Clean Coalition
Making Clean Local Energy Accessible Now

CLEAN Resource Hub Policy Brief

Locational Benefits of Distributed Generation

Introduction

Locational Benefits (LBs) are the real, measurable and material advantages associated with siting new energy generation facilities in one location compared to another. This relative value of where projects are sited needs to be factored into energy policy and procurement programs. Policies that account for the full value of distributed generation (DG), including the distinct value of wholesale distributed generation (WDG), are necessary to ensure fair competition in energy markets and realize the best value for ratepayers and communities.

This Brief explains the major types of Locational Benefits that can be associated with DG as compared to remote, "central station" generation that is typically connected to high voltage transmission lines to deliver energy. As with most CLEAN Resource Hub materials, this Brief focuses on WDG, defined as generation connected to the distribution grid and selling its output to the local utility to serve local demand. Most LBs also apply to retail / "behind the meter" DG, so little time will be spent on making the distinction.

Historically, energy procurement and planning decisions have focused on the contract price or the cost of energy at the point where it is delivered to the grid. This price is reflected in wholesale power purchase agreement prices, or in the estimated "levelized cost of energy". However, this "sticker price" approach misses entire categories of important factors that should be considered in an accurate comparison between different generating facility choices. The potential missed value can range into the hundreds of millions of dollars for major procurement programs such as a Renewable Portfolio Standard (RPS).

LBs in the form of direct cost savings to utility ratepayers include the following categories:

- Avoided costs associated with capital investments in expanding transmission and distribution grids.
- Avoided costs associated with transmission infrastructure operation and maintenance (O&M).
- Avoided costs associated with transmission and distribution grid line losses of real and reactive power that occur as energy moves through the grid.
- Avoided costs associated with congestion charges applied to energy sourced from constrained networks.
- Value of greater electric system reliability, through greater geographic and resource diversity and the distributed voltage control and voltage event ride-through capabilities of advanced inverters paired with distributed generation.

Full cost and value accounting would also recognize LBs from economic value to citizens as well, such as those driven by separate "non-ratepayer" policy goals. These types of benefits include:

- Reduced pollution, particularly in highly impacted areas
- Planning factors such as rapid and efficient deployment, as opposed to delays and uncertainty related to central generation's environmental impact, permitting, and the availability of new transmission facilities
- Increased energy security and resilience
- Local community benefits through targeted employment, auxiliary land use, and new private investment

The cost savings associated with LBs are gradually becoming part of energy policy discussions nationwide. Regulatory bodies need to formally quantify LBs, but some precedents and research studies already exist for quantifying specific sets of LBs. This Brief will review the major examples and reference the calculation methods that have been implemented.

Making procurement decisions on the basis of a "sticker price" that fails to account for LBs is harmful to ratepayers. Likewise, basing preferred siting only on costs without consideration of value, including avoided costs, may have adverse and unintended consequences. Although more analysis is needed, the significance is clearly substantial. In California's Renewable Auction Mechanism (RAM) program alone, a lack of accounting for LBs fails to recognize more than $800 million over the life of the program. Looking at this from another perspective, a recent report on the potential for DG in California showed that under certain "full cost accounting" scenarios, there are 1,000 MW or more of solar PV that can be supplied in the state at a Levelized Net Cost of Energy of 5.0¢ per kWh or less.[1]

Policy recognition of the entire range of LBs is a vital first step in ensuring that policy designers are capturing the full value of new clean energy generation for ratepayers and communities.

[1] E3, "Technical Potential for Local Distributed Photovoltaics in California," March 2012, http://www.cpuc.ca.gov/NR/rdonlyres/8A822C08-A56C-4674-A5D2-099E48B41160/0/LDPVPotentialReportMarch2012.pdf

Table of Contents

Direct Cost Savings

Direct Cost Savings are the specific costs of generating and delivering energy that utilities and ultimately ratepayers can avoid or defer with well-sited DG. Some of these costs, such as line losses, are understood by utilities today, but most are not acknowledged as true cost savings yet, and almost none are fully quantified and credited to new DG.

While specific location within the distribution system is very important to consider, all generation located on the distribution system can have categorical value relative to generation feeding onto the transmission system. DG has substantial "locational value" since these facilities are located on the distribution grid and allow utilities to avoid many grid operation costs by producing and delivering power to loads without use of transmission facilities. Ratepayer factors that are readily quantifiable and should be included in any avoided costs analysis include transmission charges, wheeling charges, line losses, congestion costs, and grid investments required to ensure local capacity and reliable delivery of energy to load.

Note that much of the avoided costs that can be credited to DG depend on a utility's ability to plan for and "see" the generation facilities during grid operations. Critics of locational value efforts may point out that retail DG, "behind the meter", cannot be planned for or visible and thus cannot actually save money in grid operations. While this may be true for certain value factors, wholesale DG is developed through utility procurement programs and is usually required to provide telemetry and communication to the grid operator. Thus, WDG can be used to save money if well sited.

Benefits of Avoided Transmission Costs

There are a number of ways that avoided transmission upgrades may accurately be quantified, which are discussed below.

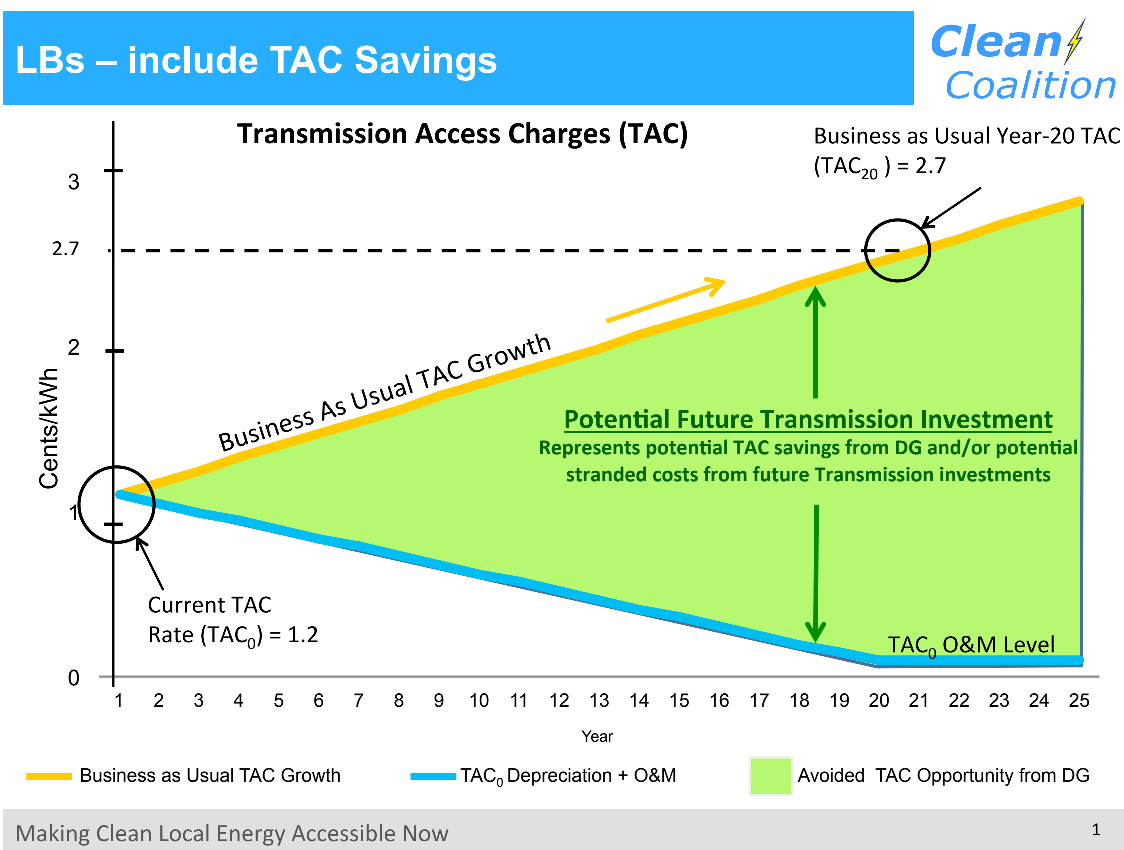
Energy efficiency standards undertaken in California over the past 40 years have avoided the need for approximately three-dozen additional conventional power plants, and the concomitant transmission capacity that would have been required to deliver the avoided conventional energy to load. Clearly, reducing the need for transmission-interconnected generation directly reduces the need for transmission facilities and the rapidly rising costs of new transmission facilities. These avoided transmission savings are significant and cannot be ignored. While it can be difficult to precisely determine the degree of deferred transmission and associated cost savings directly caused by each instance of distributed generation, the aggregate impact is clear, and should be proportionately assigned to each project that contributes to deferred or avoided transmission expenditures.

Transmission Access Charges

Transmission related costs of delivering energy from remote generation are often combined into costs that are charged by the transmission operators. In California, these costs are called Transmission Access Charges (TACs). This is a flat "postage stamp" fee for every kWh delivered to the distribution system from the transmission grid. TACs are avoided when energy is delivered directly to the distribution system by DG to serve loads on the same substation (i.e. the transmission grid is completely avoided).

DG facilities will continue saving these charges as they increase over time for the entire operational life of the DG facility. While some have argued that TACs represent committed expenditures that will need to be paid in full regardless of whether DG incurs these charges, DG reduces the level of continuing investment required for transmission, directly resulting in lower TAC charges over time, as illustrated in the below TAC chart.

Figure 1 - *Clean Coalition estimate of TACs*



The orange "Business as Usual" line represents the expected growth in TACs as more investment is made in the transmission system to accommodate additional remote generation. The blue line represents the decrease in TACs that is possible if that remote generation was entirely replaced by DG (the down ramp is based on a 40-year depreciation schedule of transmission assets such as transmission lines).

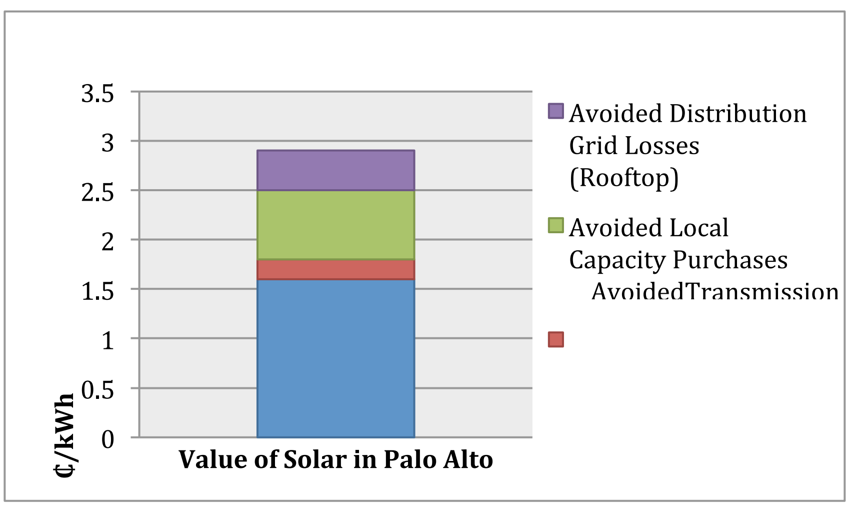
Thus, the green wedge represents the potential cost savings achieved with DG. Again, while it may be difficult to assign a specific value to each DG project, clearly DG projects should be credited with a portion of these potential savings.

Transmission Cost Examples

The City of Palo Alto Utilities conducted a study of the value of local solar relative to non-local energy in 2011[2], including local capacity value and transmission costs, and reflected this value in its procurement offers. For Palo Alto such generation avoided charges the utility would otherwise incur for use of the external transmission system, in addition to line losses and capacity charges related to the transmission and generation resources reserved to meet the utility's peak demand.

In establishing the value of avoided transmission charges, the Palo Alto Utilities recognized that the current transmission usage charge of 1.2¢/kWh had been rising and was expected to reach 2.7¢/kWh during the 20 year contract terms of local solar generation. The utility therefore used the levelized value of these costs, calculating them at approximately 1.6¢/kWh.

Figure 2 - *Palo Alto Utilities avoided cost calculations.*



---

[2] Renewable Feed-in Tariff Program Adoption Attachment E: Renewable FIT Program Pricing Methodology. City of Palo Alto, City Council Staff Report (ID # 2329) 12/12/2011. http://archive.cityofpaloalto.org/civica/filebank/blobdload.asp?BlobID=30132

In 2012, the Los Angeles Department of Water and Power (LADWP) reached similar conclusions for its 100 MW CLEAN LA solar feed-in tariff program. "Energy from these large out-of-basin projects must be brought to LA at an additional cost of $0.03/kWh for transmission, distribution, and losses." Thus, DG serving local needs was valued at 3¢/kWh above the value of non-local sources, and this differential was reflected in the prices offered.

For another recent example, the Long Island Power Authority (LIPA) has offered a 7¢/kWh premium to 40 MW of appropriately sited solar DG facilities to encourage locational capacity sufficient to avoid $84,000,000 in new transmission costs that would otherwise be incurred, resulting in a net savings of $60,000,000. LIPA's guidance states: "The rate will be a fixed price expressed in $/kWh to the nearest $0.0000 for 20 years applicable to all projects as determined by the bidding process defined below, plus a premium of $0.070 per kWh paid to projects connected to substations east of the Canal Substation on the South Fork of Long Island."[3]

The following chart is a simplified comparison of the full cost to ratepayers of different types of generation when Transmission and Distribution costs are factored in. These numbers are illustrative of the costs in California in 2011.

Total Ratepayer Cost

	Distribution Grid					T-Grid
PV Project size and type	**100kW roof**	**500kW roof**	**1 MW roof**	**1 MW ground**	**5 MW ground**	**50 MW ground**
Required PPA Rate	**16¢**	**15¢**	**13¢**	**9-11¢**	**8-10¢**	**7-9¢**
T&D costs	**0¢**	**0¢**	**0¢**	**0¢**	**0¢**	**2-4¢**
Ratepayer cost per kWh	**16¢**	**15¢**	**13¢**	**9-11¢**	**8-10¢**	**9-13¢**

Sources: CAISO, CEC, and Clean Coalition, Nov2012; see full original analysis from July 2011 at www.clean-coalition.org/studies

[3] Proposal Concerning Modifications to LIPA's Tariff for Electric Service, FIT070113 http://www.lipower.org/pdfs/company/tariff/proposals-FIT070113.pdf

Challenges to Transmission Cost Savings

A claim has been made that if the transmission required for the energy policy goals (like an RPS program) is already committed, adding DG will not avoid these transmission costs. However, this misses the critical point that reducing the use of this new transmission capacity allows every MW of transmission capacity not utilized for energy now provided by DG to be available for other transmission requirements. Even with DG reducing the immediate need for transmission, anticipated future increases in renewable generation, if not met entirely by DG, will make use of such transmission facilities.

Meanwhile, the opportunity to defer construction until that time has very substantial value. An upgrade should be deferred if required reliability levels can be maintained without the upgrade. Incentives to attract DG to avoid an upgrade should be based on the value of avoiding the upgrade relative to the cost and value of improvements that are achieved by added DG.
(This is similar to FERC Order 1000 initiatives regarding non-transmission alternatives to potential transmission upgrades).

To the degree that transmission planning is assumed to already include quantities of DG, it is sometimes claimed that any avoided transmission is already assumed and, therefore, no avoidable transmission costs should count. This also is fundamentally flawed reasoning – avoided costs must include the cost of the alternative/default resource that would be incurred if the option under study were not used. If DG is not deployed, all non-DG energy will need to be provided through transmission services.

The DG included in transmission planning should be assigned the value of the transmission that would otherwise have been required. Even if grid operators can use existing capacity, this existing capacity is then used up, and additional capacity will be required for those needs that would otherwise have been avoided/deferred.

Benefits of Avoided Congestion Costs

Congestion refers to the existence of limitations on the grid's ability to transmit power through a specific point or path on the grid, which results in a higher cost of electricity due to increased losses as transmission capacity is approached. Congestion costs and relief values can be attributed directly to the node causing or relieving the congestion. Ideally, a generator that relieves congestion should be paid a premium that reflects the locational benefits provided, and a generator that causes congestion should receive a lower price for the energy it produces.

Congestion is typically associated with lack of transmission or distribution capacity, but it is often a reflection of locational imbalance between generation, load, and transmission resources. For example, generation or load pockets may exist which stress the transmission or distribution system due to limited capacity at the location of the load or generation source. The flow of power, the loading and temperature of lines, and the voltages of the system all affect congestion.

Unfortunately, there are no uniform reporting requirements for congestion costs. Substantial data are available from the regions with organized markets (CAISO, ISO-NE, MISO, PJM, NYISO, SPP), but much less are available from the non-market regions, which cover at least 33% of the nation geographically. Furthermore, data from the regions with organized markets are often not comparable. Each has its own definitions, practices, and formats for calculating and publishing Locational Marginal Prices (LMPs) and congestion costs.

For example, the regional transmission operator, PJM[4], calls congestion costs a "Loss Penalty Factor" and the following table provides an example of the relative scale of those costs to overall transmission costs.

Table 10-14 Total PJM congestion (Dollars (Millions)): January through September for calendar years 2008 to 2012 (See 2011 SOM, Table 10-14)

	Congestion Costs (Millions)			
(Jan - Sep)	Congestion Cost	Percent Change	Total PJM Billing	Percent of PJM Billing
2008	$1,778.2	NA	$26,979.0	6.6%
2009	$543.6	(69.4%)	$19,927.0	2.7%
2010	$1,134.3	108.7%	$26,249.0	4.3%
2011	$874.9	(22.9%)	$28,836.0	3.0%
2012	$425.2	(51.4%)	$22,119.0	1.9%

Source: Monitoring Analytics[5]

Depending on the utility, congestion costs may be combined with transmission planning and capacity costs, so the calculation of congestion benefits and avoided transmission benefits from DG would be combined. Most utilities' automatic reaction to congestion issues is to add more transmission facilities, so it is vital that DG be positioned for proactive consideration relative to transmission for relieving these issues.

Because this concept of proactively considering DG is foreign to most transmission operators, a useful reference is the California Independent System Operator (CAISO) proposal put forth in 2013, which states: "energy efficiency, demand response, renewable generating resources and energy storage…such resources can constitute non-conventional solutions to meet local area needs that

---

4 PJM is the regional transmission operator (RTO) serving all or part of 13 states and the District of Columbia

5 Monitoring Analytics, "PJM State of the Market -2012", http://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2012.shtml

otherwise would require new transmission or conventional generation infrastructure…”[6]

Benefits of Avoided Distribution Costs

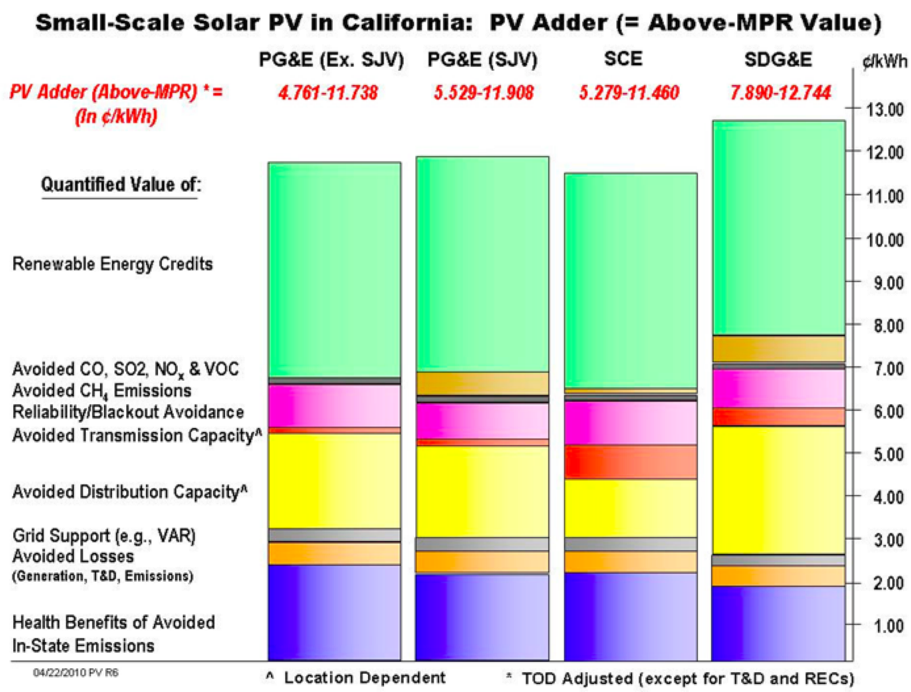
Generation close to load can defer or avoid the need for some distribution grid capital expenditures as well. The cost of operating, maintaining and upgrading the electricity distribution system is a major component of the cost of delivered energy. Existing distribution systems are designed with sufficient capacity to deliver peak power loads from remote large-scale generators to every corner of a utility’s territory. When new generation is sited closer to load, less distribution capacity is required to transport electricity from remote generators. As a result, DG can allow utilities to defer or reduce the scope of capital investment in distribution capacity upgrades.

The avoided distribution costs of replacement generation depend on the specific siting of replacement projects and the generation profile of these projects. These factors will determine whether local generation will reduce the costs of maintaining the existing distribution grid and displace or defer planned investment in distribution grid upgrades and expansions.

The correct methodology by which the utilities can calculate and properly credit DG for avoided distribution grid capacity costs is still an open question. Some of the latest research and thinking is being done within the California regulatory agencies. A September 2011 report commissioned by the California Public Utilities Commission (CPUC) showed that the locational benefits value of clean local energy can be greater than 5 cents per kWh from avoided distribution investments alone.[7] Subsequently, the California Solar Energy Industries Association produced the following chart in 2012 that claimed a range of value for Avoided Distribution Capacity.

[6] CAISO, “Consideration of alternatives to transmission or conventional generation to address local needs in the transmission planning process”, http://www.caiso.com/Documents/Paper-Non-ConventionalAlternatives-2013-2014TransmissionPlanningProcess.pdf

[7] E3 Using Avoided Costs to Set SB32 Feed-in Tariffs, SB32 Workshop, CPUC, September 26, 2011, available at: http://www.cpuc.ca.gov/NR/rdonlyres/90AA83C6-1AAC-4D7E-966E-299436C4A6BD/0/E3FITAvoidedCosts9262011.pdf



Source: CALSEIA 2010[8]

Currently, the CPUC has embarked on a 3-year effort to quantify these benefits with a focus on avoiding distribution grid costs. The latest analysis in that initiative is the study from E3 titled, "Technical Potential for Local Distributed Photovoltaics in CA – Preliminary Assessment[9]", from March 2012.

Ultimately, acknowledgment by the utilities and regulatory agencies of the potential benefits DG can provide in avoiding distribution grid costs will depend on the utilities' ability to modernize their grid investment planning processes and their willingness to treat DG as a potential solution rather than a cost they cannot plan for. DG advocates would do well to get these conversations started at their regulatory agencies to lay the groundwork for clean energy programs that fully value DG.

Benefits of Avoided Line Losses

Energy is lost throughout the system in relation to the distance, voltage, and carrying capacity of the lines involved in transmission and distribution. According to the U.S. Energy Information Administration, national transmission

---

[8] PV Above MPR Methodology, CALSEIA 20100423. available at: http://www.energy.ca.gov/bioenergy_action_plan/documents/2010-06-03_workshop/comments/CAL_SEIAs_Implementing_the_Feed_in_Tariff_for_Small-Sc_TN_57089.pdf

[9] http://www.cpuc.ca.gov/NR/rdonlyres/8A822C08-A56C-4674-A5D2-099E48B41160/0/LDPVPotentialReportMarch2012.pdf

and distribution real energy losses average 7% of all transmitted energy.[10] Most of these losses occur in the transmission system. For example, real energy losses in the California transmission system alone range from 7.5% (average load) to 14% (peak load).[11] Energy losses range well above average during peak load periods, when congestion and heat effects are highest; this is one reason why the time-of-delivery profile of the proposed replacement generation is a major consideration in the avoided costs valuation.

Obviously, DG that is sited close to load will avoid much of the line and congestion losses associated with the energy that is sourced from afar. The locational benefits of avoiding these losses are straightforward to quantify and thus are less controversial in designing clean energy policy. Some examples of utilities that have quantified avoided line loss savings are as follows:

- *Austin, Texas*: Value of Solar Tariff credited DG with $0.007/kWh for line loss savings.[12]
- *PJM*: Calculated line losses as 3.4% of overall costs.[13]
- *Palo Alto, CA*: Included $0.0062/kWh over 20 years as avoided line losses for DG projects in their CLEAN Program.[14]

Local Voltage and Reactive Power Benefits

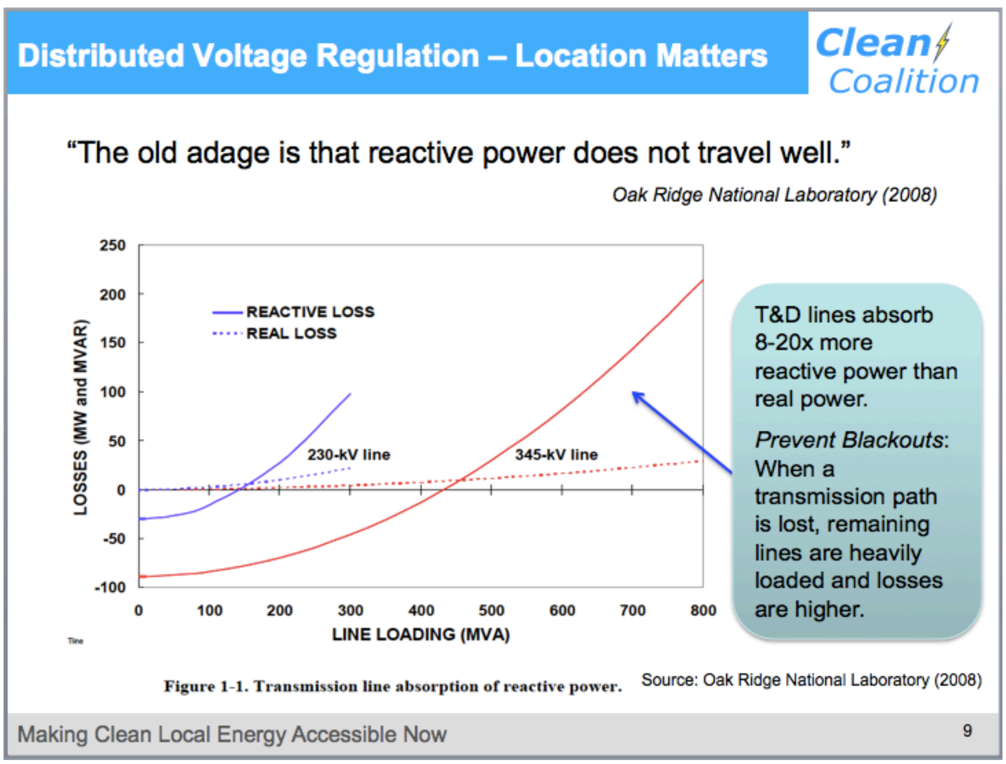
Forward-thinking utilities are now starting to develop policies to capture the benefits of the advanced inverters that are installed as part of virtually every DG project at commercial-scale or larger (the reason for this is that almost all inverters are designed for the German market where reactive power provisioning is required in all DG projects larger than 3 kW). The capabilities of these inverters can prove highly beneficial to grid operations as well as reduce the losses involved in voltage support and reactive power provisioning.

Advanced inverters offer dynamic reactive power control, which can help maintain the integrity and reliability of the electric grid. As widely demonstrated

[10] U.S. Energy Information Administration, Frequently Asked Questions, "How much electricity is lost in transmission and distribution in the United States?" 2011, *available at* http://www.eia.gov/tools/faqs/ faq.cfm?id=105&t=3.
[11] Bill Powers and Sheila Bowers, "Distributed Solar PV: Why It Should Be the Centerpiece of U.S. Solar Energy Policy," *available at* http://solardoneright.org/index.php/briefings/post/distributed_solar_pv_why_it_should_be_the_centerpiece_of_u.s._solar_energy_/.
[12] The Value of Distributed Photovoltaics to Austin Energy and the City of Austin, 2006, available at: http://imaginesolar.com/wp-content/uploads/2011/09/pv-valuereport_secured.pdf
[13] Quarterly State of the Market Report for PJM: January through September 2012, Section 10: Congestion and Marginal Losses http://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2012/2012q3-som-pjm-sec10.pdf
[14] Overview of Parameters to Consider Regarding Implementing Feed-in-Tariffs for Solar Photovoltaic Systems in Palo Alto, February 2, 2011. Palo Alto Utilities

in Germany, advanced inverters paired with distributed solar, wind, biopower, and energy storage facilities provision dynamic reactive power where it is needed. Importantly, advanced inverters are able to provision reactive power 24 hours a day, regardless of whether the sun is shining or the wind is blowing. When the sun and wind are not available, advanced inverters can draw real power from the grid, rather than from distributed resources, and convert it to reactive power, in a similar manner that capacitor banks and synchronous condensers provision reactive power).

Compared to conventional solutions, installing advanced inverters on small-scale renewable and energy storage systems improves voltage regulation throughout a distribution system. A report by the Oak Ridge National Lab found that distributed voltage control significantly outperforms centralized voltage control. Reactive power suffers far greater line losses than real power, and those losses increase as a line is more heavily loaded. Distributed reactive power improves electrical grid efficiency by minimizing these significant reactive power line losses.



In addition to provisioning reactive power, advanced inverters can be programmed to ride-through minor voltage fluctuations on the grid, which eliminate unnecessary grid disconnects. This feature, for example, enables distributed solar to stay connected longer than rotating machines because solar does not have mechanical resonance issues and can ride-through grid disturbances caused by such issues. As a result, distributed voltage regulation provides substantial energy efficiency while delivering power quality and preventing blackouts.[15]

Advanced inverters have been proven effective for enhancing grid reliability in Germany. Germany is one of the world leaders in installed PV capacity and as of 2012 has been using advanced inverters to manage local voltage via reactive power. Germany passed new grid codes that require PV systems to be capable of frequency dependent active power manipulation during abnormal grid conditions and to be capable of reactive power provisioning during normal grid operations. The German experience showed that advanced inverters can be set to automated mode, so no additional communications equipment or protocols will be needed.[16]

For DG advocates, it's important to understand that utilities in the US currently treat DG systems such as rooftop solar PV as potentially causing voltage issues. In fact, the advanced inverter functionality that allows such systems to provide voltage and reactive power support is already installed in modern systems. The technical standards and policies in the US just need to catch up so that this functionality can be utilized and DG system owners can be compensated for services provided.

Security and Resilience

Distributed generation enhances grid security and resilience. Local energy production makes U.S. communities less vulnerable to grid failures as a result of natural events, accidents, or intentional acts. Distributed generation avoids dependence upon major critical infrastructure choke points on the grid, and is therefore able to maintain delivery of power without requiring the transmission network. Likewise, at the generation level, the loss of several small generators would have much less of an impact on the system than the failure of a single large central station power plant.

Large central station grids are vulnerable to a wide range of threats, including thunderstorms, natural disasters, terrorist attacks, and human error. In September 2011, nearly six million people in southern California, western Arizona, and northern Mexico lost power when an electric transmission line failed in Arizona.[17] The addition of CLEAN generation can prevent the

---

[15] ibid.

[16] ADVANCED INVERTERS FOR DISTRIBUTED PV: Latent Opportunities for Localized Reactive Power Compensation. UC Berkeley & Clean Coalition
Energy C226, dated Spring 2013. http://www.clean-coalition.org/site/wp content/uploads/2013/10/CC_PV_AI_Paper_Final_Draft_v2.5_05_13_2013_AK.pdf

[17] Lars Paulsson, Lynn Doan and Michael B Marois, Bloomberg Business Week, "San Diego Utility Restores Power to California Household," September 9, 2011, *available at* http://www.businessweek.com/news/2011-09-09/san-diego-utility-restores-power-to-california-households.html

overloading of various grid components[18] and thereby lower the utility's statistical outage rate, often known as the "Loss of Load Probability".

The utility's cost of power outages represents only a small portion of the total costs of these disruptions. Blackouts and brownouts cost Americans an estimated $150 billion per year.[19] CLEAN generation can increase local grid security and facilitate microgrids that can provide essential services even during long-term emergencies.[20] The societal value of enhanced grid security can be estimated based on the relationship between electricity consumption and economic productivity.[21] The amount of electricity that is available after a power outage can proportionally alleviate both economic productivity losses and asset losses due to power outages.

Although much of the country is just beginning to make the connection between DG and grid reliability, high profile incidents like Hurricane Sandy and the Super Bowl blackout provide opportunities for DG advocates to argue for calculating and incorporating the potential benefits into energy policy. Climate change will only make such incidents more severe and more frequent and thus the resilience that DG can provide to the grid becomes a key climate adaptation solution, as well as an energy security solution.

Energy Planning Benefits

The planning value of WDG is significant. The small size and rapid development of DG supports greater certainty, flexibility and responsiveness in grid investment and planning than central generation; these characteristics allow precisely located and incrementally scalable enhancements in capacity to be implemented in much shorter timeframes and facilitate more accurate planning horizons than is possible with large scale facilities.

In contrast to large-scale renewable energy projects, DG minimizes environmental impacts of energy generation on environmentally sensitive areas and reduces the need for new transmission corridors. DG projects can be deployed on existing buildings and previously disturbed lands within communities, which enables these projects to avoid the major delays associated

---

[18] California Solar Energy Industries Association (CALSEIA), "Implementing the Feed in Tariff for Small-Scale Solar Photovoltaics in California as Authorized by SB 32 (2009, Negrete-Mcleod, D- Chino)."
[19] Galvin Electricity Initiative, "What are the Benefits of the Smart Microgrid Approach?", 2011, *available at* http://www.galvinpower.org/resources/microgrid-hub/smart-microgrids-faq/benfits.
[20] R. James Woolsey, Rachel Kleinfeld, and Chelsea Sexton, World Affairs Journal, September/ October 2010, *available at* http:/www.worldaffairsjournal.org/article/no-strings-attached-case-distributed- grid-and-low-oil-future;
[21] "The Value of Distributed Photovoltaics to Austin Energy and the City of Austin," Final Report to Austin Energy (SL04300013), pg. 62.

with the development of large-scale renewable projects. This allows more efficient investment to meet marginal requirements, and dramatically reduces risks associated with both project failure and "sunk costs" of large capital commitments based on uncertain long-range planning projections.

Finally, the fact that DG can be deployed more quickly means that DG provides greater value in terms of the "time value" of the renewable energy benefits. For all the benefits that are accrued to DG, such as reducing GHG emissions and creating jobs, the value to ratepayers and society is greater when those benefits are realized sooner. A GW of renewable power deployed today is more beneficial than a GW deployed 5 years from now.

Indirect Cost Savings and Benefits

The deployment of new clean energy generation close to load and in targeted communities can provide significant benefits to the residents and businesses in those locations. Utilities rarely include these benefits in their avoided cost assessments because these benefits do not directly affect utilities or ratepayers and may not be easy to quantify. However, these benefits are often critical in motivating communities and their leaders to support the implementation of a new policy or the expansion of an existing program.

Local Economic Benefits

Distributed generation deployments bring the economic benefits of energy production to local communities, including job creation, capital investment, and local government revenues. By supporting local production of renewable energy, communities can keep energy production dollars in the local economy, allowing communities to avoid exporting those energy dollars for power and/or Renewable Energy Certificates (RECs) that are produced outside the local area or the state.

Communities can begin to realize these economic benefits almost immediately. In contrast to large-scale renewable energy projects, DG projects become "shovel-ready" within months. Because these projects are relatively small-scale and can be deployed on existing buildings and previously disturbed lands within communities, these projects are not subject to the major delays associated with the development of large-scale projects or the construction of transmission lines.

Job Creation

Producing local renewable energy creates significantly more jobs than producing fossil fuel, nuclear energy, or central station renewable energy. Solar PV, which is the most common DG technology, contributes nearly nine times the number of jobs as coal or natural gas, and supports far more employment than central station renewable energy facilities.[22]

University of California, Berkeley (UC Berkeley) researchers found that a robust CLEAN Program that deployed DG for the State of California would create three times more jobs over a ten year period than the state's existing plan for meeting its renewable energy goals for two reasons: (i) more renewable energy would be purchased from within the state, and (ii) the CLEAN Program would increase procurement of energy from distributed solar photovoltaic (PV) facilities, which shifts investment away from transmission equipment and toward installation labor instead.[23] Equally important, these jobs are created sooner due to the quick development of these smaller installations, which avoid the significant barriers to development that central station projects face, including frequent delays involved in the permitting and development of new transmission infrastructure, and often intense community opposition to projects located on pristine lands.

The UC Berkeley study highlights the importance of clearly defining job creation metrics so that the projections will be meaningful. The following definitions are especially helpful[24]:

- One "job-year" is full time employment for one person for one year. "Job-years per gigawatt (GWh)" is the amount of job-years per GWh of renewable energy produced.
- "Direct" job creation includes employees hired by companies involved in the design, manufacturing, construction, installation, project management, delivery, operation, and maintenance of the new facilities.
- "Indirect" job creation refers to the "supplier effect" of upstream and downstream suppliers. Indirect job creation includes employment by companies that provide goods and services to the direct employers. For example, the task of installing and maintaining wind turbines is a direct job, whereas transporting the wind turbines equipment is an indirect job.
- "Induced" employment refers to non-industry jobs, such as retail store clerks, created by the ripple effect of increased spending due to direct and indirect employment and local government employment facilitated by additional tax revenues. Additional local jobs are created by increased

---

[22] Ditlev Engel and Daniel M. Kammen, written for the Copenhagen Climate Council, "Green Jobs and the Clean Energy Economy," 2009, *available at* http://rael.berkeley.edu/sites/default//files/old-site-files/ TLS%20Four_May2209_1.pdf.

[23] Daniel Kammen and Max Wei, Renewable and Appropriate Energy Laboratory, Energy Resources Group, University of California, Berkeley, "Economic Benefits of a Comprehensive Feed-in Tariff: An Analysis of the REESA in California," pg. 9-15, July 7, 2010, *available at* http://www.clean- coalition.org/storage/resources/studies/economic-benefits-of-a-fit/ economic_benefits_of_a_comprehensive_feed-in_tariff-july072010.pdf.

[24] Max Wei, Shana Patadia, and Dan Kammen, Renewable and Appropriate Energy Laboratory, Energy Resources Group, University of California, Berkeley, "Putting Renewables and Energy Efficiency to Work: How many jobs can the clean energy industry generate in the U.S.?," January 18, 2010, *available at* http://rael.berkeley.edu/node/585

spending due to (i) income from locally-owned DG projects, and (ii) ratepayer savings as avoided costs rise above the fixed costs associated with distributed clean energy.

It may also be useful to separately assess construction and operations period impacts. Construction-period impacts are short term; in contrast, operations-period impacts are annual impacts that accumulate over the life of the project. National Renewable Energy Laboratory researchers found that community wind projects have similar construction-period impacts as central station wind projects, but the operations period impacts of community wind projects are 1.5 to 3.4 times greater than those of central station projects.[25]

Another approach is to quickly estimate the job creation benefits of a proposed CLEAN Program based on the amount of new capacity of each renewable technology to be deployed as a result of a CLEAN Program, as shown in the table below.

Average Direct Employment for Different Energy Technologies[26]

Technology	Total Job Years per GWh
Biomass	0.21
Geothermal	0.25
Solar PV	0.87
Solar Thermal	0.23
Wind	0.17
Nuclear	0.14
Coal	0.11
Natural Gas	0.11

Source: Renewable and Appropriate Energy Laboratory, Energy Resources Group, University of California, Berkeley. Average direct employment multipliers for several energy technologies based on 15 studies.

[25] E. Lantz and S. Tegen, National Renewable Energy Laboratory, "Economic Development Impacts of Community Wind Projects: A Review and Empirical Evaluation," April 2009, *available at* http:// www.nrel.gov/docs/fy09osti/45555.pdf.

[26] Max Wei, Shana Patadia, and Dan Kammen, Renewable and Appropriate Energy Laboratory, Energy Resources Group, University of California, Berkeley, "Putting Renewables and Energy Efficiency to Work: How many jobs can the clean energy industry generate in the U.S.?," pg. 923, January 18, 2010.

Local Investment and Tax Revenues

To the extent that DG is deployed by local developers, well-designed policies can increase public and private investment in the community by reducing the risks, costs, and timeframes of development. In addition to attracting capital investment from outside parties, these projects can provide opportunities for local residents, banks, and businesses to reinvest capital in the community. A study by the United States Government Accountability Office found that local ownership of projects increases the local economic benefits by 200% to 300%.[27] Then, the return on investment from DG projects comes directly back to community members, who generally spend and reinvest a large portion of those returns in the local economy.

DG project development can also attract federal (and, where available, state) investment grants, investment tax credits, and accelerated depreciation allowances for facilities. The Database of State Incentives for Renewables & Efficiency (DSIRE) includes up-to-date information on state, local, utility, and federal renewable energy incentives and policies.[28] Again, well-designed programs can allow project developers to take advantage of federal and state incentives.

Capital investment in the community and local job creation creates new sources of local tax revenues, as described in the table below.

Potential Sources of Local Tax Revenues

Type	Description
Sales and/or use taxes	Local purchases of goods and services in connection with construction, installation, operation, and maintenance of DG facilities Local purchases of renewable energy equipment Local purchases of goods and services caused by increased local employment, capital investment, and reinvested DG energy income
Income taxes	Income from increased local employment income from energy sales
Personal property taxes	Assessed value of DG facilities equipment
Real property taxes	Increased real property values due to installation of DG facilities

It is important to note that DG deployed with a CLEAN Program will only result in positive fiscal impacts on local government budgets, because CLEAN Programs are driven by private investment, not by local rebates, subsidies, or other

[27] United States Government Accountability Office (GAO), Report to the Ranking Democratic Member, Committee on Agriculture, Nutrition, and Forestry, U.S. Senate,"Wind Power's Contribution to Electric Power Generation and Impact on Farms and Rural Communities," GAO-04-756, September 2004, *available at* http://www.gao.gov/new.items/d04756.pdf.

[28] Database of State Incentives for Renewables & Efficiency, U.S. Department of Energy, Interstate Renewable Energy Council, and North Carolina Solar Center, 2011, *available at* http://www.dsireusa.org/summarytables/finre.cfm

incentives. A significant benefit of CLEAN Programs is that they leverage private investment dollars to meet community goals.

Economic Impact Modeling

Policy designers may model the economic impact of DG deployment by using the modeling tools described below. Additional proprietary tools are also widely available. The Clean Coalition makes no express or implied endorsement of any modeling tool.

NREL's Jobs and Economic Development Impacts (JEDI) model

The Jobs and Economic Development Impact (JEDI) models are free tools developed by the National Renewable Energy Laboratory (NREL) and used by county and state policymakers, public utility commissions, and potential project owners to estimate the potential economic impacts associated with constructing and operating power generation plants at the local level.[29]

The UC Berkeley Green Jobs Calculator

The UC Berkeley Green Jobs Calculator is a free Excel spreadsheet model that includes multipliers for estimating the number of direct and indirect job-years that will be created by each new gigawatt hour (GWh) hour of renewable energy production.[30]

RIMS II

The U.S. Department of Commerce's Bureau of Economic Analysis (BEA) has created a methodology for estimating regional input–output multipliers called Regional Input–Output Modeling System (RIMS II). RIMS II is used to estimate how much a one-time or continuing increase in economic activity will be supplied by local industries.[31]

IMPLAN

IMPLAN is a modeling tool used by government agencies, colleges and universities, nonprofit organizations, corporations, and community planning

[29] National Renewable Energy Laboratory (NREL), Jobs and Economic Development Impact (JEDI),"About JEDI Models," 2011, *available at* http://www.nrel.gov/analysis/jedi/about_jedi.html.

[30] Renewable and Appropriate Energy Laboratory, Energy Resources Group, University of California, Berkeley, "Green Jobs," 2011, *available at* http://rael.berkeley.edu/greenjobs.

[31] U.S. Department of Commerce, Bureau of Economic Analysis, "Regional Input-Output Modeling System (RIMS II)," 2011, *available at* http://www.bea.gov/regional/rims.

organizations to create input–output models that quickly and efficiently model economic impacts.[32]

Regional Economic Models Inc. (REMI)

The Regional Economic Models Inc. (REMI) model is a sophisticated forecasting and policy analysis tool that combines a robust input–output component to display relationships between industries with three additional modeling approaches: (i) general equilibrium, (ii) econometrics, and (iii) New Economic Geography. The REMI model can account for dynamic changes in the economy over time, including fluctuations in prices, wage levels, migration, productivity.[33]

Environment and Public Health Benefits

The locational value of environmental and public health benefits of DG is the least well-studied value factor and is the value that utilities and policy makers are the least likely to formally account for in clean energy programs.

Land Use Benefits

In contrast to conventional generation or large-scale, remote renewables, DG has significantly less impact on pristine or arable land because it is typically deployed on existing structures or otherwise already disturbed land. But since remote land is often cheaper than land or roof space near load centers, remote generation can appear cheaper per kWh than DG, and thus DG is unfairly disadvantaged in procurement decisions. This historical preference for remote generation demonstrates a real need for the land use value of DG to be included in energy policy.

In a study by the Civil Society Institute[34], the following comparisons were made for solar power. Rooftop and building integrated PV occupies no land while:

- One source estimates land occupied by ground mounted projects at 24 to 40 m^2/kW, or 0.3 to 1.0 m2/MWh (lifetime) depending on capacity factor.
- Two studies estimate land occupied by trough CSP at 0.3 to 0.4 m^2/MWh. One of these studies puts that figure for a tower CPS plant at 0.6 m^2/MWh.

Such estimates don't include the land used by the transmission lines, which, over long distances, will impact many different types of land, from farmland to parkland. To the extent that all these values can be quantified, or approximated, DG advocates should argue for the benefits to be included in energy programs in order to direct new energy deployment to the best places.

---

[32] IMPLAN Economic Modeling, 2011, *available at* http://implan.com/V4/Index.php.

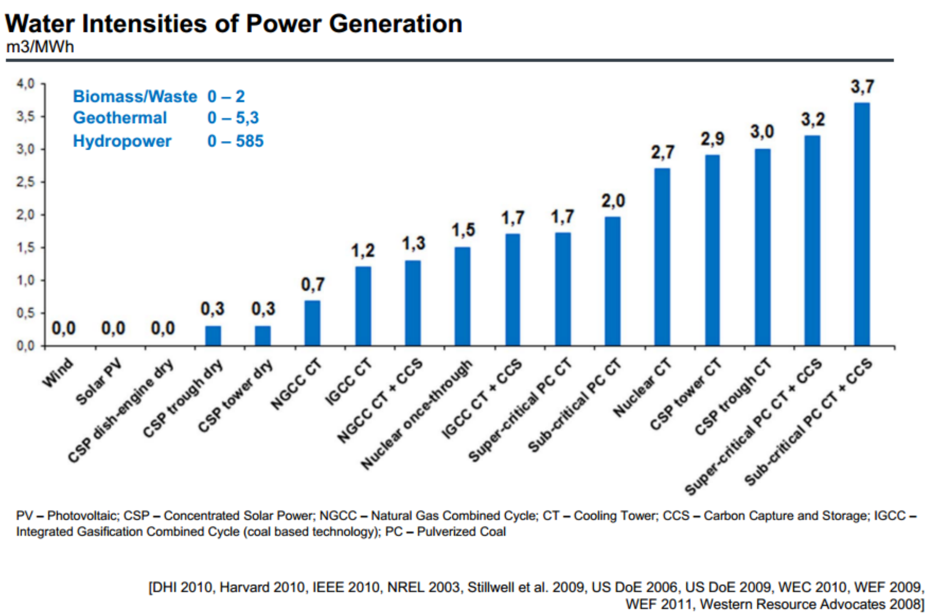
[33] Regional Economic Models, Inc. (REMI), 2011, *available at* http://www.remi.com.

[34] Civil Society Institute – "Hidden Costs of Electricity" (Sep 2012) http://www.civilsocietyinstitute.org/media/pdfs/091912%20Hidden%20Costs%20of%20Electricity%20report%20FINAL2.pdf

Local Fossil Fuel Replacement Benefits

While all clean energy can reduce environmental impacts like emissions by replacing fossil fuel generation, the value of those reductions can vary greatly by location of the generation being replaced. Where DG can replace "dirty" power plants in communities / areas with significant environmental concerns, such as poor air quality, that value can be quite significant. [See Emissions / Fossil Fuel Replacement studies in Appendix A]

With the exception of wind and photovoltaics, generation of electricity relies on the use of significant amounts of water. Common natural gas, coal, and nuclear thermal generation facilities use water for heat capture and cooling, losing this water to evaporation in the process. Setting aside for the moment the environmental consequences of various water use impacts, in many regions there are direct economic costs associated with supplying these quantities water for generation.



Conclusion

Across the United States, energy policy has historically failed to account for the full value and costs of the energy being procured. The result has been an electrical system designed around remote, large scale, mostly fossil fuel generation facilities with energy delivered over long-distance transmission lines.

Advocates for renewable distributed generation can make a strong argument for energy policies that choose DG going forward based on a full accounting of all of the locational benefits provided by DG. Successfully making this accounting a core part of the energy policy design will result in a more rapid transition to a clean energy economy with DG deployed at the most beneficial places on the grid.

This Brief provides an overview of the major concepts / value factors that should be included in a locational benefits conversation. The research on this topic is changing quickly as more utilities realize the need to understand DG. The Clean Coalition will continue to publish the latest resources and analysis on the CLEAN Resource Hub.

Appendix A: Locational Benefits Studies

The following are select technical studies that have quantified the value / benefits of renewable distributed generation. For a more comprehensive list, see the DG Catalog of Benefits document in the CLEAN Resource Hub.

Beach, Thomas R., and Patrick G. McGuire. “The Benefits and Costs of Solar Distributed Generation for Arizona Public Service” (2013). *Provided by Crossborder Energy, Berkeley, CA* (2013).

Hansen, Lena, Virginia Lacy, and Devi Glick. “A Review of Solar PV Benefit and Cost Studies” (2013). *Prepared by: Rocky Mountain Institute, Boulder, CO* (2013). *Available at* http://www.rmi.org/Content/Files/eLab-DER_cost_value_Deck_130722.pdf

Keith, Geoff, Sarah Jackson, Alice Napoleon, Tyler Comings, and Jean Ann Ramey. "The Hidden Costs of Electricity: Comparing the Hidden Costs of Power Generation Fuels" (2012). *Provided by Synapse Energy Economics Inc. (2012).*

PV Above MPR Methodology, CALSEIA 20100423. http://www.energy.ca.gov/bioenergy_action_plan/documents/2010-06-03_workshop/comments/CAL_SEIAs_Implementing_the_Feed_in_Tariff_for_Small-Sc_TN_57089.pdf

Perez, Richard, Benjamin L. Norris, and Thomas E. Hoff. “The Value of Distributed Solar Electric Generation to New Jersey and Pennsylvania” (2012). *Prepared by: Clean Power Research, Napa, CA* (2012). *Available at* http://www.solarfuturearizona.com/PVBenefitsReportNJ-PA2012-11-011.pdf

Economic Benefits

“Empowering LA’s Solar Workforce”, available at: http://innovation.luskin.ucla.edu/content/empowering-la%E2%80%99s-solar-workforce-new-policies-deliver-investments-and-jobs-0

"Bringing Solar Energy to Los Angeles: An Assessment of the Feasibility and Impacts on an In-Basin Solar Feed-in-Tariff Program", Appendix 10; available at: http://innovation.luskin.ucla.edu/content/bringing-solar-energy-los-angeles-assessment-feasibility-and-impacts-basin-solar-feed-tari-0

Environmental and Energy Studies Institute, "Fact Sheet: Jobs in Renewable Energy and Energy Efficiency," 2013
http://www.eesi.org/fact-sheet-jobs-renewable-energy-and-energy-efficiency-11-jun-2013

Robert Pollin, James Heintz & Heidi Garrett-Peltier , "The Economic Benefits of Investing in Clean Energy: How the Economic Stimulus Program and New Legislation Can Boost U.S. Economic Growth and Employment. A Green Economics Program study", Political Economy Research Institute, University of Massachusetts Amherst.
http://www.peri.umass.edu/economic_benefits/

Emissions / Fossil fuel replacement

PV Above MPR Methodology, CALSEIA 20100423.
http://www.energy.ca.gov/bioenergy_action_plan/documents/2010-06-03_workshop/comments/CAL_SEIAs_Implementing_the_Feed_in_Tariff_for_Small-Sc_TN_57089.pdf

"Full cost accounting for the life cycle of coal", Epstein, P. et al, Annals of the New York Academy of Sciences Volume 1219, Ecological Economics Reviews pages 73–98, February 2011; available at: http://chge.med.harvard.edu/resource/full-cost-accounting-life-cycle-coal

See also the National Renewable Energy Laboratory's August 2007 publication: "Energy, Economic, and Environmental Benefits of the Solar America Initiative"