SHINING REWARDS

The Value of Rooftop Solar Power for Consumers and Society

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Executive Summary

Solar energy is on the rise in the United States. At the end of the first quarter of 2015, more than 21,300 megawatts of cumulative solar electric capacity had been installed around the country, enough to power more than 4.3 million homes. The rapid growth of solar energy in the United States is the result of forward-looking policies that are helping the nation reduce its contribution to global warming and expand its use of local renewable energy sources.

One policy in particular, net energy metering, has been instrumental in the growth of solar energy, particularly on homes and businesses. Net energy metering enables solar panel owners to earn fair compensation for benefits they provide to other users of the electricity grid, and makes "going solar" an affordable option for more people. Net energy metering works by providing customers a credit on their electric bill that offsets charges for energy consumption. As solar energy has taken off in recent years, however, utilities and other special interests have increasingly attacked net metering as an unjustified "subsidy" to solar users.

A review of 11 recent analyses shows that individuals and businesses that decide to "go solar" generally deliver greater benefits to the grid and society than they receive through net metering.

Decision-makers should recognize the great value delivered by distributed solar energy by preserving and expanding access to net metering and other programs that ensure fair compensation to Americans who install solar energy.

Net metering is not a new idea. It has been the policy in some states for more than 30 years. The concept has been tested in the courts and in regulatory proceedings in the states and at federal agencies like the Federal Energy Regulatory Commission and the Internal Revenue Service. Net metering is the law of the land in 44 states today.

Net metering has been critical to solar energy's rapid expansion in the United States.

- Net metering offsets costs for solar panel owners and credits them for providing excess power to the grid at a set price (often the retail electricity rate) – equivalent to allowing consumers' meters to "run backwards."
- Net metering is conceptually simple, easy to administer, and ensures that customers receive compensation that tracks with electricity prices over time.
- Net metering also makes solar energy more economically attractive for residents and businesses.

Solar energy creates many benefits for the electricity grid.

- **Avoided energy costs**: Solar energy systems produce clean, renewable electricity on-site, reducing the amount of electricity utilities must generate or purchase from fossil fuel-fired power plants. In addition, solar photovoltaic (PV) systems reduce the amount of energy lost in generation, long-distance transmission and distribution. These losses cost the country millions of dollars every year.
- **Avoided capital and capacity investment:** By reducing overall demand for electricity, solar energy production helps ratepayers and utilities avoid the cost of investing in new power plants, transmission lines and other forms of electricity infrastructure.
- **Reduced financial risks and electricity prices:** Because the price of solar energy tends to be stable over time, while the price of fossil fuels can fluctuate sharply, integrating more solar energy into the grid reduces consumers' exposure to volatile fossil fuel prices. Also, by reducing demand for energy from the grid, solar PV systems reduce its price, saving money for all ratepayers.
- **Increased grid resiliency:** Increasing distributed solar PV decentralizes the grid, potentially safeguarding people in one region from other areas that are experiencing problems.
- **Avoided environmental compliance costs:** Increasing solar energy capacity helps utilities avoid the costs of installing new technologies to clean up fossil fuel-fired power plants or meeting renewable energy requirements.

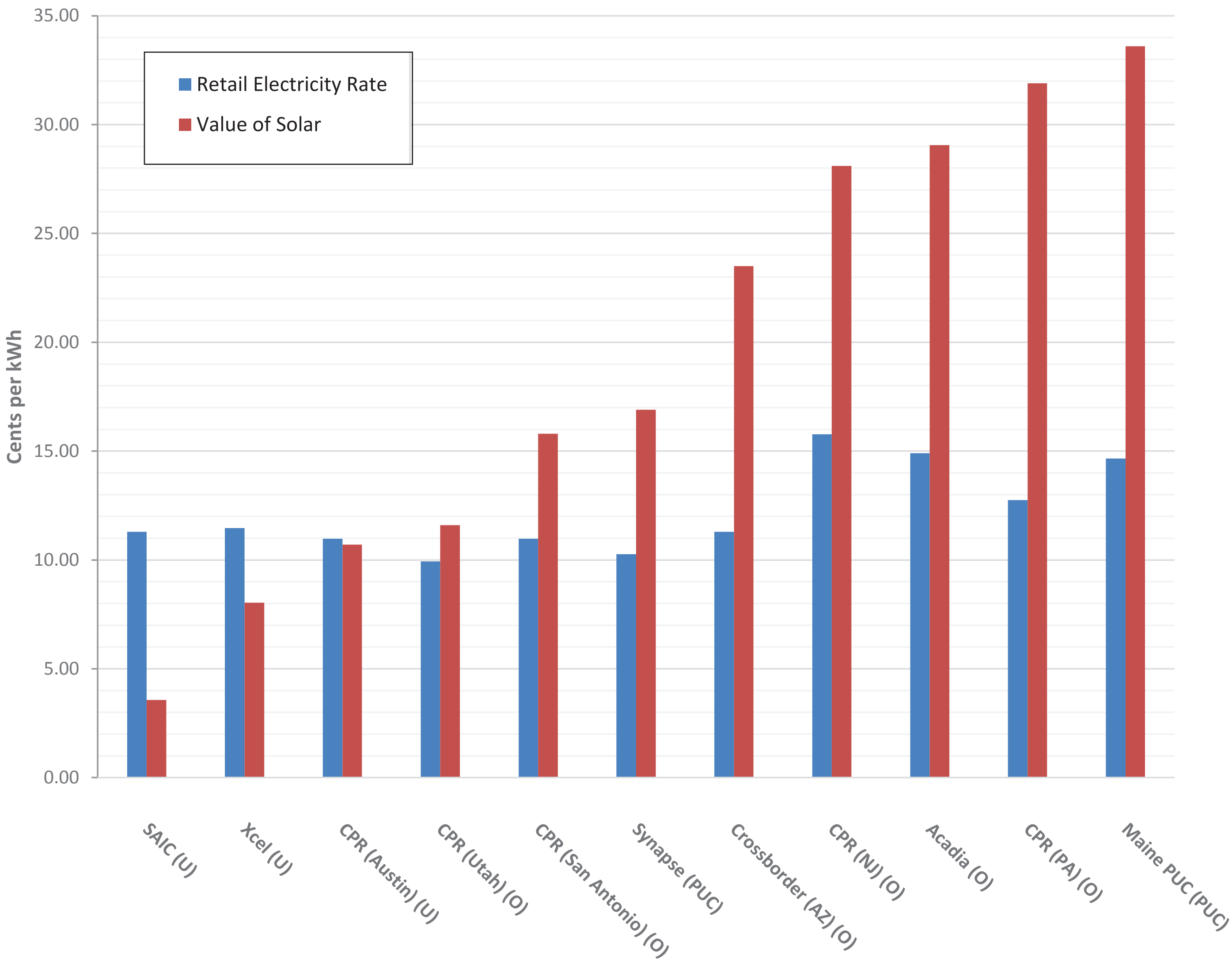
Solar energy also creates valuable benefits for the environment and society at large.

- **Avoided greenhouse gas emissions:** In 2013, the electricity sector was the largest source of global warming emissions—responsible for 31 percent of all total U.S. greenhouse gas pollution. Generating energy from the sun provides a renewable source of energy that produces no greenhouse gas emissions. Since 2007, solar energy has averted approximately 71 million metric tons of carbon dioxide emissions.
- **Reduces air pollution that harms public health:** According to the American Lung Association, 44 percent of Americans live in a place where pollution often reaches dangerous levels. Expanding the nation's ability to obtain clean electricity from the sun reduces our dependence on fossil fuels, and lessens the amount of harmful emissions that flow into the air we breathe.
- **Creates jobs and spurs local economies:** The solar energy industry is growing rapidly, creating new jobs and businesses across the nation. In 2014, the solar energy industry added jobs at a rate 20 times that of the overall economy, and economists predict that it will grow at a rate of 20.9 percent in 2015.

The benefits solar homeowners provide to the grid, and to society generally, are often worth more than the benefits they receive through net metering.

- All 11 analyses reviewed here found that solar energy brought net benefits to the grid.
- Eight analyses out of 11 found that the value of solar energy was worth more than the average residential retail electricity rate in the area at the time the analysis was conducted. The three analyses that found different results were all commissioned by utilities. (See Figure ES-1.)

Figure ES-1: Retail Electricity Rates and the Values of Solar Energy in 11 Cost-Benefit Analyses.



(U)—Studies written by, or commissioned by, utilities
(PUC)—Studies written by, or commissioned by, public utilities commissions
(O)—Studies written by, or commissioned by, non-utility organizations

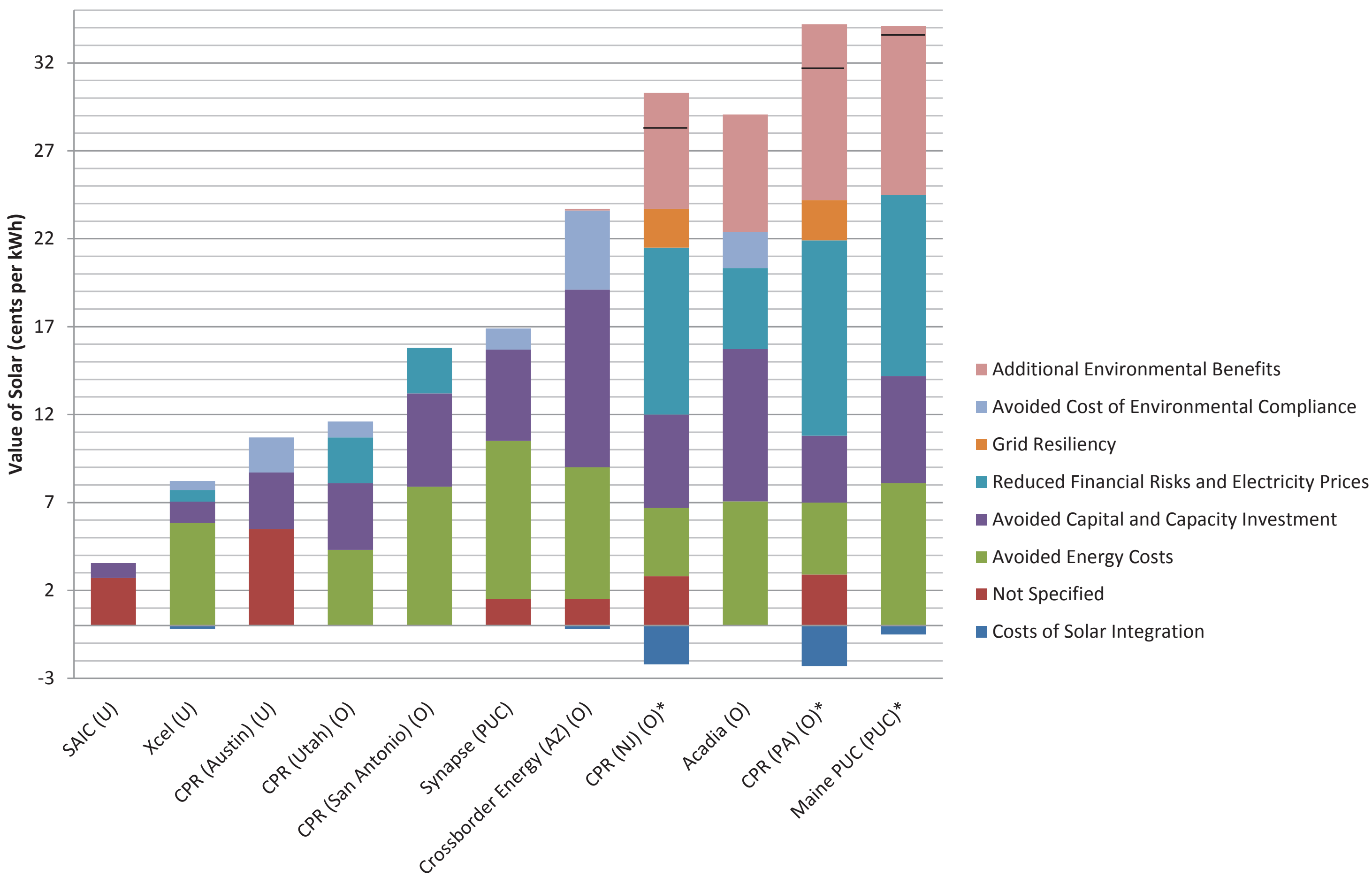
- Of these 11 analyses, the median value of rooftop solar energy was 16.90 cents per kWh, compared with an average U.S. residential retail electricity rate of 11.88 cents per kWh in 2012.
- The studies that estimated lower values for solar energy consistently undervalued, or did not include, important environmental and societal benefits that come from generating electricity from the sun.

Net metering policies have been critical to the growth of solar energy in the United States. To continue America's momentum toward a clean energy future, policymakers should continue and expand net metering policies. Specifically:

- States should lift arbitrary caps that limit availability of net metering in fast-growing solar markets.

- State or local governments that evaluate the benefits and costs of net metering should ensure that a full range of benefits is considered by using a methodology that includes environmental and societal benefits.
- State and local governments should consider the simplicity of net metering when evaluating programs that compensate customers for the solar electricity they provide to the grid.
- State and local governments should reject alternatives to net metering that do not provide residential and business customers full and fair compensation for the value they provide to the grid and society.
- State and local governments should ensure that all people can take advantage of net metering policies, including multifamily homes or homes without out sunny roofs, by implementing virtual net metering programs.

Figure ES-2: A Comparison of Cost-Benefit Analyses of Solar Energy by Study and Category.



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***Lines indicate the value of solar energy as calculated in the analysis**

Introduction

Massachusetts is not known for its abundant sunshine. But, as of May 2015, the Bay State had 841 MW of solar capacity installed, enough to power over 131,000 homes.[1]

The benefits of solar energy to Massachusetts have been great. More than 377 companies currently operate in the solar industry in Massachusetts, employing 9,400 people.[2] Expanded solar energy capacity has helped the state to clear the air and reduce greenhouse gas emissions, playing a supporting role in the 40 percent cut in power plant carbon dioxide emissions the state has achieved since 1990.[3]

Massachusetts' success in "going solar" has been, in large part, due to its forward-thinking policies. Residents and businesses can take advantage of rebates, tax credits, loan programs and bulk purchasing programs. But one of the most important steps the state took to fuel its solar revolution isn't new. In fact, it is more than three decades old.

Back in 1982, Massachusetts adopted net energy metering, allowing owners of small, distributed solar energy systems to be compensated for the extra power they supply to the grid at retail electricity rates. With the price of solar energy systems plummeting, and with additional public policies fostering widespread adoption of solar energy, state legislators have voted regularly in recent years to raise the arbitrary cap that limits participation in net metering – helping to sustain and fuel the rapid growth of solar energy in the state.

Now, however, with consumers increasingly generating their own electricity, utilities are pushing to eliminate access to net metering for new customers once the current cap is reached.[4]

Massachusetts is not the only state experiencing growing public enthusiasm for solar power – and growing utility resistance. In state after state, the rapid growth of solar energy has led to attacks by utilities on the cornerstone solar policy of net metering. Utilities and fossil fuel interests have argued that net metering represents a subsidy to solar homeowners – one that comes out of the pockets of other ratepayers.

Study after study, however, shows that the reverse is true: homeowners and businesses that invest in solar energy deliver benefits to the grid, to other ratepayers, and to society at large that often well exceed the benefits they receive through net metering.

Thanks to the steady growth of solar energy, states like Massachusetts find themselves on the cusp of a clean energy future – one with great benefits for the environment and our communities. By realizing the full benefits of solar energy, and retaining key policies like net metering, those states can continue to fuel the growth of clean solar energy for years to come.

Pro-Solar Policies are Fueling a Solar Revolution in America

The United States has witnessed a decade of impressive growth in solar energy. By the end of the first quarter of 2015, the United States had 21,300 megawatts (MW) of cumulative solar electric capacity, enough to power 4.3 million average U.S. homes.[5]

Solar power is growing exceptionally fast, but the United States is nowhere near the limit of the solar capacity it can support. The United States has the technical potential to install enough solar electricity capacity to meet the nation's electricity needs more than 100 times over.[6] If every state captured 0.1 percent of its technical potential for solar power, the United States would be generating 10 percent of its electricity from the sun by 2030.[7]

America's ability to tap that potential grows with every reduction in solar energy prices. The price of a typical solar PV system has declined an average of 6 to 8 percent annually since 1998, providing more Americans with the opportunity to generate their own electricity at home or at their business.[8]

Continued declines in the price of solar energy, coupled with Americans' increasing familiarity with this clean energy source, could lead to a continued boom in solar power. But that is only likely to happen if the United States retains the public policies that have provided a solid foundation for solar energy in many states, including net energy metering.

Net Metering Has Been Critical to the Expansion of Solar Energy

Net metering has proven to be a key public policy supporting the growth of solar energy. Net metering is not a new idea. It has been the policy in some states for more than 30 years, and is currently offered in 44 states and Washington, D.C. Of the top 10 states with the most solar energy capacity per capita in 2013, all but one had a strong net metering policy in place.[9]

Historically, the relationship between power generators and consumers had been a one-way street. Utilities generated the power and customers bought it. Utilities simply sent customers a monthly bill for the amount of power they consumed. Utilities were granted a franchise and exclusive monopoly to serve an area in return for a reasonable opportunity to make a profit. The price of power was set at a level designed to recover the utility's cost of building and operating the power plants, power lines and distribution systems needed to supply electricity to consumers.

Technologies like solar panels, however, enable electricity consumers to also be electricity producers. Because solar panels generate more electricity than needed at certain times of day and less than is needed at others, most solar homeowners are both producers and consumers of electricity from the grid, depending on the time of day and season of the year.

Net energy metering is a simple, easily understood, easy-to-administer system designed to ensure that solar panel owners are fairly compensated for the benefits they provide to the grid. Under net energy metering, solar panel owners are compensated for the extra power they supply to the grid at a fixed rate, often the retail cost of electricity – the amount that a residential customer would pay to draw a unit of electricity from the grid. Stated simply, net energy means that the customer meter spins forward for every bit of electricity the customer uses, but it also allows the customer's power meter to "spin backwards" at times when solar power production exceeds on-site needs. The balance, or the "net," is what the customer is charged or credited for at the end of the month. As a result, over the course of a year, a customer with a solar photovoltaic system pays for only the *net* amount of electricity used over a 12-month period (electricity consumed minus electricity produced), plus utility service charges.

Charging solar panel owners based on their net consumption of electricity is not the only possible option for compensating them for the power they supply to the grid. Even in the absence of net metering, federal law requires utilities to purchase any excess power from customer-owned solar photovoltaic systems at a state-regulated rate based on the "avoided cost" of the electricity the utility would have otherwise had to generate or purchase – a figure usually far lower than the retail rate.[10] Some states and localities have adopted other methods for calculating compensation, such as "value of solar" rates that attempt to pay solar panel owners based on the estimated value of the benefits they supply to the grid.

Unfortunately, net metering is often misunderstood as a "subsidy" to solar homeowners, rather than as a system for compensating them for the benefits they provide to the grid and to society. A series of studies in recent years has shown that those benefits are significant.

Solar Energy Provides Clear Benefits to Electricity Consumers and to Society

Solar energy provides a wide variety of benefits for the grid and for society in general. These benefits can be divided into two categories: benefits to the grid (and, by extension, all electricity consumers) and benefits to the environment and society.

Grid Benefits

Avoided Energy Costs

Of all the benefits that solar energy creates for the grid, reduced expenditure for power generation is perhaps the most obvious. Solar energy systems produce clean, renewable electricity on-site, reducing the amount of electricity utilities must generate or purchase from fossil fuel-fired power plants.

The value of this avoided electricity consumption is generally greatest in the summer months, when demand for electricity rises due to increased air conditioning demand and solar energy production is near its peak. Adding solar energy to the system reduces the need to power up expensive, often inefficient generators that run only a few times a year, or to purchase expensive peak power on wholesale markets, reducing the cost of electricity for all ratepayers.

Reduced Line Losses

Our nation's electricity grid was built around large, centralized power plants, with power transmitted over long distances to our homes and businesses. As it travels from the power plant to our sockets, a portion of the electricity is "lost" as heat and never arrives at its destination.

The Energy Information Administration estimated that the United States lost about 203 million megawatt hours of electricity in 2012, or 5 percent of the total amount of electricity generated that year. These losses cost the country millions of dollars, and cause us to generate more electricity than we need, increasing costs for ratepayers.[11] Solar PV systems drastically reduce the amount of system losses by producing electricity on-site, thereby reducing the amount of electricity transmitted and distributed through the grid.

Avoided Capacity Investment

Expanding the amount of electricity we generate from the sun can defer, or eliminate, the need for new grid capacity investments. By reducing overall demand, expanding solar energy production helps ratepayers and utilities avoid the cost of investing in new power plants, transmission lines, reserve capacity and other forms of electricity infrastructure.

Reduced Financial Risks and Electricity Prices

Price volatility in the fossil fuel market has long been a concern for utilities and ratepayers alike, but the risk has become greater as power companies have shifted from coal to natural gas—a fuel with a history of price volatility.[12] Because solar panels, once installed, do not incur fuel costs, integrating more solar energy capacity onto the electric grid can reduce exposure to sudden swings in the price of fossil fuels or wholesale electricity. Utilities commonly engage in strategies to hedge against fossil fuel price volatility – such as by securing long-term contracts, where possible, for fossil fuels or electricity – for which utilities are often willing to pay a premium. Solar energy can help meet these same needs to increase price stability, a contribution with financial value for utilities and grid users.[13]

In competitive energy markets, distributed solar energy also reduces the *price* of electricity by reducing overall demand on the grid. In these areas, ratepayers not only benefit when utilities must purchase less electricity to satisfy demand, but they also gain because each unit of electricity purchased becomes cheaper.[14] These demand reduction-induced price effects can represent an important value to ratepayers.

Grid Resiliency

The centralized nature of our power grid leaves it vulnerable to frequent and prolonged outages. In 2003, four downed power lines in Ohio left more than 50 million people in eight states and Canada without power and cost an estimated $6 billion.[15] Increasing distributed solar PV capacity and energy storage options not only reduces the demand that combines to overload the system, but it also decentralizes our grid, potentially safeguarding people in one part of the country from other areas that are experiencing problems. Additionally, advances in smart inverter technology allow higher percentages of solar energy to be safely integrated into the grid, increasing grid resiliency and reliability.[16]

Avoided Environmental Compliance Costs

Adding solar energy to the grid allows local utilities and municipalities to avoid some of the growing costs of compliance with environmental regulations. Many states have air quality and water quality regulations and 29 states and Washington, D.C., have Renewable Electricity Standards that require states to source a certain percentage of their energy demand from renewable resources, including from the sun.[17] Increasing solar energy capacity helps utilities avoid or reduce the costs of installing new technologies to curb air and water pollution or installing renewable energy.

Environmental and Societal Benefits

Avoided Greenhouse Gas Emissions

In 2013, the electricity sector was the nation's largest source of global warming emissions—responsible for 31 percent of all total U.S. greenhouse gas pollution.[18] Coal is the most carbon intensive of the fossil fuels we burn for electricity, accounting for 77 percent of carbon dioxide emissions from the electricity sector. The combustion of natural gas, while emitting less carbon dioxide than coal, has now been shown to emit large amounts of methane—a far more potent greenhouse gas.[19]

Conservative studies suggest that every ton of carbon dioxide released into the air causes $37 of economic and social damage.[20] In 2013, the United States emitted nearly 5.4 billion metric tons of energy-related carbon dioxide emissions, equivalent to nearly $200 billion in economic and social damages.[21] Solar energy, however, is a renewable source of energy that produces no greenhouse gas emissions.

Reduced Public Health Threats

Solar energy will not only reduce greenhouse gas emissions and help to mitigate the worst impacts of climate change, but it will also reduce emissions of dangerous air pollutants such as nitrogen oxides, mercury and particulate matter that harm public health.[22]

According to a new report by the American Lung Association, 44 percent of Americans live in a place where air pollution often reaches dangerous levels.[23] Air pollution is linked to increased incidence of asthma and chronic bronchitis, and has also been shown to cause hundreds of thousands of premature deaths per year.[24] A typical coal-fired power plant, without technology to limit emissions, sends 170 pounds of mercury —an extremely harmful neurological toxin – into the air each year.[25]

Expanding the nation's ability to source clean electricity from the sun reduces our dependence on fossil fuels, and lessens the amount of harmful emissions that flow into the air we breathe.

Job Creation and Economic Development

The solar energy industry is rapidly growing, creating new jobs and businesses across the nation. In 2014, the solar energy industry added jobs at a rate 20 times that of the overall economy, and economists predict that it will grow at a rate of 20.9 percent in 2015.[26] Many of these jobs are in installation and maintenance, jobs that cannot be sent overseas. In addition, studies show that these jobs are well-paid, with average wages in installation and assembly ranging from $18-24 per hour.[27] In Colorado, for example, the solar energy industry has added $1.42 billion to the state economy since 2007, while creating 10,700 full-time jobs.[28]

Solar Energy is Worth More Than the Benefits from Net Metering

Net metering is intended to compensate the owners of solar energy systems for the value they provide to the grid. In recent years, however, as solar energy has spread across the United States, utilities and fossil fuel interests have begun to argue that net metering represents an unfair subsidy that shifts costs onto other electricity ratepayers.

This report reviews 11 of those analyses, and seeks to compare the studies by author, categories valued and

Table 1: A List of Studies Reviewed in this Report

Author	Abbreviation Used in Graphs	Organization that Commissioned the Report	Geographic Area Covered	Date
SAIC Energy, Environment and Infrastructure, LLC	SAIC	Arizona Public Service Company, an investor-owned utility	Arizona Public Service territory	May 2013
Xcel Energy, Inc.	Xcel	Written by Xcel Energy, a local utility	Xcel Energy service territory in Colorado	May 2013
Clean Power Research	CPR (Austin)	Commissioned by Austin Energy, the incumbent investor-owned utility.	Austin Energy service territory (Texas)	December 2013
Clean Power Research	CPR (Utah)	Utah Clean Energy, a non-profit group.	Rocky Mountain Power service territory	Janurary 2014
Clean Power Research and Solar San Antonio	CPR (San Antonio)	Written by Clean Power Research, a consulting and research group, and Solar San Antonio, a non-profit	CPS Energy service territory	March 2013
Synapse Energy Economics, Inc.	Synapse	Prepared for the Public Service Commission of Mississippi	State of Mississippi	September 2014
Maine Public Utilities Commission and Clean Power Research	Maine PUC	Prepared for the Maine Public Utilities Commission	State of Maine	March 2015
Crossborder Energy	Crossborder Energy (AZ)	Written by Crossborder Energy, a consulting group.	Arizona Public Service territory	May 2013
Clean Power Research	CPR (NJ, PA)	Prepared for the Mid-Atlantic Solar Energy Industries Association and the Pennsylvania Solar Energy Industries Association	Examined four different fleet locations and seven different locations in New Jersey and Pennsylvania	November 2012
Acadia Center	Acadia	Written by Acadia Center, a non-profit research and advocacy group	State of Massachusetts	April 2015

perspective. It shows that all of the studies find that solar energy brings net benefits to the grid and to society. It also finds that non-utility analysts generally value solar energy at higher rates than utilities and public utilities commissions, that the majority of analyses find solar energy to be worth more than the credits offered to solar energy system owners through net metering, and that studies that find lower values for solar energy often exclude consideration of key benefits that solar panel owners provide to the grid and society.

The Value of Solar Power is More than Just Avoided Costs

A key difference between reports that valued solar energy at lower levels and those that valued it at higher rates concerned the types of benefits considered in the analysis: did the report consider the ways that solar created benefits that accrue to all of society, or did it only consider a limited number of direct benefits to the grid and the utility?

The most basic way to value solar, and the most common, is to calculate the avoided costs that result from its expansion.[29] In other words, what costs do ratepayers and the utility avoid or defer as more solar energy is integrated into the grid? The avoided costs most commonly used in a solar cost-benefit analysis are: avoided energy costs, avoided capacity and capital investment, costs of market price fluctuation and avoided environmental compliance costs. The majority of the studies reviewed in this report included all or most of these avoided costs. (See Table 2 and Figure 1.)

Equating avoided costs with the value of solar, however, does not capture all of the benefits that solar energy creates, such as reduced greenhouse gas emissions, improved public health, increased job creation and economic development, and the potential for increased resiliency of local electric grids with greater levels of distributed generation. Analyses that considered these additional benefits consistently calculated higher values of solar energy than reports that did not.

Value Provided by Solar Energy Usually Exceeds Benefits from Net Metering

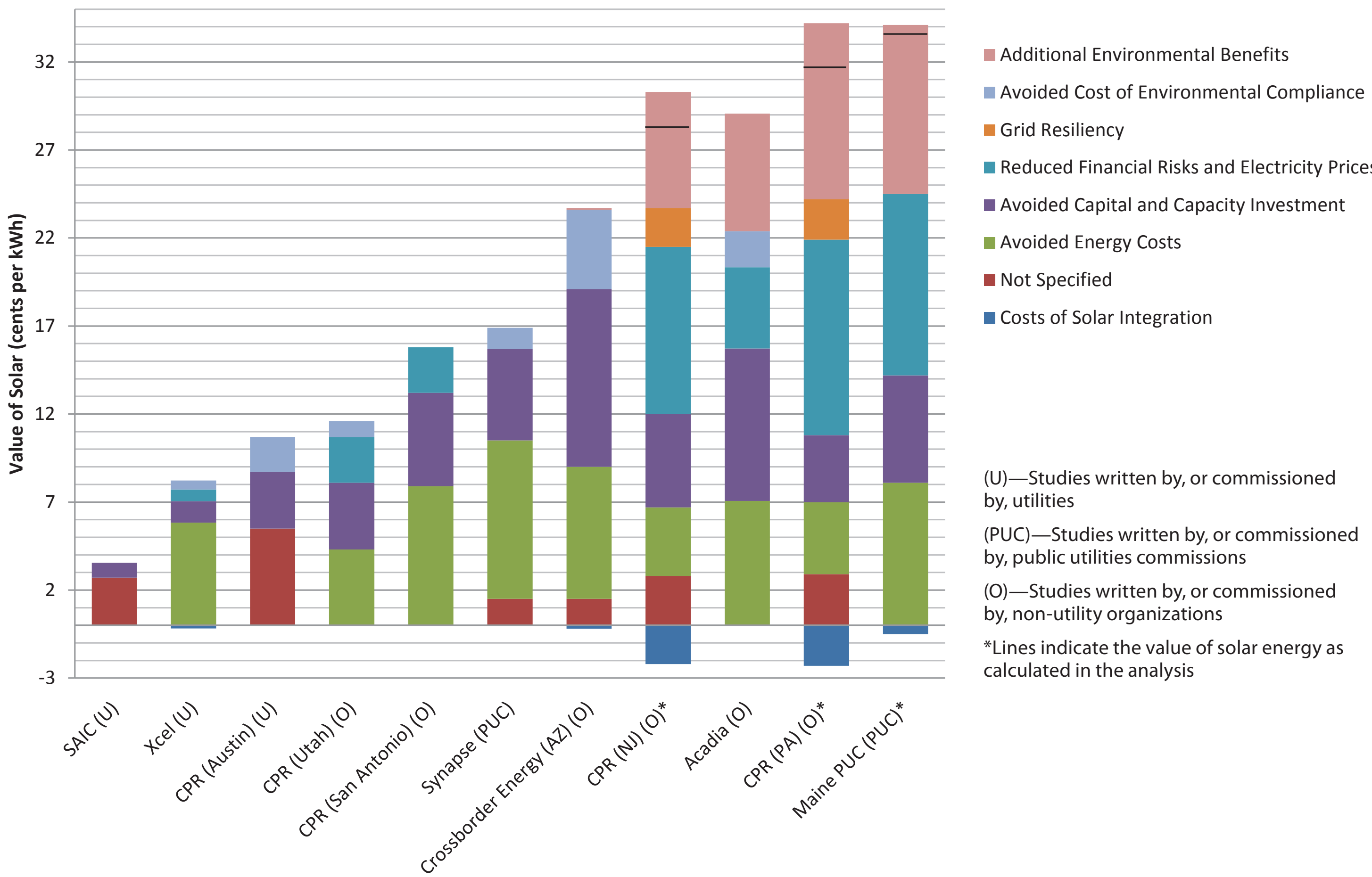
Nearly all analyses that consider a full range of solar energy benefits find that the value provided by

Table 2: Categories of Benefits and Costs Included in Each Solar Energy Cost-Benefit Analysis.*

Author	Costs of Solar Integration	Not Specified	Avoided Energy Costs	Avoided Capital and Capacity Investment	Reduced Financial Risks	Grid Resiliency	Cost of Environmental Compliance	Avoided Greenhouse Gas Emissions	Economic Development	Total (cents per kWh)
SAIC		■		■						3.56
Xcel	■		■	■	■		■			8.04
CPR (Austin)		■		■			■			10.70
CPR (Utah)			■	■	■		■			11.60
CPR (San Antonio)			■	■	■					15.80
Synapse		■	■	■			■			16.90
Crossborder Energy (AZ)	■	■	■	■			■			23.50
CPR (NJ)	■	■	■	■	■	■		■	■	28.10
Acadia			■	■	■		■	■		29.06
CPR (PA)	■	■	■	■	■	■		■	■	31.90
Maine PUC	■		■	■	■			■		33.60

*Colored cells represent categories that were included in the solar energy cost-benefit calculation

Figure 1: A Comparison of Solar Energy Cost-Benefit Analyses by Report and Category.

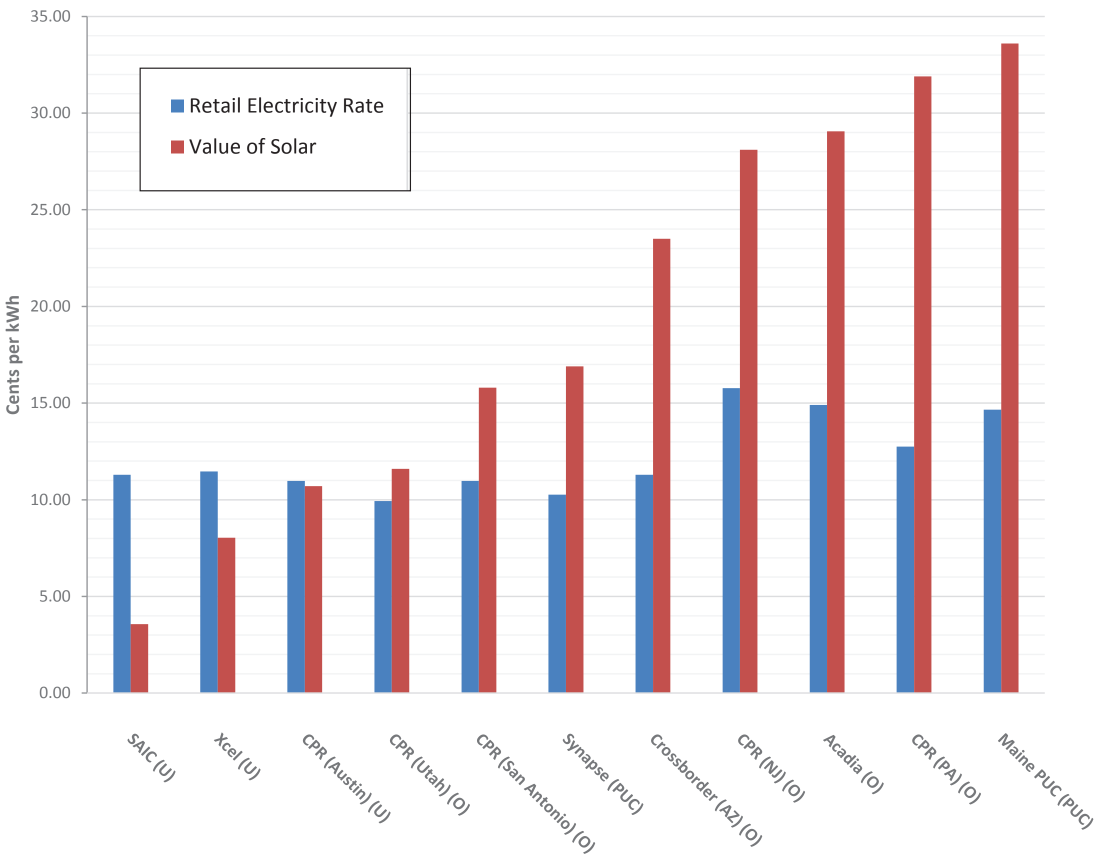


installing solar energy exceeds local retail electricity rates. In other words, far from being an overly generous subsidy, net metering often *under-compensates* solar energy system owners for the benefits they provide to all customers and to society. Of these 11 analyses, the median value of rooftop solar energy was 16.90 cents per kWh, while the average residential retail electricity rate in the United States was 11.88 cents per kWh.[30]

Non-Utility Analysts Value Solar Power at Higher Rates than Utilities

Studies of the value of solar conducted by utilities routinely arrive at estimates lower than those of studies conducted by public utilities commissions and other organizations. One reason for this is the tendency of utility-produced studies to exclude benefits of solar energy accruing to the environment and society by focusing only on costs and savings that affect the direct costs of operating the grid. Out of the 11 analyses reviewed in this report, those authored by non-utility groups consistently included valued environmental categories at a higher rate than utilities, while analyses conducted by public utilities commissions were a mixed bag. In fact, all eight of the non-utility and public utilities commission value-of-solar studies evaluated here found that solar energy delivered greater value than retail electricity rates, while none of the three utility-commissioned studies came to that conclusion.

Figure 2: Average Retail Residential Electricity Rates Compared to the Values of Solar in 11 Cost-Benefit Analyses.[31]



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The Battle over the Value of Solar in Minnesota

In 2013, Minnesota became the first state to pass legislation establishing a new reimbursement option for solar energy generators: a "value of solar tariff." In contrast to net metering, in which utilities compensate solar energy customers at the retail electricity rate for the excess electricity they feed into the grid, a value-of-solar tariff sets a long-term fixed price for solar energy that attempts to account for all the benefits solar customers provide to the environment and the grid.

The legislation required the Minnesota Department of Commerce and the Minnesota Public Utilities Commission to adopt a statewide methodology that would be used by any utility that chose to offer the value-of-solar rate to its customers (utilities retained the option to offer net metering as they had in the past).[32] Clean Power Research, the organization that designed the value-of-solar methodology used for a similar tariff in Austin, Texas (reviewed in this report), prepared the methodology that was eventually approved in Minnesota as well. The methodology accounted for the benefits solar energy created for the grid as well as benefits to the environment.[33]

By including the full benefits of solar energy, utilities applying the methodology found that the result would have been a rate that was more generous than net metering, with Xcel Energy submitting a sample value-of-solar tariff rate at just under 12.5 cents per kWh while the retail electricity rate in 2012 was 11.35 cents per kWh.[34] Faced with the prospect of providing credit for solar at its full value, higher than at the retail rate representing the value of generic utility energy, not a single Minnesota utility opted into the value-of-solar program.

The Minnesota example shows that a full and fair evaluation of solar benefits is likely to yield a value greater than that provided through net metering.

Conclusion: A Clean Energy Future Depends on Full and Fair Compensation for Homes and Businesses that "Go Solar"

The benefits of increased solar energy capacity are clear: reduced greenhouse gas emissions, lower monthly electricity bills, and cleaner air, to name just a few. It is also clear that pro-solar policies, such as net metering, are critical to the success of solar energy.

Recently, however, net metering has come under attack. Utilities and fossil fuel interests have sought to portray the program as an unfair subsidy to solar energy system owners.

Most analyses – especially those that consider the full range of benefits that solar energy delivers to the grid and to society – find that the value to all customers created by installing solar panels on a home or business generally exceeds the private benefits received through net metering by customers who invest in solar.

Eliminating or constraining programs that compensate solar homeowners, therefore, would do more than discourage the spread of a key clean energy technology. It would also reduce fairness by failing to compensate Americans who "go solar" for the ample benefits they provide for the rest of society.

Net metering is a critical tool to ensure fair compensation for owners of solar energy systems and to continue to fuel the growth of solar energy. Public officials should support and strengthen net metering as sound public policy to stimulate private investment and job growth, and to encourage utilities to diversify and strengthen the grid. Specifically:

- States should lift arbitrary caps that limit availability of net metering in fast-growing solar markets.
- State or local governments that evaluate the benefits and costs of net metering should ensure that a full range of benefits is considered, including environmental and societal benefits. This isn't just good policy for solar energy—utility decision-making should fully account for the costs and benefits of all resource options.
- State and local governments should consider the simplicity of net metering when evaluating programs that compensate customers for the solar they provide to the grid.

- State and local governments should reject alternatives to net metering that do not provide residential and business customers full and fair compensation for the value they provide to the grid and society.
- State and local governments should ensure that all people can take advantage of net metering policies, even those who do not live in single family homes, by implementing virtual net metering programs.

Local, state and federal governments should adopt other policies to encourage the growth of solar energy.

- States should set aggressive goals for solar energy adoption, and implement policies that will encourage homeowners and businesses to meet them.
- The federal government should retain the 30 percent Investment Tax Credit for renewable energy currently set to expire on December 31, 2016, and make it refundable so that it can incentivize solar being installed by non-profits.
- States should remove other financial and regulatory hurdles to solar energy that slow down installation and discourage homes and businesses from investing in solar energy systems.

Methodology

This report reviewed 11 analyses of the value of solar energy in states across the country. Each analysis is unique, using its own methodology and setting its own parameters. As such, in order to enable a fair comparison of the studies, we created a standard set of categories for the various benefits and costs of solar power addressed in the studies. A few analyses used categories that were not translatable into our categories. In those cases, we created a "Not Specified" category, and the details of that can be found in the methodology of those analyses.

Details of how the benefits and costs of solar energy in each report were allocated are described below.

Acadia Center

Report Citation: Acadia Center, *Value of Distributed Generation: Solar PV in Massachusetts*, April 2015.

This study assessed the grid and societal value of six solar PV systems to better understand the overall value that solar PV provides to the grid. We used the 25-year levelized value of the system labelled "South Facing—Fixed, 35 Degrees." Other orientations of solar panels produce different estimates of value, ranging from 29.28 cents per kWh to 34.26 cents per kWh. The total value of solar found for this system is 29.06 cents per kWh.

A. **Avoided Energy Costs:** consists of the category "Avoided Energy Costs" (7.07 cents per kWh).

B. **Avoided Capacity and Capital Costs**: calculated by adding the category "Avoided Capacity Costs" (4.41 cents per kWh), the category "Avoided Transmission Costs" (2.43 cents per kWh) and the category "Avoided Distribution Costs" (1.81 cents per kWh). The total value for this category is 8.65 cents per kWh.

C. **Reduced Financial Risks and Electricity Prices**: calculated by adding the category "Demand Reduction Induced Price Effects-Energy" (3.66 cents per kWh) and the category "Demand Reduction Induced Price Effects-Capacity" (1.55 cents per kWh.) The total value for this category is 5.21 cents per kWh.

D. **Avoided Environmental Compliance Costs**: calculated by adding the category "Avoided CO_2 Compliance Costs" (2.04 cents per kWh) and the category "Avoided NO_x Compliance Costs" (0.0006 cents per kWh). The total value for this category is 2.0406 cents per kWh.

E. **Avoided Emissions Costs**: calculated by adding the category "Net Social Cost of CO_2" (3.11 cents per kWh), the category "Net Social Cost of SO_2" (2.86 cents per kWh) and the category "Net Social Cost of NO_x" (0.71 cents per kWh). The total value for this category is 6.68 cents per kWh.

CPR (Austin)

Report Citation: Thomas E. Hoff and Ben Norris, Clean Power Research, *2014 Value of Solar Executive Summary,* 12 December 2013.

This report is part of an annual update conducted by Austin Energy and Clean Power Research that calculates the value of solar in Austin Energy's territory and is used as input in decisions over the following year's Value of Solar tariff. We used the Distributed PV Value for each category, which equals the "Economic Value (levelized $/kWh) times Load Match (%) (for capacity related components) times 1 plus Loss Savings (%)." As in the report, we then added each category together to arrive at a total value of solar of 10.7 cents per kWh.

A. **Not Specified**: consists of the category "Guaranteed Fuel Value" (5.5 cents per kWh). We put this into the "not specified" category because it accounts for both current *and* future avoided energy costs (which, in other cases, we put into the "Reduced Financial Risk and Electricity Prices" category).

B. **Avoided Capacity and Capital Costs:** calculated by adding the category "Plant O&M Value" (0.5 cents per kWh), the category "Generation Capacity Value" (1.7 cents per kWh), the category "Avoided Transmission Capacity Cost" (1.0 cents per kWh), and the category "Avoided Distribution Capacity Cost" (0.0 cents per kWh). The total value for this category is 3.2 cents per kWh.

C. **Avoided Environmental Compliance Cost:** consists of the category "Avoided Environmental Compliance Costs" (2.0 cents per kWh).

CPR (NJ and PA)

Report Citation: Richard Perez, Benjamin L. Norris and Thomas E. Hoff, Clean Power Research, *The Value of Distributed Solar Electric Generation to New Jersey and Pennsylvania,* November 2012.

This report analyzed the value of solar at seven different locations across New Jersey and Pennsylvania. The analyses represent the levelized value of PV for a "fleet" of PV systems. Four different fleet configurations were evaluated at each of the seven locations. We used the highest values from each state – Newark, New Jersey, and Scranton, Pennsylvania. Other orientations of solar panels produce different estimates of value, ranging from 25.6 cents per kWh to 31.5 cents per kWh.

Scranton, Pennsylvania:

A. **Cost of Solar Integration:** consists of the category "Solar Penetration Cost" (-2.3 cents per kWh).

B. **Not Specified:** consists of the category "Long Term Societal Value" (2.9 cents per kWh), which the report defines as "potential value (defined by all other components) if the life of PV is 40 years instead of the assumed 30 years."

C. **Avoided Energy Costs:** consists of the category "Fuel Cost Savings" (4.1 cents per kWh).

D. **Avoided Capacity and Capital Costs:** calculated by adding the category "O&M Cost Savings" (2.0 cents per kWh), the category "Generation Capacity Value" (1.7 cents per kWh), and the category "T&D Capacity Value" (0.1 cents per kWh). The total value for this category is 3.8 cents per kWh.

E. **Reduced Financial Risks and Electricity Prices:** calculated by adding the category "Fuel Price Hedge Value" (4.2 cents per kWh) and the category "Market Price Reduction Value" (6.9 cents per kWh). The total value for this category is 11.1 cents per kWh.

F. **Grid Resiliency:** consists of the category "Security Enhancement Value" (2.3 cents per kWh).

G. **Avoided Emissions Costs:** consists of the category "Environmental Value" (5.5 cents per kWh).

H. Economic Development Value: consists of the category "Economic Development Value" (4.5 cents per kWh).

Newark, New Jersey

A. Cost of Solar Integration: consists of the category "Solar Penetration Cost" (-2.2 cents per kWh).

B. Not Specified: consists of the category "Long Term Societal Value" (2.8 cents per kWh), which the report defines as "Potential value (defined by all other components) if the life of PV is 40 years instead of the assumed 30 years."

C. Avoided Energy Costs: consists of the category "Fuel Cost Savings" (3.9 cents per kWh).

D. Avoided Capacity and Capital Costs: calculated by adding the category "O&M Cost Savings" (1.9 cents per kWh), the category "Generation Capacity Value" (2.6 cents per kWh), and the category "T&D Capacity Value" (0.8 cents per kWh). The total value for this category is 5.3 cents per kWh.

E. Reduced Financial Risks and Electricity Prices: calculated by adding the category "Fuel Price Hedge Value" (4.4 cents per kWh) and the category "Market Price Reduction Value" (5.1 cents per kWh). The total value for this category is 9.5 cents per kWh.

F. Grid Resiliency: consists of the category "Security Enhancement Value" (2.2 cents per kWh).

G. Avoided Greenhouse Gas Emissions: consists of the category "Environmental Value" (2.2 cents per kWh).

H. Economic Development Value: consists of the category "Economic Development Value" (4.4 cents per kWh).

CPR (San Antonio)

Report Citation: Ben Norris, Clean Power Research, Nic Jones, Solar San Antonio, *The Value of Distributed Solar Electric Generation to San Antonio*, March 2013.

This report conducted analyses on four different solar PV systems, each facing a different direction and placed at different angles. We used the value from the analysis conducted on the system labelled "West-15."

A. Avoided Energy Costs: consists of the category "Fuel Cost Savings" (7.9 cents per kWh).

B. Avoided Capacity and Capital Costs: calculated by adding the category "O&M Cost Savings (2.7 cents per kWh), the category "Generation Capacity" (1.9 cents per kWh), the category "Transmission and Distribution Capacity" (0.4 cents per kWh), and the category "Reserve Capacity" (0.3 cents per kWh). The total value for this category is 5.3 cents per kWh.

C. Reduced Financial Risks and Electricity Prices: consists of the category "Fuel Price Hedge" (2.6 cents per kWh).

CPR (Utah)

Report Citation: Clean Power Research, *Value of Solar in Utah,* 7 January 2014.

We used the Distributed PV Value for each category from this report, which, according to the report, is the economic value modified using "Load Match" factors "to reflect the match between PV production profiles and utility loads." To arrive at the distributed PV value, the study then applied a "Loss Savings" factor "to reflect the distributed nature of the resource." The final value is 11.6 cents per kWh. This value is a levelized value representing all avoided costs over a 25-year assumed PV life.

A. Avoided Energy Costs: consists of the category "Fuel Value" (4.3 cents per kWh).

B. **Avoided Capacity and Capital Investment**: calculated by adding the category "Plant O&M Value" (1.3 cents per kWh), the category "Generation Capacity Value" (1.4 cents per kWh), and the category "Avoided T&D Capacity Cost" (1.1 cents per kWh). The total value for this category is 3.8 cents per kWh.

C. **Reduced Financial Risks and Electricity Prices**: consists of category "Fuel Price Guarantee" (2.6 cents per kWh).The total value for this category is 2.6 cents per kWh.

D. **Avoided Environmental Compliance Costs**: consists of category "Avoided Environmental Cost" (0.9 cents per kWh). The total value for this category is 0.9 cents per kWh.

Crossborder Energy (AZ)

Report Citation: R. Thomas Beach and Patrick G. McGuire, Crossborder Energy, *The Benefits and Costs of Solar Distributed Generation for Arizona Public Service,* 8 May 2013.

The scope of this report is limited to assessing how demand-side solar will impact Arizona Public Service's ratepayers. The total value of solar found in this report is 23.5 cents per kWh.

A. **Costs of Solar Integration**: consists of the category "Integration Costs" (-0.2 cents per kWh).

B. **Not Specified:** Consists of the category "Ancillary Services and Capacity Reserves" (1.5 cents per kWh).

C. **Avoided Energy Costs**: consists of the category "Energy" (7.5 cents per kWh).

D. **Avoided Capacity and Capital Costs:** calculated by adding the category "Generation Capacity" (7.6 cents per kWh), the category "Transmission" (2.3 cents per kWh) and the category "Distribution" (0.2 cents per kWh). The total value for this category is 10.1 cents per kWh.

E. **Avoided Environmental Compliance Costs:** consists of the category "Avoided Renewables" (4.5 cents per kWh).

F. **Avoided Emissions Costs**: consists of the category "Environmental" (0.1 cents per kWh).

Maine PUC

Report Citation: Benjamin L. Norris, et al., *Maine Distributed Solar Valuation Study*, 1 March 2015.

This report calculated a 25-year Levelized Distributed PV Value for the Central Maine Power service territory. The total value of solar found in this report is 33.7 cents per kWh.

A. **Costs of Solar Integration**: consists of the category "Solar Integration Costs" (-0.5 cents per kWh).

B. **Avoided Energy Costs**: consists of the category "Avoided Energy Cost" (8.1 cents per kWh).

C. **Avoided Capital and Capacity Costs**: calculated by adding the category "Avoided Generation Capacity Costs" (4.0 cents per kWh), the category "Avoided Reserve Capacity Costs" (0.5 cents per kWh), and the category "Avoided Transmission Capacity Costs" (1.6 cents per kWh). The total value for this category is 6.1 cents per kWh.

D. **Reduced Financial Risks and Electricity Prices:** calculated by adding the category "Market Price Response" (6.6 cents per kWh) and the category "Avoided Fuel Price Uncertainty" (3.7 cents per kWh). The total value for this category is 10.3 cents per kWh.

E. **Avoided Emissions Costs**: calculated by adding the category "Net Social Cost of Carbon" (2.1 cents per kWh), the category "Net Social Cost of SO_2" (6.2 cents per kWh) and the category "Net Social Cost of NO_x" (1.3 cents per kWh). The total value for this category is 9.6 cents per kWh.

SAIC

Report Citation: SAIC Energy, Environment and Infrastructure, LLC, *2013 Updated Solar PV Value Report*, 10 May 2013.

We used the "present value" from this analysis. The present value, as calculated by the report, "is the 2025 nominal value using the APS discount rate of 7.21 percent." This report calculated the overall value using different categories than many other reports did, and aggregated many values that are separate in other reports. As a result, the review of this report has a category called "Not Specified" that makes up a large percentage of the overall value and includes many of the categories that were calculated separately in other reports. The total value of solar found in this report is 3.56 cents per kWh.

A. **Not Specified**: calculated by adding category "Fixed O&M, Gas Transportation" (0.13 cents per kWh) and category "Fuel, Variable O&M, Emissions, Purchased Power." The total value for this category is 2.7 cents per kWh.

B. **Avoided Capital and Capacity Costs:** calculated by adding the category "Generation" (0.72 cents per kWh), the category "Distribution" (0.0 cents per kWh) and the category "Transmission" (0.14 cents per kWh). The total value for this category is 0.86 cents per kWh.

Synapse

Report Citation: Elizabeth A. Stanton, et al., Synapse Energy Economics, Inc., *Net Metering in Mississippi*

Costs, Benefits, and Policy Considerations, 19 September 2014.

We used the "Levelized Avoided Cost Value," which levelized the value of solar over a 25-year period.

A. **Not Specified:** consists of the category "Avoided Risk" (1.5 cents per kWh).

B. **Avoided Energy Costs**: calculated by adding the category "Avoided Energy Costs" and the category "Avoided System Losses" (0.9 cents per kWh). The total value of this category is 9.0 cents per kWh.

C. **Avoided Capital and Capacity Costs:** calculated by adding the category "Avoided Capacity Costs" (1.2 cents per kWh) and the category "Avoided Transmission and Distribution Costs" (4.0 cents per kWh). The total value for this category is 5.2 cents per kWh.

D. **Environmental compliance Costs:** consists of the category "Avoided Environmental Compliance Costs" (1.2 cents per kWh).

Xcel Energy

Report Citation: Xcel Energy, Inc., *Costs and Benefits of Distributed Solar Generation on the Public Service Company of Colorado System,* 23 May 2013.

This study examined the first 59 MW of distributed solar generation ("DSG") installed on the Public Service of Colorado system as of 30 September 2012, in addition to a projection of an additional 81 MW of DSG being installed by 31 December 2014, for a total of 140 MW. We used the levelized net avoided cost value calculated under the "Base Gas" scenario. The total value of solar found in this report is 8.04 cents per kWh.

A. **Avoided Energy Costs**: calculated by adding the category "Avoided Energy Costs" (5.21 cents per kWh) and the category "Avoided Line Losses" (0.62 cents per kWh). The total value for this category is 5.83 cents per kWh.

B. **Avoided Capacity and Capital Costs**: calculated by adding the category "Avoided Capacity & 7FOM (fixed operation and management) costs" (1.15 cents per kWh), the category "Avoided Distribution Upgrades" (0.05 cents per kWh), and the category

"Avoided Transmission Upgrades" (0.02 cents per kWh). The total value for this category is 1.22 cents per kWh.

C. **Reduced Financial Risks and Electricity Prices**: consists of the category "Fuel Hedge Value" (0.66 cents per kWh).

D. **Avoided Environmental Compliance Costs**: consists of the category "Avoided Emissions Cost" (0.51 cents per kWh).

Notes

1. Solar capacity of Massachusetts: Massachusetts Department of Energy Resources, *Installed Solar Capacity of Massachusetts,* accessed at www.mass.gov/eea/docs/doer/renewables/installed-solar.pdf, 14 June 2015. Number of homes: Solar Energy Industries Association, "Massachusetts Solar," accessed at: www.seia.org/state-solar-policy/massachusetts, 12 June 2015.

2. Solar Energy Industries Association, "Massachusetts Solar," accessed at: www.seia.org/state-solar-policy/massachusetts, 27 May 2015

3. Matt Murphy, "Mass. Ahead Of Emissions Cut Goals Laid Out In EPA Plan," *WBUR,* 2 June 2014.

4. Jack Newsham, "Mass. Solar Projects Could Soon Reach a Limit

5. Solar Energy Industries Association, Solar Industry Data*, Solar Market Insight Report 2015 Q1*, accessed at http://www.seia.org/research-resources/solar-market-insight-report-2015-q1, 12 June 2015.

6. This includes potential solar power generation from rooftop solar panels, large utility-scale solar installations, and concentrating solar power plants. Judee Burr and Lindsey Hallock, Frontier Group, Rob Sargent, Environment America Research & Policy Center, *Star Power: The Growing Role of Solar Energy in America*, November 2014.

7. Judee Burr and Lindsey Hallock, Frontier Group, Rob Sargent, Environment America Research & Policy Center, *Star Power: The Growing Role of Solar Energy in America*, November 2014.

8. National Renewable Energy Laboratory, *Photovoltaic System Pricing Trends: Historical, Recent, and Near-Term Projections, 2014 Edition*, 22 September 2014.

9. Number of states with net metering: DSIRE, *Detailed Summary Maps: Net Metering Policies,* accessed at www.dsireusa.org/resources/detailed-summary-maps/, updated March 2015. Top ten states with net metering: Jordan Schneider, Frontier Group, Rob Sargent, Environment America Research & Policy Center, *Lighting the Way: The Top Ten States that Helped Drive America's Solar Energy Boom in 2013,* August 2014.

10. The Public Utilities Regulatory Policies Act of 1978 (PURPA), which can be found at 18 CFR §292.303.

11. Estimated electricity losses in 2012 amounted to 203,399,772 megawatt-hours. When multiplied by the average retail electricity rate in the U.S for the same year, losses cost over 20 million dollars in 2012. Energy Information Administration, "Table 10. Supply and Disposition of Electricity, 1990 through 2012," accessed at: www.eia.gov/electricity/state/unitedstates/index.cfm Revised 19 June 2014.

12. Union of Concerned Scientists, *The Natural Gas Gamble: A Risky Bet on America's Clean Energy Future,* March 2015.

13. Thomas Jenkin et al, National Renewable Energy Laboratory, Ray Byrne, Sandia National Laboratories, *The Use of Solar and Wind as a Physical Hedge against Price Variability within a Generation Portfolio*, August 2013.

14. Paul Chernick, Resource Insight, Inc., John J. Plunkett, Green Energy Economics Group Inc., *Price Effects as a Benefit of Energy-Efficiency Programs*, 2014.

15. JR Minkel, "The 2003 Northeast Blackout–Five Years Later," *Scientific American,* 13 August 2008.

16. Herman K. Trabish, "Smart inverters: The Secret to Integrating Distributed Energy onto the Grid?" *Utility Dive*, 4 June 2014.

17. Number of states with renewable portfolio standards: DSIRE, *Renewable Portfolio Standard Policies,* accessed at ncsolarcen-prod.s3.amazonaws.com/wp-content/uploads/2014/11/Renewable-Portfolio-Standards.pdf, 1 June 2015.

18. US Environmental Protection Agency, *Sources of Greenhouse Gas Emissions,* accessed at www.epa.gov/climatechange/ghgemissions/sources/electricity.html, 27 May 2015.

19. Robert W. Howarth, Cornell University, "A Bridge to Nowhere: Methane Emissions and the Greenhouse Gas Footprint of Natural Gas," *Energy Science & Engineering,* 22 April 2014, doi: 10.1002/ese3.35.

20. Peter Howard, Environmental Defense Fund, Institute for Policy Integrity and the Natural Resources Defense Council, *Omitted Damages: What's Missing from the Social Cost of Carbon,* 13 March 2014.

21. Number was calculated by converting metric tons to short tons, and then multiplying that number by $37. Energy-related carbon dioxide emissions: U.S. Energy Information Administration, *U.S. Energy-Related Carbon Dioxide Emissions, 2013,* accessed at: www.eia.gov/environment/emissions/carbon/, 1 June 2015.

22. U.S. Environmental Protection Agency, *Air Pollutants,* accessed at: www.epa.gov/air/airpollutants.html, 1 June 2015.

23. American Lung Association, *State of the Air 2015,* 2015.

24. Ibid.

25. Union of Concerned Scientists, *Environmental Impacts of Coal Power: Air Pollution*, accessed at www.ucsusa.org/clean_energy/coalvswind/c02c.html#.VW5vus9Viko, 2 June 2015.

26. The Solar Foundation, *National Solar Jobs Census 2014,* January 2015.

27. Ibid.

28. The Solar Foundation, *An Assessment of the Economic, Revenue, and Societal Impacts of Colorado's Solar Industry,* October 2013.

29. This methodology is the most common because many utility commissioned reports only seek to calculate the costs of benefits of solar energy to the utility or to the ratepayer.

30. U.S. Energy Information Administration, *Table 8. Retail Sales, Revenue, and Average Retail Price by Sector, 1990-2012-United States*, accessed at www.eia.gov/electricity/state/unitedstates/, 12 June 2015.

31. Retail electricity rates are from the year that the study was conducted, when possible. If the study was conducted after 2012, however, we used the most recently available information from the Energy Information Administration- the average residential retail electricity rate of 2012. Several of the studies calculated values on a levelized basis, which makes comparing the value to a retail electricity rate from a single year problematic. This is, however, a way to show the comparison between current rates under net metering in most places, and the true value of solar.

32. Karlynn Cory, "Minnesota Values Solar Generation with New "Value of Solar" Tariff," National Renewable Energy Laboratory, 3 October 2014.

33. Clean Power Research, *Minnesota Value of Solar: Methodology,* 31 January 2014.

34. Xcel value of solar submission: Minnesota Public Utilities Commission, *Staff Briefing Papers: (CSG Rate),* 7 August 2014, accessed at www.edockets.state.mn.us/EFiling/edockets/searchDocuments.do?method=showPoup&documentId=%7b58DEA4D8-1E10-405A-85DA-2C81F77154E2%7d&documentTitle=20147-101753-01. Retail Electricity Rate: U.S. Energy Information Administration, *Table 8. Retail Sales, Revenue, and Average Retail Price by Sector, 1990-2012, Minnesota*, accessed at www.eia.gov/electricity/state/minnesota/.