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Integrated Utility-Driven Solar PV: Key to Keeping Clean Distributed Resources in the Race to Meet Carbon-Reduction Goals

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ABSTRACT

A change in perspective on solar PV development, emphasizing utility investment and technology integration, can rapidly grow a profitable market for PV and other clean distributed resources, including load management, energy storage, and energy efficiency. Through this approach, utilities can capture economic benefits of PV that are left on the table under the current customer-driven solar regime. The resulting cost-savings can be widely shared, yielding additional community benefits. Utility-driven solar does not require technical breakthroughs at the outset and necessary policy support is relatively straightforward. This approach offers an institutional framework that can speed growth and cut costs along every link in the product-delivery chain, supporting substantially more solar than the U.S. currently targets in the next 20 to 25 years. As a result, distributed PV—with related technologies—can play a significant role in meeting the energy needs of a fast-growing, carbon-constrained world.

Introduction

With its longstanding reputation as "green power," solar energy naturally comes to mind as a prime solution to global warming. Recent polls by the Program on International Policy Attitudes found that more than 80 percent of Americans support "environmentally clean energy, such as solar and wind power," as a solution to global warming. (PIPA, 2005) But PIPA, along with the American public, seems sadly misinformed about the utility strategies currently expected to address global warming. Not only is solar energy an extremely small contributor to current national electricity needs (below 0.1%), but it is also becoming increasingly inconsequential in mainstream climate recovery strategies.

The U.S. Electric Power Sector and Climate Change Mitigation, prepared for the Pew Center on Global Climate Change (Morgan et al. 2005) barely mentions solar photovoltaics (PV) in its assessment of changes in electricity generation and delivery that could lower greenhouse gas emissions in the near- to mid-term. The report dismisses PV based on installed capital cost, which it calculates at six times more than the capital cost for a new conventional coal plant and 15 times more than the capital cost of a new gas generating unit. "Until costs fall dramatically," it states, "PV systems will not be economic except in selected off-grid niche markets." The Pew study contends that there is a strong historical case for the continued dominance of coal—accompanied by carbon sequestration and other less significant (and non-solar) resources.

The U.S. Energy Information Administration *Annual Energy Outlook 2006* (EIA, 2006) also makes little mention of PV. The EIA offers a stronger outlook for renewables than it had in the past, predicting that non-hydro renewables in the U.S. could grow by 95 percent, from 2.2 percent to 4.3 percent of national energy resources, between 2004 to 2030. However, it states, "Grid-connected solar generation remains at less than 0.1 percent of total generation through

2030." Another EIA publication, the International Energy Outlook 2005 (EIA 2005), suggests that nations subject to the Kyoto Protocol may see a *decline* in the role of renewables by 2025. This is because growing needs for energy may be more easily met by nuclear power, energy conservation, and eventually, coal with carbon sequestration.[1]

Some other analysts see more promise in PV. For example, the United Nations Environment Programme Renewable Energy Policy Network for the 21st Century (REP 2005) released a draft paper in December 2005, which assessed a number of energy forecasts. REP 21 concludes that solar price declines could bring PV into strong competition with clean fossil fuels and most other renewables by 2030. The problem, it suggests, is that PV marketed aggressively after 2030 would not reach significant market penetrations until after 2050. Major reductions in carbon emissions will be required by 2030, and planning for those reductions must begin today.

Considering all the sobering facts and predictions of PV development too-little-too-late, this paper seeks to put a new focus on why distributed solar PV remains an important technology for serious and rapid development. This paper will also present a relatively untested, but readily accessible marketing channel for solar PV—that is, direct utility deployment, in concert with load control, local energy storage, and energy efficiency. To date, and especially since utility industry restructuring, PV has been presented as a customer-driven energy option. Individual customers must purchase, install, and operate PV, often in conflict with a utility that sees little economic benefit in accommodating them. This paper argues that policies promoting utility-driven solar can put more of PV's economic benefits in play, and it can speed growth and cut costs along every link in the product-delivery chain. As a result, PV can become a significant part of national and international carbon reduction plans within the next 20 years or less.

1. Five Reasons Why Solar PV Matters

Compared to average per-kilowatt-hour electric rates, solar PV is currently very expensive. But the value of PV needs to be assessed in a context that is location-specific, time-specific, and in combination with other compatible technologies. Other aspects, such as long-term energy-cost stability, also could turn today's view of PV on its head. Section 2 of this paper will describe how utilities may capture the full range of PV benefits and drive rapid market transformation. But first, this Section briefly describes why it is important to do so.

1.1 Peak capacity benefits. In most of the U.S., solar PV is a peak capacity resource. Studies of locations as disparate as New Jersey and California suggest that properly sited PV with no accompanying energy storage or load control matches many utility peaks about 50 to 60 percent of the time. (Sliker 2004) In tandem with modest load control or energy storage, PV can be available on peak nearly 100 percent of the time. (Hoff et al. 2005) This is important because peak capacity drives utility plant and infrastructure construction. If a large amount of PV could be deployed within the next 10 to 20 years, its peak-reduction impacts would ease the demand for natural gas peaking plants and natural gas fuel. Other renewables would help, too, but notably, solar has an edge over wind power in this regard, since wind is generally less available on peak.

Robust solar deployment may slow the rush to some new baseload plants, too. About 75 GW of U.S. coal capacity will be at least 50 years old by 2015. (Hawkins, 2004) This need for

[1] PV was not specifically addressed in the IEA analysis, due to its projected negligible role.

plant replacement comes in addition to increasing U.S. energy needs. Some utilities could delay plant construction with natural gas peakers, but increasingly, they prefer to move now to build conventional coal plants. They believe they will need the capacity eventually; they know coal is cheaper and less price-volatile than natural gas, and if they act now, they may escape some anticipated carbon regulations. About 120 coal plants are under development in the U.S. today, and nearly all of these will use conventional pulverized coal technologies. After decades of little coal-plant construction, EIA predicts that half of generating capacity built between now and 2030 will use coal. (EIA 2006)

Expecting solar PV to replace a 700 to 1000 MW coal plant is not asking the right question. In the near term, robust solar deployment may delay construction of conventional coal plants that are not urgently needed. Distributed renewables, load management, and energy efficiency are all more likely to thrive in a market that is *not* temporarily over capacity—a condition that typically accompanies new plant construction. (Lovins et al. 2002) Distributed resources, including PV, bring their own benefits, and they can buy time for the hopefully rapid evolution of better baseload solutions.

1.2 Integrative with load management. Although it is primarily a peak resource, solar PV is not always available on peak. Where near-100 percent availability of solar on peak is important, PV must be integrated with load management (demand response, load control) and/or dispatchable storage. It is also compatible with energy efficiency, which can moderate peak energy needs. In short, integrated PV strategies are worth much more than the sum of their parts.

This is especially true of solar and load control. Perez and others have modeled cost-effective results for integration of PV and load control or energy storage in New York, Pennsylvania, New Jersey, California, and other locations. One key to this strategy is that the energy storage (typically batteries) or load control (air conditioner cycling, lighting controls, etc.) would be needed only during an interruption of the PV on peak, and not for long periods of time. For example, a study of utility-scale solar load control for the Sacramento Municipal Utility District found that PV sized for a 10 percent peak load reduction, together with modest use of load control, could double the load control's instantaneous dispatchable capacity. (Perez et al. 2002) This study also showed dramatic impacts at greater PV penetrations, where a 20 percent utility peak load reduction could be achieved with PV and just 12.4 hours of load control per year, compared to about 63 hours per year without PV. In this case, load control would, in effect, stretch the effective on-peak solar resource from 211 to 532 MW.

Sacramento has also documented the compatibility of PV and the peak-dampening effects of energy efficiency in its Zero Energy Homes. (Keese & Hammon 2006) An energy-efficient building tends to stay cooler and require less air conditioning on peak. Grid-connected PV can provide on-peak energy, not only for use at the "host site," but anywhere on the system.

We suggest testing another likely benefit of integrating PV and load control. That is, that coupling control with PV would lessen the load shifting that often characterizes load control. If service were seldom and only briefly interrupted, customers may be less likely to increase energy use off-peak. This effect is key if demand response is to contribute to climate-impact reductions.

Finally, an integrative approach presents opportunities to broaden and increase Renewable Portfolio Standards (RPS). Coupled with PV, load management (and energy efficiency) performs much more like the supply-side resources they are intended to displace. This could strengthen political ties between demand response and renewable energy advocates, who are working toward very similar goals.

1.3 Supportive of smart grid development. The "smart grid" refers to highly integrated generation, transmission, and distribution strategies that use information technology to optimize the overall system. This includes improving power quality, reliability, and cost-effectiveness and offering new services that can be managed through the grid. Sophisticated load management technology is part of the smart grid, and so are solar PV and other distributed generation.

We have already discussed how PV requires load control or dispatchable storage to perform as a highly available peak resource. There are other benefits to integrating PV with the smart grid, too. For example, a field study of distributed generation for the California Energy Commission identified network benefits from distributed generation that were proportionally greater than the amount of distributed generation installed. Benefits included reduced system losses and an improved voltage profile. The study's author notes, "The prime mover doesn't matter. PV and other renewables count." (Evans 2004)

Especially in the wake of recent hurricanes, distributed PV has also been identified as a potentially reliable, fuel-free source of electricity. If fossil fuels become unavailable or if the conventional grid is disrupted, PV may be designed to drop safely off the grid so that essential and sensitive loads would continue to be served. Certainly, PV is not the only distributed generation technology that can be used on the smart grid, but it is one of only a few renewable energy options. Its development and the development of the smart grid are mutually supportive.

1.4 Long-term domestic supply and price stability. Like other renewable energy resources, solar PV has high capital costs and zero fuel costs. This is in dramatic contrast to natural gas, which is costly, price-volatile, and—as evidenced by LNG forecasts—potentially insecure. Solar is less price-volatile than coal, too, because coal prices rise with those of oil and gas. These factors have implications for all kinds of PV applications.

For example, policymakers are beginning to consider electricity as a long-range alternative transportation fuel. The Pew report on the U.S. electric power sector and climate change discusses the possibility that plug-in hybrid or hydrogen-fueled vehicles could become prevalent by 2050. Either scenario could lead to total demand growth of as much as 2,000 billion kWh/year by 2050. (Morgan 2005) While the Plug-in Partners campaign, which is backed by numerous utilities (Plug-in Partners 2006), currently looks to conventional generation options, a robust PV strategy could help to meet this demand with minimal environmental impacts. The challenge of deploying and coordinating the requisite grid-integrated distributed PV networks could be eased by direct utility investment in distributed PV.

1.5 Spurring PV use worldwide. The EIA International Energy Outlook 2005 predicts that net electricity consumption worldwide will nearly double from 2002 to 2025, and that more than half of demand growth will occur in emerging economies. (EIA 2005) The cost in terms of carbon-dioxide emissions will be enormous—from 24.4 billion metric tons of carbon dioxide in 2002 to 38.3 billion metric tons in 2025. These predictions are based on scenarios that largely exclude energy conservation and renewables, but the fact remains: the energy needs of emerging economies are enormous. If renewables do not play a big role in meeting growing electricity demand, then one must hope for clean coal and nuclear development. Either of these solutions comes with technology-development, waste-management, and security risks, which are heightened in relatively unstable countries.

As they review the options, some countries are issuing energy policies that counter EIA's dour view of renewables. They foresee using diverse energy resources and balancing the risks associated with clean coal and nuclear. Especially where infrastructure is lacking, they see a big role for distributed renewables, including PV. For example, India released a draft energy policy in early 2006 that aims to use renewables to serve 30 to 50 percent of national energy needs by mid-century. Solar technologies, including PV, would provide more than 40 percent of this renewable capacity, followed by biomass and wind. According to *Refocus Weekly* (ISES 2006), the Indian minister for non-conventional energy sources announced that the situation for renewables "would only improve in the future as 1 million MW of power generating capacity from renewable sources by 2050 is no longer a dream but a stark reality."

Working from a similar vision, former Soviet President Gorbachev recently called for immediate establishment of a $50 billion Global Solar Fund. The fund could be raised by cutting subsidies for fossil fuels and nuclear energy in industrialized nations, Gorbachev said.

Though it did not foresee the urgency of international interest, the 2003 Solar Photovoltaic Industry Roadmap from the National Center for Photovoltaics (NCP 2003) anticipated the need for U.S. leadership in PV research, development, and commercialization. The Roadmap points out the enormous economic opportunities for PV, noting that the U.S. must deploy a significant amount of PV technology at home, if it hopes to lead in world markets.

2. PV Deployment Under the Customer-Driven Model

Since the 1970s, the prevalent model for solar deployment has been customer-driven. It is deeply rooted in social and political context, and perhaps for that reason it has seldom been challenged. As the president of the Hawaii Solar Energy Association put it, "At the end of the day, we are saving the world one rooftop at a time." (AP 2006)

2.1 Progress in context. By some measures, this model has been successful. It accounts for nearly all of the 365 MW of PV that has been installed in the U.S. to date, and for most of the 2.6 GW installed worldwide. Industry growth has been in the range of 30 to 40 percent per year. This is a phenomenal accomplishment, rendered small only because it must affect a market of such huge and growing proportions.

The necessary question is, can PV industry growth and market penetration be pushed much faster and further? To date, incentive funding, including rebates and tax breaks, and a range of supportive policies have played a major role in stimulating customer investments. U.S. market incentives for PV in 2004 totaled about $180 million. Research, development and demonstration funding totaled about $96 million. (PPSP 2005) New strategies, such as performance-based incentives and feed-in tariffs, time-of-use net metering, integration with zero energy buildings, and customer sales of green tags have tweaked customer-driven model, driving hopes for solar market transformation, though at some public cost.

A 2004 study for the Energy Foundation explores the limits of PV grid-connected potential in the U.S. (Chaudhari et al. 2004) The study assumes a customer-driven model. It also assumes technology breakthroughs to bring the price of rooftop PV down to $2.50 (residential) $2.00 (commercial) per installed peak-Watt by 2010. Considering assumed improvements in PV performance and U.S. building trends, it estimates technical potential for rooftop PV at 1000 GW by 2025. This translates into market potential of 47 GW by 2025.

In its entirety, the study sheds light on the potential and the limitations of the customer-driven model. If the model can deliver 47 GW of PV by 2025, this would be about twice the amount of PV targeted by the 2003 PV Roadmap and two to three times the amount targeted by the new DOE Solar America Initiative.[1] In context, the Energy Outlook (EIA 2006) base case calls for about 350 GW of new capacity (including plant replacements) in the U.S. by 2030. Forty-seven GW represents a truly significant portion—more than 13 percent—of that need.

2.2 Issues raised. However, the study hinges on big assumptions, including timely PV cost reductions driven by heroic technology breakthroughs and uncalculated support from government and investors. At the same time, it is conservative in assuming only standard Federal tax credits, no state incentives, modest REC value, and net metering. Because it focused on customer-ownership, the study did not assume peak-oriented PV siting or integration with utility demand response. It based most of its economic analysis on simple payback. It recognized but could not account for utility system benefits and it assumed that utility investment in distributed PV would be nil. In short, the study contributes to our understanding of the technical potential for PV. But it offers only assumptions to address its enormous implementation challenge, which in the end relies on millions of individual home and business owners, each shouldering a sizable investment to support a new energy service industry.

We expect that the momentum behind the customer-driven model will increase in regions where it is established. However, given the climate stakes, we suggest that a different, utility-driven model should be tested as a complementary way to accelerate PV market transformation.

3. PV Deployment Under a Utility-Driven Model

Some policy discussions about how to drive PV development have recognized the need for business models that would facilitate greater utility support for distributed resources. Numerous studies have identified—even quantified—theoretical utility benefits from distributed PV. (Neff 2004; Smeloff 2004) However, utilities argue that many of these benefits cannot be secured under the customer-driven model, and others are greatly discounted by typical PV siting and a lack of supplemental load control. (Silsbee 2005) The utility-driven model, which is defined by utility ownership or control of PV systems, provides a framework for capturing these benefits and for supporting other key aspects of solar market transformation, including

- Significant and increasing technology investments
- Large-scale implementation
- Value-chain management
- Integration with the utility grid and emerging smart grid
- Disruptive technology management, and
- More equitable distribution of public costs and benefits.

3.1 Utility economic benefits. The key to this model is the range of benefits that are realized uniquely from strategic utility investments in PV. These include savings on traditional capital and operating costs and a range of risk management benefits. The economics of utility-

[1] It is useful to roughly compare various targets, but they are only roughly comparable, as each is focused on different solar technologies and milestones.

driven PV are discussed elsewhere (Robertson and Cliburn 2006), and it is beyond the scope of this paper to detail that discussion. However, we review relevant portions here.

Table 1 summarizes the economic benefits of utility-owned PV. Most of these benefits are listed in the EPRI E2I work and similar studies of PV value, but we assess them from a utility-ownership perspective. Our approach focuses on the *net resource cost* of strategically deployed PV, and not the conventional busbar cost (the cost per kWh at the output terminals of the generator). This net cost includes utility costs (e.g., Installed system costs, maintenance and administration costs, plus estimated $150/kW for short-term local energy storage and $60/kW for load control), which are assessed against utility benefits.

Using public sources of utility data, we have estimated ranges of values for a subset of the benefits listed in Table 1, based on a generic utility in the Northeastern U.S. In this case, net value to the utility exceeds the cost of PV capacity at $6,000 per kW.[1] Leading sources of utility value include generation capacity on peak and related peak operational costs, distribution deferral, transmission congestion relief, and solar Renewable Energy Certificates. We found that any of these leading benefits could be minimized—even zeroed out, and so long as the utility could count other available benefits, the result would still be a net utility gain.

The dynamic nature of the economic case is important for practical reasons. Utilities that resist change or are limited in their ability to integrate interdepartmental benefits may tailor their economic justification for PV. We expect that the initial market for utility-driven PV will be limited to the most robust opportunities. As utilities gain experience with solar PV or as regulation encourages them to act, more benefits will be realized and programs will expand. For example, if utilities were rewarded for maximizing the benefits of their PV investments, then it would be in their economic interest to quantify relevant risk-management benefits. These benefits could be enormous, leveraging massive deployment.

It is also instructive to compare net results *from the utility perspective* of the utility-driven versus customer-driven PV model. In our analysis, the difference for the utility between economic benefits gained in the utility-driven case and those lost in the customer-driven case is nearly $2,500 per kW. This is largely because customer owned systems (sited for energy payback) have lower peak resource value, utilities lose revenue from customer generation, and utilities that need RECs must buy them from customers if they do not produce RECs themselves.

Strong utility cost-effectiveness would trigger market forces to increase solar REC supply and eventually to lower REC costs. In addition utility-driven PV deployment invites regulation aimed at benefits-sharing. If solar is profitable for utilities, then the benefits should be shared among stockholders and customers.

3.2 Increasing Technology Investments and Reducing Solar Costs. In contrast to the Energy Foundation study of PV market transformation, the utility-driven model does not assume a prerequisite technology breakthrough. Our assessment assumes PV investment at low-end market costs today. At the same time, cost reductions are increasingly likely.

The impact of economies of scale for PV deployment has been documented in California, Europe, and Japan. The solar industry has evidenced an 80 percent learning curve, expressed as a 20 percent cost reduction for every doubling of output. The current industry shortage of electronic-grade silicon will disrupt this curve for the next few years, but the raw materials are

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[1] This is an estimated installed cost for commercial PV that incorporates an economy of scale. (Wiser et al. 2006) It also includes modest load control or local energy storage costs. Price trends for PV are discussed further in Section 3.2.

abundant. A summary of a 2005 international forum on PV feedstock concluded that market uncertainty, characterized by year-to-year government incentives and a lack of long-term bulk purchase agreements, is the root of the silicon supply problem. (Schmela 2005) The utility industry could break this logjam and prime the PV industry to flow from feedstock production through deployment. A recent study of PV cost trends in California tends to confirm that all aspects of value chain management—from bulk purchasing of equipment through integrated management of design and construction—could result in installed system price declines. (Wiser et al. 2006) Utilities are positioned to promote all kinds of streamlining and value-chain management. For example, if utilities were to lease commercial and residential roof space for solar installations, they would be more likely to cover entire rooftops with PV than to install 2- or 3-kW units, because it is much more cost-effective to do so.

Technical innovation is part of this picture, too. Investor confidence increases as large players, such as utilities, enter a market and as that market expands. Under this model, utilities would have a stake in improving demand-response and storage technology, as well as PV materials and systems. A robust utility solar market would be a boon to investment in all smart-grid technologies.

3.3 Technology and advocacy integration. Utility-driven solar strategies offer unprecedented opportunities for clean technology integration. As utilities deploy solar with load control and/or local energy storage in order to enhance PV's on-peak energy value, they must begin to integrate supply-side and demand-side tools. In some cases (for example, in the case of Sacramento's Zero Energy Home program, described above) utilities may also recognize the role that energy efficiency can play to dampen peak loads. And if utilities begin to recognize PV opportunities to support smart grids or plug-in hybrid cars, the opportunities for technology integration increase. We recognize that utilities are typically challenged by integrated strategies, largely because they are big organizations with insulated departmental functions and even more insulated departmental budgets. A utility-driven business plan, aimed at capturing the economic benefits of an integrated PV strategy could be a strong incentive to overcome such challenges.

Moreover, utility-driven PV strategies present a strong opportunity for clean energy advocates to work together in pursuit of their own business interests and of significant climate recovery. Energy efficiency and demand response advocates have often said, "The cheapest kilowatt of capacity is the one that you don't have to build." In support of a utility-driven PV strategy, these advocates would be joined by PV advocates who hope to defer natural gas and possibly coal plant construction. Energy efficiency, demand response, smart grid, and renewable energy advocates have a great deal in common, but they have seldom had projects like this, which require their sustained collaboration. One example of an campaign related to utility-driven distributed PV might be an expanded national RPS, which would reward investments in all kinds of clean distributed resources, including distributed PV integrated with load control.

3.4 Public benefits and policy implications. The economic opportunity that PV offers to the utility industry is still hard for that industry to comprehend. Today, utilities are more likely to see distributed PV as a nuisance, which has the potential to drive utility costs up. The market development model for customer-driven PV does, in fact, resemble that of a classic disruptive technology: It presents an initially costly technology that allows customers to circumvent traditional products and services, and its success could undo an industry. (Steigelmann & Cliburn 2005) Yet, while disruptions in industries like computers had little immediate impact on working-class and low-income citizens, this would not be the case for a disruption of the utility industry. Unless the disruption is managed, non-participants in the PV revolution will pay rising energy costs as their wealthier "greener" neighbors enjoy watching the meter spin backwards.

Regulators in some states recognize this issue. California utilities are testing more utility-friendly tools such as performance driven incentives and incentives for adding load control to homes that have PV. The Mid-Atlantic Distributed Resource Initiative is also exploring ways to encourage optimal placement of customer-owned distributed generation on the grid.

We believe utilities could have a much deeper stake in cost-effective PV development. The resulting savings from strategic utility-owned PV could be shared between stockholders and all customers. This regulatory model, first introduced by the New England Utility Collaborative in the late 1980s, successfully drove more than $500 million in cost-effective energy efficiency. (Related "decoupling" regulatory strategies are still in place today.) Regulatory refinements could drive utilities to maximize the benefits of PV throughout their systems. Solar deployment would become a community cause, because any home or business that was properly sited could be a candidate for an installation, and everyone would feel the rate-dampening effects.

We recognize that this model suggests partial reversal of regulatory policies, popular in the last decade, which prohibited utilities from offering energy services. In some jurisdictions, utilities currently may not own distributed generation. The utility-driven distributed PV model would require a change in such policies, but it need not prohibit competitors from promoting customer-owned PV. This type of competition, building on years of effort to create fair interconnection standards and policies, could provide a yardstick for evaluating utility PV program costs and effectiveness, and it could only help to grow the overall PV market.

Other policies might include a variety of "carrot and stick" measures. The tax benefits that are available to private investors in solar should be extended to utilities. Economic development incentives could encourage utilities to develop strong supportive relationships with solar industries. Utility-owned, customer-sited PV might be encouraged by supportive zoning, by targets requiring new public buildings to host customer- or utility-owned PV, or by measures to support distributed solar liability coverage. At the same time, utilities should face challenging solar-RPS targets. They could be required (as recently suggested by the Regulatory Assistance Project) to implement and publish thorough studies of distribution system costs, so they would be more likely to include distributed energy in their best-cost service delivery plans.

Moreover, regulations on carbon emissions and other regulations aimed at slowing the growth of fossil and nuclear generation would spur PV and all low-carbon energy options.

Conclusion

In the context of growing world energy needs and an unprecedented rush to build new conventional generation, this paper calls for immediate, serious development of an alternate approach: supporting large-scale utility deployment of distributed PV.

Clearly, a more complete study of utility benefits, internal and external barriers, and regulatory tools is in order. Further study of the model in the market context (typical sites, contract requirements, integration and operational issues, etc.) would shed more light on utility implementation. The integration of PV, demand response, and energy storage could also be detailed. At the same time, there is nothing to preclude immediate utility adoption of this model in many regions of the country, raising the potential for rapid, large-scale distributed-solar market transformation and supporting the growth of related clean, distributed energy solutions.

Table 1: Sources of Value (Cost) in Utility Budgets from Utility-Driven PV

Source of Value	Example or Value if Publicly Available
Peak Load Value	
Distribution investment deferral	< $0 to > $6000 per marginal kW 5 yr deferral
Transmission congestion relief	$30 - $50/kW-yr
Transmission investment deferral	$45/kW-yr
Generation capacity	$475/kW; 3x more if IGCC + C Sequestration
Generation O&M	~$10/kW-yr
Generation reserve	$.014/kWh
Natural gas	$8.50/MMBTU; highly volatile future price
Purchased power	PV supply offsets high cost peak power
Minimum load power plant dispatch	$28/kW-yr
Environmental	$0.014/kWh NO_X; Mercury, SO_2, CO_2 also
Line losses	Up to 25% in some constrained systems
Reactive power & voltage support	$15/kW-yr
Network O&M	$16 to $88/kW-yr
Intermediate Load Value	
Natural gas	$8.50/MMBTU; highly volatile future price
Environmental	$0.014/kWh NOx; others
Line losses	6% - 8%
Policy-Driven Value	
Net metering payments	Normal utility rate; moving to TOU rate
Customer rebate payments	Varies by jurisdiction
Solar renewable energy credits	PJM $200 - $600/MWh; other regions much less
Business Model Value	
Customer revenue retention	Normal utility rate revenue
Peak-period DPV revenue	Sell DPV capacity into peak power market
Tax investor participation	30% PV capital cost through '07; 10% after that
PV system portability	~$2000/kW if redeployed 4x
(Payment to PV host site)	Perhaps 10% of rate, plus insurance coverage
Risk Management Value	
Grid reliability & outage prevention	$Billions & lives lost -- societal
Natural gas availability	Threat of Fuel Use Act; peak oil effects
Financial	Lower interest rates for PV due to low risk
Regulatory	Avoid regulatory pre-emption
Carbon	New requirements likely
Insurance	Global warming liability coverage
Share price & fiduciary duty	Investor expectations for CEO's risk mgmt.
Generation portfolio cost and risk	DPV *net* cost reduces gen. portfolio cost & risk

Source: ElectrticSUN synthesis from numerous studies of publicly available data on distributed energy resource benefits and costs. Actual values would vary, depending on specific utility analysis.

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