Assessing Rooftop Solar-Electric Distributed Energy Resources for the California Local Government Commission

Christy Herig
National Renewable Energy Laboratory
1617 Cole Blvd., Golden, CO

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Summary

The energy economics are favorable for rooftop solar-electric systems on California municipal buildings, even without considering the financial benefits of emission offsets, the green market, building-material offsets, or economic development. A commercial-use municipal building can pay $5.50 per watt for rooftop solar because of high utility energy rates, the State s emerging technology buy-down, and a good solar resource. Furthermore, the building can break even annually when considering municipal-bond finance payments and energy-bill savings. Because the Sacramento Municipal Utility District (SMUD) is offering photovoltaic (PV) systems for less than $5 per watt and industry can supply single purchases for $7 per watt, there is the potential for municipal energy savings, especially when additional economic benefits are added to the value proposition.

Local governments as large energy users can demonstrate the benefits of solar-electric rooftops, as well as facilitate the implementation of state policy to their constituency. The value of distributed-generation technologies is directly proportional to the benefits exploited, and the benefits of rooftop solar electricity (also called photovoltaics or PV in this paper) are best realized if aligned with energy efficiency and load-management measures to provide distributed energy resources (DER). For instance, a municipal building with an energy demand of 50 kilowatts (kW) and an energy usage of 20,000 kilowatt-hours (kWh) may see a monthly energy-bill savings of 12% a month from a 15-kW rooftop solar system. However, simple energy-efficiency measures in lighting, motor loads, and load management could easily save 30% on energy costs. The solar-rooftop contribution to savings would then be 25% of the energy-bill savings of the energy-efficient building. Additionally, the energy savings from the efficiency measures could be targeted for funding the capital costs of the rooftop solar system. Though the focus of the information presented is the assessing of PV for local government buildings, it is important to remember the benefits of DER technology alignment, particularly of PV and efficiency.

Background

In 1998, the State of California tackled the restructuring and deregulation of the electric industry. Though the role of local governments may have been evident at that time, the events in San Diego during the summer of 2000 clearly highlighted the role.[1] Local governments can play a vital role in smoothing the swings of the economic pendulum caused by market transitioning during deregulation and can protect or even enhance their regional economy. Local governments serve as the natural interface between state legislation, regulation, and infrastructure planning and the consumers making up their constituency. As such, local governments can maximize the benefits and minimize the impacts of energy policy by being involved in targeted regional planning. The future vision for electricity service through a highly reliable, intelligent, interactive digital grid requires the proliferation of DER. Local governments are the beneficiaries of the "digital grid" vision, as well as being the key facilitators by demonstrating technology, developing infrastructure, and removing barriers.

Local governments, as large electricity *customers*, play a vital consumer role in new-technology pilot projects, volume purchases, aggregate purchases, and the development of procurement

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[1] San Diego Gas and Electric (SDG&E), after meeting the requirements of selling all generation assets and clearing the company s stranded debt, began passing market prices directly on to consumers, thus doubling electric bills and throwing the region into economic chaos. The California legislation quickly passed retroactive emergency legislation capping consumer prices and putting the economic burden back on SDG&E.

practices. As *planners and implementers* of regional infrastructure and economic development, local governments can integrate an energy element into regional planning. And as *service providers* to regional consumers, local governments will define the minimum level of service and the portion of the electricity industry that will convert regional infrastructure (regulated by the local government after the industry transition) to a competitive market. Finally, local governments facilitate educational programs, assuring that the lifestyle of future generations relative to electricity service is just as much an assumed, deserved part of life.

This report is organized in four sections: 1) Analysis of state and local energy policy relating to solar electricity and the potential for local governments; 2) Analysis of information benefits; 3) Assessment of the California Local Government Rooftops program; and 4) Discussion on integrating energy as an infrastructure planning element and interagency connections for facilitation; the discussion includes a list of actions that may be taken at the local government level.

State and Local Policy

The implementation mechanisms set up by the California Energy Commission for AB1890 provided for an emerging technologies buy-down program.[2] Included within the allowable emerging technologies is grid-connected PV. Currently, the program buys down the cost of a solar-electric system by about $2.50 per peak watt (Wp), which is between 20% and 50% of the system cost. The economic benefit of this program is evident to local governments and the consumers within their region. However, as the name of the program implies, PV is an *emerging* technology. To receive the buy-down, the program requires local construction permitting, inspections, and the listing of system components.

As California local governments pursue solar rooftop installations on their own buildings, the expertise of support agencies will be developed, which will then facilitate the ease of installation for consumers. Through the experience with municipal buildings, the local jurisdiction can ensure that its building agency personnel are trained on the most up-to-date codes, standards, and equipment testing protocols for operational safety listing. At this time, these codes, standards, and protocols are included in the following:

- Underwriters Laboratory 1747 testing protocol for solar electric systems
- National Electric Code Article 690
- Institute of Electrical and Electronic Engineers Standard 929.

Assessing the property value for property taxes can also be an added expense[3] of solar-electric systems. For example, in the residential and small-business sector, a 2-kW PV system that costs $20,000 may increase property taxes by $200 per year, thus negating a large portion of the energy-benefit value of the system. Many states[4] have set forth policy to exempt solar systems from property taxes. However, because property value assessment is often under the jurisdiction of local governments, the same effect could be accomplished at the local level by exempting PV from the taxable assessed value of the property.

The State of California is working diligently on interconnection[5] for distributed generation. However, putting forth rulings at the State level and implementing those rulings at the local level are two different matters. For instance, in a related area, California passed a net-metering rule in

[2] The original fund was for a 4-year program, but was recently extended by an additional 10 years.
[3] Attachment 1 provides results of actual consumer interviews, coupled with an analysis on barriers and related expenses of customer-sited solar rooftop installations.
[4] State renewable energy policy information was obtained from the Database of State Incentives for Renewable Energy (DSIRE) http://www-solar.mck.ncsu.edu/dsire.htm
[5] The current report may be reviewed at http://www.energy.ca.gov/distgen/documents/

1996 that included PV systems. But it took more than 3 years before consumers could contact the local utility through the normal customer service number and set up their PV system for net metering. Local governments could have expedited this implementation time. The issues relating to interconnection that affect PV systems and that local governments may be able to facilitate are the following:

- Standardizing and simplifying the legal contractual interconnection agreement between the utility and the customer. Some agreements are lengthy and cumbersome, requiring the consumer to obtain legal review and resulting in added expense.[6]

- Some electric service providers (ESPs) may require design review and inspection at the owner s expense. Local governments can assure the ESP that local building code permit and inspector officials are knowledgeable and can provide this service for at least the smaller systems (10 kW or less).

- Liability insurance and indemnification required by the utility for interconnection can also add expense to the system. Some states have either limited or prevented additional insurance requirements on small systems, and this could also be accomplished at the local government level.

Local governments and electric service providers have historically had good relationships through franchise agreements, easement allowances and community programs. These same relationships can help local governments meet their region s needs and accomplish the activities outlined above as the energy industry transitions to a more competitive environment. Local governments are also aggregating regionally or with agencies within the same jurisdiction to combine bills which can result in energy cost reductions due to building demand diversity, or to bid out purchasing power. The local government aggregate bids can target values important to the jurisdiction beyond energy costs, such as reliability, and renewable generation mix.
The California local governments could also facilitate mechanisms between constituency and the utility. One idea for school programs would be to negotiate curtailment credits for large commercial and industrial customers signed up for the energy curtailment program (and experienced business related economic impacts this summer) for investment in rooftop solar for the community schools.

Benefits Analysis

The benefits realized depend on the application, purpose, and goals of the projects. Local governments may pursue rooftop solar-electric systems for the following beneficial reasons:

- Energy cost reductions through direct energy-bill reductions of energy (kWh) and demand (kW). The average solar *capacity factor* for California is about 21%, which means that 21% of the hours every day are full-sun hours or that each installed kW of PV provides 5 kWh per day (= 24 hours x 1 kW x 21%). In California, the average *effective load-carrying capacity* of PV is 64%, which means that for every kW of PV installed, the building s demand should be reduced by 0.64 kW. Experiments have shown that load management can increase this load reduction to well above 90%. Additionally, if customer price signals (e.g., real-time pricing) allowed consumers to realize market price spikes, the value may be even greater. The physical orientation of the system may also add to the value, as shown below.

[6] A simplified standard interconnection agreement has been provided with this document as Attachment 2 for use by the Local Government Commission to negotiate agreements with their electric service providers. The main issues for ESPs are safety, system reliability, and power quality. These issues are resolved in the document provided by requiring compliance with applicable codes and standards in the agreement.

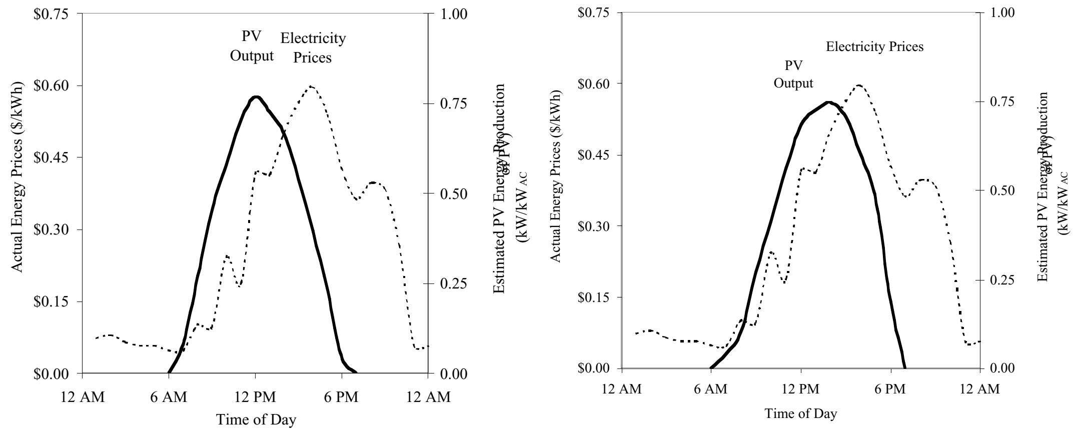

Figure 1. June 14, 2000 SDG&E electricity prices. Left: south-facing PV. Right: west-facing PV[7]

- Electric reliability. Most outages are at the distribution level, but at current PV manufacturing levels, a local government PV deployment program will not relieve transmission and generation capacity constraints over the next few years. A well-designed system with battery back-up can also provide uninterruptible power supply to critical building loads. Additionally, high ambient temperatures and the resulting increase in heating, ventilating, air conditioning (HVAC) load has consistently been the cause of recent large-area outages and critical demand events that have caused market price spikes. It follows logically that this solar load is met by sustained development of the solar resource through rooftop solar-electric systems (see Attachment 3).

- Fuel diversity and price volatility. As our nation's dependency on imports increases to meet our fossil fuel demand, the value of fuel diversity and the fuel price volatility relative to alternative fuel energy systems also increase. Local governments are affected through regional economies. The development of integrated distributed energy resources combines energy efficiency measures, PV, and cogeneration (i.e., combined heat and power) fossil technology, as depicted in Attachment 4. SMUD reports the following reduction of the consumption of natural resources: 124,300 pounds of coal, or 8,800 gallons of oil, or 13.5 million cubic feet of natural gas for every kW of PV installed over the life of the system.

- Environmental mitigation is also a direct benefit for local government solar rooftops. Benefits are incurred not only by mitigating actual emissions, but also, by placing solar generating and/or manufacturing facilities on brownfield sites. SMUD reports reduced emissions of 217,000 pounds of CO_2, 1500 pounds of SO_2, and 830 pounds of NO_x for every kW of PV installed over the life of the system.

- Economic development provides benefits not only in jobs, but also in the quality of jobs, and if the local government program includes deployment at the consumer level the gross regional product is increased due to decreased electric bills. It is an emerging industry, but estimates are for one new job created for every $30,000 spent.

[7] Source is Local Governments and Distributed Generation, which can be downloaded at http://www.clean-power.com

Rooftop Solar-Electric Assessment

The Local Government Commission for California provides the following estimates of roof area: 66 million square feet for municipal buildings and 500 million square feet for school buildings. Assuming that only 40% of the roof area is free of existing penetrations and equipment and that it has full solar access, the usable roof surface area would be 26.4 million square feet for municipal buildings and 200 million square feet of school buildings. And if we assume an average peak PV capacity of 10 watts per square foot and about 25% system and spacing losses, we then estimate a capacity potential of 198 megawatts (MW) on municipal buildings and 1500 MW on schools. Both local governments and schools have parking lots associated with their buildings. Although not a part of this report, the generation potential for local governments and schools would be much greater if parking lots are also used to house PVs.

This rough calculation is not for determining roof area[8] and capacity, but rather, to demonstrate that an aggregate purchase facilitated by the Local Government Commission should have the volume necessary to obtain pricing similar to that from SMUD. The figure below provides some estimate of capital costs for rooftop PV systems at various prices.

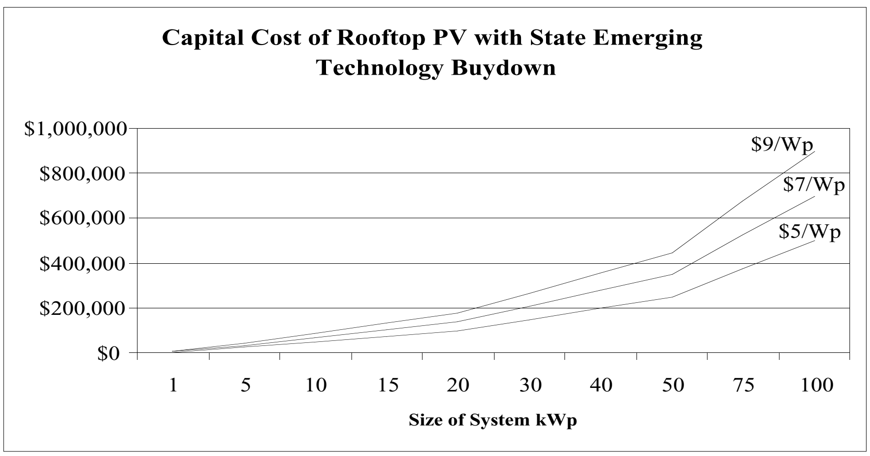

Figure 2. Capital costs for PV rooftop systems of varying sizes assuming an installed cost of $5.00/Wp.

[8] Attachment 5 provides actual roof-area requirements for different PV efficiencies.

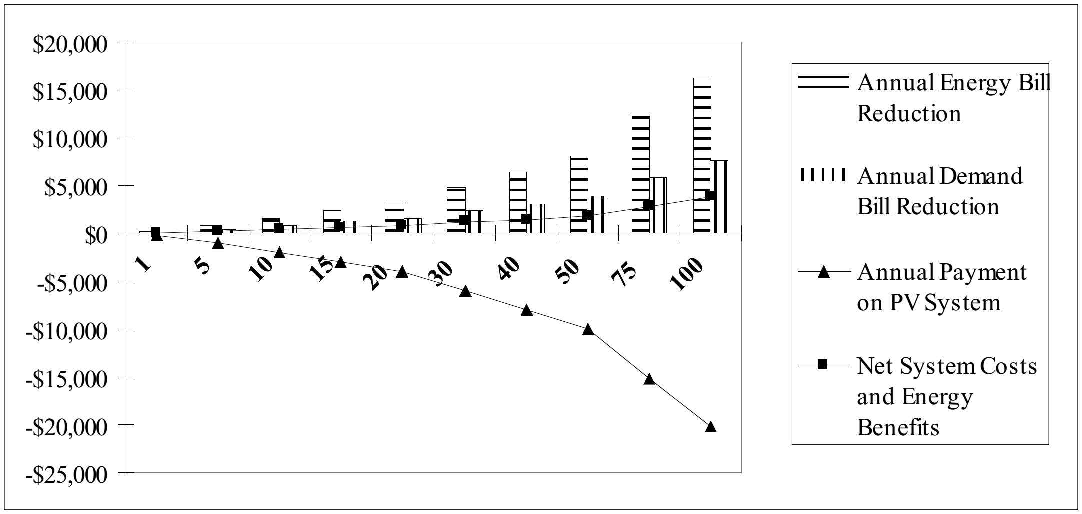

Figure 3. Annual costs and benefits for a system costing $5/W, with 7% municipal financing, 30-year system life and financing, an average energy charge of 9¢/kWh, and a demand charge of $10 per kW. System production per kW was assumed to be 1800 kWh/kW-yr.[9] These numbers decline as the system costs increase. The breakeven figure is $5.50 per watt. And the higher-cost systems may be building-integrated systems that have additional value such as building-material replacement, or, in the case of one flat-roof product, thermal insulation providing reduced HVAC operating costs of 15% or more. In addition, we have *not* included the benefits related to the environment, economic development, and power reliability.

As an example of this assessment, consider the City of San Jose, with two million square feet of municipal rooftop area. Using the same assumptions of 40% availability for solar electric and 75% losses, the City could saturate their available rooftop capacity with 6 megawatts of solar rooftop. At a system installed cost of $5 per watt (minus the State s emerging buy-down of $2.50 per watt[10]), the City s investment would be $15 million. With 7% municipal financing, the annual payment is $1.2 million but the energy savings are more than $1.43 million, for a net energy savings of $230,000 per year. One should also consider the potential emission mitigation of 1,300 million pounds of CO_2, 9 million pounds of SO_x, and 5 million pounds of NO_x. And though San Jose may not need more jobs, this project could represent some 1,000 high-quality jobs.

Integrating Energy as an Infrastructure Planning Element

The energy industry, as a regulated monopoly, guaranteed electric service for all. But now, the waters of restructuring and deregulation are murky. And local governments must determine what portions of the energy industry will become local jurisdiction infrastructure and must integrate energy plans into their comprehensive growth management plan. The energy component of a comprehensive plan is interdependent with other infrastructure components, such as:

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[9] Attachment 6 shows the variation of production values for the State.

[10] Although this would more than saturate the current amount available, the system benefit charge fund from which the emerging technology buy-down was established has been extended for 10 years.

- **Land Use.** Built-out areas where electric consumption is increasing due to E-commerce may require transmission and distribution (T&D) upgrades or even small service drops, which may be too expensive or disruptive. Such locations are prime for PV, especially because the built-out areas will require a quieter, cleaner DER technology. Also, areas slated for redevelopment can also be targeted for implementing new sustainable, green, and/or aesthetic building standards. Brownfields are another opportunity for PV system manufacturing and deployment, because the technology is minimally disruptive to the property.

- **Air Quality.** The goals for air quality in a comprehensive plan can partially be met by the deployment of PV by the local jurisdiction.

- **Transportation.** Transportation is also interrelated with air quality. Electric public transit, service fleets, or even programs that promote consumer electric vehicles are more easily implemented with easily accessed charging stations, which can be powered by PV. Additionally, parking areas are prime real estate for PV deployment, and highly desirable parking shade is also provided.

- **Waste Management and Water Delivery.** These services require highly reliable power, which may be provided by PV.

- **Parks and Recreation.** Green spaces are often pristine preservation lands that would be disrupted by power lines or dirty noisy generators. PV systems are quiet, free of emissions, and don't require trenching or poles for power lines.

The above bullets are by no means exhaustive, but rather, provide a sample of the relationships that an energy component would have with other infrastructure components. As local governments begin the development process of this energy component, they must integrate it with all other infrastructure components and even more importantly, develop the connections with the agencies responsible for implementing the goals. Additionally, regional support offices of state and federal agencies can be a source of information and potential funding. A partial list of suggested agency connections includes:
- Department of Energy
- Environmental Protection Agency
- Housing Authorities
- Community Affairs
- Water
- Sewer
- Building Maintenance
- Buildings Department.

Finally, it is important for personnel in local jurisdictions to obtain experience if an emerging technology is to be accepted. The following action items are suggested means for obtaining experience and getting local jurisdiction agencies and departments involved:

- Implement efficiency measures in municipal buildings while evaluating solar-electric rooftop applications.
  - Lighting
  - Motor loads
  - Load management.

- Identify critical needs for energy reliability that may be met by a PV uninterruptible power supply.
  - Sewage handling
  - Water delivery

- Safety lighting
- Traffic control.

- Saturate cost-effective PV off-grid applications.
  - Built-out areas where new-service installation costs are prohibitive
  - Existing small loads where minimum charge dominates the energy bill.

- Update building codes to allow ease of PV/DER installation.
  - Train code officials
  - Implement impact fee alternatives to include green, sustainable building.

- Incorporate into growth management or comprehensive plan; municipal planning software does have energy modules.

- Aggregate purchase to align electric service providers with City needs.
  - Reliability
  - Clean power
  - Interconnection
  - Energy infrastructure reserve account
  - Use distributed generation to mitigate environmental impacts
  - Transportation
  - Power generation.

Conclusions

The Local Government Commission of California can install rooftop solar-electric systems and save money. At a PV system cost of $5 per watt, including the state emerging-technology buy-down, an annual energy-bill savings can be realized. Though this is considered a low system cost, the aggregate rooftop PV potential of nearly 200 MW on municipal buildings and 1500 MW on schools represents an aggregate purchase that should obtain least-cost. However, in our analysis, it should be emphasized that we *only* considered the energy value stream. Values associated with the green power market, environmental mitigation, power reliability, building integration, and economic development would obviously increase the benefits. The assessment provided in this report is only an estimate. Actual investment decisions require calculations that must include exact rate tariffs, manufacturers' information, and details on all the value streams mentioned above.

Attachment 1

Barriers in Cost for Residential Solar-Electric Rooftop Applications

Issue	Cost	Years of PV Savings
Permitting	$300 (one-time) *(1.5% of PV system cost)*	0.75
Property Taxes	$240 per year (recurring) *(1.2 % of PV system cost)*	25.5
Sales Taxes	$1,400 (one-time) *(7% of PV system cost)*	3.50
Utility Design Review	$500 to $1,000 (one-time)	1.25 – 2.50
Utility metering, interconnection, and protection fees	$200 to $1,000 (one-time)	0.50 – 2.50
Utility minimum charges and standby charges	$5 to $15 per month (recurring)	4.50 – 13.50
Utility insurance requirements	$5 to $25 per month (recurring)	4.50 – 22.50
Competitive transition charge	Varies, ~ $0.04/kWh in CA	1.5
TOTAL	**$3,000 one-time, plus ~ $500 per year**	**Equal to about 45 years of energy savings !!**

Based on Wenger (1998); Starrs & Wenger (1998)

Attachment 2

Interconnection Agreement for Solar Power Systems 10 kW or Smaller

Section 1. Customer Information

Name: ____

Mailing Address: ____

City: ________________________________, OR, Zip Code: ____________

Street address (if different than above): ____

Daytime Phone: ____________________________ Evening Phone: ____________________________

Utility Customer Account Number (from utility bill): _____________________________

Section 2. Generating Facility Information

System Type (check box): Solar Wind Generator Size (kW AC): _______

Inverter Manufacturer: ____________________ Inverter Model: ______________________

Inverter Serial Number: _________________ Inverter Power Rating: ______________________

Inverter Location: ______________________________________

Disconnect Type: Meter Removal Separate Manual Disconnect — Location: ________________

Section 3. Installation Information

Licensed Electrician: _____________________________________ OR Contractor #: _______________

Mailing Address: ____

City: ________________________________, OR, Zip Code: ____________

Daytime Phone #: ___________________________ Installation date: _________________

Section 4. Certifications

1. The generating facility s inverter meets the requirements of IEEE 929, Recommended Practice for Utility Interface of Photovoltaic (PV) Systems and Underwriters Laboratories (UL) Subject 1741, Standard for Static Inverters and Charge Controllers for Use in Photovoltaic Power Systems ; and

Signed (Equipment Vendor): ______________________________________ Date: _________________

Name (Printed) _____________________________ Company: ________________________________

2. The generating facility has been installed in compliance with the City of ****** Standards for Interconnection and Parallel Operation of Small-Scale, Customer-Owned Solar or Wind Powered Generating Facilities of 10˚kW or Smaller ; and with all applicable requirements of the National Electrical Code and the City of ********* building and electrical codes.

Signed (Electrician): __________________________________ Date: __________________

Name (printed) _____________________________ Company: ________________________________

3. The system has been installed to my satisfaction and I have been given system warranty information and an operation manual, and have been instructed in the operation of the system.

Signed (Owner): ______________________________________ Date: _________________

Section 5. City of ****** Utility and Building Division Inspection and Approval**

1. Application Approved: ______________________________ Date: _____________________

2. System Inspection by : ______________________________ Inspection Date: __________

Attachment 3

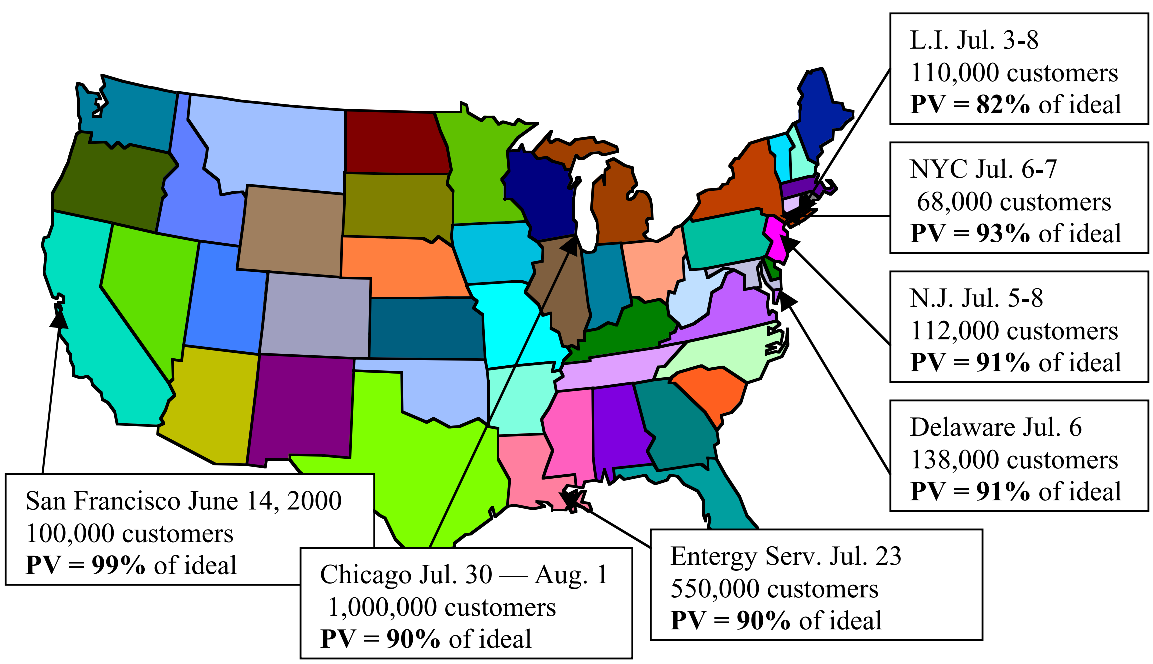
PV is On   When the Grid is Out

Richard Perez, ASRC; Steven Letendre, GMC; Christy Herig, NREL-NCPV

A recent report from the U.S. Department of Energy s Power Outage Study Team, titled Findings and Recommendations to Enhance Reliability from the Summer of 1999, identified six major power outages. These outages occurred when high, heat wave-driven local demands causing stress on distribution systems, which resulted in an inability to generate, purchase, and/or distribute enough electrical power.

An analysis of the solar resource during these outages, based upon satellite remote sensing data, shows that the output of local solar electricity systems would have been above 90% of ideal clear day output during five of the six outages and above 80% for the remaining one (as shown below). An analysis for a recent outage in San Francisco has also been included. All show that local availability of solar electricity can mitigate the conditions that lead to, and reliably prevent, this type of outage.

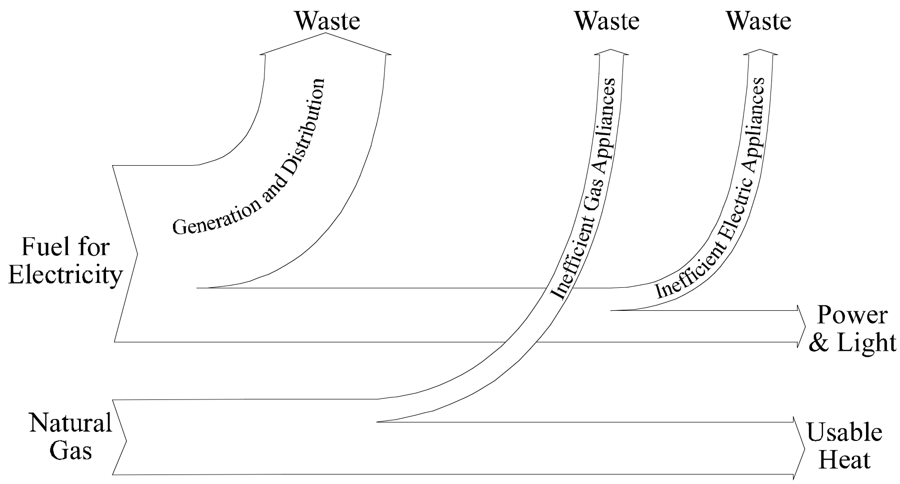
Factor in the results of commercial and residential customer-sited solar electric system economic analyses[11] showing cost-effective niches in Illinois, New York, and New Jersey (five of the six outages) and potential customer-oriented solutions emerge. In fact, the Solar Energy Industries Association identifies power quality and reliability as the major market drivers for the domestic solar electric market. Consumers already pay an average of 40¢/kWh for uninterruptible power supplies (UPS). A solar electric system integrated into the UPS for a relatively small incremental cost can extend the power outage back-up time, particularly during the worst outages as noted below. Contact: Christy Herig, NREL, 303-384-6546



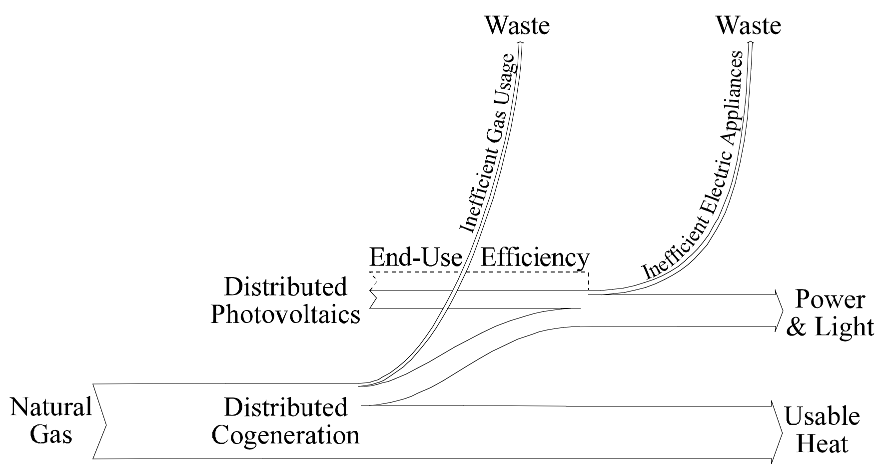
[11] Residential Customer-Sited Photovoltaics Niche Markets 1999, Herig et al., and Mapping the Value of Commercial PV Applications in the US Accounting for Externalities, Perez et al., American Solar Energy Society Conference Proceedings, Portland, Maine, June 1999.

Attachment 4

Residential Sector Consumption and Waste Streams to Scale (1995)



Potential Residential Sector Consumption with DER (PV, Efficiency, and Cogen)



Attachment 5

Roof-Area Requirements for Different PV Efficiencies

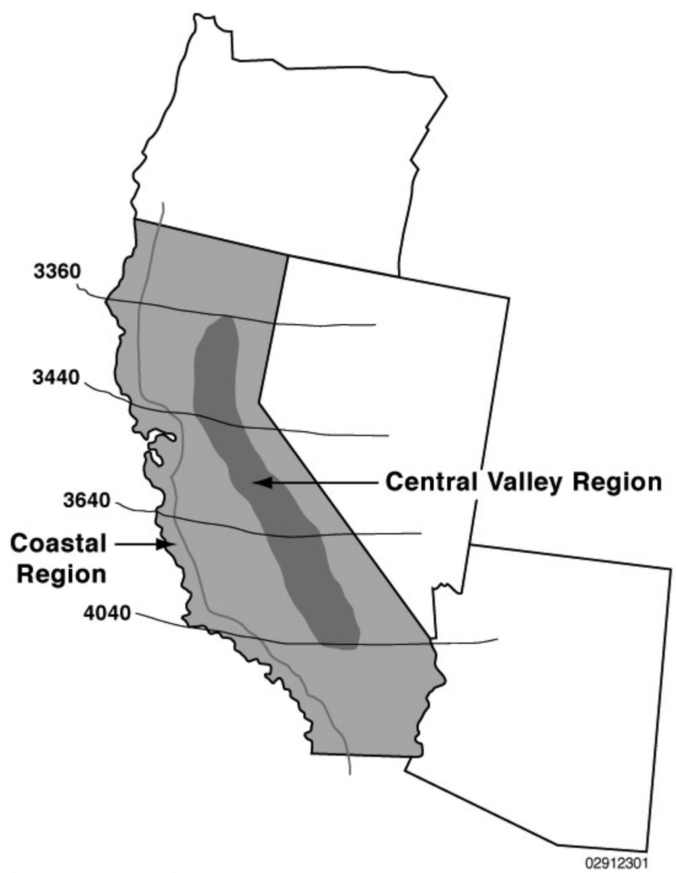
Roof Area Needed in Square Feet (Shown in **Bold Type**)

PV module efficiency (%)	PV Capacity Rating (watts)							
	100	250	500	1,000	2,000	4,000	10,000	100,000
4	**31**	**78**	**155**	**310**	**620**	**1,240**	**3,100**	**30,950**
8	**16**	**39**	**75**	**155**	**310**	**620**	**1,550**	**15,500**
12	**11**	**26**	**50**	**105**	**205**	**415**	**1,030**	**10,300**
16	**8**	**19**	**40**	**75**	**155**	**310**	**775**	**7,750**

Attachment 6

**Annual kWh Production of 2-kW Rooftop PV System
Facing Due South at a 20-Degree Tilt**

- Deduct 15% if system is located within 30 miles of the coast (Coastal Region).
- Deduct 7% if system is located in valley regions subject to fog conditions (Central Valley Region).



Source: California Energy Commission staff estimates derived from Pacific Energy Group estimates.