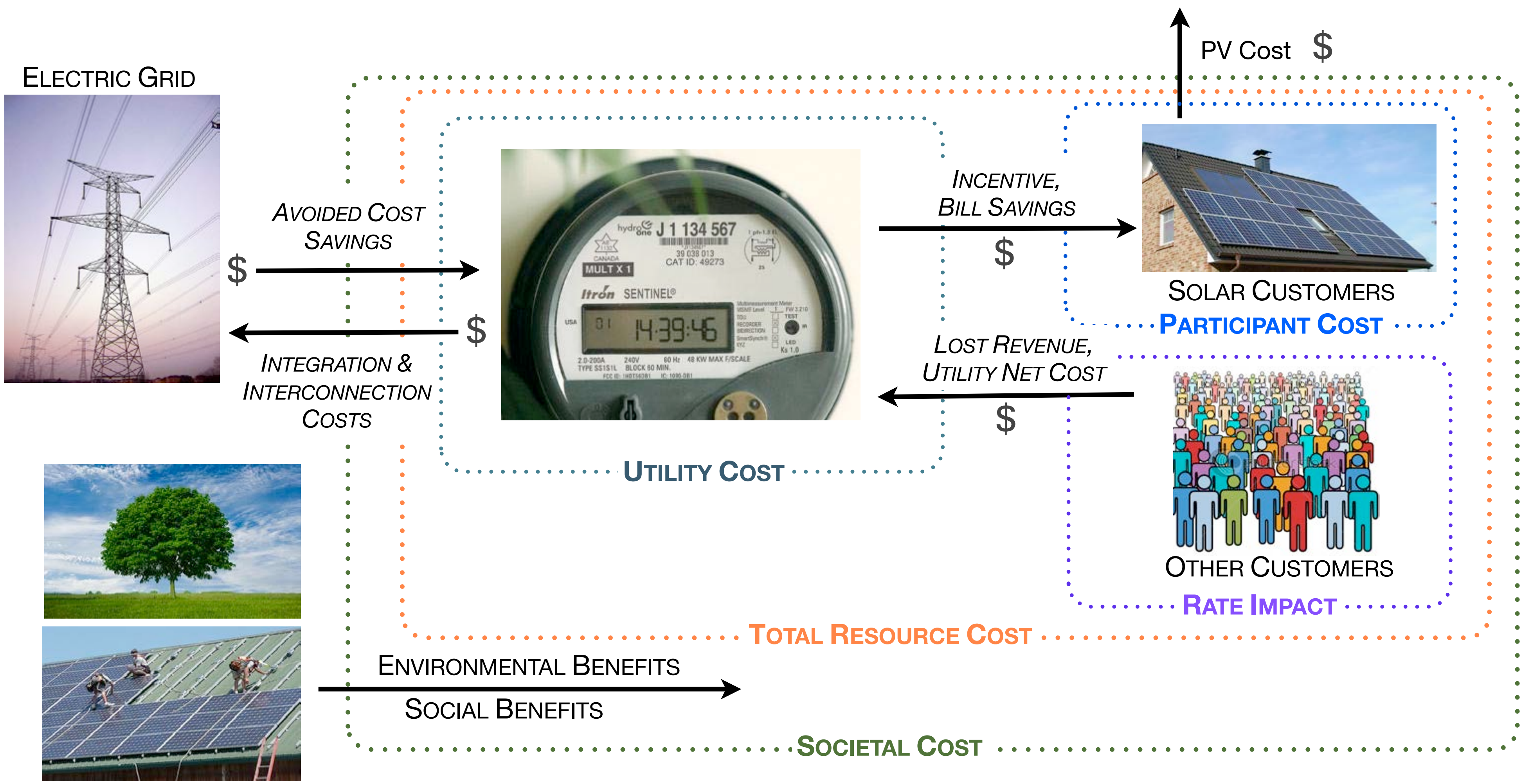
FLOW OF BENEFITS AND COSTS

BENEFITS AND COSTS ACCRUE TO DIFFERENT STAKEHOLDERS IN THE SYSTEM

The California Standard Practice Manual established the general standard for evaluating the flow of benefits and costs among stakeholders.



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STAKEHOLDER PERSPECTIVES

stakeholder perspective		factors affecting value
PV CUSTOMER 	"I want to have a predictable return on my investment, and I want to be compensated for benefits I provide."	Benefits include the reduction in the customer's utility bill, any incentive paid by the utility or other third parties, and any federal, state, or local tax credit received. Costs include cost of the equipment and materials purchased (inc. tax & installation), ongoing O&M, removal costs, and the customer's time in arranging the installation.
OTHER CUSTOMERS 	"I want reliable power at lowest cost."	Benefits include reduction in transmission, distribution, and generation, capacity costs; energy costs and grid support services. Costs include administrative costs, rebates/ incentives, and decreased utility revenue that is offset by increased rates.
UTILITY 	"I want to serve my customers reliably and safely at the lowest cost, provide shareholder value and meet regulatory requirements."	Benefits include reduction in transmission, distribution, and generation, capacity costs; energy costs and grid support services. Costs include administrative costs, rebates/ incentives, and decreased revenue.
SOCIETY 	"We want improved air/water quality as well as an improved economy."	The sum of the benefits and costs to all stakeholder, plus any additional benefits or costs that accrue to society at large rather than any individual stakeholder.

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ANALYSIS FINDINGS

03

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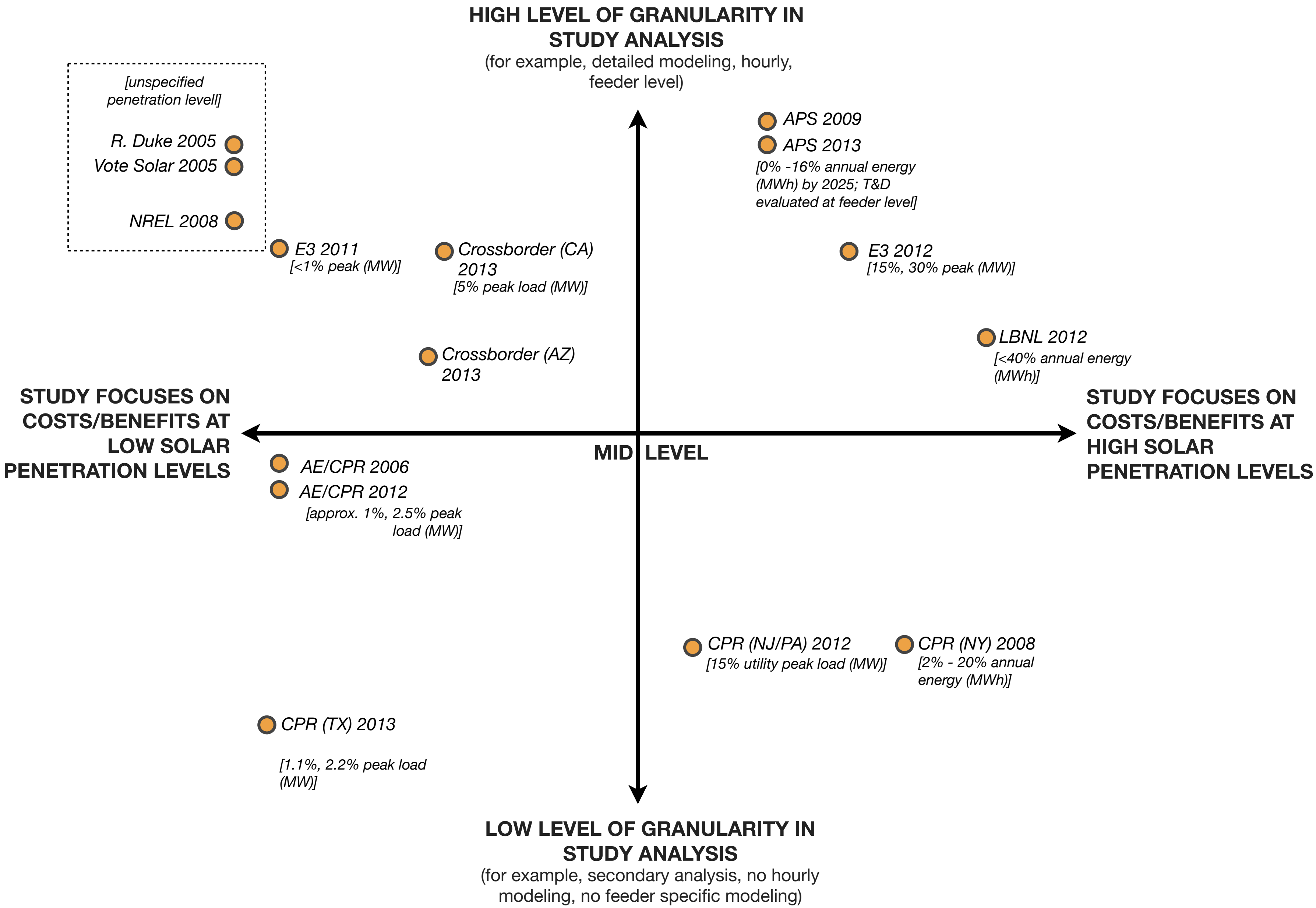
ANALYSIS OVERVIEW

THIS ANALYSIS INCLUDES 15 STUDIES, REFLECTING DIVERSE DPV PENETRATION LEVELS AND ANALYTICAL GRANULARITY



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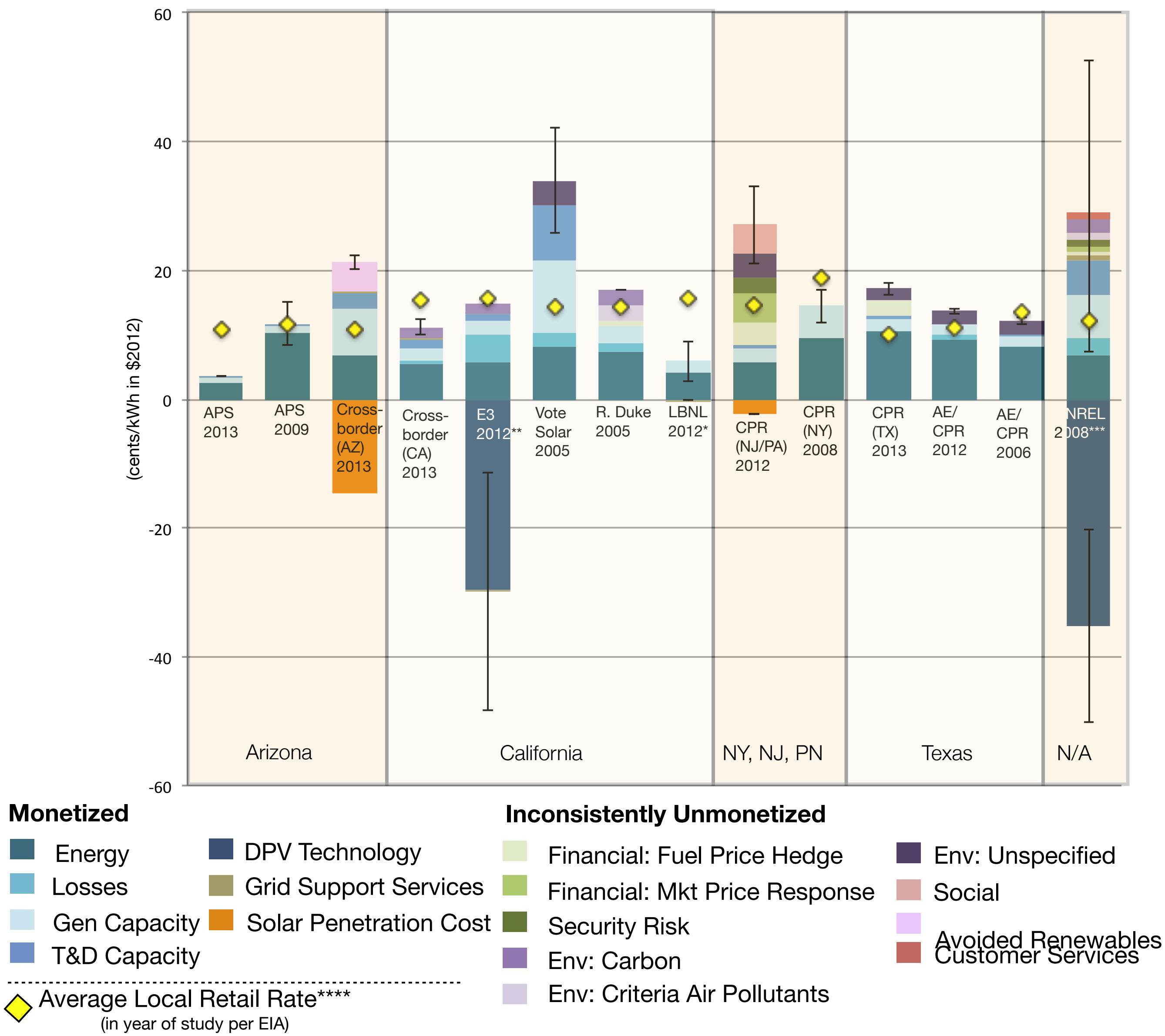
SUMMARY OF DPV BENEFITS AND COSTS

BENEFITS AND COSTS OF DISTRIBUTED PV BY STUDY



INSIGHTS

- No study comprehensively evaluated the benefits and costs of DPV, although many acknowledge additional sources of benefit or cost and many agree on the broad categories of benefit and cost.
- There is a significant range of estimated value across studies, driven primarily by differences in local context, input assumptions, and methodological approaches.
- Because of these differences, comparing results across studies can be informative, but should be done with the understanding that results must be normalized for context, assumptions, or methodology.
- While detailed methodological differences abound, there is some agreement on overall approach to estimating energy and capacity value. There is significantly less agreement on overall approach to estimating grid support services and currently unmonetized values including financial and security risk, environment, and social value.

* The LBNL study only gives the net value for ancillary services
** E3's DPV technology cost includes LCOE + interconnection cost
*** The Navigant study is a meta-analysis, not a research study
****Average retail rate is included for reference; it is not necessarily appropriate to compare the average retail rate to total benefits presented without also reflecting costs (i.e., net value) and any material differences within rate designs (i.e., not average).

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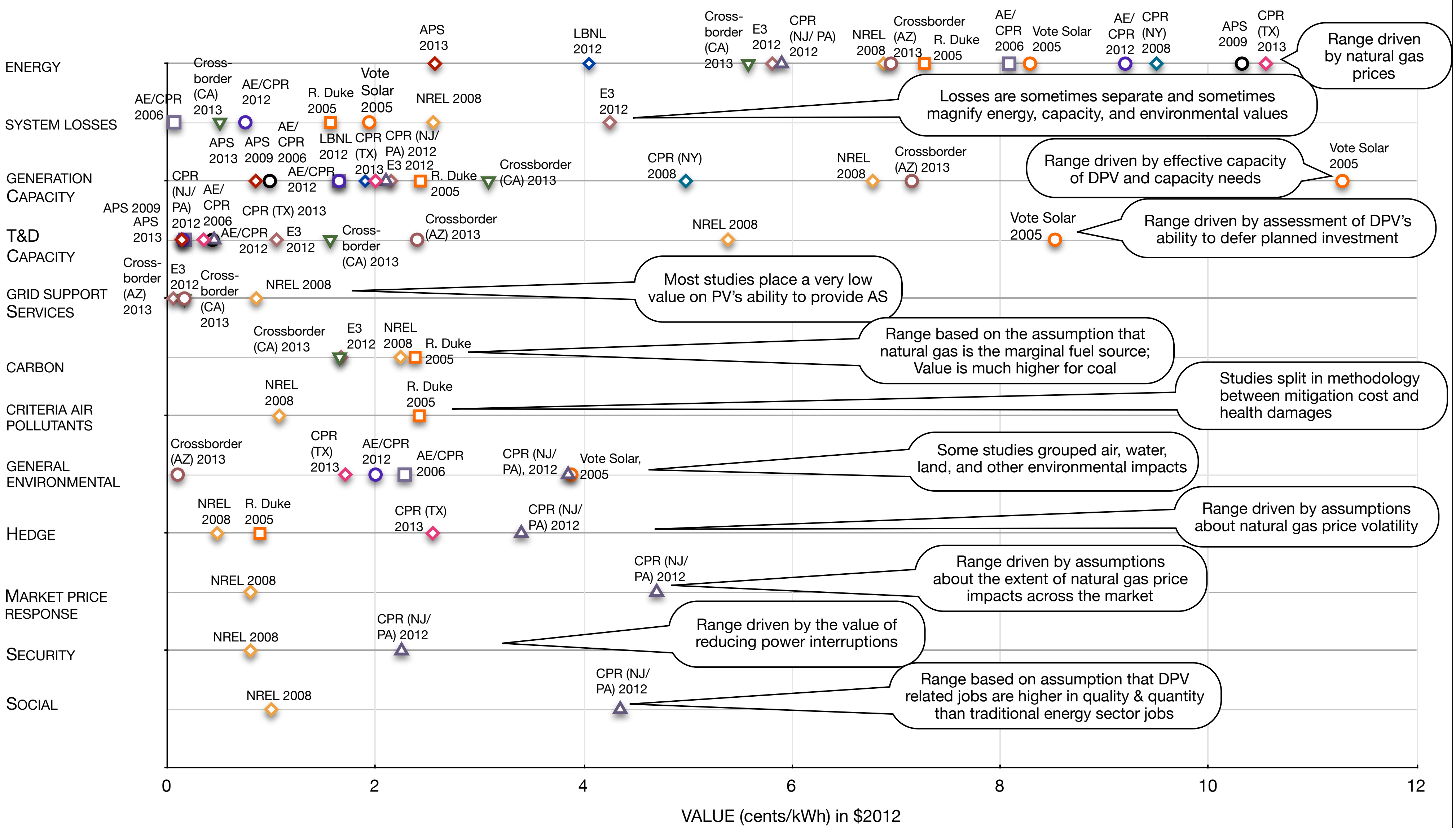
BENEFIT ESTIMATES

RANGE IN BENEFIT ESTIMATES ACROSS STUDIES DRIVEN BY VARIATION IN SYSTEM CONTEXT, INPUT ASSUMPTIONS, AND METHODOLOGIES

PUBLISHED AVERAGE BENEFIT ESTIMATES*



*For the full range of values observed see the individual methodology slides.

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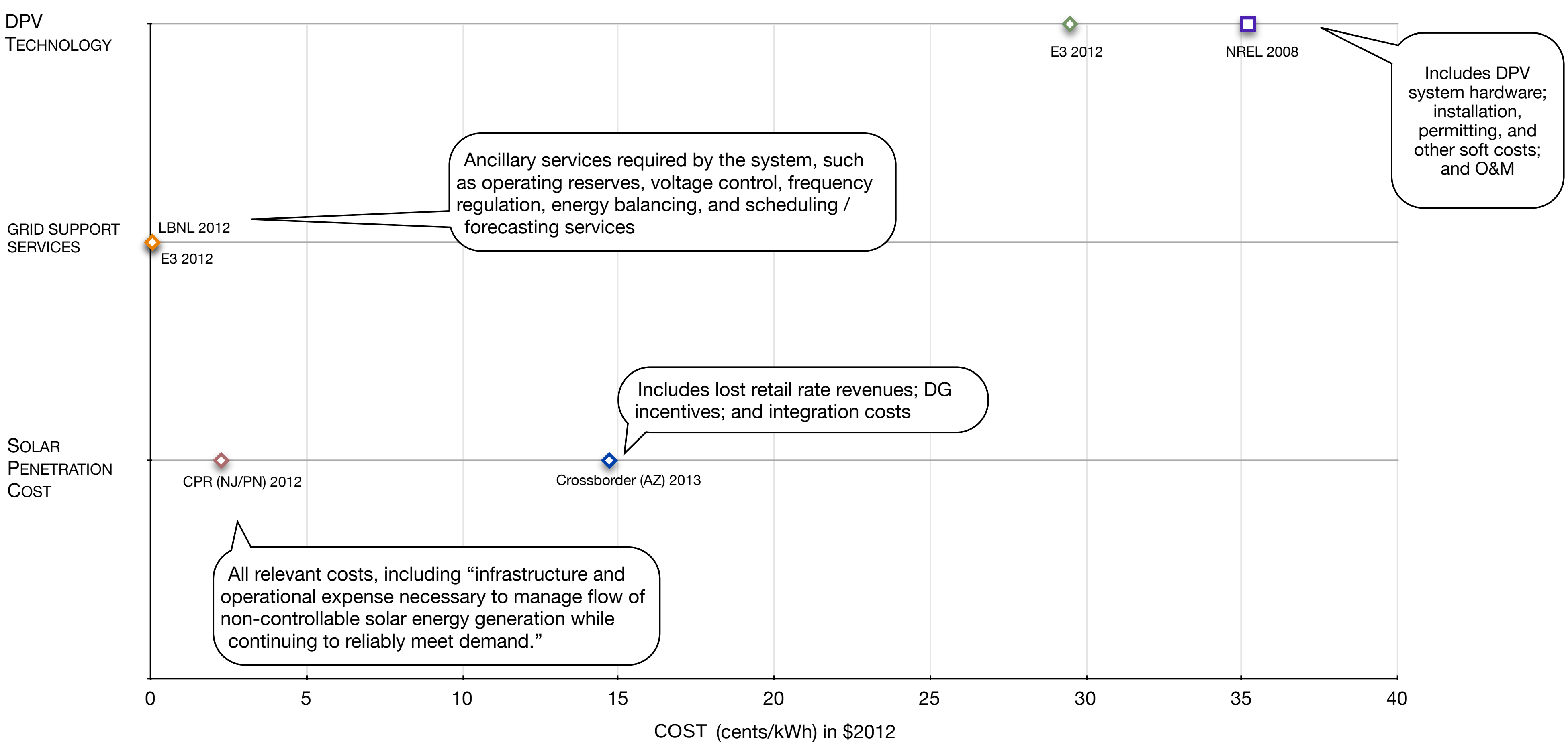
COST ESTIMATES

COSTS ASSOCIATED WITH INCREASED DPV DEPLOYMENT ARE NOT ADEQUATELY ASSESSED

PUBLISHED AVERAGE COST VALUES FOR REVIEWED SOURCES



Other studies (for example E3 2011) include costs, but results are not presented individually in the studies and so not included in the chart above. Costs generally include costs of program rebates or incentives paid by the utility, program administration costs, lost revenue to the utility, stranded assets, and costs and inefficiencies associated with throttling down existing plants.

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ENERGY

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VALUE OVERVIEW

Energy value is created when DPV generates energy (kWh) that displaces the need to produce energy from another resource. There are two components of energy value: the amount of energy that would have been generated equal to the DPV generation, and the additional energy that would have been generated but lost in delivery due to inherent inefficiencies in the transmission and distribution system.

APPROACH OVERVIEW

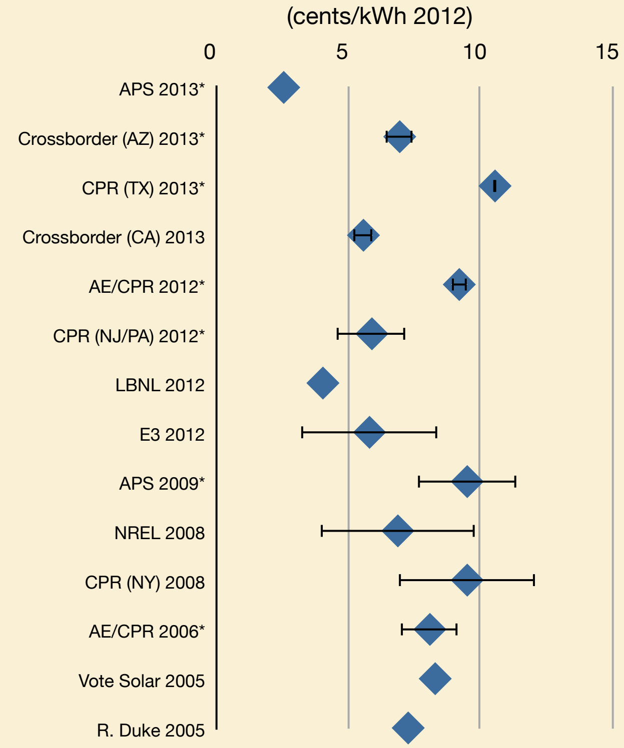
There is broad agreement on the general approach to calculating energy value, although numerous differences in methodological details. Energy is frequently the most significant source of benefit.

- Energy value is the avoided cost of the marginal resource, generally assumed to be natural gas.
- Key assumptions generally include fuel price forecast, operating & maintenance costs, and heat rate, and depending on the study, can include line losses and a carbon price.

WHY AND HOW VALUES DIFFER

- **System Context:**
  - **Market structure** - Some ISOs and states value capacity and energy separately, whereas some ISOs only have energy markets but no capacity markets. ISOs with only energy markets may reflect capacity value in the energy price.
  - **Marginal resource** - Regions with ISOs may calculate the marginal price based on wholesale market prices, rather than on the cost of the marginal power plant; different resources may be on the margin in different regions or with different solar penetrations.
- **Input Assumptions:**
  - **Fuel price forecast** - Since gas is usually on the margin, most studies focus on gas prices. Studies most often base natural gas prices on the NYMEX forward market and then extrapolate to some future date (varied approaches to this extrapolation), but some take a different approach to forecasting, for example, based on Energy Information Administration projections.
  - **Power plant efficiency** - The efficiency of the marginal resource significantly impacts energy value; studies show a wide range of assumed natural gas plant heat rates.
  - **Variable operating & maintenance costs** - While there is some difference in values assumed by studies, variable O&M costs are generally low.
  - **Carbon price** - Some studies include an estimated carbon price in energy value, others account for it separately, and others do not include it at all.
- **Methodologies:**
  - **Study window** - Some studies (for example, APS 2013) calculate energy value in a sample year, whereas others (for example, Crossborder (AZ) 2013) calculate energy value as a levelized cost over 20 years.
  - **Level of granularity/what's on the margin** - Studies take one of three general approaches: (1) DPV displaces energy from a gas plant, generally a combined cycle, (2) DPV displaces energy from one type of plant (generally a combined cycle) off-peak and a different type of plant (generally a combustion turbine) on-peak, (3) DPV displaces the resource on the margin during every hour of the year, based on a dispatch analysis.

BENEFIT AND COST ESTIMATES AS REPORTED BY REVIEWED STUDIES



* = value includes losses

ENERGY (CONT'D)

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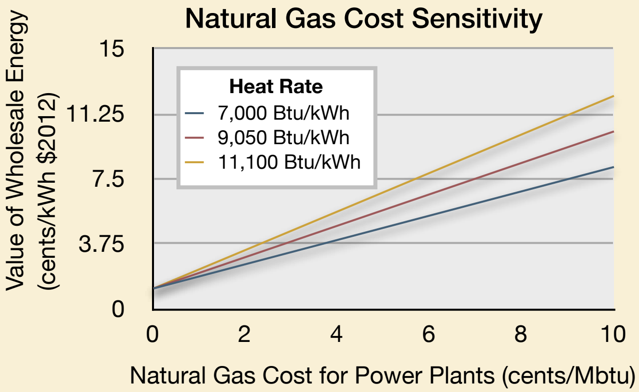
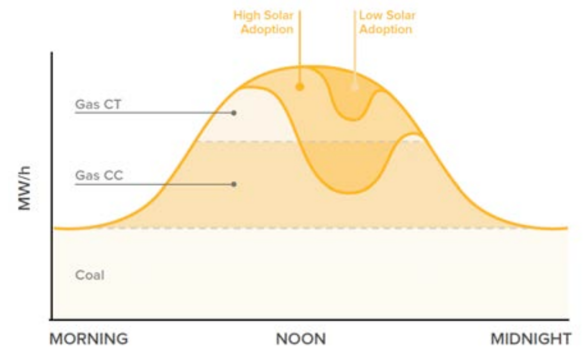
SENSITIVITIES TO MAIN DRIVERS

Electric Generation: Natural Gas Cost Sensitivity



INSIGHTS & IMPLICATIONS

- Accurately defining the marginal resource that DPV displaces requires an increasingly sophisticated approach as DPV penetration increases.



What DPV displaces depends on the dispatch order of other resources, when the solar is generated, and how much is generated.

More accurate, more complex ↓

Marginal Resource Characterization	Pros	Cons
Single power plant assumed to be on the margin (typically gas CC)	Simple; often sufficiently accurate at low solar penetrations	Not necessarily accurate at higher penetrations or in all jurisdictions
Plant on the margin on-peak/plant on the margin off-peak	More accurately captures differences in energy value reflected in merit-order dispatch	Not necessarily accurate at higher penetrations or in all jurisdictions
Hourly dispatch or market assessment to determine marginal resource in every hour	Most accurate, especially with increasing penetration	More complex analysis required; solar shape and load shape must be from same years

- Taking a more granular approach to determining energy value also requires a more detailed characterization of DPV's generation profile. It's also critical to use solar and load profiles from the same year(s), to accurately reflect weather drivers and therefore generation and demand correlation.

- In cases where DPV is displacing natural gas, the NYMEX natural gas forward market is a reasonable basis for a natural gas price forecast, adjusted appropriately for delivery to the region in question. It is not apparent from studies reviewed what the most effective method is for escalating prices beyond the year in which the NYMEX market ends.

LOOKING FORWARD

As renewable and distributed resource (not just DPV) penetration increases, those resources will start to impact the underlying load shape differently, requiring more granular analysis to determine energy value.

SYSTEM LOSSES

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VALUE OVERVIEW

Energy losses are the value of the additional energy generated by central plants that is lost due to inherent inefficiencies (electrical resistance) in delivering energy to the customer via the transmission and distribution system. Since DPV generates energy at or near the customer, that additional energy is not lost. Energy losses can also act as a magnifier of value for capacity and environmental benefits, since avoided energy losses result in lower required capacity and lower emissions.

APPROACH OVERVIEW

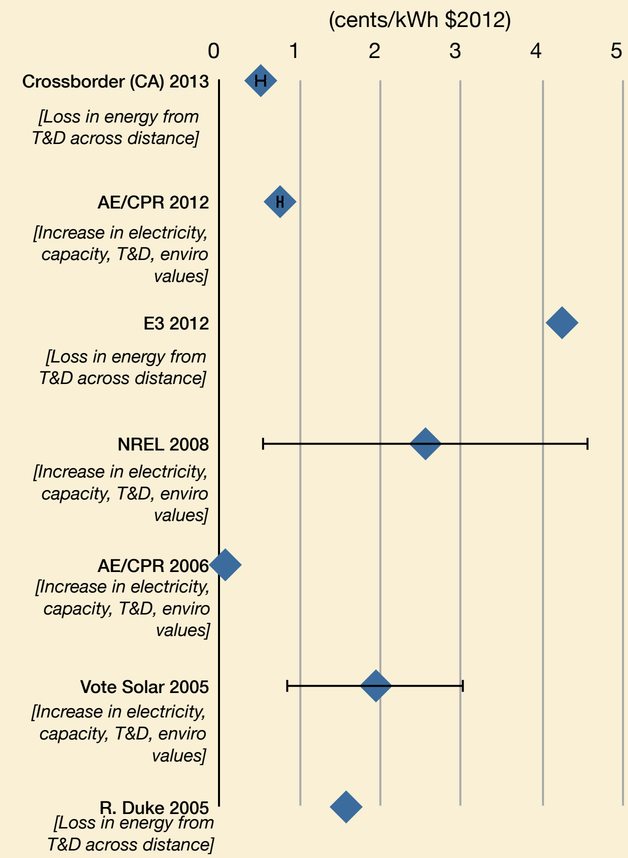
Losses are generally recognized as a value, although there is significant variation around what type of losses are included and how they are assessed. Losses usually represent a small but not insignificant source of value, although some studies report comparatively high values.

- Energy lost in delivery magnify the value of other benefits, including capacity and environment.
- Calculate loss factor(s) (amount of loss per unit of energy delivered) based on modeled or observed data.

WHY AND HOW VALUES DIFFER

- **System Context:**
  - **Congestion** - Because energy losses are proportional to the inverse of current squared, the higher the utilization of the transmission & distribution system, the greater the energy losses.
  - **Solar characterization**—The timing, quantity, and geographic location of DPV, and therefore its coincidence with delivery system utilization, impacts losses.
- **Input Assumptions:**
  - **Loss factors** - Some studies apply loss factors based on actual observation, others develop theoretical loss factors based on system modeling. Further, some utility systems have higher losses than others.
- **Methodologies:**
  - **Types of losses recognized** - Most studies recognize energy losses, some recognize capacity losses, and a few recognize environmental losses.
  - **Adder vs. stand-alone value** - There is no common approach to whether losses are represented as stand-alone values (for example, NREL 2008 and E3 2012) or as adders to energy, capacity, and environmental value (for example, Crossborder (AZ) 2013 and APS 2013), complicating comparison across studies.
  - **Level of time and geographic granularity** - Some studies apply an average loss factor to all energy generated by DPV, others apply peak/off-peak factors, and others conduct hourly analysis. Some studies also reflect geographically-varying losses.

SYSTEM LOSSES BENEFIT AND COST ESTIMATES AS REPORTED BY REVIEWED STUDIES



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LOSSES (CONT'D)

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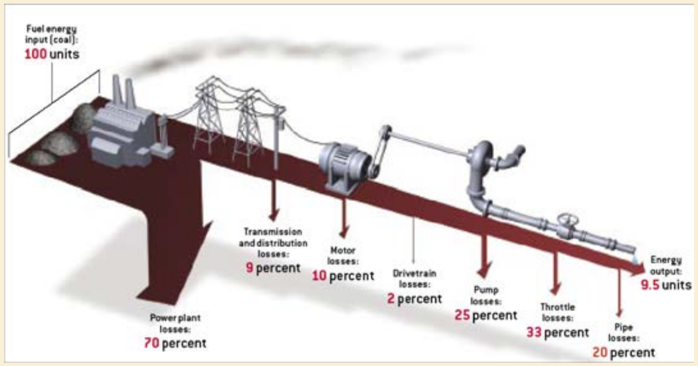
WHAT ARE LOSSES?

Some energy generated at a power plant is lost as it travels through the transmission and distribution system to the customer. As shown in the graphic below, more than 90% of primary energy input into a power plant is lost before it reaches the end use, or stated in reverse, for every one unit of energy saved or generated close to where it is needed, 10 units of primary energy are saved.



For the purposes of this discussion document, relevant losses are those driven by inherent inefficiencies (electrical resistance) in the transmission and distribution system, not those in the power plant or customer equipment. Energy losses are proportional to the square of current, and associated capacity benefit is proportional to the square of reduced load.

INSIGHTS & IMPLICATIONS

- All relevant system losses—energy, capacity, and environment—should be assessed.
- Because losses are driven by the square of current, losses are significantly higher during peak periods. Therefore, when calculating losses, it's critical to reflect marginal losses, not just average losses.
- Whether or not losses are ultimately represented as an adder to an underlying value or as a stand-alone value, they are generally calculated separately. Studies should distinguish these values from the underlying value for transparency and to drive consistency of methodology.

LOOKING FORWARD

Losses will change over time as the loading on transmission and distribution lines changes due to a combination of changing customer demand and DPV generation.

GENERATION CAPACITY

VALUE OVERVIEW

Generation capacity value is the amount of central generation capacity that can be deferred of avoided due to DPV. Key drivers of value include (1) DPV's dependable capacity and (2) system capacity needs.

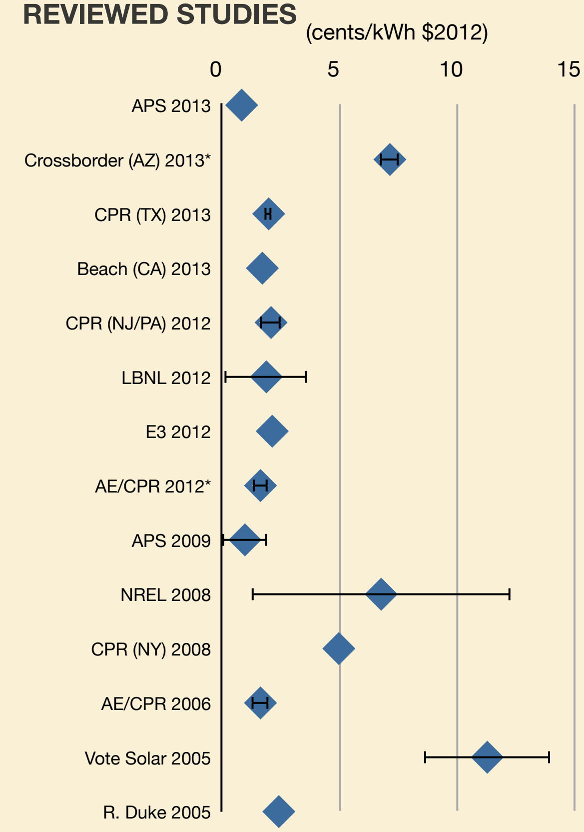
APPROACH OVERVIEW

Generation capacity value is the avoided cost of the marginal capacity resource, most frequently assumed to be a gas combustion turbine, and based on a calculation of DPV dependable capacity, most commonly based on effective load carrying capability (ELCC).

WHY AND HOW VALUES DIFFER

- **System Context:**
  - **Load growth/generation capacity investment plan** - The ability to avoid or defer generation capacity depends on underlying load growth and how much additional capacity will be needed, when.
  - **Solar characterization** - The timing, quantity, and geographic location of DPV, and therefore its coincidence with system peak, impacts DPV's dependable capacity (see methodology below).
  - **Market structure** - Some ISOs and states value capacity and energy separately, whereas some ISOs only have energy markets but no capacity markets. ISOs with only energy markets may reflect capacity value as part of the energy price. For California, E3 2012 calculates capacity value based on "net capacity cost"—the annual fixed cost of the marginal unit minus the gross margins captured in the energy and ancillary service market.
- **Input Assumptions:**
  - **Marginal resource** - Most studies assume that a gas combustion turbine, or occasionally a gas combined cycle, is the generation capacity resource that could be deferred. What this resource is and its associated capital and fixed O&M costs are a primary determinant of capacity value.
- **Methodologies:**
  - **Formulation of dependable capacity** - There is broad agreement that DPV's dependable capacity is most accurately determined using an effective load carrying capability (ELCC) approach, which measures the amount of additional load that can be met with the same level of reliability after adding DPV. There is some variation across studies in ELCC results, likely driven by a combination of underlying solar resource profile and ELCC calculation methodology. The approach to dependable capacity is sometimes different when considering T&D capacity.
  - **Minimum DPV required to defer capacity** - Some studies (for example, Crossborder (AZ) 2013) credit every unit of dependable DPV capacity with capacity value, whereas others (for example, APS 2009) require a certain minimum amount of solar be installed to defer an actual planned resource before capacity value is credited.
  - **Inclusion of losses** - Some studies include capacity losses as an adder to capacity value rather than as a stand-alone benefit.

GENERATION CAPACITY BENEFIT AND COST ESTIMATES AS REPORTED BY REVIEWED STUDIES



* = value takes into account loss savings

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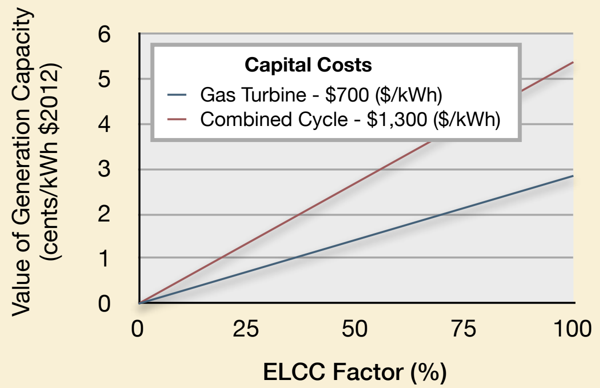
GENERATION CAPACITY (CONT'D)

KEY DRIVERS OF VALUE AND MAIN ASSUMPTIONS

Sensitivity of Generation Capacity Value to the ELCC Factor

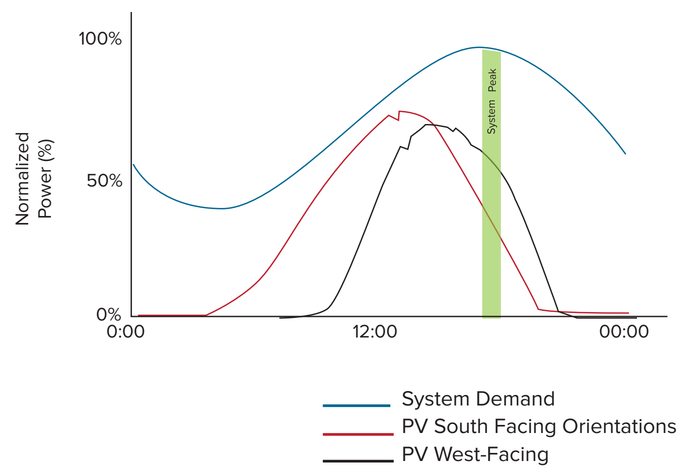


ASSUMPTIONS:

Capacity Factor: 20%
Discount Rate: 5%
Plant Lifetime: 25 years

INSIGHTS & IMPLICATIONS

- Generation capacity value is highly dependent on the correlation of DPV generation to load, so it's critical to accurately assess that correlation using an ELCC approach, as all studies reviewed do. Hoewver, varying results indicate possible different formulations of ELCC.



While ELCC assesses DPV's contribution to reliability throughout the year, generation capacity value will generally be higher if DPV output is more coincident with peak.

- The value also depends on whether new capacity is needed on the system, and therefore whether DPV defers new capacity. It's important to assess what capacity would have been needed without any additional, expected, or planned DPV.

- Generation capacity value is likely to change significantly as more DPV, and more renewable and distributed resources of all kinds are added to the system. Some amount of DPV can displace the most costly resources in the capacity stack, but increasing amounts of DPV could begin to displace less costly resources. Similarly, the underlying load shape, and therefore even the concept of a peak could begin to shift.

LOOKING FORWARD

Generation capacity is one of the values most likely to change, most quickly, with increasing DPV penetration. Key reasons for this are (1) increasing DPV penetration could have the effect of pushing the peak to later in the day, when DPV generation is lower, and (2) increasing DPV penetration will displace expensive peaking resources, but once those resources are displaced, the cost of the next resource may be lower. Beyond DPV, it's important to note that a shift towards more renewables could change the underlying concept of a daily or seasonal peak.

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TRANSMISSION & DISTRIBUTION CAPACITY

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VALUE OVERVIEW

The transmission and distribution (T&D) capacity value is a measure of the net change in T&D infrastructure as a result of the addition of DPV. Benefits occur when DPV is able to meet rising demand locally, relieving capacity constraints upstream and deferring or avoiding transmission or distribution upgrades. Costs are incurred when additional transmission or distribution investment are necessary to support the addition of DPV, which could occur when the amount of solar energy exceeds the demand in the local area and increases needed line capacity.

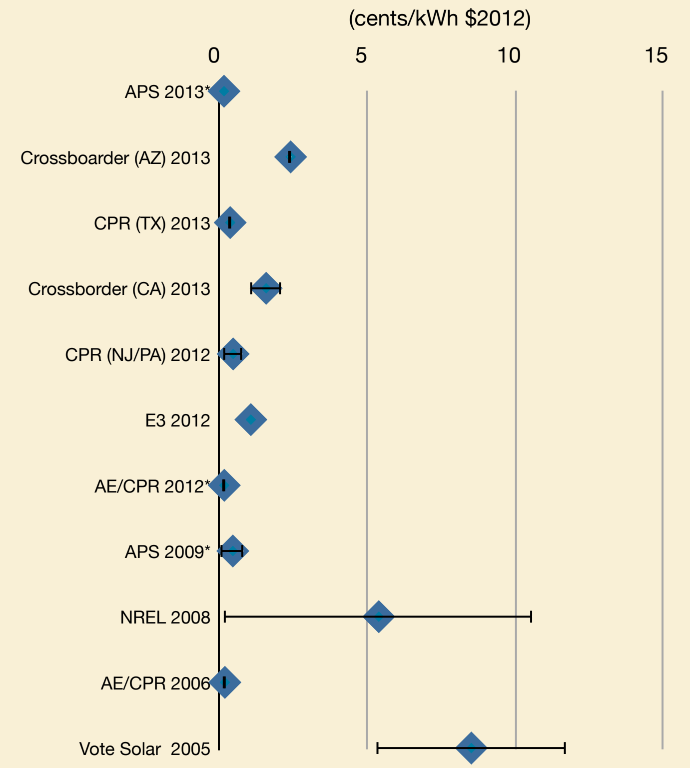
APPROACH OVERVIEW

The net value of deferring or avoiding T&D investments is driven by rate of load growth, DPV configuration and energy production, peak coincidence and dependable capacity. Given the site specific nature of T&D, especially distribution, there can be significant range in the calculated value of DPV. Historically low penetrations of DPV has meant that studies have primarily focused on analyzing the ability of DPV to defer transmission or distribution upgrades and have not focused on potential costs, which would likely not arise until greater levels of penetration. Studies typically determine the T&D capacity value based on the capital costs of planned expansion projects in the region of interest. However, the granularity of analysis differs.

WHY AND HOW VALUES DIFFER

- **System Context:**
  - **Locational characteristics -** Transmission and distribution infrastructure projects are inherently site-specific and their age, service life, and use can vary significantly. Thus, the need, size and cost of upgrades, replacement or expansion correspondingly vary.
  - **Projected load growth** - Expected rate of demand growth affects the need, scale and cost of T&D upgrades and the ability of DPV to defer or offset anticipated T&D expansions. The rate of growth of DPV would need to keep pace with the growth in demand, both by order of magnitude and speed.
  - **PV temporal coincidence with system and/ or local demand** - The timing of energy production from DPV and its coincidence with system peaks (transmission) and local peaks (distribution) drive the ability of DPV to contribute as dependable capacity that could defer or displace a transmission or distribution capacity upgrade.
  - **The length of time the investment is deferred** -The length of time that T&D can be deferred by the installation of PV varies by the rate of load growth, the assumed dependable capacity of the PV, and PV's correlation with peak. The cost of capital saved will increase with the length of deferment.
- **Input Assumptions:**
  - **T or D investment plan characteristics -** Depending upon data available and depth of analysis, studies vary by the level of granularity in which T&D investment plans were assessed–project by project or broader generalizations across service territories.
- **Methodologies:**
  - **Accrual of capacity value to DPV** - One of the most significant methodological differences is whether DPV has incremental T&D capacity value the face of "lumpy" T&D investments. (see implications and insights).
  - **Losses -** Some studies include the magnified benefit of deferred T&D capacity due to avoided losses within the calculation of T&D value, while others itemize line losses separately.

T&D CAPACITY BENEFIT AND COST ESTIMATES AS REPORTED BY REVIEWED STUDIES



* = value includes losses

TRANSMISSION & DISTRIBUTION CAPACITY

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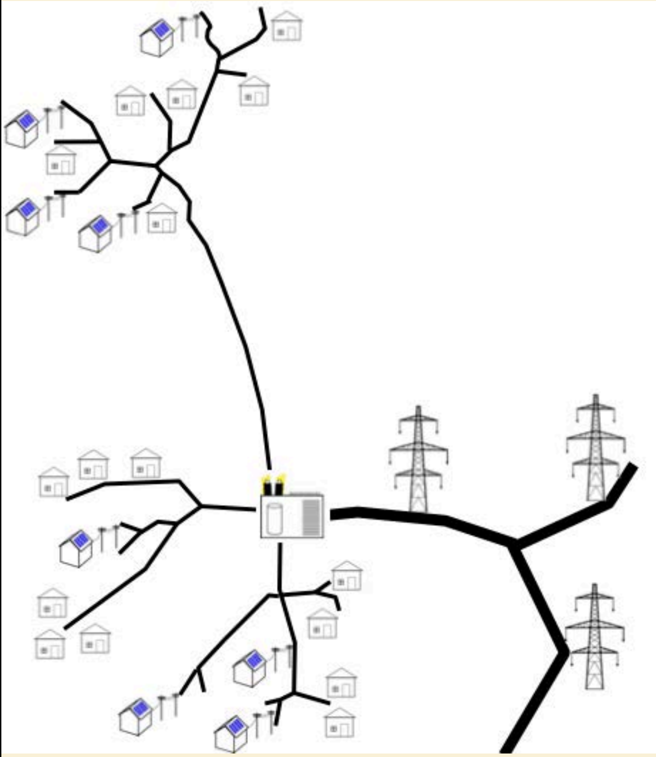
TRANSMISSION & DISTRIBUTION SYSTEM



INSIGHTS & IMPLICATIONS

- Strategically targeted DPV deployment can relieve T&D capacity constraints by providing power close to demand and potentially defer capacity investments, but dispersed deployment has been found to provide less benefit. Thus, the ability to access DPV's T&D deferral value will require proactive distribution planning that incorporates distributed energy resources, such as DPV, into the evaluation.

- The values of T&D are often grouped together, but they are unique when considering the potential costs and benefits that result from DPV.
  - While the ability to defer or avoid transmission is still locational dependent, it is less so than distribution. Transmission aggregates disparate distribution areas and the effects of additional DPV at the distribution level typically require less granular data and analysis.
  - The distribution system requires more geographically specific data that reflects the site specific characteristics such as local hourly PV production and correlation with local load.

- There are significantly differing approaches on the ability of DPV to accrue T&D capacity deferment or avoidance value that require resolution:
  - How should DPV's capacity deferral value be estimated in the face of "lumpy" T&D investments? While APS 2009 and APS 2013 posit that a minimum amount of solar must be installed to defer capacity before credit is warranted, Crossborder (AZ) 2013 credits every unit of reliable capacity with capacity value.
  - What standard should be applied to estimate PV's ability to defer a specific distribution expansion project? While most studies use ELCC to determine effective capacity, APS 2009 and APS 2013 use the level at which there is a 90% confidence of that amount of generation.

LOOKING FORWARD

Any distributed resources, not just DPV, that can be installed near the end user to reduce use of, and congestion along, the T&D network could potentially provide T&D value. This includes technologies that allow energy to be used more efficiently or at different times, reducing the quantity of electricity traveling through the T&D network (especially during peak hours).

GRID SUPPORT SERVICES

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VALUE OVERVIEW

Grid support services, also commonly referred to as ancillary services (AS) in wholesale energy markets, are required to enable the reliable operation of interconnected electric grid systems, including operating reserves, reactive supply and voltage control; frequency regulation; energy imbalance; and scheduling.

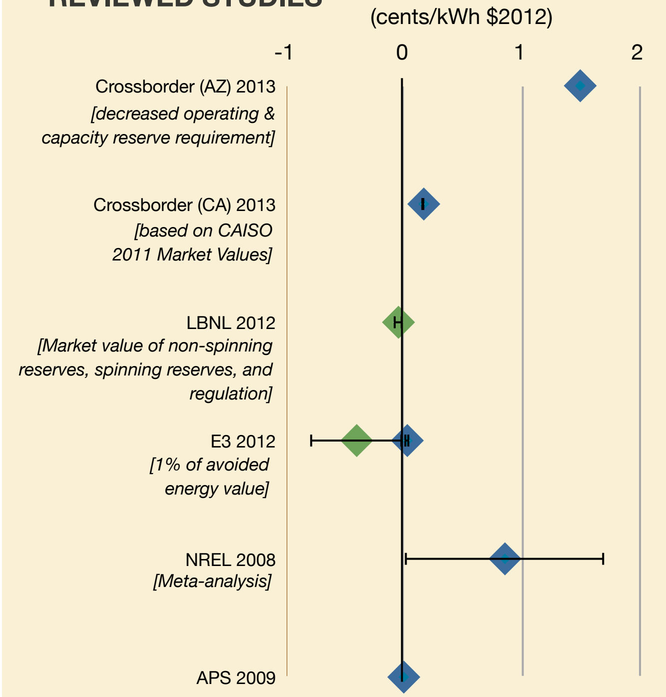
APPROACH OVERVIEW

There is significant variation across studies on the impact DPV will have on the addition or reduction in the need of grid support services and the associated cost or benefit. Most studies focus on the cost DPV could incur in requiring additional grid support services, while a minority evaluate the value DPV could provide by reducing load and required reserves or the AS that DPV could provide when coupled with other technologies. While methodologies are inconsistent, the approaches generally focus on methods for calculating changes in necessary operating reserves, and less precision or rules of thumb are applied to the remainder of AS, such as voltage regulation. Operating reserves are typically estimated by determining the reliable capacity for which PV can be counted on to provide capacity when demanded over the year.

WHY AND HOW VALUES DIFFER

- **System Context:**
  - **Reliability standards and market rules** - The standards and rules for reliability that govern the requirements for grid support services and reserve margins differ. These standards directly impact the potential net value of adding DPV to the system.
  - **Availability of ancillary services market** - Where wholesale electricity markets exist, the estimated value is correlated to the market prices of AS.
  - **PV temporal coincidence with system and/ or local demand** - The timing of energy production from DPV and it's coincidence with system peaks differs locationally.
  - **Penetration of PV** - As PV penetrations increase, the value of its reliable capacity decreases and, under standard reliability planning approaches, would increase the amount of system reserves necessary to maintain reliable operations.
  - **System generation mix -** The performance characteristics of the existing generation mix, including the generators ability to respond quickly by increasing or decreasing production, can significantly change the supply value of ancillary services and the value.
- **Methodologies:**
  - **Reliable or dependable capacity of PV** - The degree that DPV can be depended to provide capacity when demanded has a direct effect on the amount of operating reserves that the rest of the system must supply. The higher the "dependable capacity," the less operating reserves necessary.
  - **Correlating reduced load with reduced ancillary service needs** - Crossborder (AZ) 2013 calculated a net benefit of PDV based on 1) load reduction & reduced operating reserve requirements; 2) peak demand reduction and utility capacity requirements.
  - **Potential of PV to provide grid support with technology coupling** - While the primary focus across studies was the impact DPV would have on the need for additional AS, NREL 2008 & AE/CPR 2006 both noted that PV could provide voltage regulation with smart inverters were installed.

GRID SUPPORT SERVICES BENEFIT AND COST ESTIMATES AS REPORTED BY REVIEWED STUDIES



GRID SUPPORT SERVICES

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Grid Support Services	The potential for PV to provide grid support services (with technology modifications)
REACTIVE SUPPLY AND VOLTAGE CONTROL	(+/-) PV with an advanced inverter can inject/consume VARs, adjusting to control voltage
FREQUENCY REGULATION	(+/-) Advanced inverters can adjust output frequency; standard inverters may
ENERGY IMBALANCE	(+/-) If PV output < expected, imbalance service is required. Advanced inverters could adjust output to provide imbalance
OPERATING RESERVES	(-) Depending on weather, controllability, standalone PV may introduce additional forecast error
SCHEDULING / FORECASTING	(-) The variability of the solar resource requires additional forecasting to reduce uncertainty

INSIGHTS & IMPLICATIONS

- As with large scale renewable integration, there is still controversy over determining the net change in "ancillary services due to variable generation and much more controversy regarding how to allocate those costs between specific generators or loads." (LBNL 2012)
- Areas with wholesale AS markets enable easier quantification of the provision of AS services. Regions without markets have less standard methodologies for quantifying the value of AS services.
- One of the most significant differences in reviewed methodological approaches is whether the necessary amount of operating reserves, as specified by required reserve margin, decreases by DPV's capacity value (as determined by ELCC, for example). Crossborder (CA) 2013, E3 2012 and Vote Solar 2005 note that the addition of DPV reduces load served by central generation, thus allowing utilities to reduce procured reserves. Additional analysis is needed to determine whether the required level of reserves should be adjusted in the face of a changing system.
- Studies varied in their assessments of grid support services. APS, 2009 did not expect DPV would contribute significantly to spinning or operating reserves, but predicted regulation reserves could be affected at high penetration levels.

LOOKING FORWARD

Increasing levels of distributed energy resources and variable renewable generation will begin to shift both the need for grid support services as well as the types of assets that can and need to provide them. The ability of DPV to provide grid support requires technology modifications or additions, such as advanced inverters or storage, which incur additional costs. However, it is likely that the net value proposition will increase as technology costs decrease and the opportunity (or requirements) to provide these services increase with penetration.

U-17302 ELPC/Rabago Exhibit KRR-3

FINANCIAL: FUEL PRICE HEDGE

VALUE OVERVIEW
DPV produces roughly constant-cost power compared to fossil fuel generation, which is tied to potentially volatile fuel prices. DPV can provide a “hedge” against it, reducing risk exposure to utilities and customers.

APPROACH OVERVIEW
More than half the studies reviewed acknowledge DPV’s fuel price hedge benefit, although fewer quantify it and those that do take different, although conceptually similar, approaches.

- In future years when natural gas futures market prices are available, using those NYMEX prices to develop a natural gas price forecast should include the value of volatility.
- In future years beyond when natural gas futures market prices are available, estimate natural gas price and volatility value separately. Differing approaches include:
    - Escalating NYMEX prices at a constant rate, under the assumption that doing so would continue to reflect hedge value (Crossborder (AZ) 2013); or
    - Estimating volatility hedge value separately as the value or an option/swap, or as the actual price adder the utility is incurring now to hedge gas prices (CPR (NJ/PA 2012), NREL 2008).

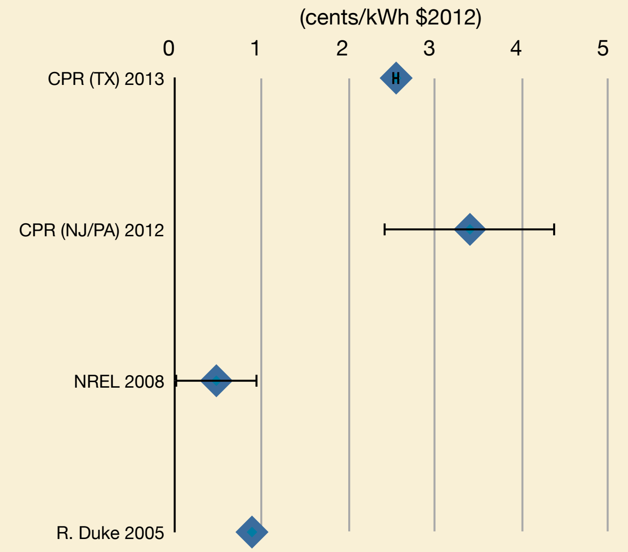
WHY AND HOW VALUES DIFFER

- **System Context:**
    - **Marginal resource** - What resource is on the margin, and therefore how much fuel is displaced varies.
    - **Exposure to fuel price volatility** - Most utilities already hedge some portion of their natural gas purchases for some period of time in the future.
- **Methodologies:**
    - **Approach to estimating value** - While most studies agree that NYMEX futures prices are an adequate reflection of volatility, there is no largely agreed upon approach to estimating volatility beyond when those prices are available.

INSIGHTS & IMPLICATIONS

- NYMEX futures market prices are an adequate reflection of volatility in the years in which it operates.
- Beyond that, volatility should be estimated, although there is no obvious best practice. Further work is required to develop an approach that accurately measures hedge value.

FUEL PRICE HEDGE BENEFIT AND COST ESTIMATES AS REPORTED BY REVIEWED STUDIES



FINANCIAL: MARKET PRICE RESPONSE

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VALUE OVERVIEW

The addition of DPV, especially at higher penetrations, can affect the market price of electricity in a particular market or service territory. These market price effects span energy and capacity values in the short term and long term, all of which are interrelated. Benefits can occur as DPV provides electricity close to demand, reducing the demand for centrally-supplied electricity and the fuel powering those generators, thereby lowering electricity prices and potentially fuel commodity prices. A related benefit is derived from the effect of DPV's contribution at higher penetrations to reshape the load profile that central generators need to meet. Depending upon the correlation of DPV production and load, the peak demand could be reduced and the marginal generator could be more efficient and less costly, reducing total electricity cost. However, these benefits could potentially be reduced in the longer term as energy prices decline, which could result in higher demand. Additionally, depressed prices in the energy market could have a feedback effect by raising capacity prices.

APPROACH OVERVIEW

While several studies evaluate a market price response of DPV, distinct approaches were employed by E3 2012, CPR (NJ/PN) 2012, and NREL 2008.

WHY AND HOW VALUES DIFFER

- **Methodologies:**
  - **Considering market price effects of DPV in the context of other renewable technologies** - E3 2012 incorporated market price effect in its high penetration case by adjusting downward the marginal value of energy that DPV would displace. However, for the purposes of the study, E3 2012 did not add this as a benefit to the avoided cost because they "assume the market price effect would also occur with alternative approaches to meeting [CA's] RPS."
  - **Incorporating capacity effects** - E3 2012 represented a potential feedback effect between the energy and capacity by assuming an energy market calibration factor. That is, it assumes that, in the long run, the CCGT's energy market revenues plus the capacity payment equal the fixed and variable costs of the CCGT. Therefore, a CCGT would collect more revenue through the capacity and energy markets than is needed to cover its costs, and a decrease in energy costs would result in a relative increase in capacity costs.
  - CPR (NJ/PA) 2012 incorporates market price effect "by reducing demand during the high priced hours [resulting in] a cost savings realized by all consumers." They note "that further investigation of the methods may be warranted in light of two arguments...that the methodology does address induced increase in demand due to price reductions, and that it only addresses short-run effects (ignoring the impact on capacity markets)."

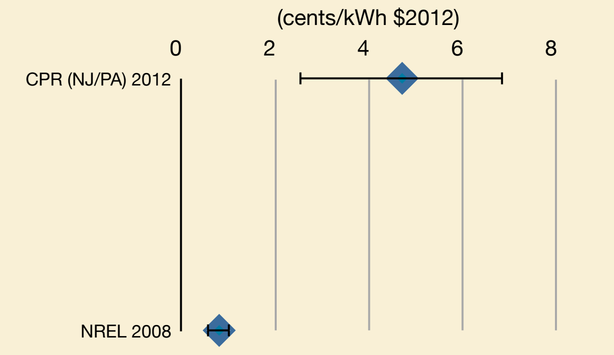
INSIGHTS & IMPLICATIONS

- The market price reduction value only assesses the initial market reaction of reduced price, not subsequent market dynamics (e.g. increased demand in response to price reductions, or the impact on the capacity market), which has to be studied and considered, especially in light of higher penetrations of DPV.

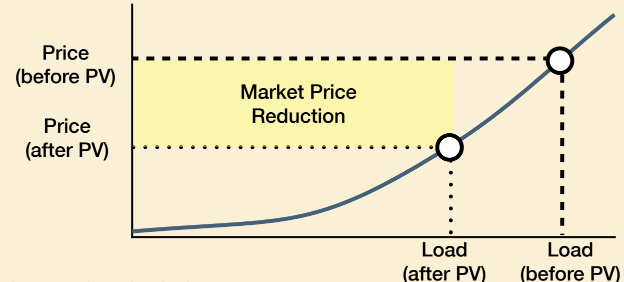
LOOKING FORWARD

Technologies powered by risk-free fuel sources (such as wind) and technologies that increase the efficiency of energy use and decrease consumption would also have similar effects.

MARKET PRICE RESPONSE BENEFIT AND COST ESTIMATES AS REPORTED BY REVIEWED STUDIES



MARKET PRICE VS. LOAD



Source: CPR (NJ/PA) 2012

SECURITY: RELIABILITY AND RESILIENCY

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VALUE OVERVIEW

The grid security value that DPV could provide is attributable to three primary factors, the last of which would require coupling DPV with other technologies to achieve the benefit:

1. The potential to reduce outages by reducing congestion along the T&D network. Power outages and rolling blackouts are more likely when demand is high and the T&D system is stressed.
2. The ability to reduce large-scale outages by increasing the diversity of the electricity system's generation portfolio with smaller generators that are geographically dispersed.
3. The benefit to customers to provide back-up power sources available during outages through the combination of PV, control technologies, inverters and storage.

APPROACH OVERVIEW

While there is general agreement across studies that integrating DPV near the point of use will decrease stress on the broader T&D system, most studies do not calculate a benefit due to the difficulty of quantification. CPR 2012 and 2011 did represent the value as the value of avoided outages based on the total cost of power outages to the U.S. each year, and the perceived ability of DPV to decrease the incidence of outages.

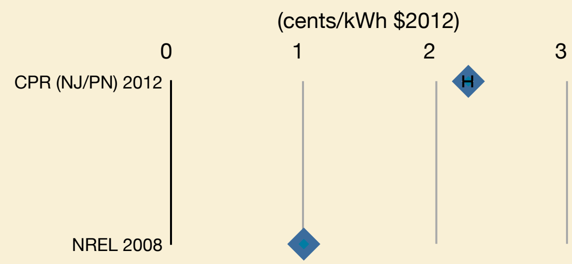
INSIGHTS & IMPLICATIONS

- The value of increased reliability is significant, but there is a need to quantify and demonstrate how much value can be provided by DPV. Rules-of-thumb assumptions and calculations for security impacts require significant analysis and review.
- Opportunities to leverage combinations of distributed technologies to increase customer reliability are starting to be tested. The value of DPV in increasing suppling power during outages can only be realized if DPV is coupled with storage and equipped with the capability to island itself from the grid during a power outage, which come at additional capital cost.

LOOKING FORWARD

Any distributed resources that can be installed near the end user to reduce use of, and congestion along, the T&D network could potentially reduce transmission stress. This includes technologies that allow energy to be used more efficiently or at different times, reducing the quantity of electricity traveling through the T&D network (especially during peak hours). Any distributed technologies with the capability to be islanded from the grid could also play a role.

RELIABILITY AND RESILIENCY BENEFIT AND COST ESTIMATES AS REPORTED BY REVIEWED STUDIES



Disruption Value Range by Sector
(cents/kWh $2012)

Sector	Min	Max
Residential	0.028	0.41
Commercial	11.77	14.40
Industrial	0.4	1.99

Source: The National Research Council, 2010

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ENVIRONMENT: CARBON

VALUE OVERVIEW

The benefits of reducing carbon emissions include (1) reducing future compliance costs, carbon taxes, or other fees, and (2) mitigating the heath and ecosystem damages potentially caused by climate change.

APPROACH OVERVIEW

By and large, studies that addressed carbon focused on the compliance costs or fees associated with future carbon emissions, and conclude that carbon reduction can increase DPV's value by more than two cents per kilowatt-hour, depending heavily on the price placed on carbon. While there is some agreement that carbon reduction provides value and on the general formulation of carbon value, there are widely varying assumptions, and not all studies include carbon value.

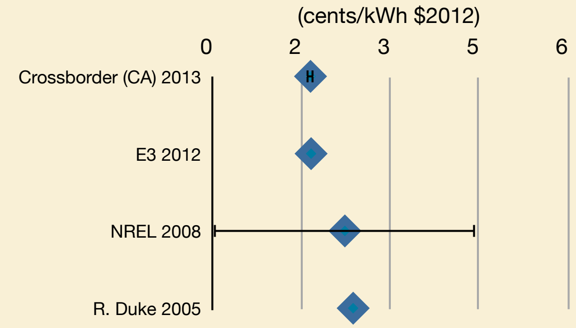
Carbon reduction benefit is the amount of carbon displaced times the price of reducing a ton of carbon. The amount of carbon displaced is directly linked to the amount of energy displaced, when it is displaced, and the carbon intensity of the resource being displaced.

WHY AND HOW VALUES DIFFER

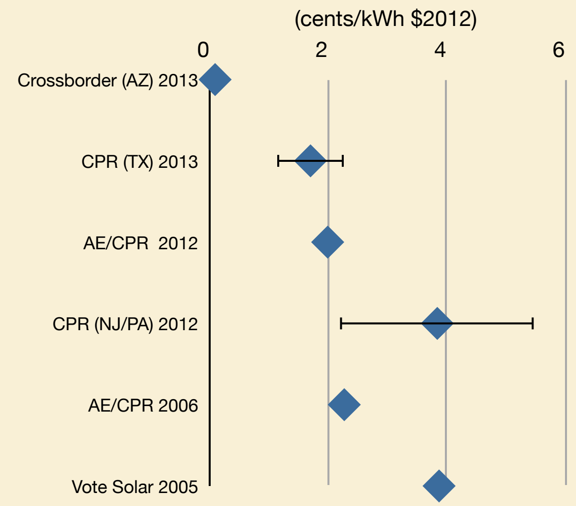
- **System Context:**
  - **Marginal resource** - Different resources may be on the margin in different regions or with different solar penetrations. Carbon reduction is significantly different if energy is displaced from coal, gas combined cycles, or gas combustion turbines.
- **Input Assumptions:**
  - **Value of carbon reduction** - Studies have widely varying assumptions about the price or carbon. Some studies base price on reported prices in European markets, others on forecasts based on policy expectations, others on a combination. The increased uncertainty around U.S. Federal carbon legislation has made price estimates more difficult.
  - **Heat rates of marginal resources** - The assumed efficiency of the marginal power plant is directly correlated to amount of carbon displaced by DPV.
- **Methodologies:**
  - **Adder vs. stand-alone value** - There is no common approach to whether carbon is represented as a stand-alone value (for example, NREL 2008 and E3 2012) or as an adder to energy value (for example, APS 2013).
  - **Level of granularity/what's on the margin** - Just as with energy (which is directly linked to carbon reduction), studies take one of three general approaches: (1) DPV displaces energy from a gas plant, generally a combined cycle, (2) DPV displaces energy from one type of plant (generally a combined cycle) off-peak and a different type of plant (generally a combustion turbine) on-peak, (3) DPV displaces whatever resource is on the margin during every hour of the year, based on a dispatch analysis.

BENEFIT AND COST ESTIMATES AS REPORTED BY REVIEWED STUDIES

Range of Benefits and Costs from Studies that Evaluate Carbon Separately



Range of Benefits and Costs from Studies that Group All Environmental Values



ENVIRONMENT: CARBON (CONT'D)

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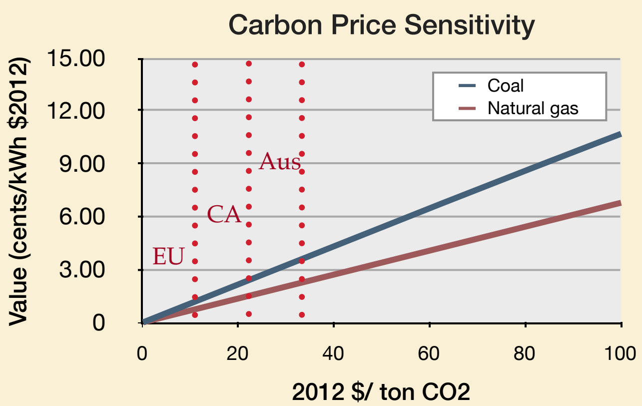
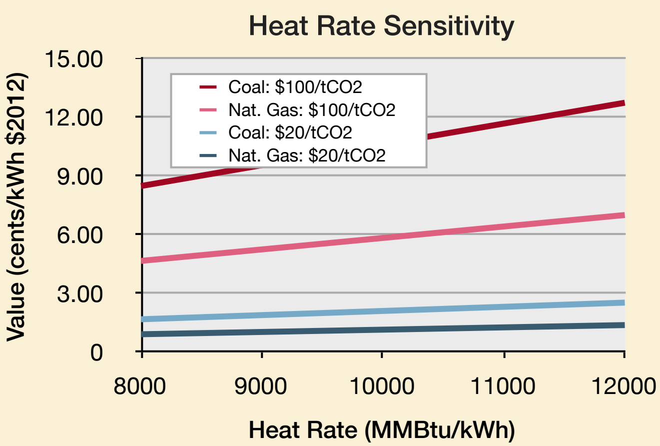
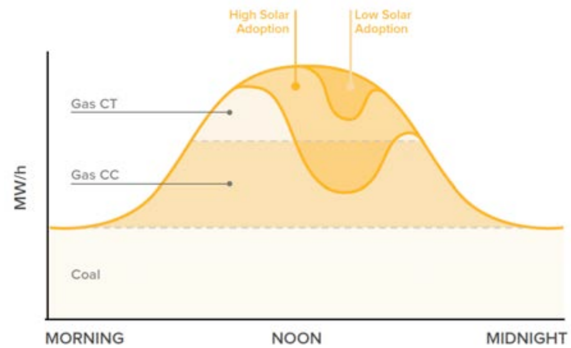
KEY DRIVERS OF VALUE AND MAIN ASSUMPTIONS





INSIGHTS & IMPLICATIONS

- Just as with energy value, carbon value depends heavily on what the marginal resource is that is being displaced. The same determination of the marginal resource should be used to drive both energy and carbon values.



How much carbon DPV displaces depends on the dispatch order of other resources, when the solar is generated, and how much is generated.

- While there is little agreement on what the $/ton price of carbon is or should be, it is likely non-zero.

LOOKING FORWARD

While there has been no Federal action on climate over the last few years, leading to greater uncertainty about potential future prices, many states and utilities continue to value carbon as a reflection of assumed benefit. There appears to be increasing likelihood that the US Environmental Protection Agency will take action to limit emissions from coal plants, potentially providing a more concrete indicator of price.

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ENVIRONMENT: OTHER FACTORS

In addition to carbon, DPV has several other environmental benefits (or potentially costs) that, while commonly acknowledged, are included in only a few of the studies reviewed here. That said, there is a significant body of thought for each outside the realm of DPV cost/benefit valuation.

CRITERIA AIR POLLUTANTS

SUMMARY: Criteria air pollutants (NOX, SO_2, and particulate matter) released from the burning of fossil fuels can produce both health and ecosystem damages. The economic cost of these pollutants is generally estimated as:

1. The compliance costs of reducing pollutant emissions from power plants, or the added compliance costs to further decrease emissions beyond some baseline standard; and/or

2. The estimated cost of damages, such as medical expenses for asthma patients or the value of mortality risk, which attempts to measure willingness to pay for a small reduction in risk of dying due to air pollution.

VALUE: Crossborder (AZ) 2013 estimated the value of criteria air pollutant reductions, based on APS's Integrated Resource Plan, as $0.365/MWh, and NREL 2008 as $0.2-14/MWh (2012$). CPR (NJ/PA) 2012 and AE/CPR 2012 also acknowledged criteria air pollutants, but estimate cost based on a combined environmental value.

RESOURCES:

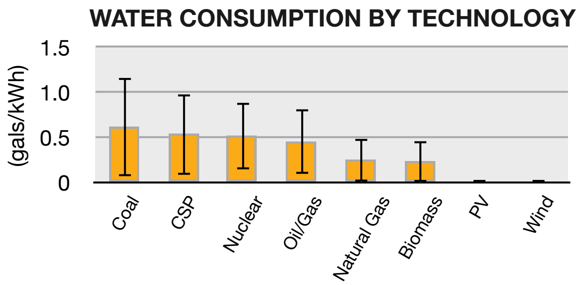
Epstein, P., Buonocore, J., Eckerle, K. et al., *Full Cost Accounting for the Life Cycle of Coal*, 2011.

Muller, N., Mendelsohn, R., Nordhaus, W., *Environmental Accounting for Pollution in the US Economy.* American Economic Review 101, Aug. 2011. pp. 1649 - 1675.

National Research Council. *Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use,* 2010.

WATER

SUMMARY: Coal and natural gas power plants withdraw and consume water primarily for cooling. Approaches to valuing reduced water usage have focused on the cost or value of water in competing sectors, potentially including municipal, agricultural, and environmental/recreational uses.



Source: Fthenakis

VALUE: The only study reviewed that explicitly values water reduction is Crossborder (AZ) 2013, which estimates a $1.084/MWh value based on APS's IRP.

RESOURCES:

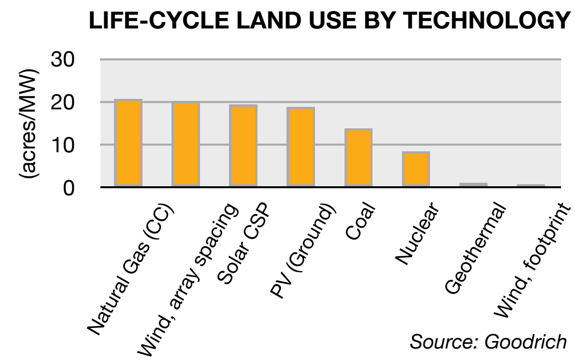
Tellinghulsen, S., *Every Drop Counts.* Western Resources Advocates, Jan. 2011.

Fthenakis, V., Hyungl, C., *Life-cycle Use of Water in U.S. Electricity Generation.* Renewable and Sustainable Energy Review 14, Sept. 2010. pp.2039-2048.

LAND

SUMMARY: DPV can impact land in three ways:

1. Change in property value with the addition of DPV;
2. Land requirement; or
3. Ecosystem impacts.



Source: Goodrich

VALUE: None of the studies reviewed explicitly estimate land impacts.

RESOURCES:

Goodrich et al. Residential, Commercial, and Utility Scale Photovoltaic (V) System Prices in the United States: Current Drivers and Cost-Reduction Opportunities. NREL. February 2012. Pages 14, 23—28

SOCIAL: ECONOMIC DEVELOPMENT

VALUE OVERVIEW

The assumed social value from DPV is based on any job and economic growth benefits that DPV brings to the economy, including jobs and higher tax revenue. The value of economic development depends on number of jobs created or displaced, as measured by a job multiplier, as well as the value of each job, as measured by average salary and/or tax revenue.

APPROACH OVERVIEW

Very few studies reviewed quantify employment and tax revenue value, although a number of them acknowledge the value. *CPR (NJ/PN) 2012* calculated job impact based on enhanced tax revenues associated with the net job creating for solar vs conventional power resources. The 2011 study included increased tax revenue, decreased unemployment, and increased confidence for business development economic growth benefits, but only quantified the tax revenue benefit.

IMPLICATIONS AND INSIGHTS

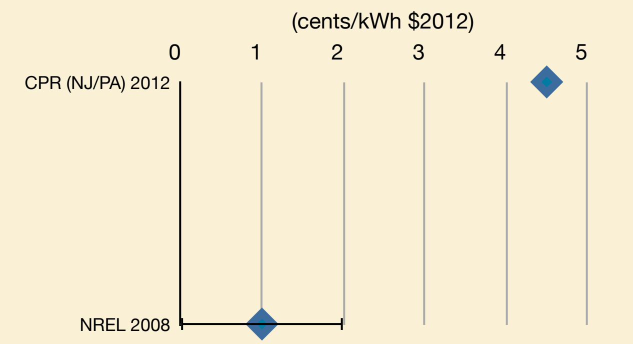
- There is significant variability in the range of job multipliers.
- Many of the jobs created from PV, particularly those associated with installation, are local, so there can be value to society and local communities from growth in quantity and quality of jobs available. The locations where jobs are created are likely not the same as where jobs are lost. While there could be a net benefit to society, some regions could bear a net cost from the transition in the job market.
- While employment and tax revenues have not generally been quantified in studies reviewed, E3 2011 recommends an input-output modeling approach as an adequate representation of this value.

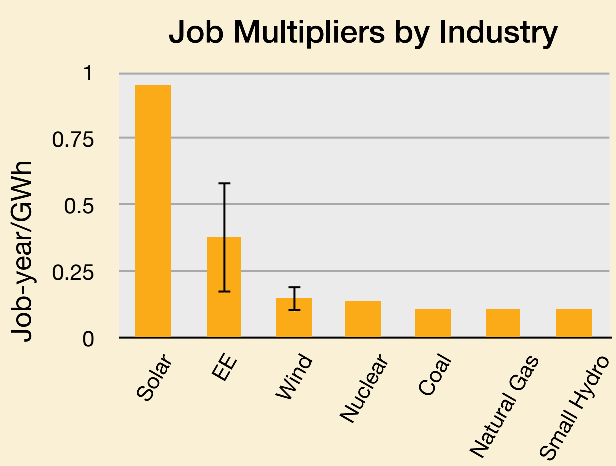
RESOURCES:

Wei, M., Patadia, S., and Kammen, D., Putting Renewables and Energy Efficiency to Work: How Many Jobs Can the Energy Industry Generate in the US? Energy Policy 38, 2010. pp. 919-931.

Brookings Institute, Sizing the Clean Economy: A National and Regional Green Jobs Assessment, 2011.

ECONOMIC DEVELOPMENT BENEFIT AND COST ESTIMATES AS REPORTED BY REVIEWED STUDIES





Sources: Wei, 2010

STUDY OVERVIEWS

04

RW Beck for Arizona Public Service, 2009

Distributed Renewable Energy Operating Impacts & Valuation Study

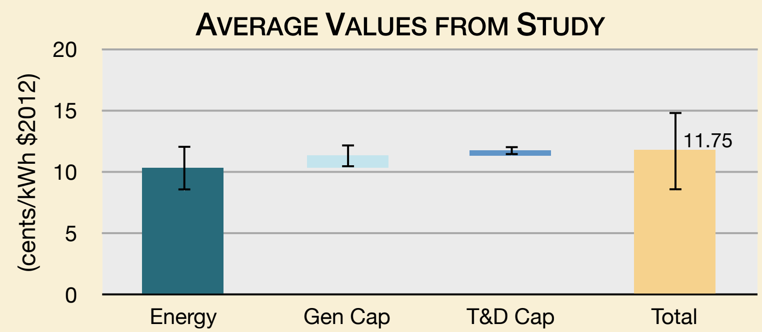
eLab Electricity Innovation Lab ROCKY MOUNTAIN INSTITUTE

System Characteristics	
STUDY OBJECTIVE	To determine the potential value of DPV for Arizona Public Service, and to understand the likely operating impacts.
GEOGRAPHIC FOCUS	Arizona Public Service territory
SYSTEM CONTEXT	Vertically integrated IOU, 15% RPS by 2025 with 30% distributed resource carveout
LEVEL OF SOLAR ANALYZED	0.2-16% by 2025 (by energy)
STAKEHOLDER PERSPECTIVE	Utility
GRANULARITY OF ANALYSIS	Feeder level, hourly, measures incremental value in 2010, 2015, and 2025
TOOLS USED	• ABB's Feeder-All • EPRI's Distribution System Simulator • PROMOD

Highlights

- The study approach combined system modeling, empirical testing, and information review, and represents one of the more technically rigorous approaches of reviewed studies.
- A key methodological assumption in the study is that generation, transmission, and distribution capacity value can only be given to DPV when it actually defers or avoids a planned investment. The implications are that a certain minimum amount of DPV must be installed in a certain time period (and in a certain location for distribution capacity) to create value.
- The study determines that total value decreases over time, primarily driven by decreasing capacity value. Increasing levels of DPV effectively pushes the system peak to later hours.
- The study acknowledged but did not quantify a number of other values including job creation, a more sustainable environment, carbon reduction, and increased worker productivity.

OVERVIEW OF VALUE CATEGORIES



**this chart represents the present value of 2025 incremental value, not a levelized cost*

Energy = Energy provides the largest source of value to the APS system. Value is calculated based on a PROMOD hourly commitment and dispatch simulation. DPV reduces fuel, purchased power requirements, line losses, and fixed O&M. The natural gas price forecast is based on NYMEX forward prices with adjustment for delivery to APS's system.

Generation capacity = There is little, but some, generation capacity value. Generation capacity value does not differ based on the geographic location of solar, but generation capacity investments are "lumpy", so a significant amount of solar is needed to displace it.

Capacity value includes benefits from reduced losses. Capacity value is determined by comparing DPV's dependable capacity (determined as the ELCC) to APS's generation investment plan.

T&D capacity = There is very little distribution capacity value, and what value exists comes from targeting specific feeders. Solar generation peaks earlier in the day than the system's peak load, DPV only has value if it is on a feeder that is facing an overloaded condition, and DPV's dependable capacity diminishes as solar penetration increases. Distribution value includes capacity, extension of service life, reduction in equipment sizing, and system performance issues.

There is little, but some, transmission capacity value since value does not differ based on the geographic location of solar, but transmission investments are "lumpy", so a significant amount of solar is needed to displaced it. Transmission value includes capacity and potential detrimental impacts to transient stability and spinning resources (i.e., ancillary services).

T&D capacity value includes benefits from reduced losses, modeled with a combination of hourly system-wide and feeder-specific modeling. T&D capacity value is determined by comparing DPV's dependable capacity to APS's T&D investment plan. For T&D, as compared to generation, dependable capacity is determined as the level of solar output that will occur with 90% confidence during the daily five hours of peak during summer months.

U-17302 ELPC/Rabago Exhibit KRR-3

SAIC for Arizona Public Service, 2013

2013 Updated Solar PV Value Report

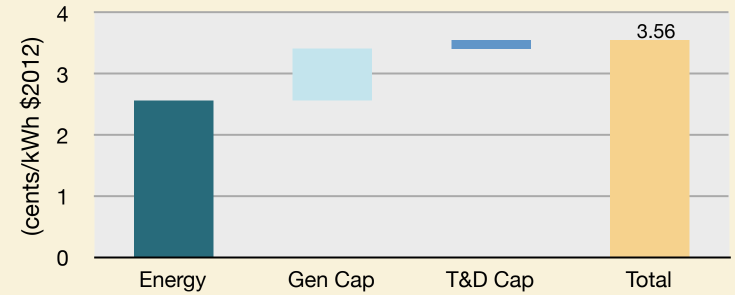
Electricity Innovation Lab
ROCKY MOUNTAIN INSTITUTE

Study Characteristics	
STUDY OBJECTIVE	To update the valuation of future DPV systems in the Arizona Public Service (APS) territory installed after 2012.
GEOGRAPHIC FOCUS	Arizona Public Service territory
SYSTEM CONTEXT	Vertically integrated IOU, 15% RPS by 2025 with 30% distributed resource carve out, peak extends past sunset
LEVEL OF SOLAR ANALYZED	4.5-16% by 2025 (by energy)
STAKEHOLDER PERSPECTIVE	Ratepayers
GRANULARITY OF ANALYSIS	Feeder level, hourly, measures incremental value in 2015, 2020, and 2025
TOOLS USED	• NREL's SAM 2.0 • EPRI's DSS Distribution Feeder Model • PROMOD

Highlights

- DPV provides less value than in APS's 2009 study, due to changing power market and system conditions. Energy generation and wholesale purchase costs have decreased due to lower natural gas prices. Expected CO2 costs are significantly lower due to decreased likelihood of Federal legislation. Load forecasts are lower, meaning reduced generation, distribution and transmission capacity requirements.
- The study notes the potential for increased value (primarily in T&D capacity) if DPV can be geographically targeted in sufficient quantities. However, it notes that actual deployment since the 2009 study does not show significant clustering or targeting.
- Like the 2009 study, capacity value is assumed to be based on DPV's ability to defer planned investments, rather than assuming every installed unit of DPV defers capacity.

OVERVIEW OF VALUE CATEGORIES



**this chart represents the present value of 2025 incremental value, not a levelized cost*

Energy = Energy provides the largest source of value to the APS system. Value is calculated based on a PROMOD hourly commitment and dispatch simulation. DPV reduces fuel, purchased power requirements, line losses, and fixed O&M. The natural gas price forecast is based on NYMEX forward prices with adjustment for delivery to APS's system. Energy losses are included as part of energy value, and unlike the 2009 report, are based on a recorded average energy loss.

Generation capacity = Generation capacity value is highly dependent on DPV's dependable capacity during peak. Generation capacity value is based on PROMOD simulations, and results in the deferral of combustion turbines. Benefits from avoided energy losses are included as part of capacity value, and unlike the 2009 report, are based on a recorded peak demand loss. Like the 2009 study, generation capacity value is based on an ELCC calculation.

T&D capacity = The study concludes that there are an insufficient number of feeders that can defer capacity upgrades based on non-targeted solar PV installations to determine measurable capacity savings. Distribution capacity savings can only be realized if distributed solar systems are installed at adequate penetration levels and located on specific feeders to relieve congestion or delay specific projects, but solar adoption has been geographically dispersed. Distribution value includes reduced losses, capacity, extended service life, and reduced equipment sizing.

Transmission capacity value is highly dependent on DPV's dependable capacity during peak. No transmission projects can be deferred more than one year, and none past the target years. As with the 2009 study, DPV dependable capacity for the purposes of T&D benefits is calculated based on a 90% confidence of generation during peak summer hours. Benefits from avoided energy losses are included.

CROSSBORDER ENERGY, 2013

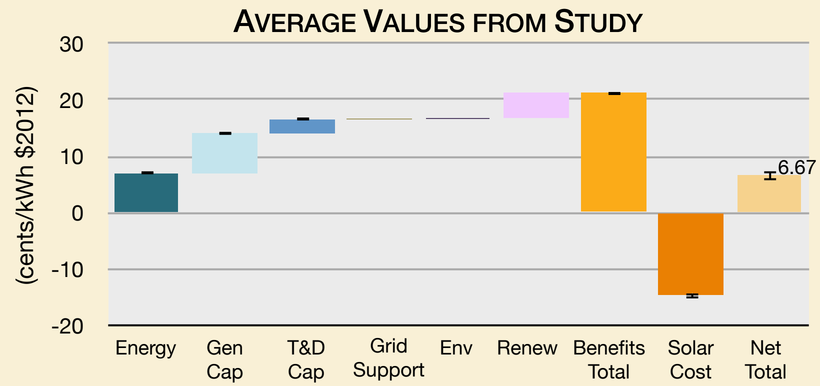
THE BENEFITS AND COSTS OF SOLAR DISTRIBUTED GENERATION FOR ARIZONA PUBLIC SERVICE

System Characteristics	
STUDY OBJECTIVE	To determine how demand-side solar will impact APS's ratepayers; a response to the APS 2013 study.
GEOGRAPHIC FOCUS	Arizona Public Service territory
SYSTEM CONTEXT	Vertically integrated IOU, 15% RPS by 2025
LEVEL OF SOLAR ANALYZED	DPV likely to be installed between 2013-2015; estimated here to be approximately 1.5%
STAKEHOLDER PERSPECTIVE	Ratepayers
GRANULARITY OF ANALYSIS	Derived from APS 2013
TOOLS USED	• Secondary analysis based on SAIC and APS detailed modeling

Highlights

- The benefits of DPV on the APS system exceed the cost by more than 50%. Key methodological differences between this study and the APS 2009 and 2013 studies include:
  - Determining value levelized over 20 years, as compared to incremental value in test years.
  - Crediting capacity value to every unit of solar DG installed, rather than requiring solar DG to be installed in "lumpy" increments.
  - Using ELCC to determine dependable capacity for generation, transmission, and distribution capacity values, as compared to using ELCC for generation capacity and a 90% confidence during peak summer hours for T&D capacity.
  - Focusing on solar installed over next few years years, rather than examining whether there is diminishing value with increasing penetration.
- The study notes that DPV must be considered in the context of efficiency and demand response—together they defer generation, transmission, and distribution capacity until 2017.

OVERVIEW OF VALUE CATEGORIES



Energy = Avoided energy costs are the most significant source of value. APS's long-term marginal resource is assumed to be a combustion turbine in peak months and a combined cycle in off-peak months, and avoided energy is based on these resources. The natural gas price forecast is based on NYMEX forward market gas prices, and the study determines that it adequately captures the fuel price hedge benefit. Key assumptions: $15/ton carbon adder, 12.1% line losses included in the energy value.

Generation capacity = Generation capacity value is calculated as DPV dependable capacity (based on DPV's near-term ELCC from APS's 2012 IRP) times the fixed costs of a gas combustion turbine. Every installed unit of DPV receives that capacity value, based on the assumption that, when coupled with efficiency and demand response, capacity would have otherwise been needed before APS's planned investment.

T&D capacity = T&D capacity value is calculated as DPV dependable capacity (ELCC) times APS's reported costs of T&D investments. Like generation capacity, every installed unit is credited with T&D capacity, with the assumption that 50% of distribution feeders can see deferral benefit. The study notes that APS could take a proactive approach to targeting DPV deployment, thereby increasing distribution value.

Grid Support (Ancillary services) = DPV in effect reduces load and therefore reduces the need for ancillary services that would otherwise be required, including spinning, non-spinning, and capacity reserves.

Environment = DPV effectively reduces load and therefore reduces environmental impacts that would otherwise be incurred. Lower load means reduced criteria air pollutant emissions and lower water use (carbon is included as an adder to energy value).

Renewable Value = DPV helps APS meet its Renewable Energy Standard, thereby lowering APS's compliance costs.

Solar Cost = Since the study takes a utility perspective, costs included are lost retail rate revenues, incentive payments, and integration costs.

E3 for California Public Utilities Commission, 2011

California Solar Initiative Cost-Effectiveness Evaluation

System Characteristics	
STUDY OBJECTIVE	"To perform a cost-effectiveness evaluation of the California Solar Initiative (CSI) in accordance with the CSI Program Evaluation Plan."
GEOGRAPHIC FOCUS	California
SYSTEM CONTEXT	Study: CSI program, retail net metering CA: 33% RPS, ISO market
LEVEL OF SOLAR ANALYZED	1,940 MW program goal (<1% of 2016 peak load)
STAKEHOLDER PERSPECTIVE	Participants (DPV customers), Ratepayers, Program Administrator, Total Resource, Society
GRANULARITY OF ANALYSIS	Hourly
TOOLS/APPROACH USED	• E3 avoided cost model (2011)

Highlights

- The study concludes that DPV is not expected to be cost-effective from a total resource or rate impact perspective during the study period, but that participant economics will not hinder CSI adoption goals. Program incentives support participant economics in the short-run, but DPV is expected to be cost-effective for many residential customers without program incentives by 2017. The study suggests that the value of non-economic benefits of DPV should be explored to determine if and how they provide value to California.

- The study focuses seven benefits including energy, line losses, generation capacity, T&D capacity, emissions, ancillary services, and avoided RPS purchases. It focuses on costs including net energy metering bill credits, rebates/incentives, utility interconnection, costs of the DG system, net metering costs, and program administration.

- The study assesses hourly avoided costs in each of California's 16 climate zones to reflect varying costs in those zones, and calculates benefits and costs as 20-year levelized values. It uses E3's avoided cost model.

OVERVIEW OF VALUE CATEGORIES

This study assesses overall cost-effectiveness based on five cost tests (participant cost test, ratepayer impact measure, program administrator cost, total resource cost, and societal cost) as defined in the California Standard Practices Manual, and presents total rather than itemized results. Therefore, individual results are not shown here in a chart.

Energy = Hourly wholesale value of energy measured at the point of wholesale energy transaction. Natural gas price is based on NYMEX forward market and then on a long-run forecast of natural gas prices.

Losses = Losses between the delivery location and the point of wholesale energy transaction. Losses scale with energy value, and reflect changing losses at peak periods.

Generation capacity = Value of avoiding new generation capacity (assumed to be a gas combustion turbine) to meet system peak loads, including additional capacity avoided due to decrease energy losses. DPV receives the full value of avoided capacity after the resource balance year. Value is less in the short-run (before the resource balance year) because of CAISO's substantial planning reserve margin.

T&D capacity = Value of deferring T&D capacity to meet peak loads.

Grid support services (ancillary services) = Value based on historical ancillary services market prices, scaled with the price of natural gas. Individual ancillary services included are regulation up, regulation down, spinning reserves, and non-spinning reserves, and value is based on how a load reduction affects the procurement of each AS.

Avoided RPS = Value is the incremental avoided cost of purchasing renewable resources to meet California's RPS.

Environmental = Value of CO_2 reduction, with $/ton price based on a meta-analysis of forecasts. Unpriced externalities (primarily health effects) were valued at $0.01-0.03/kWh based on secondary sources.

Social = The study acknowledges that customers who install DPV may also install more energy efficiency, but does not attempt to quantify that value. The study also acknowledges potential benefits associated with employment and tax revenues and suggests that an input-output model would be an appropriate approach, although these benefits are not quantified in this study.

ENERGY AND ENVIRONMENTAL ECONOMICS, INC. (E3), 2012

TECHNICAL POTENTIAL FOR LOCAL DISTRIBUTED PHOTOVOLTAICS IN CALIFORNIA

eLab Electricity Innovation Lab ROCKY MOUNTAIN INSTITUTE

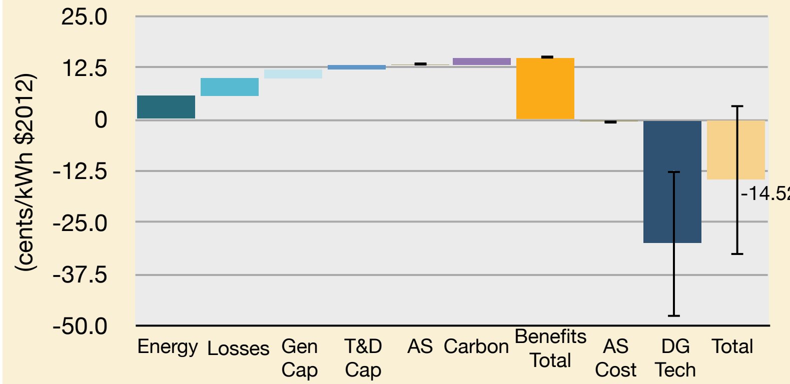
STUDY CHARACTERISTICS	
STUDY OBJECTIVE	To estimate the technical potential of local DPV in California, and the associated costs and benefits.
GEOGRAPHIC FOCUS	California
SYSTEM CONTEXT	California's 3 investor-owned utilities (IOU): PG&E, SDG&E, SCE
SOLAR PENETRATION LEVEL ANALYZED	15% of system peak load
STAKEHOLDER PERSPECTIVES	Total resource cost (TRC)
GRANULARITY OF ANALYSIS	1,800 substations
TOOLS USED	E3 Avoided Cost Calculator

Highlights

- Local DPV is defined as PV sized such that its output will be consumed by load on the feeder or substation where it is interconnected. Specifically, the generation cannot backflow from the distribution system onto the transmission system.
- The process for identifying sites included using GIS data to identify sites surrounding each of approximately 1,800 substations in PG&E, SDG&E and SCE. The study compared hourly load that the individual substation level to potential PV generation at the same location.
- Cost of local distributed PV increases significantly with Investment Tax Credit (ITC) expiration in 2017.
- When PV is procured on a least net cost basis, opportunities may exist to locate in areas with high avoided costs. In 2012, a least net cost procurement approach results in net costs that are approximately $65 million lower assuming avoided transmission and distribution costs can be realized. These benefits carry through to 2016 for the most part, but disappear by 2020, when all potential has been realized regardless of cost.

OVERVIEW OF VALUE CATEGORIES

AVERAGE VALUES FROM STUDY



Energy savings (Generation Energy) = Estimate of hourly wholesale value of energy adjusted for losses between the point of wholesale transaction and delivery. Annual forecast based on market forwards that transition to annual average market price needed to cover the fixed and operating costs of a new CCGT, less net revenue from day-ahead energy, ancillary service, and capacity markets. Hourly forecast derived based on historical hourly day-ahead market price shapes are from CAISO's MRTU system.

Losses (Line Losses) = The loss in energy from transmission and distribution across distance.

Generation capacity = In the long-run (after the resource balance year), generation capacity value is based on the fixed cost of a new CT less expected revenues from real-time energy and ancillary services markets. Prior to resource balance, value is based on a resource adequacy value.

T&D capacity = Value is based on the "present worth" approach to calculate deferment value, incorporating investment plans as reported by utilities.

Grid support services = Value based on the value of avoided reserves, scaling with energy.

Environmental benefits = Value of CO_2 emissions, based on an estimate of the marginal resource and a meta-analysis of forecasted carbon prices.

*E3's components of electricity avoided costs include generation energy, line losses, system capacity, ancillary services, T&D capacity, environment.

U-17302 ELPC/Rabago Exhibit KRR-3

CROSSBORDER ENERGY FOR VOTE SOLAR INITIATIVE, 2013

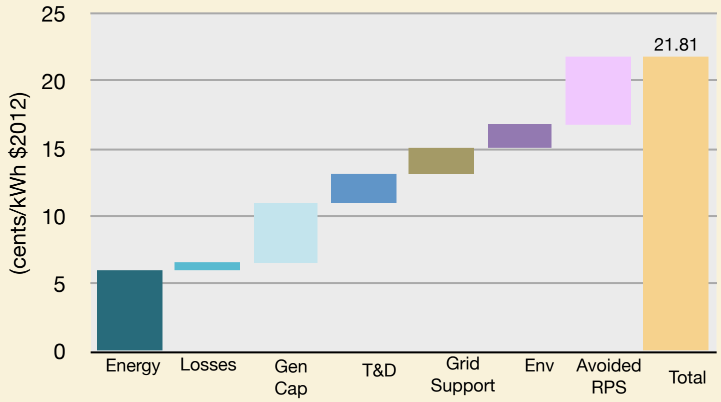
EVALUATING THE BENEFITS AND COSTS OF NET ENERGY METERING IN CALIFORNIA

Electricity Innovation Lab
ROCKY MOUNTAIN INSTITUTE

System Characteristics	
STUDY OBJECTIVE	"To explore recent claims from California's investor-owner utilities that the state's NEM policy causes substantial cost shifts between energy customers with Solar PV systems and non-solar customers, particularly in residential market."
GEOGRAPHIC FOCUS	California
SYSTEM CONTEXT	33% RPS, retail net metering, increasing solar penetration, ISO market
LEVEL OF SOLAR ANALYZED	Up to 5% of peak (by capacity)
STAKEHOLDER PERSPECTIVE	Other customers (ratepayers)
GRANULARITY OF ANALYSIS	Hourly, by climate zone
TOOLS USED	• E3 avoided cost model (2011), PVWatts

OVERVIEW OF VALUE CATEGORIES

AVERAGE VALUES FROM STUDY



Energy = Wholesale value of energy adjusted for losses between the point of the wholesale transaction and the point of delivery. Crossborder adjusted natural gas price forecast and greenhouse gas price forecast.

Losses = The loss in energy from transmission and distribution across distance.

Grid support services (ancillary services) = The marginal cost of providing system operations and reserves for electricity grid reliability. Crossborder updated assumed ancillary services revenues.

Environment = The cost of carbon dioxide emissions associated with the marginal generating resource.

Generation capacity = The cost of building new generation capacity to meet system peak loads. Crossborder does not use E3's "resource balance year" approach, which means that generation capacity value is based on long-run avoided capacity costs.

T&D capacity = The costs of expanding transmission and distribution capacity to meet peak loads.

Avoided RPS = The avoided net cost of procuring renewable resources to meet an RPS Portfolio that is a percentage of total retail sales due to a reduction in retail loads.

Highlights

- The study concludes that "on average over the residential markets of the state's three big IOUs, NEM does not impose costs on non-participating ratepayers, and instead creates a small net benefit." This conclusion is driven by "recent significant changes that the CPUC has adopted in IOUs' residential rate designs" plus "recognition that [DPV]...avoid other purchases or renewable power, resulting in a significant improvement in the economics of NEM compared to the CPUC's 2009 E3 NEM Study."
- The study focused on seven benefits: avoided energy, avoided generation capacity, reduced cost for ancillary services, lower line losses, reduced T&D investments, lower costs for the utility's purchase of other renewable generation, and avoided emissions. The study's analysis reflects costs to other customers (ratepayers) from "bill credits that the utility provides to solar customers as compensation for NEM exports, plus any incremental utility costs to meter and bill NEM customers." These costs are not quantified and levelized individually in the report, so they are not reflected in the chart to the right.
- The study bases its DPV value assessment on E3's avoided cost model and approach. It updates key assumptions including natural gas price forecast, greenhouse gas allowance prices, and ancillary services revenues, and excludes the resource balance year approach (the year in which avoided costs change from short-run to long-run). The study views the resource balance year as inconsistent with the modular, short lead-time nature of DPV.
- The study only considered the value of the exports to the grid under the utility's net metering program.

VOTE SOLAR INITIATIVE, 2005

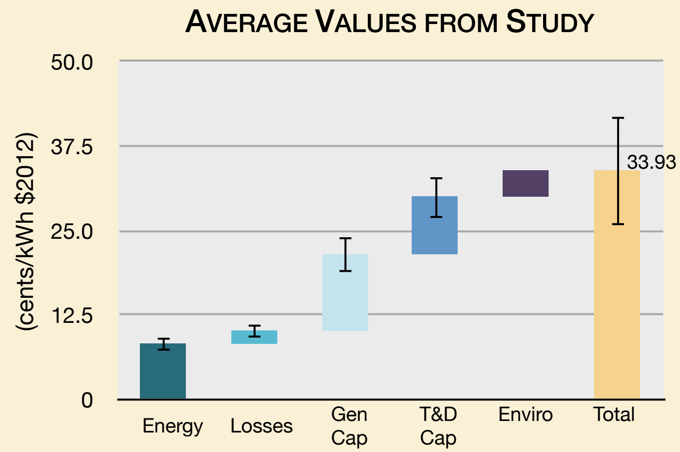
QUANTIFYING THE BENEFITS OF SOLAR POWER FOR CALIFORNIA

STUDY CHARACTERISTICS	
STUDY OBJECTIVE	To provide a quantitative analysis of key benefits of solar energy for California.
GEOGRAPHIC FOCUS	California
SYSTEM CONTEXT	California's 3 investor-owned utilities (IOU): PG&E, SDG&E, SCE
SOLAR PENETRATION LEVEL ANALYZED	Unspecified
STAKEHOLDER PERSPECTIVES	Utility, ratepayer, participant, society
GRANULARITY OF ANALYSIS	Average ELCC assumed to be 50% from range of 36%-70% derived from NREL study[1]
TOOLS USED	Spreadsheet analysis

Highlights

- The value of on-peak solar energy in 2005 ranged from $0.23 - 0.35 /kWh.
- The analysis looks at avoided costs under two alternative scenarios for the year 2005. The two scenarios vary the cost of developing new power plants and the price of natural gas.
  - Scenario 1 assumed new peaking generation will be built by the electric utility at a cost of capital of 9.5% with cost recovery over a 20 year period; the price of natural gas is based on the 2005 summer market price (average gas price)
  - Scenario 2 assumed new peaking generation will be built by a merchant power plant developer at a cost of capital of 15% with cost recovery over a 10 year period; the price of natural gas is based on the average gas price in California for the period of May 2000 through June 2001 (high gas price – 24% higher)
- While numerous unquantifiable benefits were noted, five benefits were quantified:
  - 1. deferral of investments in new peaking power capacity
  - 2. avoided purchase of natural gas used to produce electricity
  - 3. avoided emissions of CO_2 and NOx that impact global climate and local air quality
  - 4. reduction in transmission and distribution system power losses
  - 5. deferral of transmission and distribution investments that would be needed to meet growing loads.
- The study assumed that, "in California, natural gas is the fuel used by power plants on the margin both for peak demand periods and non-peak periods. Therefore it is reasonable to assume the solar electric facilities will displace the burning of natural gas in all hours that they produce electricity."

OVERVIEW OF VALUE CATEGORIES



Energy (Avoided Fuel and Variable O&M) = Natural gas fuel price multiplied by assumed heat rate of peaking power plant (9360 MMBTU/ kWh). Assumed value of consumables such as water and ammonia to be approximately 0.5 cents/kWh. For non-peak, average heat rates of existing fleet of natural gas plants were used for each electric utility's service area. Those heat rates are as follows: PG&E: 8740 MMBTU/ kWh, SCE - 9690 MMBTU/kWh, SDG&E – 9720 MMBTU/kWh.

Losses (Line Losses) = Solar assumed to be delivered at secondary voltage. The summer peak and the summer shoulder loss factors are used to calculate the additional benefit derived from solar power systems because of their location at load.

Generation capacity = Cost of installing a simple cycle gas turbine peaking plant multiplied by DPV's ELCC and a capital recovery factor, converted into costs per kilowatt hour by expected hours of on-peak operation.

T&D capacity = One study area was selected for each utility to calculate the value of solar electricity in avoiding T&D upgrades. to simplify the analysis the need for T&D upgrades was assumed to be driven by growth in demand during 5% of the hours in a year. The 50% ELCC was used used in calculating the value of avoided T&D upgrades.

Environmental benefits = Assumed to be the avoided air emissions, carbon dioxide and NOx, created from marginal generator (natural gas). CO_2 = $100/ton; NOx = $.014/kWh

1 "Solar Resource-Utility Load-Matching Assessment," Richard Perez, National Renewable Energy Laboratory, 1994

RICHARD DUKE, ENERGY POLICY, 2005

ACCELERATING RESIDENTIAL PV EXPANSION: DEMAND ANALYSIS FOR COMPETITIVE ELECTRICITY MARKETS

Study Characteristics	
STUDY OBJECTIVE	To quantify the potential market for grid-connected, residential PV electricity integrated into new houses built in the US.
GEOGRAPHIC FOCUS	California and Illinois
SYSTEM CONTEXT	California: 33% RPS, mostly gas generation; Illinois: mostly coal generation
LEVEL OF SOLAR ANALYZED	not stated; assumed low
STAKEHOLDER PERSPECTIVE	System
GRANULARITY OF ANALYSIS	High level, largely based on secondary analysis
TOOLS USED	• n/a

Highlights

- Total value varies significantly between the two regions studied largely driven by what the off-peak marginal resource is (gas vs coal). Coal has significantly higher air pollution costs, although lower fuel costs.
- The study notes that true value varies dramatically with local conditions, so precise calculations at a high-level analysis level are impossible. As such, transmission and distribution impacts were acknowledged but not included.

OVERVIEW OF VALUE CATEGORIES

AVERAGE VALUES FROM STUDY

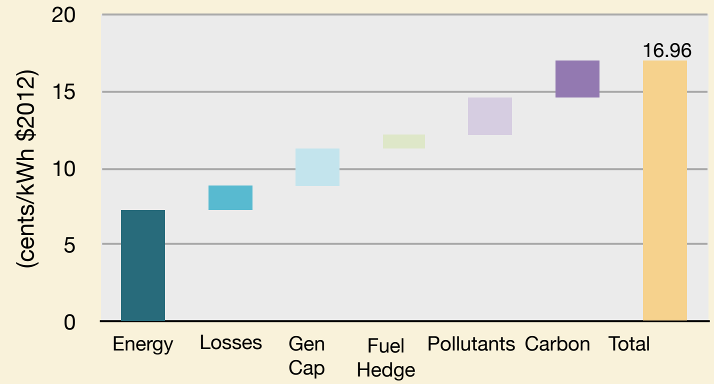


**Chart data only reflects California assessment for comparison*

Energy = Energy value is based on the marginal resource on-peak (gas combustion turbine) and off-peak (inefficient gas in California, and coal in Illinois). Fuel prices are based on Energy Information Administration projections, and levelized.

Losses = Energy losses are assumed to be 7-8% off-peak, and up to twice that on-peak. Losses are only included as energy losses.

Generation capacity = Generation capacity value is based on the assumption that the marginal resource is always a gas combustion turbine. Dependable capacity is based on an ELCC estimate from secondary sources.

Financial (Fuel price hedge) = Hedge value is estimated based on the market value to utilities of a fixed natural gas price for up to 10 years based on market swap data. The hedge is assumed to be additive since EIA gas prices were used rather than NYMEX futures market.

Environment (criteria air pollutants, carbon) = Criteria air pollutant reduction value is based on avoided costs of health impacts, estimated by secondary sources. Carbon value is the price of carbon (estimated based on European market projections) times the amount of carbon displaced.

LAWRENCE BERKELEY NATIONAL LAB, 2012

CHANGES IN THE ECONOMIC VALUE OF VARIABLE GENERATION AT HIGH PENETRATION LEVELS: A PILOT CASE STUDY OF CALIFORNIA

Electricity Innovation Lab
ROCKY MOUNTAIN INSTITUTE

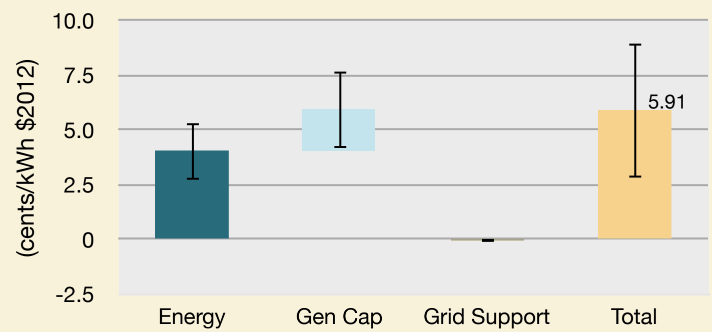
Study Characteristics	
STUDY OBJECTIVE	To quantify the change in value for a subset of economic benefits (energy, capacity, ancillary services, DA forecasting error) that results from using renewable generation technologies (wind, PV, CSP, & Thermal Energy Storage) at different penetration levels.
GEOGRAPHIC FOCUS	Loosely based on California
SYSTEM CONTEXT	33% RPS, ISO market
LEVEL OF SOLAR ANALYZED	Up to 40% (by energy)
STAKEHOLDER PERSPECTIVE	System
GRANULARITY OF ANALYSIS	Long-run investment decisions and short-term dispatch and operations
TOOLS USED	• Customized model

Highlights

- The marginal economic value of solar exceeds the value of flat block power at low penetration levels, largely attributable to generation capacity value and solar coincidence with peak.
- The marginal value of DPV drops considerably as the penetration of solar increases, initially, driven by a decrease in capacity value with increasing solar generation. At the highest renewable penetrations considered, there is also a decrease in energy value as PV displaces lower cost resources.
- The study notes that it is critical to use an analysis framework that addresses long-term investment decisions as well as short-term dispatch and operational constraints.
- Several costs and impacts are not considered in the study, including environmental impacts, transmission and distribution costs or benefits, effects related to the lumpiness and irreversibility of investment decisions, uncertainty in future fuel and investment capital costs, and DPV's capital cost.

OVERVIEW OF VALUE CATEGORIES

AVERAGE VALUES FROM STUDY



Energy = Energy value decreases at high penetrations because the marginal resource that DPV displaces changes as the system moves down the dispatch stack to a lower cost generator. Energy value is based on the short-run profit earned in non-scarcity hours (those hours where market prices are under $500/MWh), and generally displaces energy from a gas combined cycle. Fuel costs are based on Energy Information Administration projections.

Generation capacity = Generation capacity value is based on the portion of short-run profit earned during hours with scarcity prices (those hours where market price equals or exceeds $500/MWh). Dependable DPV capacity is based on an implied capacity credit as a result of the model's investment decisions, rather than a detailed reliability or ELCC analysis.

Grid Support (Ancillary Services) = Ancillary services value is the net earnings from selling ancillary services in the market as well as paying for increased ancillary services due to increased short-term variability and uncertainty.

Clean Power Research, 2012

The Value of Distributed Solar Electric Generation To New Jersey and Pennsylvania

Electricity Innovation Lab
ROCKY MOUNTAIN INSTITUTE

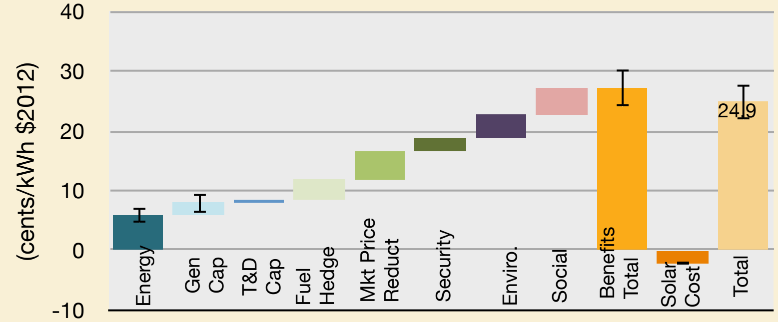
Study Characteristics	
Study Objective	To quantify the cost and value components provided to utilities, ratepayers, and taxpayers by grid-connected, distributed PV in Pennsylvania and New Jersey.
Geographic Focus	7 cities across PA and NJ
System Context	PJM ISO
Solar Penetration Level Analyzed	15% of system peak load, totaling 7 GW across the 7 utility hubs
Stakeholder Perspectives	Utility, ratepayers, taxpayer
Granularity of Analysis	Locational Marginal Price node
Tools Used	Clean Power Research's Distributed PV Value Calculator; Solar Anywhere, 2012

Highlights

- The study evaluated 10 benefits and 1 cost. Evaluated benefits included: Fuel cost savings, O&M cost savings, security enhancement, long term societal benefit, fuel price hedge, generation capacity, T&D capacity, market price reduction, environmental benefit, economic development benefit. The cost evaluated was the solar penetration cost.
- The analysis represents the value of PV for a "fleet" of PV systems, evaluated in 4 orientations, each at 7 locations (Pittsburgh, PA; Harrisburg, PA; Scranton, PA; Philadelphia, PA; Jamesburg, NJ; Newark, NJ; and Atlantic City, NJ), spanning 6 utility service territories, each differing by: cost of capital, hourly loads, T&D loss factors, distribution expansion costs, and growth rate.
- The total value ranged from $256 to $318/MWh. Of this, the highest value components were the Market Price Reduction (avg $55/MWh) and the Economic Development Value (avg $44/MWh).
- The moderate generation capacity value is driven by a moderate match between DPV output and utility system load. The effective capacity ranges from 28% to 45% of rated output (in line with the assigned PJM value of 38% for solar resources).
- Loss savings were not treated as a stand-alone benefit under the convention used in this methodology. Rather, the effect of loss savings is included separately for each value component.

Overview of Value Categories

Average Values from Study



Energy savings (Fuel cost savings + O&M Cost Savings) = PV output plus loss savings times marginal energy cost, summed all hrs of the year, discounted over PV life (30 years). Marginal energy costs are based on fuel and O&M costs of the generator most likely operating on the margin (assumed to be a combined cycle gas turbine). Assumed natural gas price forecast: NYMEX futures years 0-12; NYMEX futures price for year 12 x 2.33% escalation factor. Escalation rate assumed to be rate of wellhead price escalation from 1981-2011.

Generation capacity = Capital cost of displace generation times PV's effective load carrying capability (ELCC), taking into account loss savings.

T&D capacity = Expected long-term T&D system capacity upgrade cost, divided by load growth, times financial term, times a factor that represents match between PV system output (adjusted for losses) and T&D system load. In this study, T&D values were based on utility-wide average loads, which may obscure higher value areas.

Fuel price hedge value = Cost to eliminate the fuel price uncertainty associated with natural gas generation through procurement of commodity futures. The value is directly related to the utility's cost of capital.

Market Price Reduction = Value to customers of the reduced cost of wholesale energy as a result of PV installation decreasing the demand for wholesale energy. Quantified through an analysis of the supply curve and reduction in demand, and the accompanying new market clearing price.

Security (Security Enhancement Value) = Annual cost of power outages in the U.S. times the percent (5%) that are high-demand stress type that can be effectively mitigated by distributed PV at a capacity penetration of 15%.

Social (Economic Development Value) = Value of tax revenues associated with net job creation for solar vs conventional power generation. PV hard and soft cost /kW times portion of each attributed to local jobs, divided by annual PV system energy produced, minus CCGT cost/kW times portion attributed to local jobs divided by annual energy produced. Levelized over the 30 year lifetime of PV system, adjusted for lost utility jobs, multiplied by tax rate of a $75K salary, multiplied by indirect job multiplier.

Environmental benefits = Environmental cost of a displaced conventional generation technology times the portion of this technology in the energy generation mix, repeated and summed for each conventional generation sources displaced by PV. Environmental cost for each generation source based on costs of GHG, SOx / NOx emissions, mining degradations, ground-water contamination, toxic releases and wastes. etc...as calculated in several environmental health studies.

CLEAN POWER RESEARCH & SOLAR SAN ANTONIO, 2013

THE VALUE OF DISTRIBUTED SOLAR ELECTRIC GENERATION TO SAN ANTONIO

Electricity Innovation Lab
ROCKY MOUNTAIN INSTITUTE

System Characteristics	
STUDY OBJECTIVE	To quantify the value provided by grid-connected, distributed PV in San Antonio from a utility perspective.
GEOGRAPHIC FOCUS	CPS Energy territory
SYSTEM CONTEXT	Municipal utility
LEVEL OF SOLAR ANALYZED	1.1-2.2% of peak load (by capacity)
STAKEHOLDER PERSPECTIVE	Utility
GRANULARITY OF ANALYSIS	Single marginal resource assumed, ELCC approach
TOOLS USED	• SolarAnywhere • PVSimulator • DGValuator

Highlights

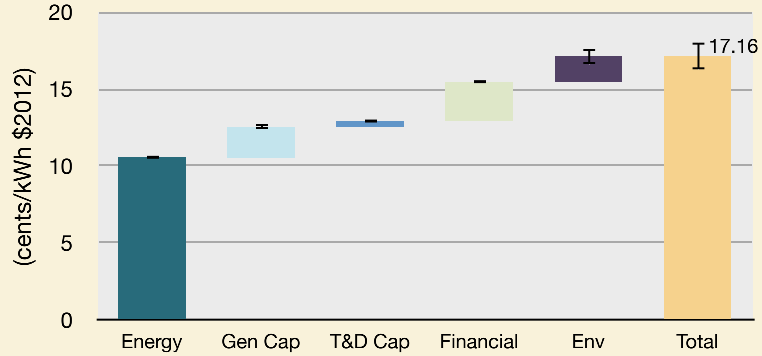
- The study concludes that DPV provides significant value to CPS Energy, primarily driven by energy, generation capacity deferment, and fuel price hedge value. The study is based solely on publicly-available data; it notes that results would be more representative with actual financial and operating data. Value is a levelized over 30 years.

- The study notes that value likely decreases with increasing penetration, although higher penetration levels needed to estimate this decrease were not analyzed.

- The study acknowledged but did not quantify a number of other values including climate change mitigation, environmental mitigation, and economic development.

OVERVIEW OF VALUE CATEGORIES

AVERAGE VALUES FROM STUDY



Energy = The study shows high energy value compared to other studies, driven by using EIA's "advanced gas turbine" with a high heat rate as the marginal resource. The natural gas price forecast is based on NYMEX forward market gas prices, then escalated at a constant rate. Energy losses are included in energy value, and are calculated on an hourly marginal basis.

Generation capacity = Generation capacity value is DPV's dependable capacity times the fixed costs of an "advanced gas turbine", assumed to be the marginal resource. Dependable capacity based on ELCC; the reported ELCC is significantly higher than other studies. Every installed unit of DPV is given generation capacity value.

T&D capacity = The study takes a two step approach: first, an economic screening to determine expansion plan costs and load growth expectations by geographic area, and second, to assess the correlation of DPV and load in the most promising locations.

Financial (Fuel price hedge) = The study estimates hedge value as a combination of two financial instruments, risk-free zero-coupon bonds and a set of natural gas futures contracts, to represent the avoided cost of reducing fuel price volatility risk.

Environmental = The study quantified environmental value, as shown in the chart above, but did not include it in its final assessment of benefit since the study was from the utility perspective.

AUSTIN ENERGY & CLEAN POWER RESEARCH, 2006

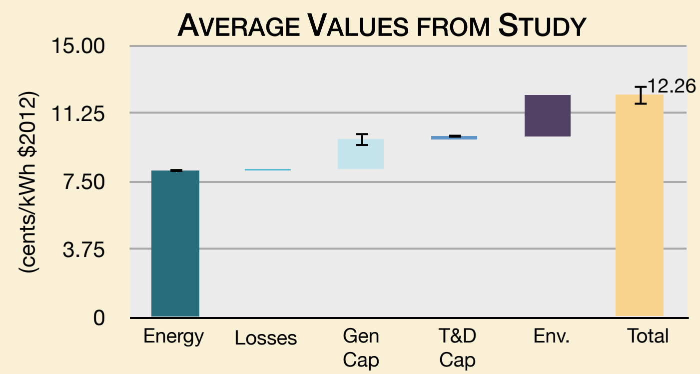
THE VALUE OF DISTRIBUTED PHOTOVOLTAICS IN AUSTIN ENERGY AND THE CITY OF AUSTIN

STUDY CHARACTERISTICS	
STUDY OBJECTIVE	To quantify the comprehensive value of DPV to Austin Energy (AE) in 2006 and document methodologies to assist AE in performing analysis as conditions change and apply to other technologies
GEOGRAPHIC FOCUS	Austin, TX
SYSTEM CONTEXT	Municipal utility
SOLAR PENETRATION LEVEL ANALYZED	2%* system peak load
STAKEHOLDER PERSPECTIVES	Utility, ratepayer, participant, society
GRANULARITY OF ANALYSIS	PV capacity value (ELCC) calculated system wide; Distribution expansion
TOOLS USED	CPR internal analysis; satellite solar data; PVFORM 4.0 for solar simulation; AE's load flow analysis for T&D losses

Highlights

- The study evaluated 7 benefits–energy production, line losses, generation capacity, T&D capacity, reactive power control (*grid support*), environment, natural gas price hedge (*financial*), and disaster recovery (*security*).
- The analysis assumed a 15 MW system in 7 PV system orientations, including 5 fixed and 2 single-axis.
- Avoided energy costs are the most significant source of value (about two-thirds of the total value), which is highly sensitive to the price of natural gas.
- Distribution capacity deferral value was relatively minimal. AE personnel estimated that 15% of the distribution capacity expansion plans have the potential to be deferred after the first ten years (assuming growth rates remain constant). Therefore, the study assumed that currently budgeted distribution projects were not deferrable, but the addition of PV could possibly defer distribution projects in the 11th year of the study period.
- Two studied values were excluded from the final results:
  - While reactive power benefits was estimated, the value ($0-$20/kW) was assumed not to justify the cost of the inverter that would be required to access the benefit. (The estimated cost was not included.)
  - The value of disaster recovery could be significant but more work is needed before this value can be explicitly captured.

OVERVIEW OF VALUE CATEGORIES



Energy = PV output plus loss savings times marginal energy cost. Marginal energy costs are based on fuel and O&M costs of the generator most likely operating on the margin (typically, a combined cycle gas turbine).

Losses = Computed differently depending upon benefit category. For all categories, loss savings are calculated hourly on the margin.

Generation capacity = Cost of capacity times PV's effective load carrying capability (ELCC), taking into account loss savings.

Financial (Fuel price hedge value) = Cost to eliminate the fuel price uncertainty associated with natural gas generation through procurement of commodity futures. Fuel price hedge value is included in the energy value.

T&D capacity = Expected long-term T&D system capacity upgrade cost, divided by load growth, times financial term, times a factor that represents match between PV system output (adjusted for losses) and T&D system load.

Environmental benefits = PV output times REC price—the incremental cost of offsetting a unit of conventional generation.

*ELCC was evaluated from 0%-20%; however, the ELCC estimate for 2% penetration was used in final value.

AUSTIN ENERGY & CLEAN POWER RESEARCH, 2012

DESIGNING AUSTIN ENERGY'S SOLAR TARIFF USING A DISTRIBUTED PV CALCULATOR

Electricity Innovation Lab
ROCKY MOUNTAIN INSTITUTE

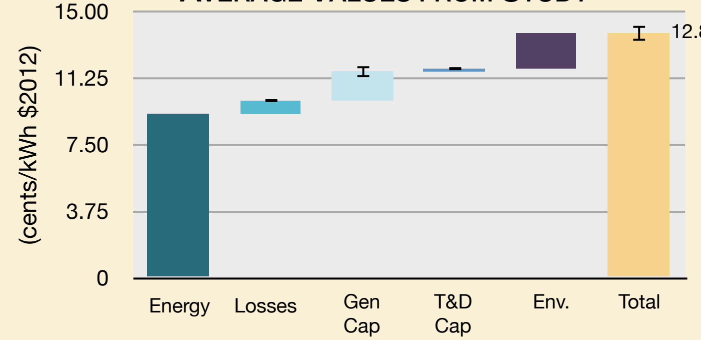
STUDY CHARACTERISTICS	
STUDY OBJECTIVE	To design a residential solar tariff based on the value of solar energy generated from DPV systems to Austin Energy
GEOGRAPHIC FOCUS	Austin, TX
SYSTEM CONTEXT	Municipal utility with access to ISO (ERCOT)
SOLAR PENETRATION LEVEL ANALYZED	Assumed to be 2012 levels of penetration (5 MW)[1] <0.5% penetration by energy[2]
STAKEHOLDER PERSPECTIVES	Utility
GRANULARITY OF ANALYSIS	Assumed to replicate granularity of AE/CPR 2006 study
TOOLS USED	Clean Power Research's Distributed PV Value Calculator; Solar Anywhere, 2012

Highlights

- The study focused on 6 benefits–energy, generation capacity, fuel price hedge value (included in energy savings), T&D capacity, and environmental benefits–which represent "a 'break-even' value...at which the utility is economically neutral to whether it supplies such a unit of energy or obtains it from the customer." The approach, which builds on the 2006 CPR study, is "an avoided cost calculation at heart, but improves on [an avoided cost calculation]... by calculating a unique, annually adjusted value for distributed solar energy."
- The fixed, south-facing PV system with a 30-degree tilt, the most common configuration and orientation in AE's service territory of approximately 1,500 DPV systems, was used as the reference system.
- As with the AE/CPR 2006 study, avoided energy costs are the most significant source of value, which is very sensitive to natural gas price assumptions.
- The levelized value of solar was calculated to total $12.8/kWh.
- Two separate calculation approaches were used to estimate the near term and long term value, combined to represent the "total benefits of DPV to Austin Energy" over the life time of a DPV system.
  - For the the near term (2 years) value of DPV energy, A PV output weighted nodal price was used to try to capture the relatively good correlation between PV output and electricity demand (and high price) that is not captured in the average nodal price.
  - To value the DPV energy produced during the mid and long term–through the rest of the 30-year assumed life of solar PV systems–the typical value calculator methodology was used.

OVERVIEW OF VALUE CATEGORIES

AVERAGE VALUES FROM STUDY



Energy = PV output plus loss savings times marginal energy cost. Marginal energy costs are based on fuel and O&M costs of the generator most likely operating on the margin (typically, a combined cycle gas turbine).

Losses = Computed differently depending upon benefit category. For all categories, loss savings are calculated hourly on the margin.

Generation capacity = Cost of capacity times PV's effective load carrying capability (ELCC), taking into account loss savings.

Fuel price hedge value = Cost to eliminate the fuel price uncertainty associated with natural gas generation through procurement of commodity futures. Fuel price hedge value is included in the energy value.

T&D capacity = Expected long-term T&D system capacity upgrade cost, divided by load growth, times financial term, times a factor that represents match between PV system output (adjusted for losses) and T&D system load.

Environmental benefits = PV output times Renewable Energy Credit (REC) price—the incremental cost of offsetting a unit of conventional generation.

1 http://www.austinenergy.com/About%20Us/Newsroom/Reports/solarGoalsUpdate.pdf
2 http://www.austinenergy.com/About%20Us/Newsroom/Reports/2012AnnualPerformanceReportDRAFT.pdf

U-17302 ELPC/Rabago Exhibit KRR-3

NAVIGANT CONSULTING FOR NREL, 2008

PHOTOVOLTAICS VALUE ANALYSIS

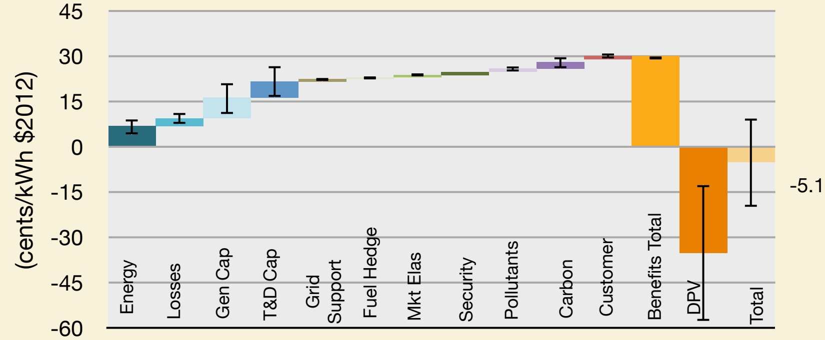
Study Characteristics	
STUDY OBJECTIVE	To summarize and describe the methodologies and range of values for the costs and values of 19 services provided or needed by DPV from existing studies.
GEOGRAPHIC FOCUS	Studies reviewed reflected varying geographies; case studies from TX, CA, MN, WI, MD, NY, MA, and WA
SYSTEM CONTEXT	n/a
LEVEL OF SOLAR ANALYZED	n/a
STAKEHOLDER PERSPECTIVE	Participating customers, utilities, ratepayers, society
GRANULARITY OF ANALYSIS	n/a
TOOLS USED	• Custom-designed Excel tool to compare results and sensitivities

Highlights

- There are 19 key values of distributed PV, but the study concludes that only 6 have significant benefits (energy, generation capacity, T&D costs, GHG emissions, criteria air pollutant emissions, and implicit value of PV).
- Deployment location and solar output profile are the most significant drivers of DPV value.
- Several values require additional R&D to establish a standardized quantification methodology.
- Value can be proactively increased.

OVERVIEW OF VALUE CATEGORIES

AVERAGE VALUES FROM STUDY



Energy = Energy value is fuel cost times the heat rate plus operating and maintenance costs for the marginal power plant, generally assumed to be natural gas.

Losses = Avoided loss value is the amount of loss associated with energy, generation capacity, T&D capacity, and environmental impact, times the cost of that loss.

Generation capacity = Generation capacity value is the capital cost of the marginal power plant times the dependable capacity (ELCC) of DPV.

T&D capacity = T&D capacity value is T&D investment plan costs times the value of money times the dependable capacity, divided by load growth, levelized.

Grid support services (Ancillary Services) = Ancillary services include VAR support, load following, operating reserves, and dispatch and scheduling. PV is unlikely to be able to provide all of these.

Financial (Fuel price hedge, Market price response) = Hedge value is the cost to guarantee a portion of electricity costs are fixed. Reduced demand for electricity decreases the price of electricity for all customers and creates a customer surplus.

Security = Customer reliability in the form of increased outage support can be realized, but only when DPV is coupled with storage.

Environment (Criteria air pollutants, Carbon) = Value is either the market value of penalties or costs, or the value of avoided health costs and shortened lifetimes. Carbon value is the emission intensity of the marginal resource times the value of emissions.

Customer = Value to customer of having green option, as indicate by their willingness to pay.

DPV cost = Costs include capital cost of equipment plus fixed operating and maintenance costs.

SOURCES

05

U-17302 ELPC/Rabago Exhibit KRR-3

STUDIES REVIEWED IN ANALYSIS

eLab Electricity Innovation Lab ROCKY MOUNTAIN INSTITUTE

Study	Funded / Commissioned by	Prepared by
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Beach, R., McGuire, P., *Evaluating the Benefits and Costs of Net Energy Metering for Residential Customers in California.* Crossborder Energy, Jan. 2013.	Vote Solar Initiative	Crossborder Energy
Rabago, K., Norris, B., Hoff, T., *Designing Austin Energy's Solar Tariff Using A Distributed PV Calculator.* Clean Power Research & Austin Energy, 2012.	Austin Energy	Clean Power Research & Solar San Antonio
Perez, R., Norris, B., Hoff, T., *The Value of Distributed Solar Electric Generation to New Jersey and Pennsylvania.* Clean Power Research, 2012.	The Mid-Atlantic Solar Energy Industries Association, & The Pennsylvania Solar Energy Industries Association	Clean Power Research
Mills, A., Wiser, R., *Changes in the Economic Value of Variable Generation at High Penetration Levels: A Pilot Case Study of California*. Lawrence Berkeley National Laboratory, June 2012.	DOE office of Energy Efficiency and Renewable Energy and Office of Electricity Delivery and Energy Reliability	Lawrence Berkeley National Laboratory
Energy and Environmental Economics, Inc. Technical Potential for Local Distributed Photovoltaics in California, Preliminary Assessment. March 2012.	California Public Utilities Commission	Energy and Environmental Economics, Inc. (E3)
Energy and Environmental Economics, Inc.California Solar Initiative Cost-Effectiveness Evaluation. April 2011.	California Public Utilities Commission	Energy and Environmental Economics, Inc. (E3)
R.W. Beck, Arizona Public Service, *Distributed Renewable Energy Operating Impacts and Valuation Study.* Jan. 2009.	Arizona Public Service	R.W. Beck, Inc with Energized Solutions, LLC, Phasor Energy Company, Inc, & Summit Blue Consulting, LLC
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Contreras, J.L., Frantzis, L., Blazewicz, S., Pinault, D., Sawyer, H., *Photovoltaics Value Analysis.* Navigant Consulting, Feb, 2008.	National Renewable Energy Laboratory	Navigant Consulting, Inc.
Hoff, T., Perez, R., Braun, G., Kuhn, M., Norris, B., *The Value of Distributed Photovoltaics to Austin Energy and the City of Austin.* Clean Power Research, March 2006.	Austin Energy	Clean Power Research
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