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Democratizing the Electricity System

A Vision for the 21st Century Grid

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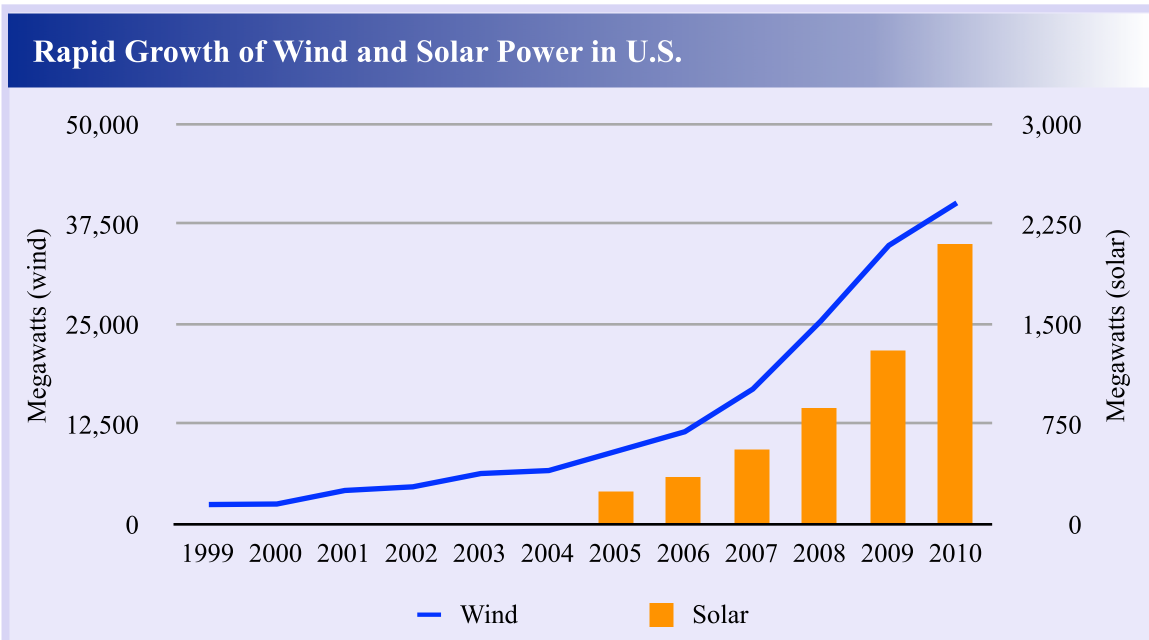
Executive Summary

Wind and sun are available everywhere, so renewable energy can be economically harnessed at small scales across the country, state and community. This nature of renewable energy, coupled with an exponential increase of renewable energy generation here and abroad promises to transform the structure and scale of the nation's grid system. But the greater transformation is the democratization of the electric grid, abandoning a 20th century grid dominated by large, centralized utilities for a 21st century grid, a democratized network of independently-owned and widely dispersed renewable energy generators, with the economic benefits of electricity generation as widely dispersed as the ownership.



This paradigm of energy production – called "distributed generation"* because it is geographically dispersed and connects to the existing (distribution) electric grid infrastructure – is changing the nature of energy generation. It's the same way in which personal computers replaced mainframes, or how Wikipedia and the internet have supplanted the library encyclopedia.

Germany has installed over 10,000 MW of distributed solar photovoltaics (PV) – mostly on rooftops – in the past two years and renewable energy now constitutes 17 percent of overall electricity generation. Half of their wind power and three-quarters of German solar is locally owned.

California intends to generate 12,000 megawatts (MW) from renewable distributed power plants by 2020. Utilities are testing and developing new energy storage technologies just as manufacturers are prepared to put 100,000 fully electric vehicles on U.S. roads by 2012. Sixteen states have added a solar or distributed generation mandate to their renewable electricity requirements. The potential for local ownership and economic benefits from energy generation – energy self-reliance – has never been greater.

The rapid growth of distributed renewable energy has led utility planners and state and local governments to examine what the new rules of electricity generation and distribution will be in an age where households and businesses will be both producers and consumers of electricity. The result is a historic opportunity to democratize energy, develop energy efficiency, energy self-reliance and renew local communities.

Integration of Distributed Generation

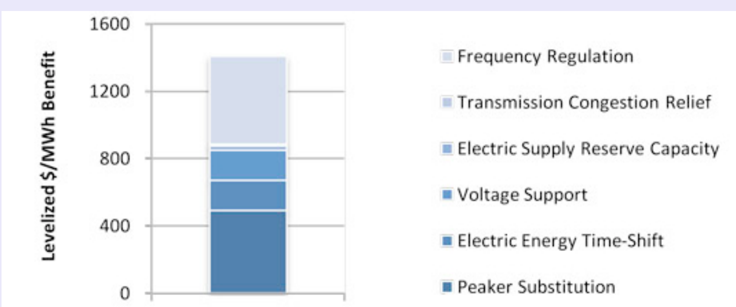
Until recently, utilities believed that even small amounts of variable renewable energy like solar and wind would generate problems on the local electric grid. But currently in Kona, Hawaii, a 700 kilowatt (kW) solar array provides 35% of the capacity of the local distribution feeder. In Las Vegas, 10 MW of commercial solar PV on a distribution line provides 50% of capacity (and up to 100% during periods of low load). In each case, the utility has reported no significant issues managing the integration of local distributed solar power.

In Las Vegas, 10 MW of commercial solar PV on a distribution line provides 50% of capacity (and up to 100% during periods of low load) ...the utility has reported no significant issues managing the integration.

The growth of democratic, distributed renewable energy will also mitigate the need for new backup generation to smooth the variations in wind and solar power production. Geographic dispersion will significantly reduce backup requirements, and existing fossil fuel power plants (particularly natural gas) will have sufficient capacity to smooth out the remaining variations in wind and solar generation for many years.

In the long term, the increasingly renewable energy electricity grid will also use more energy storage. New technological developments and an increasing recognition of the many system benefits of storage (e.g. frequency regulation, voltage support, etc.) has led the Federal Energy Regulatory Commission (FERC) to issue new rules that give storage and generation equal standing. This opens the door for large energy storage systems from batteries to pumping systems to compete with fossil fuel backup power to smooth out wind and solar power production.

Energy Storage is More Than Big Batteries

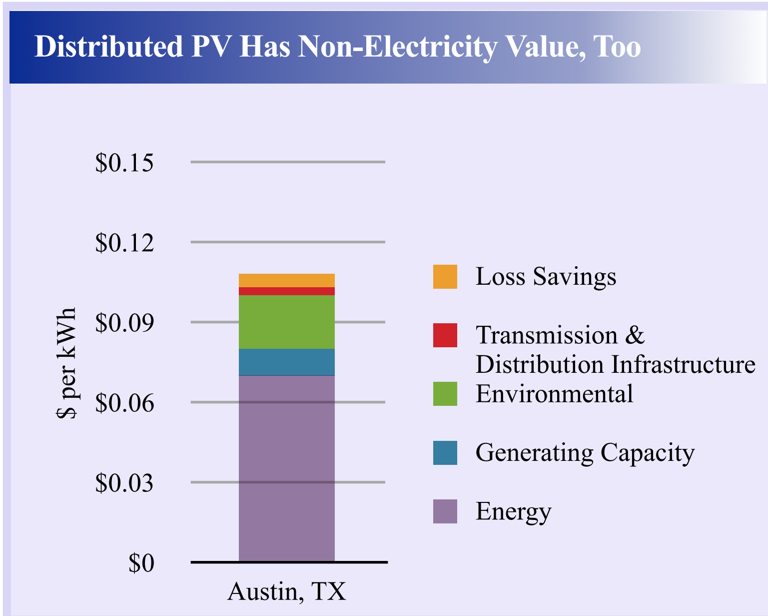


The new distributed grid paradigm is already being tested by utilities. Xcel Energy installed and has been testing a 1-MW (7.2 MWh) sodium-sulfide battery integrated with a 11.5-MW wind energy project in Luverne, MN. The Long Island Power Authority is considering a proposal to meet growing demand with a 400 MW battery storage facility rather than new power generation.

Value to the Grid and Economy

A cornerstone of the democratization of the grid with distributed renewable energy is its economic competitiveness. New wind, hydro, and geothermal power can increasingly compete head-to-head with new fossil fuel power plants with the use of federal tax incentives.[1] Solar power is competitive in a few select regions with high electricity prices and a strong solar resource, but its rapidly declining costs (50% in 5 years) suggest a pending explosion of distributed solar power.

This transition is aided by re-evaluations of the value of distributed energy by regulators and utilities. Municipal utilities in Colorado, Florida, and Texas have found valuable benefits beyond its electricity output. The following chart highlights the additional electricity system benefits of distributed solar PV (the items other than "energy") identified by the Austin, TX, municipal utility.



Furthermore, distributed generation reduces efficiency losses from long-distance transmission of electricity and can help reduce the incidence of blackouts (just 500 MW of distributed solar could have prevented the massive Northeast blackout of 2003, saving $6 billion).

The modest economies of scale in wind and solar power also create a positive feedback loop of cost effectiveness and economic value. Wind power is most cost effective in arrays of 5-20 MW, a handful of utility-scale turbines. The economies of scale of solar PV are largely captured at the modest size of 10 kW, with modest additional savings for community-scale (up to 1 MW) projects.

Wind power is most cost effective in a size range of 5 to 20 megawatts. Historically, solar PV economies of scale have largely been captured at an individual project size of 10 kilowatts, with modest additional savings for community-scale projects.

The small scale cost-effectiveness of distributed wind and solar enables the democratization of energy production and local ownership. For states and cities looking to maximize the local value of renewable energy, the 1.5 to 3.4 times greater economic returns of local ownership compared to absentee ownership are compelling.

Breaking Down Barriers

While technology advances and costs drop, the major obstacle confronting distributed generation is a century of rules and institutional structures predicated on the outdated assumption that power plants will continually grow in size and electricity will continue to be transmitted over ever-longer distances. From federal energy incentives to rules issued by the Federal Energy Regulatory Commission (FERC) to state interconnection rules, there is a systemic bias toward centralized power and one-way grid systems.

Expanding and adopting new policies can help level the playing field.

Federal

The Federal Energy Regulatory Commission can abandon its policy of providing lavish and unnecessary incentives to new high-voltage transmission at the expense of democratic, distributed generation. The federal government can also aid the transformation to a 21st century grid by extending the cash option in lieu of tax credits that dramatically broadens the potential participation in renewable energy generation.

State

CLEAN Contracts (i.e. feed-in tariffs) make electricity generation “plug and play,” democratizing the grid and allowing energy consumers to become producers. Data sharing rules enforced by state public utility commissions require utilities to publish information about their distribution network, to let distributed generators locate the best opportunities for developing new projects. Interconnection reform at the federal and state level can drastically simplify the process of connecting distributed generation to the electricity grid.

Local

Community choice aggregation and municipalization can give communities the power and authority to establish energy self-reliance. Lacking these major moves, communities can increase democratic, local energy development by passing solar access laws giving everyone a right to capture sunshine on their property for solar electricity and by changing building codes to encourage or require more on-site power generation.

The U.S. electric grid is poised for a transformation. Without new rules, the renewable energy future and its economic benefits will be developed under an outdated paradigm and owned by the same few large utilities. With new rules, we can unlock the potential of distributed generation and the potential of people to power the clean energy future.

Acknowledgments

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All shortcomings, of course, are the responsibility of the author.

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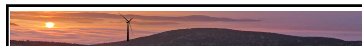

Energy Self-Reliant States: an ongoing web resource
http://energyselfreliantstates.org

Since 1974, the Institute for Local Self-Reliance (ILSR) has worked with citizen groups, governments and private businesses to extract the maximum value from local resources.

A program of ILSR, the New Rules Project helps policy makers design rules as if community matters.

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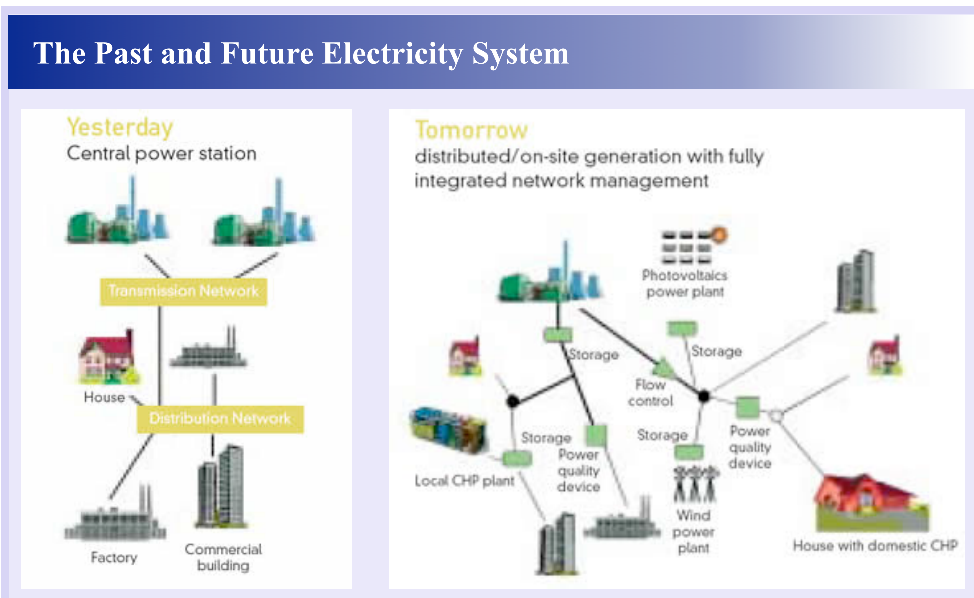
The Electric System: Inflection Point

The 20th century of electricity generation was characterized by ever larger and more distant central power plants. But a 21st century technological dynamic offers the possibility of a dramatically different electricity future: millions of widely dispersed renewable energy plants and storage systems tied into a smart grid. It's a more democratic and participatory paradigm, with homes and businesses and communities becoming energy producers as well as consumers actively involved in designing the rules for the new electricity system.

Several decades ago, several people – Amory Lovins in *Brittle Power*, David Morris in *Self-Reliant Cities* – explored the implications of this decentralized vision. Most importantly, this vision represents a transformation in the ownership and control of the electricity system. Instead of a 20th century grid dominated by large, centralized utilities, the 21st century grid would be a democratized network of independently-owned and widely dispersed renewable energy generators, with the economic benefits of electricity generation as widely dispersed as the ownership.

This graphic from the European Commission illustrates the paradigm change:



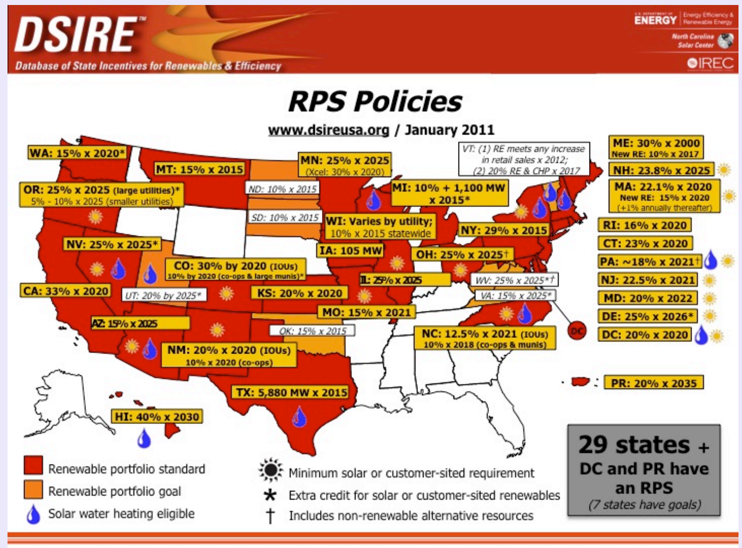
The difference in the ensuing decades is the commoditization of distributed energy production (e.g. solar panels sold at Home Depot), the renewable energy industry growing to $100 billion, and the critical mass of such production on the electricity grid.

In the last two years a number of events have forced policymakers at the local, state and national level to grapple with the implications of a decentralized grid system and how the policies they adopt help or hinder such a 21st century energy system:

- Sixteen (16) states of the twenty-nine (29) that have renewable energy mandates have added mandates for solar and other distributed energy technologies.
- Germany installed an astonishing 7,400 megawatts (MW) of distributed solar PV in 2010. It has begun to change its incentive program to not only maximize solar power but on-site self-reliance via a combination of distributed generation, demand shifting and storage.

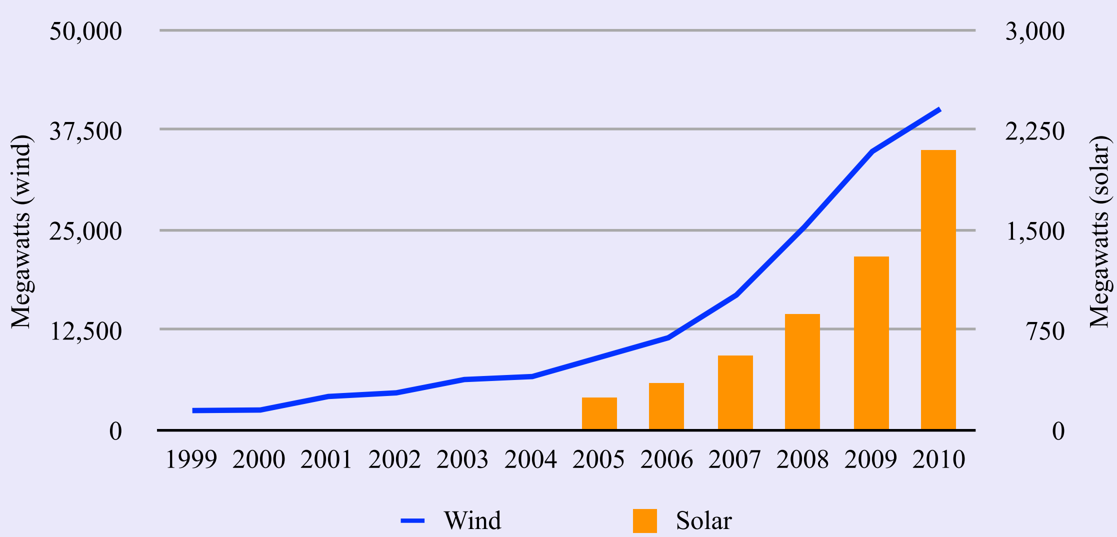
- In this country's largest solar market, California, the number of rooftop solar PV systems has grown from 500 to 50,000 in 10 years.[2] The number of buildings with rooftop solar in San Francisco alone has increased from 9 to 7,050 in the same period.
- California's governor announced his goal for the state to generate 12,000 MW from renewable distributed power plants by 2020.[3] The state public utility commission has established a new renewable auction mechanism for up to 1,000 MW of distributed renewable energy projects 20 MW and smaller.
- Southern California Edison recently completed its solicitation for 250 MW of distributed solar PV on dozens of commercial rooftops with the price of electricity expected to be lower than natural gas generation.[4]
- *And many more (see endnote)*[5]

Over 30 States Support Renewable Energy



These events coincide with a dramatic rise in the amount of renewable energy on the U.S. electric grid. Although total renewable generation is only 10 percent of total electricity, in some regions the concentration has reached 15 to 20 percent or more. The rapid growth rate of this distributed renewable energy means that regulatory and utility policy must change immediately, to plan appropriately for the coming distributed generation grid.

Rapid Growth of Wind and Solar Power in U.S.



Why Distributed Generation?

There are a number of benefits to a democratized electricity system, in addition to the monumental shift toward energy self-reliance.

1. *Vast potential and deployment speed*. Nearly every state could meet 20 percent of its electricity needs with rooftop solar PV alone. Two-thirds of states have sufficient wind, solar and geothermal power to get 100 percent of their electricity from in-state (and distributed) sources.[6]

Distributed generation can also come online much faster than centralized generation. For example, while the entire world has installed barely 1,000 MW of centralized solar thermal power, Germany installed 7,400 MW of distributed solar PV in 2010 alone.[7] Similarly, large wind projects often experience long delays awaiting new transmission capacity whereas distributed wind projects can often connect to the grid without significant infrastructure upgrades. Ontario's feed-in tariff program, for example, provides fast-tracking for small-scale distributed generation (projects smaller than 500 kilowatts) because it rarely creates significant grid impacts.

2. *Favorable economics*. Some renewable energy technologies (with federal subsidies) already compete toe-to-toe with fossil fuel generation, and others – like solar – are rapidly becoming less expensive. Furthermore, the vast majority of economies of scale for renewable energy technologies are captured at a modest size, well within accepted size definitions of distributed generation.

3. *Local ownership and political support*. The economic impact of locally owned renewable energy projects can be several times greater than absentee owned ones, and distributed generation lends itself to ownership. Such local ownership also dramatically increases local acceptance of more renewable energy production. And because it's a more efficient use of the electricity grid, distributed generation reduces the number of political fights over new high-voltage transmission lines.

The political support for distributed generation also stems from its inherent democratic nature. By dispersing the sources of power generation and opening the grid to producers large and small, a distributed grid allows for maximum participation in power production, creating a constituency for supporting the expansion of clean energy and distributed generation.

4. *Value to the grid*. Distributed generation is more resilient to disruption, with power generation spread over thousands of generators and over a wide geographic area. This makes it harder for a large area to be without power and easier to maintain grid stability.

A distributed grid can also be more efficient, by maximizing the potential of existing infrastructure. In California, the Public Utility Commission requires utilities to publish data on "sweet spots" on their grids, to assist distributed energy developers plug in where it's of greatest benefit. This efficient usage can reduce the demand for new grid infrastructure, particularly expensive high-voltage transmission lines.

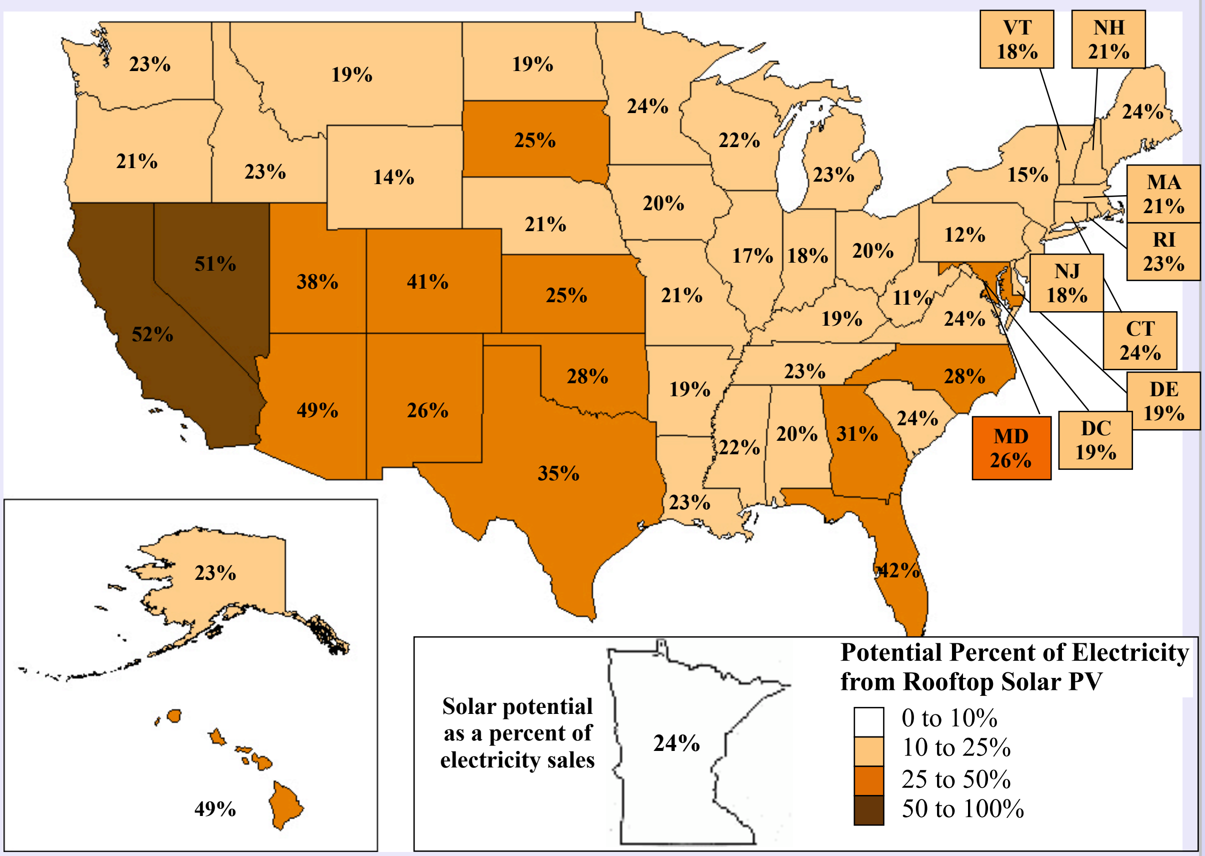
For an exhaustive list of the benefits of distributed generation, see the 207 benefits of distributed resources in the Rocky Mountain Institute's *Small is Profitable*.[8]

The Potential for Distributed Generation

Most U.S. states have enormous potential for renewable electricity production that could be developed in a distributed, democratic fashion. In our 2009 report, Energy Self-Reliant States, we provided maps of the renewable energy potential by state based on current electricity demand. The following map illustrates the potential state self-sufficiency from rooftop solar PV alone.

Most States Could Get 20% of Electricity from Rooftop Solar PV

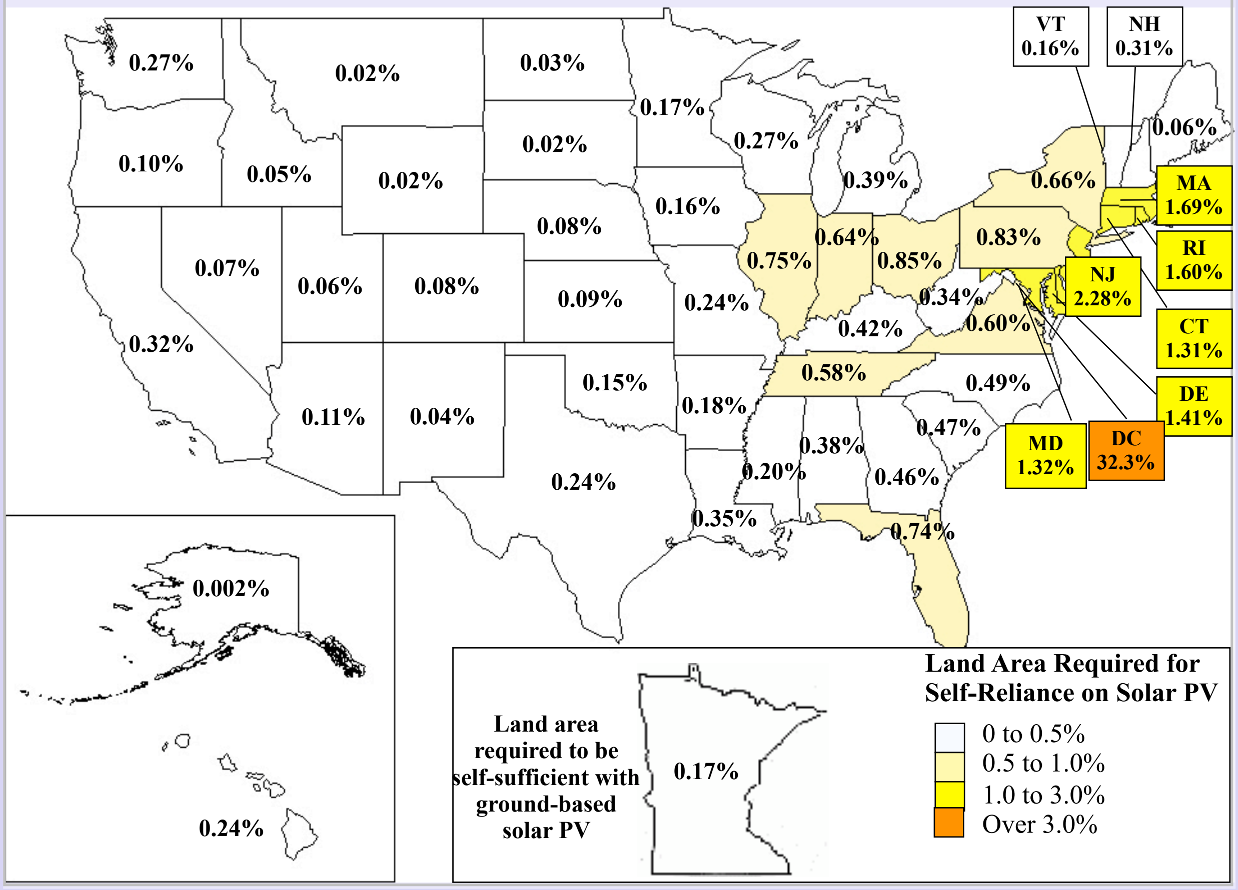
Figure 6 - Potential State Electricity Self-Sufficiency using Rooftop Solar PV



Almost every state could get 20 percent or more of its electricity from rooftop solar. This does not include the electricity generated from ground mounted arrays. Sufficient sunshine falls on every state to meet all its electricity needs from the sun provided that enough energy storage was also available. The following map shows the portion of a state's land area that would be required to meet all its electricity needs with solar power. California's 0.32% is equivalent to about half of Orange County; New York's 0.66% is equivalent to less than half of Long Island. While a fully renewable, distributed grid would benefit from greater diversity than just solar power, the map provides a picture of the potential to power every state's grid with local, distributed electricity.

Sun Could Power Most States With Minimal Land Area

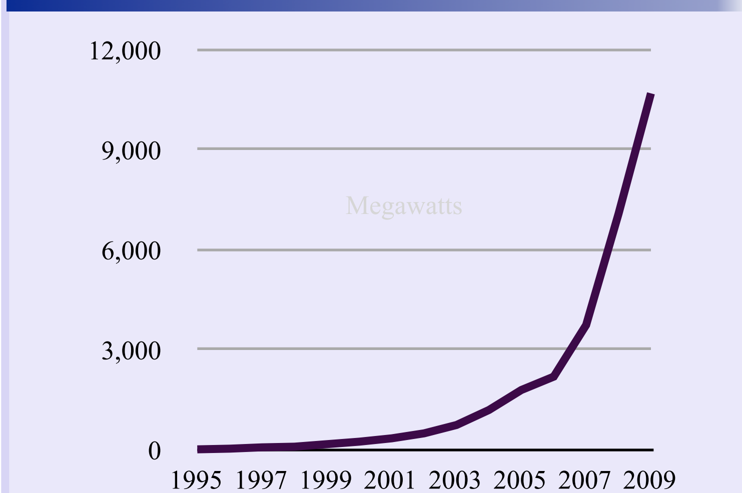
Figure 7 - Percent of Land Area Required to be Self Sufficient with Solar PV



The exponential growth rate of distributed generation like solar PV suggests that even if distributed generation makes up a small portion of generation now, its growth profile suggests that within the planning horizons of many utilities, it will comprise a significant and possibly majority portion of generation.

Germany, for example, deployed over 10,000 MW of solar PV projects in the past two years, over 80 percent on rooftops. Distributed generation is poised for massive growth in the United States.

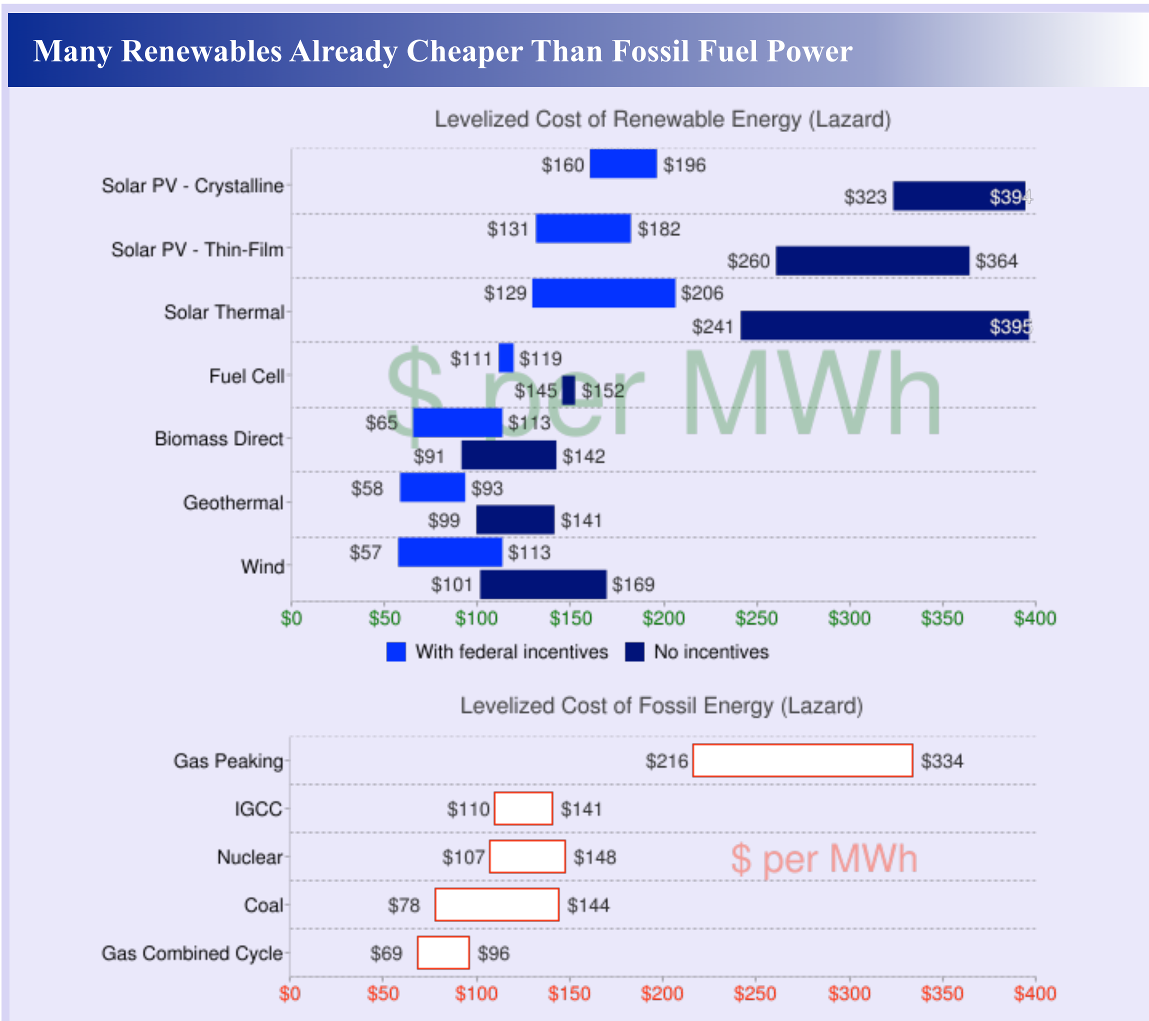
Exponential Growth: World PV Module Production



The Economics of Distributed Renewable Generation

The falling cost of distributed renewable generation has been one of the key drivers of the transformation of the U.S. electric grid.

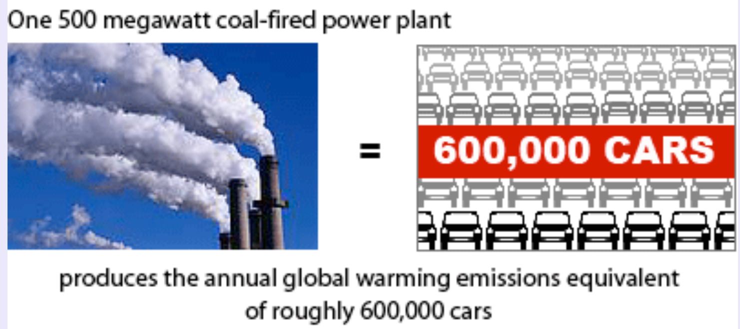
The following chart illustrates the cost of power generation calculated by averaging the total lifetime cost over the total electricity generated ("levelized cost"), as estimated by the investment bank, Lazard.[9] Federal incentives cause a significant reduction in the levelized cost of renewable energy, in the form of upfront tax credits as well as ongoing production-based tax credits.



Wind, geothermal and biomass are already less expensive than any fossil fuel energy source, when factoring in federal incentives for all three sources.

Solar PV is the most expensive, but has strong prospects for lower price. Already, the average cost for German solar PV (10 to 100 kilowatt (kW) systems) has fallen to $3.70 per Watt,[10] and some 1 MW solar PV systems in the U.S. are being installed at $3.50 per Watt, pushing the lower bound of the prices in the chart. A design charette aimed at reducing balance of system costs found that best practices could reduce solar PV installed costs by nearly 60 percent within five years, not counting further cost reductions in solar modules.[11] At these prices, renewable energy competes very favorably against most new fossil fuel generation.

Hidden Subsidies for Fossil Fuels



Source: Union of Concerned Scientists, http://tinyurl.com/26bbvm9

Not all costs are covered in this levelized cost comparison. A grid with majority renewable power (from variable sources like wind and solar) will require a different approach than the existing grid. Whereas current generation scheduling, peaking and backup are tailored to a system with large, centralized baseload power plants, a grid with distributed renewable resources will require new load balancing ingenuity. It will be necessary to use smart grid technologies to enable greater demand response and to defer elective electricity use (such as electric vehicle charging) to times with greater supply, and to use energy storage like pumped hydro or batteries to shift surplus production to times of higher demand. It's also a question of whether any additional costs incurred would be offset by other economic benefits. These issues are discussed later in this report.

Likewise, hidden subsidies for fossil fuels – incentives they once received for technological development, the cost of military operations to secure fossil fuel energy sources, and massive environmental externalities – are also omitted.

The Issue of Scale

Even as renewable energy challenges fossil fuels on cost, the average size of renewable energy projects continues to defy the conventional wisdom that bigger is better. The average solar PV system in the U.S. is just 10 kW and the average wind power project is 80 MW.[12] Wind power is often seen as the largest scale renewable energy source, and it provides an interesting lesson.

> *Average Size of U.S. solar PV project: **10 kilowatts***
>
> *Average Size of U.S. wind power project: **80 megawatts***

While the average wind farm size has increased from 35 to 90 MW in the past 10 years, it's almost entirely due to larger turbines (the average size has jumped from 0.71 MW to 1.74 MW in the same time frame).[13] Wind projects don't have more turbines, they just use larger ones. While a wind farm of larger turbines may require more total land area (to space them further apart), the amount of occupied land is relatively the same, but delivers more power.

In the same fashion, solar modules have increased in efficiency and quality, allowing for greater electricity output per module. The technological advance actually reduces the need to be bigger.

Because renewable energy projects can lend themselves to smaller scale and geographic dispersion, they encourage the development of a distributed grid. It's not always the case, however.

Solar Power

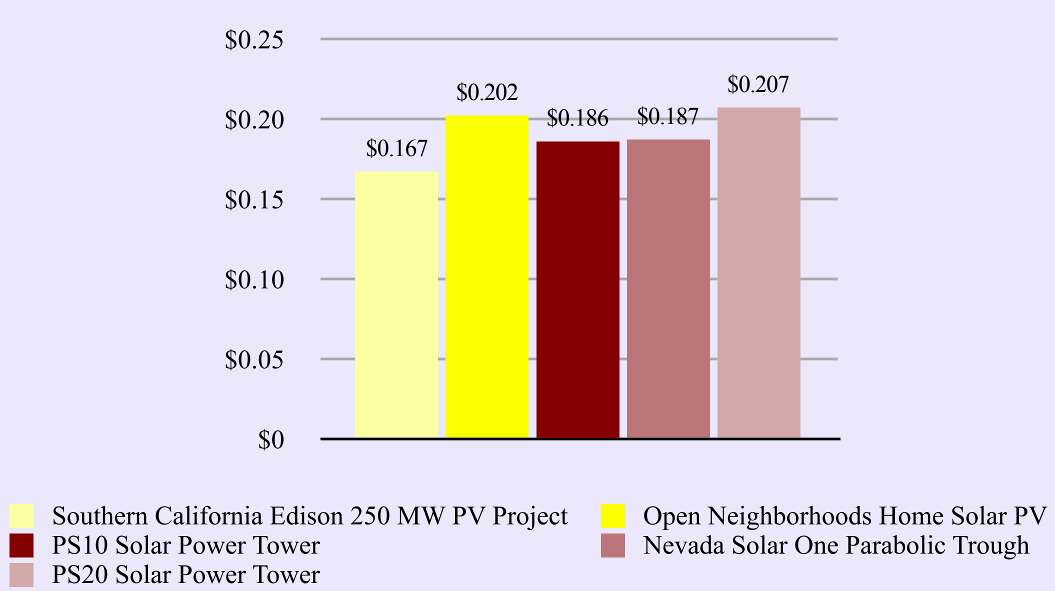
There are two electricity technologies, solar PV and solar thermal. Solar PV directly converts sunlight to electricity, and is modular, generating power by interconnecting individual solar modules of approximately 200 Watts into arrays of 5 kW to 50,000 kW (50 MW). Solar PV costs have fallen steadily,[14] with modules representing about half the cost of a solar PV installation, "balance of system," and labor and installation the remainder.

Concentrating solar thermal generates electricity in several ways, with the common element of a solar concentrator (mirror or lens) used to concentrate sunlight to create heat that will be converted to electricity. Projects are generally 5 MW or larger, with several proposed projects in the U.S. and internationally of several hundred megawatts. Every commercial concentrating solar technology also lends itself to thermal energy storage, because the sun's heat can be stored in a variety of methods (most involving molten salts) for several hours.

Because solar PV power is often installed on residential rooftops at a fairly small scale, many people believe that it is inherently more expensive than its central-station counterpart, concentrating solar.

The data suggest otherwise. The following chart illustrates the cost of electricity from two sample solar PV projects, one commercial and one residential, as well as the three most cost-effective concentrating solar thermal power plants.[15] Solar PV at commercial scale comes out cheaper. Even smaller scale solar is comparable to large-scale concentrating solar. These figures do not factor in the cost of long-distance transmission, a common additional line item for concentrating solar power plants.

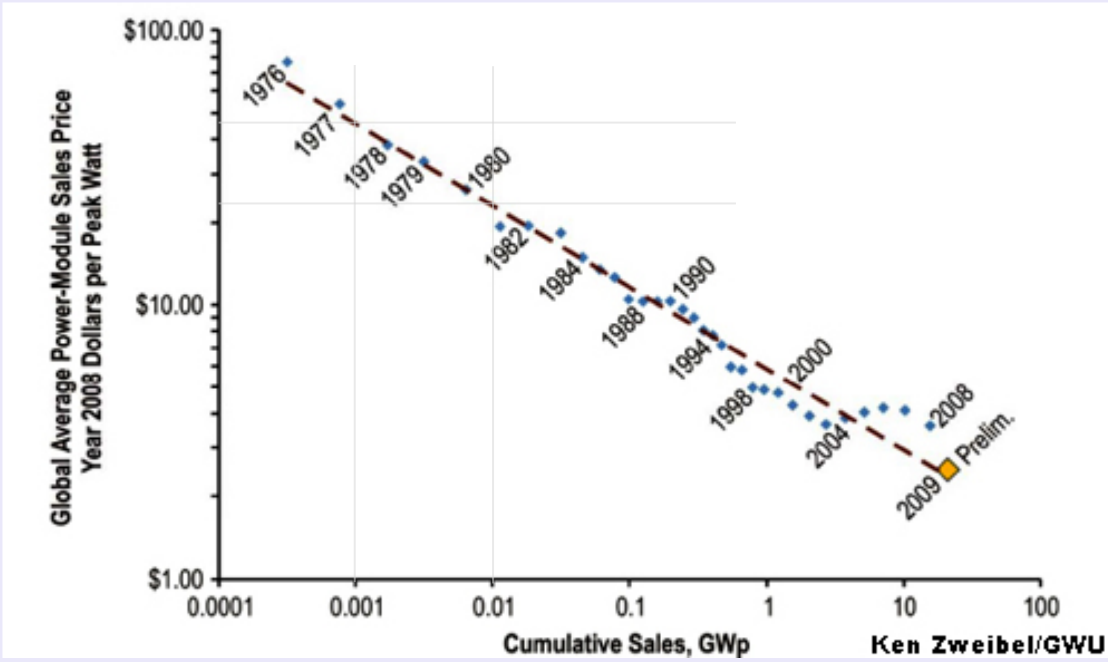
Solar PV Cost Beats Any Concentrating Solar Power Plant



These costs are supported by the lower cost of distributed solar in Germany,[16] as well as recent bids for utility-run distributed solar programs in the United States.[17]

There may be prospects for price decreases for either technology, but it's hard to see how concentrating solar could win the price war. An oft-shared graphic (below) illustrates the solar PV experience curve, and shows how solar PV module prices have dropped as the total installed capacity has grown (a ten-fold increase installed capacity has generally reduced module prices by half).[18] The small dots show actual module prices, and the large dotted line is the trend.

Solar PV Module Cost Drops by Half for 10-Fold Capacity Increase



The installed base of solar thermal power plants is just over 1,000 MW, split among several technologies, while solar PV is being installed at a rate of 4,000 MW per year in Germany alone. Since solar thermal projects tend to require years of planning, financing, and construction, it's unlikely that centralized solar thermal prices will fall as rapidly as decentralized solar PV, supported by this excerpt from a recent Solar Electric Power Association report:[19]

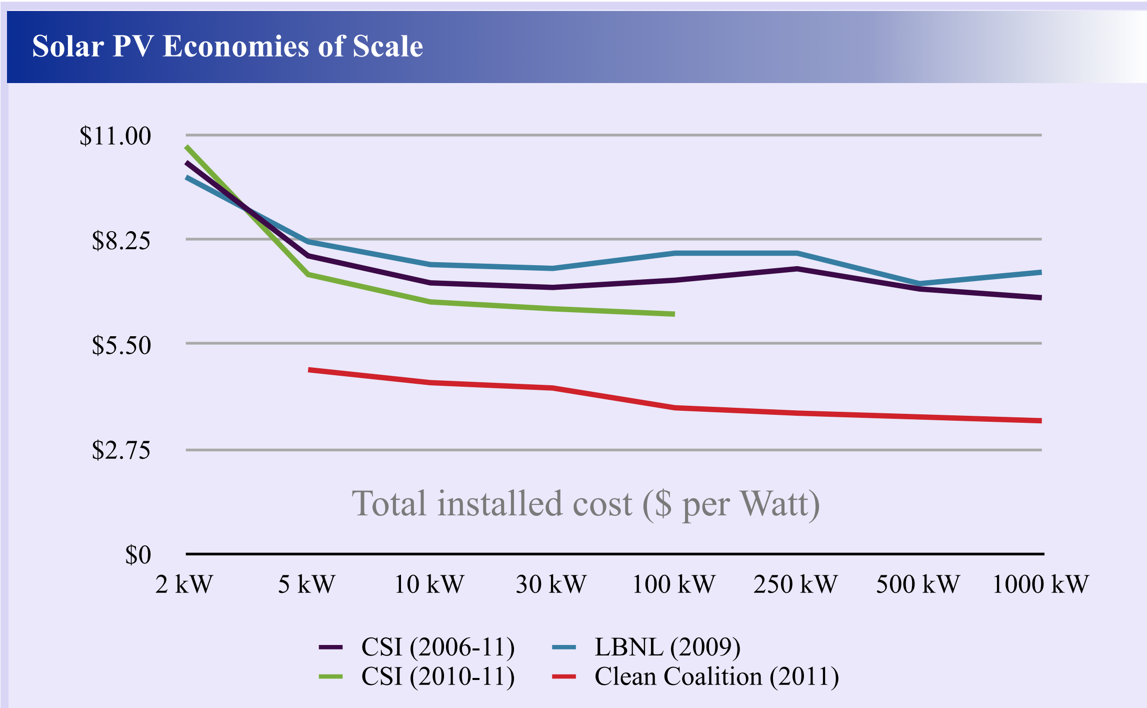
> *[Concentrating solar power] (CSP) represents over 6,000 MW of the over 15,000 MW of future solar projects that SEPA is tracking, but there are differences in project development between CSP and PV. PV can be built and sub-sections of the larger project can be energized over time, resulting in lower construction risk and balance-sheet impact. CSP projects need to be completed in full before commissioning, a period which takes several years from start to finish.*

Even if solar thermal power can keep pace on cost with solar PV, the latter is much more amenable to distributed generation and local ownership and would be preferable even if the costs were similar.

>

The second economies of scale question for solar power is big solar PV versus small solar PV. Here the data are less conclusive.

The following chart provides an illustration of the installed cost per Watt for solar PV at a range of sizes. The top three lines are historical data from Lawrence Berkeley Labs (LBNL) and the California Solar Initiative (CSI).[20,21] The lowest line represents installed prices reported to the Clean Coalition from their network of installers in California.[22]



There are economies of scale for distributed solar, especially for very small (residential scale) systems. Historical U.S. data suggests that the savings from size level off beyond 10 kW, but contemporary installed data suggests that there are two breakpoints in economies of scale, at 10 kW and 1,000 kW.

Data from Germany's feed-in tariff solar incentive program supports this theory. There is a 25% price differential between the smallest rooftop solar arrays (up to 30 kW) and the largest (over 1000 kW), with 15 percentage points of the savings in the jump from the 100-1000 kW size tranch to the largest one.[23]

In other words, there are valuable economies of scale for projects up to 1 MW. However, there are additional barriers to cost-effectiveness for larger solar PV projects, described in the Solar Electric Power Association's 2010 Utility Solar Rankings report:[24]

> *PV projects, which ranged in size from 1-kilowatt residential installations to 48-megawatt power plants, have much shorter planning horizons and project completion times, along with lesser siting, permitting, financing and transmission requirements at these small- and medium-sized scales. However, larger PV and CSP projects (those greater than 50 MW) require overcoming financing, siting/permitting, and transmission barriers that might emerge at these larger sizes.*

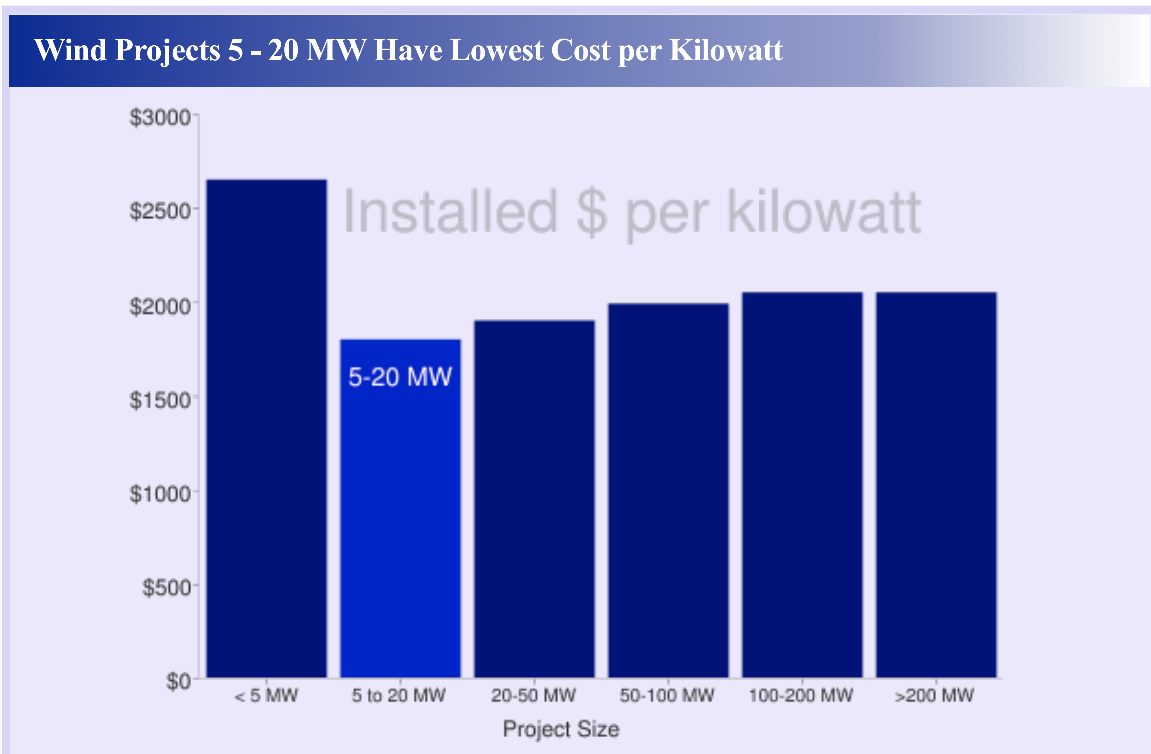
The trend noted by SEPA is illustrated in a particular example. Sunpower has a 250 MW centralized solar PV power plant planned for the California Valley, secured by a $1 billion federal loan guarantee. The installed cost of the system is $5.70 per Watt, 60% higher than installed costs for 1-20 MW projects.[25]

In short, PV is the preferential technology, and distributed solar is better than centralized. As we discuss later, this has significant implications for the economic benefits of solar power.

Wind Power

The economies of scale of wind power are similar. The power output of a wind turbine increases exponentially with higher wind speeds, as well as with larger diameter blades. Since wind speeds rise quickly as height increases, and taller turbines can host larger blades, utility-scale turbines (generally 1 MW and above) at heights of 80 meters or more are unquestionably more cost-effective than small-scale turbines.

When it comes to multi-turbine projects, however, the data show limited economies of scale. In their *2009 Wind Technologies Market Report* for the U.S. Department of Energy, the Berkeley Lab authors showed that costs fell for projects that aggregated a few turbines (5 to 20 MW), but that larger projects had higher levelized costs of operation.[26] The following chart (redrawn from the report) illustrates:



The lesson from the report is that wind projects built at a smaller scale capture most of the construction and project economies of scale, but also may avoid diseconomies of scale that affect larger projects. These diseconomies can include higher financing costs due to multi-billion dollar project costs, time and money costs for new transmission infrastructure, and legal costs to secure the land rights for a large project as well as the cost of overcoming local resistance. In Germany, home to some of the most effective renewable energy policies in the world, more than half of its 27,000 MW of wind are in projects 20 MW and smaller.[27] It's no coincidence that half of Germany's wind power capacity is also locally owned by farmers and cooperatives.[28]

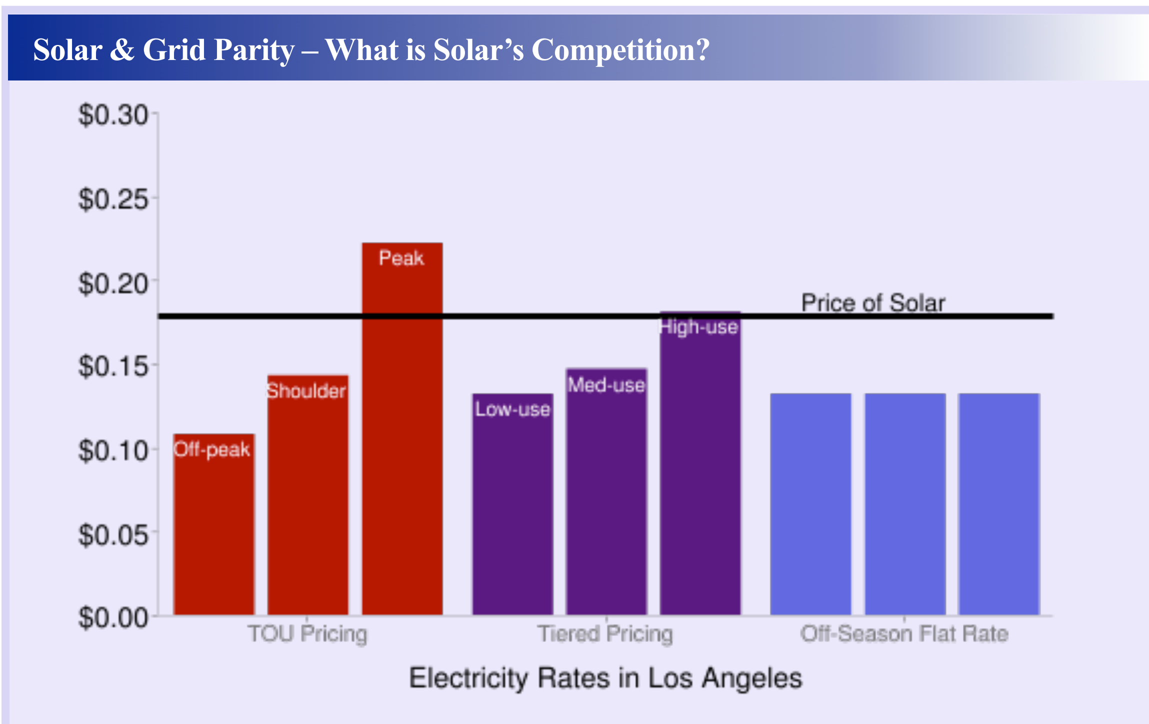
There are also some potential economies of operation and maintenance, although these shrink as wind projects become more ubiquitous and services are more broadly available.

Is Distributed Solar Competitive at Retail?

For many distributed projects, the issue is not a comparison to other large-scale power plant costs or economies of scale, but how distributed generation compares to grid electricity. The liability in such comparison is that grid electricity is mostly from old fossil fuel power plants that were paid off years ago and that generate significant pollution (including carbon emissions). Furthermore, the price of grid electricity is not static (it's gone up 3.8% per year since 2000).[29] However, many prospective customers use their existing electric bill when considering solar, so the comparison has merit.

Consider a residential solar PV system installed in Los Angeles. A local buying group negotiated a price of $4.78 per Watt, equivalent to 17.9 cents per kilowatt-hour (kWh) with federal incentives. Since the average electricity price in Los Angeles is 11.5 cents, solar doesn't appear to compete. Or does it?

The following chart illustrates the difficulty in determining whether solar has reached "grid parity" (e.g. the same price as electricity from the grid).



In Los Angeles, there are three sets of electricity prices. From October to May (off-season), all pricing plans have a flat rate per kWh and total consumption. During peak season (June to September), however, the utility offers two different pricing plans: time-of use pricing and tiered pricing. Time-of-use pricing offers lower rates – 10.8 cents – during late evening and early morning hours, but costs as much as 22 cents per kWh during peak hours. Prices fluctuate by the hour. Tiered pricing offers the same, flat rate at any hour of the day, but as total consumption increases the rate does as well. For monthly consumption of 350 kWh or less, the price is 13.2 cents. From 350 to 1,050 kWh, the price is 14.7 cents. Above 1,050 kWh, each unit of electricity costs 18.1 cents.

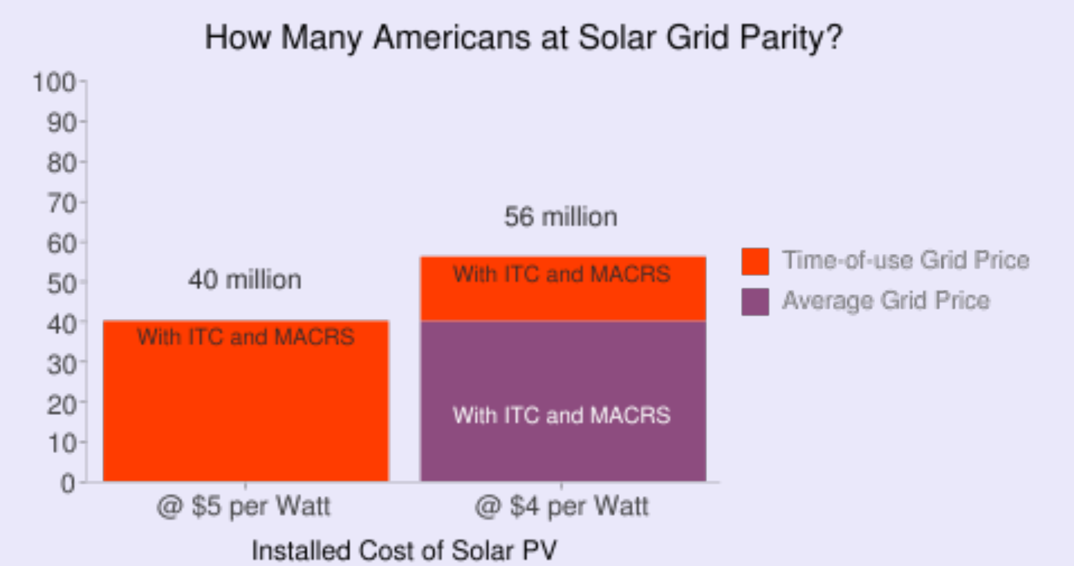
A very rough calculation of the expected time of day production of a solar array in Los Angeles finds that the average value of a solar-produced kWh is 15.1 cents over a year.[30] That suggests that solar power is not yet at grid parity, even with time-of-use pricing. A similar value was found when examining time-of-use pricing in PG&E's service territory.[31] A more robust analysis with assumptions about higher levels of on-site electricity use during peak hours could change these estimates.

There are other considerations, as well. With a grid connected system, the most common policy governing the connection is net metering. It allows self-generators to roll their electricity meter backward as they generate electricity, but there are limits. Users typically only get a credit for the energy charges on their bill, and not for fixed charges utilities apply to recover the costs of grid maintenance (and associated taxes and fees). Producing more than is consumed onsite can mean giving free power to the utility company. So even if a solar array could produce all the electricity consumed on-site, the billing arrangement would not allow the customer to zero out their electricity bill. Some policies, like CLEAN contracts, eliminate this problem.

Based on ILSR's analysis, solar PV is becoming competitive with average grid electricity prices in select areas of the United States. As prices fall to $4 per Watt, solar PV projects that can take advantage of the federal tax credits and accelerated depreciation – an incentive only available to commercial operations – would compete favorably with average grid electricity prices in New York, San Francisco and Los Angeles (representing 40 million Americans).

Under a time-of-use pricing plan (where prices could be 30% higher during hours with good sunshine, as in Los Angeles), the equation changes. An additional 16 million Americans could use solar PV (along with both federal incentives) to beat their grid electricity price at an installed cost of $4 per Watt. Even at $5 per Watt, 40 million Americans could use solar PV and federal incentives to best their utility's time-of-use electricity rate.

Falling Solar Costs Reach Grid Parity with Time-of-Use Pricing



As noted above, this grid parity calculation assumes that solar producers can use federal depreciation, an incentive worth as much as 25% of the project cost and only available to businesses or to homeowners who lease their solar panels. Without any federal incentives, solar PV would have to be installed at approximately $2.40 per Watt to be at grid parity for 56 million Americans.

In the current environment of incentives, distributed solar is nearing a cost-effectiveness threshold, when it will suddenly become an economic opportunity for millions of Americans.

Ownership and Political Support for Distributed Generation

While technology has helped change the economics of electricity production (in favor of renewables and distributed generation), this new dynamic can as easily be controlled by the incumbent utilities as the old paradigm of centralized fossil fuel power generation.

The cornerstone of the distributed generation revolution is its potential democratizing influence on the electric grid, the opportunity unlocked for local ownership and the coincident political support for more renewable energy. In no place is that clearer than in the public support for renewable energy.

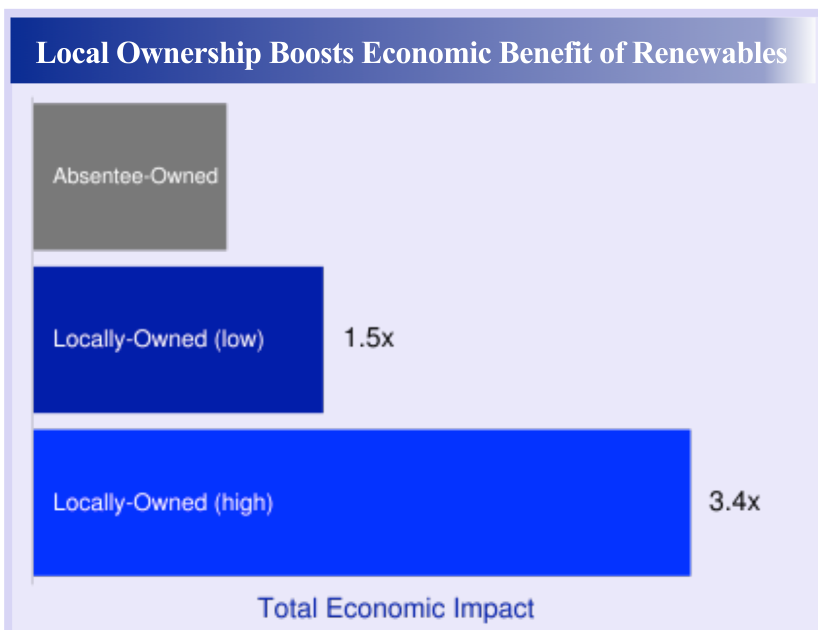
An increasing number of renewable energy projects (primarily wind, but also large-scale solar) have met with resistance from local residents or environmentalists. Centralized, remote generation might seem to avoid NIMBY issues by placing wind turbines or solar power plants far from population centers; but in practice, there have been opponents to these projects as well. Large power plants raise questions about environmental impact from creature habitat to water consumption. Power from distant plants must be transmitted over high-voltage transmission lines to get to load centers without significant losses, and such lines are built only at great ratepayer expense, over many years, and with the taking of land with eminent domain. Some folks just hate the look of power plants, regardless of their sustainable nature.

Resistance has been organized enough to win restrictive state siting policies (e.g. wind policy in Wisconsin) or to coordinate environmental advocacy organizations to oppose solar power plants on undeveloped desert lands. In some cases, resistance takes on the strange aspect of "wind turbine syndrome," or other mysterious illnesses.

At the heart of the matter, citizens rightly see renewable energy as different, and find it frustrating to see new, widely available resources like sun and wind developed under the old, centralized paradigm and owned by the usual suspects. In a recent study by the ever-methodical Europeans, they found that opponents to new wind and solar power have two key desires: "people want to avoid environmental and personal harm" and they also want to "share in the economic benefits of their local renewable energy resources."[32]

It's not that people are made physically ill by new renewable energy projects. Rather, they are sick and tired of seeing the economic benefits of their local wind and sun leaving their community.

Such opposition is perfectly rational, since investments in renewable energy can be quite lucrative (private developers and their equity partners routinely seek 10% return on investment or higher). And the economic benefits of local ownership far outweigh the economic colonialism of absentee owners profiting from local renewable energy resources.



Additionally, when projects are absentee owned, local residents see little to no economic advantage to offset their concerns about health or the environment.

It's not just centralized renewable energy projects facing opposition; distributed generation (DG) can also face resistance. While DG projects are of a more modest scale than centralized power generation, they also reside closer to actual electricity demand; thus, they are closer to population centers. For solar, this is largely a non-issue, because it can be easily installed on rooftops or other existing structures. Similarly, other technologies like geothermal or even natural gas generate little hostility from locals. On the other hand, for wind power there's little distinction between a 30 MW and 300 MW project, because all the turbines are the same size. A distributed wind project will place very large turbines close to population centers and wind projects of all sizes have met with stiffer resistance.

For both centralized and distributed generation, local ownership becomes the key to unlocking local support. For example, the following chart illustrates the local support for wind power in two German towns, Nossen and Zschadraß.

Local Ownership Boosts Public Support for Wind

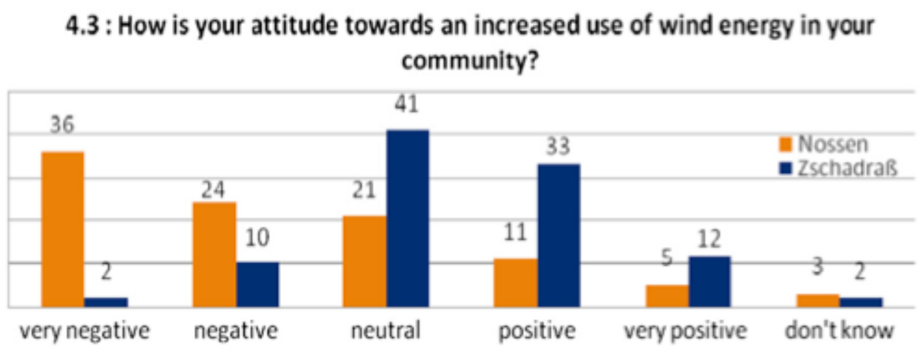


Fig. 5. Item 4.3 from the questionnaire. Total number=%, n=200.

With local ownership of the wind project, 45% of residents had a positive view toward more wind energy (Zschadraß). In the town with an absentee-owned project (Nossen), only 16% of residents had a positive view of expanding wind power; a majority had a negative view.

By unlocking economic opportunity, distributed generation and local ownership of renewable energy create a positive feedback loop for more investment in renewable energy.

Avoiding Eminent Domain

Distributed generation also avoids one of the major drawbacks to centralized generation: the need for new transmission infrastructure, commonly constructed by seizing land with the power of eminent domain. According to the Federal Energy Regulatory Commission (FERC), there are nearly 15,000 miles of new, high-voltage transmission lines planned to be in service by 2013. With most transmission lines requiring significant right-of-way (200 feet), this is equivalent to 363,500 acres of property needed. A substantial portion that will be taken with eminent domain or negotiated with landowners under the threat of eminent domain.

One issue for many landowners is that their land is taken or easement granted for a one-time payment, while the utility continues to draw revenue from selling access to the transmission line for decades. In Wyoming, landowners have organized to try to change the law to require an annual payment, in part because the transmission lines are being constructed to ferry wind power from Wyoming to places out-of-state.[33]

There are few solutions to the eminent domain challenge, although a bill introduced during the 2009 Minnesota state legislative session would have tried to make the process fairer in that state. Currently, Minnesota utilities are exempt from many of the rules restricting how local government entities can use eminent domain. Utilities, unlike governments, do not have to negotiate in good faith, are not required to show landowners any appraisals of their property and do not have to compensate businesses for losses stemming from a forced change of location. The proposed legislation (which failed) would have harmonized the rules for utilities and local governments, and made eminent domain for transmission fairer.

Distributed Generation and the Grid

While the distributed generation transformation of the grid is a political and economic one, the process also involves a significant paradigm shift in the operation and physical nature of the grid, as well. In the short run these challenges are minimal, and in the long run they are surmountable.

Integration of Distributed Generation

The spread and growth of solar PV and other distributed renewable energy in the United States has led to significant modeling and engineering analyses of distributed generation and the grid. The data shows that previous conventions may have been wrong, and that the grid is capable of absorbing significant amounts of distributed solar and other technologies without significant harm.

California, the leader in PV installations, has done the most modeling and empirical work on integrating distributed generation. Utilities in California generally agree that 15% distributed generation on a local distribution circuit is the threshold for any problems.[34] This figure is reinforced by a distributed generation technical study in Nevada that suggested no significant impacts on the distribution network when distributed generation is 15% or less of the total generation.[35] For reference, 15% of California's peak summer demand would be equivalent to around 7,500 MW of distributed generation, more than is currently on the state's grid, and much more than is present on the grid system in any other U.S. state.

The **distribution** portion of the electric grid covers those power lines operating at 69 kilovolts (kV) or lower.

Some studies are more conservative. A 2001 study by the Electric Power Research Institute suggested that integrating distributed resources larger than 500 kW on distribution feeders would require "utility system changes."[36]

Other studies and experiences suggest that the 15% convention may be too conservative.

However, a study by the California Energy Commission showed that over two-thirds of California substations could handle distributed projects of 10 MW or smaller. Also, distribution feeders could handle new generation of 15 to 50% of capacity depending on its distribution along the line, with higher percentages possible with smart grid and energy storage improvements.[37]

In total, the Commission study suggested that the state's grid system could handle 75,000 MW of distributed generation (under 20 MW) at the substation level and 113,000 MW (of sub-3 MW projects) at the distribution feeder level, far more than actual peak summer demand.[38] Even in the short term (prior to 2020), the California grid system could handle enough DG to fill half of the resource gap toward the proposed 33% renewable standard.[39]

A recent modeling exercise by the California Independent System Operator suggests that no new "flexible" (backup) generation will be needed to support renewables for the state's aggressive 33% by 2020 target.[40]

California Independent System Operator: No new backup needed to reach 33% renewables by 2020.

Several sites in the U.S. also offer anecdotal evidence that significant quantities of distributed generation will not be problematic:[41]

- Kona, HI, has a 700 kW solar array that is 35% of the capacity of its distribution feeder, with no reported issues.
- Lanai, HI, has a 600 kW solar array that is 12% of distribution circuit capacity (25% during low load), with no reported issues.
- Anatolia, CA, has 238 kW of residential PV (4% of capacity, 13% during low load) with no reported issues.
- Las Vegas, NV, has over 10,000 kW of commercial solar PV on a 35 kilovolt (kV) interconnection (50% of capacity, 100% during low load) with no reported issues.
- Atlantic City, NJ, has 1,900 kW of commercial solar PV on a 23 kV interconnection (24% of capacity, 63% during low load) with no reported issues.

Las Vegas, NV, has over 10,000 kW of commercial solar PV on a 35 kV interconnection (50% of capacity, 100% during low load) with no reported issues

The strongest evidence may be from Europe, where distributed generation on the grid has already far exceeded the most robust distributed generation markets in the U.S. In Germany, with over 15,000 MW of PV (99% of it distributed generation), there have been no significant issues even though PV can at peak times meet 20% of peak demand (and German wind power, half in projects 20 MW and smaller, can meet nearly twice that at peak). Spain has 3,400 MW of distributed PV, enough to meet 15% of peak demand during the sunniest periods, and again without significant grid issues.[42]

In a recent article on the *Renewable Energy World* website, Kelly Foley of Vote Solar suggested that the issue is not adding variable distributed energy generators, but rather grid protocols that enforce a paradigm of a centralized grid based on large, inflexible power stations. She notes that hourly scheduling and a fleet of gas turbines provide the regulatory and backup power required by centralized coal and nuclear power production, and that similar strategies could minimize any grid impacts from variable distributed resources.

> ***By separating the impacts of solar variability due to the daily movement of the sun (called DMV – diurnal movement variability) from the weather change impacts (WBV – weather based variability), grid planners can begin to address their intermittency concerns****. The former is predictable and known, such that it can be addressed ex-ante, meaning that its grid impacts can be effectively eliminated in a least cost manner. The latter, WBV, however, is more likely to require ex-post solutions, such as requiring grid operators to consider solar generation on a fleet wide basis, rather than assessing performance on each individual unit. Thus, while WBV cannot be entirely avoided, it can certainly be significantly minimized.*
>
> *Again by way of example,* ***the current California Public Utilities Commission (CPUC) long-term planning proceeding does not distinguish DMV and WBV from each other. This lack of separation could potentially cause the CPUC's integration model to overestimate the amount of new gas resources needed to firm, follow or back-up solar generation****.*[43] *[emphasis added]*

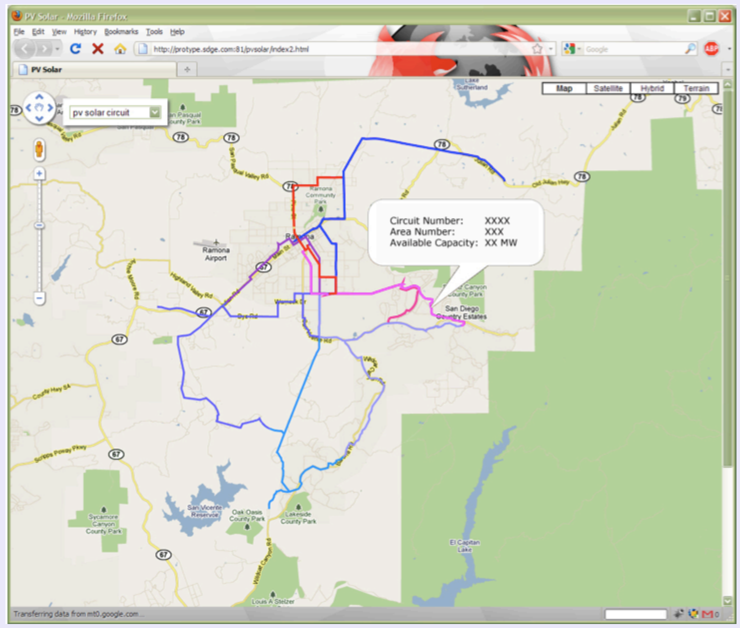
Utilities are also developing (with regulatory nudging) public information access to their distribution grids. The interactive maps allow prospective developers to identify areas on the distribution system where their project can connect with a minimum of interconnection costs. Southern California Edison (SCE), for example, provides a map with this notification:

> *Based on initial screening studies, locating your [solar] project inside one of the identified areas could potentially minimize your costs of interconnection to the SCE system.*

San Diego Gas & Electric (SDG&E) was required by the public utility commission to acquire 74 MW of solar via competitive solicitations and "create an interactive mapping website where Respondents can visit to obtain circuit-level information. Respondents can zoom to areas of interest to see circuit feeder routes and available capacities of the feeders. In addition, SDG&E will provide spreadsheets indicating available capacities of substations and circuits in local communities served by SDG&E."[44]

Challenges remain for evaluating the impact of distributed generators on the electrical grid. In a 2010 study for the California PUC, the authors note that, "there are currently no distribution planning models that can accurately simulate the interaction of PV components such as the inverters with substation equipment."[45]

Utilities Map their Distribution Networks



Thus, research continues. A number of regulatory agencies and utilities are continuing to explore the impact of high quantities of distributed generation on utility grid systems:

- The National Renewable Energy Laboratory released a study in 2010 showing the technical potential for the western U.S. electric grid to integrate 35% wind and solar power.[46]
- The U.S. Department of Energy is doing a study of the impacts of large solar PV quantities on the distribution system.[47]
- An electric utility on the Hawaiian island of Kauai is testing a high penetration scenario for solar PV. A 1.2 MW solar farm has a peak load identical to the local circuit and has so far caused no major problems.[48]

The Grid Benefits of Distributed Generation

While utilities have yet to experience serious issues from distributed solar generation, they are already experiencing benefits to the grid.

Distributed solar power provides electricity on-site or near to demand, reducing transmission losses, as well as wear-and-tear on utility equipment by mitigating peak demand. It also eliminates the need to hedge against fuel price swings. A recent study found that these benefits add 3 to 14 cents per kWh to the utility bottom line.[49]

Distributed solar power has value to the grid (above the electricity produced) of 14 to 30 cents per kilowatt-hour.

Distributed solar also provides value to society, by reducing the economic losses of blackouts (just 500 MW of distributed solar could have prevented the massive 2003 Northeast blackout), reducing pollution and greenhouse gas emissions, hedging against finite fossil fuel supplies, and creating jobs. These benefits add 11 to 16 cents to the taxpayer's bottom line for every kWh of distributed solar. Combined, distributed solar power has value to the grid (above the electricity produced) of 14 to 30 cents per kilowatt-hour.

In a CPUC study, the researchers found that, “As a result of the local PV generation, electrical heating losses on the PG&E distribution circuits analyzed were reduced from 1.7-2.4% at the time of peak circuit loading.”[50]

The study concluded that PV reduced peak demand on a distribution line by 0.35 kW for every kW of “rebated PV,” and reduced peak demand on transmission lines by 0.3 kW for every kW of “rebated SGIP capacity.”[51] Rebated capacity reflects the system size that received a cash rebate and may be less than the system’s nameplate capacity. The value of solar PV to the grid reflects its high capacity factor during hours of peak demand. Solar delivers close to 60% of its rated capacity during the entire peak demand period, e.g. hot, sunny days.[52]

The value of solar PV to the grid reflects its high capacity factor during hours of peak demand. During peak periods in California, solar produces close to 60% of its rated capacity.

In two recent decisions (described below), the CPUC has estimated the value of distributed generation to the grid system in terms of avoided infrastructure costs.

In the first – a hearing before the Federal Energy Regulatory Commission on California’s standard offer program for combined-heat-and-power (CHP) producers – CPUC asserted that, “for CHP systems located in transmission-constrained areas, there should be a 10 percent price adder to reflect the avoided costs of the construction of distribution and transmission upgrades that would otherwise be needed.”[53]

The cost savings from distributed generation are not restricted to transmission-constrained areas. In its second decision – to establish a Renewable Auction Mechanism (RAM) to develop 1,000 MW of distributed generation – the CPUC emphasized that the concerns of investor owned utilities (IOUs) about needing additional transmission infrastructure were unfounded.[54]

> *IOUs argue that such an expansive approach will increase costs by necessitating construction of additional transmission and distribution (T&D). We are not persuaded.*

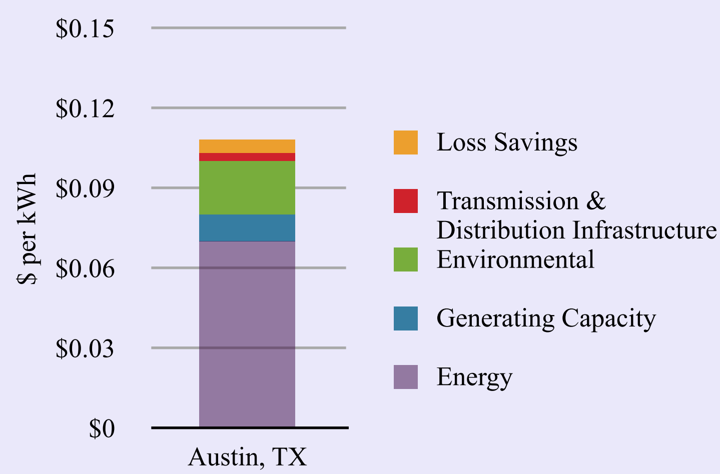
CPUC noted that the short timeframe of the auction would minimize demand for new infrastructure and that developers would have to share those (reasonable) costs. Finally, CPUC challenged the utilities’ assertion than there are large bulk power transfers burdening their transmission networks. Rather, these exchanges are largely on paper.

A California Energy Commission working group on distributed generation estimated that distributed generation created avoided capacity costs of $34 per kilowatt-year on both the distribution and sub-transmission systems (based on the avoided cost savings from energy efficiency measures of similar capacity).[55] Presumably this is because on-site generation is treated as load reduction.

Cost savings from distributed solar were also found in a study for the Austin, TX, municipal utility. While the energy value of the solar power was only around 7 cents per kWh (the value of the electricity it would displace), the available capacity, deferral of grid infrastructure upgrades and avoidance of delivery losses (e.g. transmission) added significantly to the value of PV to the utility as shown in the chart to the right.[56]

Another study by Arizona Public Service will put 1.5 MW of distributed solar PV on a single distribution feeder in order to more clearly identify the integration costs of distributed generation and its unique value to the grid.[57]

Distributed PV Has Non-Electricity Value, Too

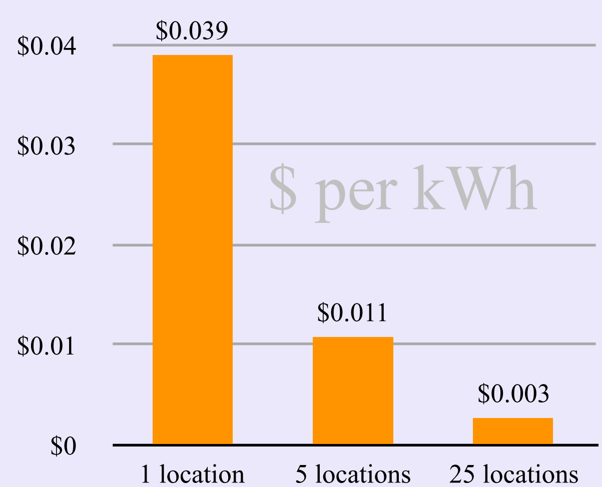


Levelized value of solar PV to Austin municipal utility, over 30 years.

Backup & Storage

In the short run, the major challenge for distributed generation is the variability of renewable energy. This problem can be mitigated in part by using more distributed generation. Using solar as an example, a single solar PV power plant has backup costs for the utility of around 4 cents per kWh (to have other power plants available to cover variations in output). However, if 25 solar power plants are dispersed across a broad region (e.g. a metropolitan area), these backup costs fall by 93 percent, to far less than a penny per kWh.[58] Dispersing wind power generation has similar impacts, albeit requiring a larger geographic area.[59]

Dispersing Solar Cuts Backup Costs Dramatically



The good news is that, as more and more technical research is completed, the findings are consistently showing that the amount of backup power (e.g. spinning reserve) decreases as more distributed renewables are put in place and as the grid is made "smarter." The bad news is that we don't yet have a lot of experience from which to draw conclusions. Most of the research has focused on the impacts of bringing in dispersed wind energy and there has been less study of integrating large amounts of distributed solar projects into the grid. That dynamic is starting to change as more states are poised to bring substantial quantities of distributed solar energy projects onto the grid in the coming years.

Once again, the Europeans are leaders. Their experiments with "virtual power plants" – essentially, using information technology to coordinate decentralized renewable energy generators on a smart grid – are reducing the need for traditional fossil fuel backup power and increasing the efficiency of networked renewable energy generators.[60]

In the long run, distributed and variable renewable energy generation will become a more significant portion of the electricity grid, and the existing system will not be able to smoothly accommodate this new generation without changes.

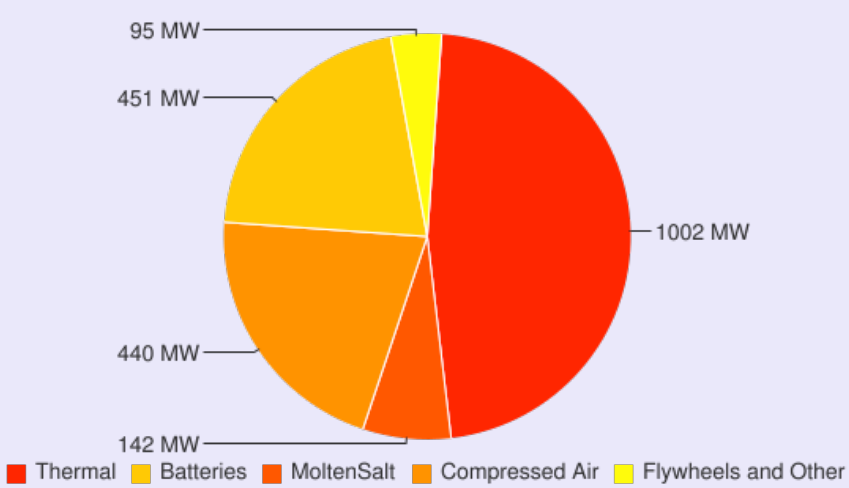
A Future with Natural Gas?

Many renewable energy advocates are convinced that the grid will adapt largely by introducing more natural gas generators, able to cycle quickly to accommodate fluctuating production from wind and solar power plants. General Electric has even developed a new natural gas turbine with the purpose of more effective backup to variable renewable energy sources.[61]

There's also a surprisingly substantial amount of emergency and on-site backup available that may be more useful to a distributed grid. In 2003, distributed power systems comprised 200 gigawatts of capacity and generated 6 percent of total U.S. electricity.[62] Most were used for emergency backup, and only 10-15% of these systems were connected to the grid. But there may be an opportunity to tap these systems to integrate more variable, renewable distributed generation.

As the quantity of renewable energy generators rises further, energy storage may play as much or more of a role than backup generation. Today in the United States about 2.5% of total electricity is provided through energy storage technologies. The vast majority comes from pumped hydroelectric projects. Along with pumped hydro, compressed air energy storage and advanced lead-acid battery storage are the most widely pursued by utilities.

Estimated Worldwide Installed Advanced Energy Storage



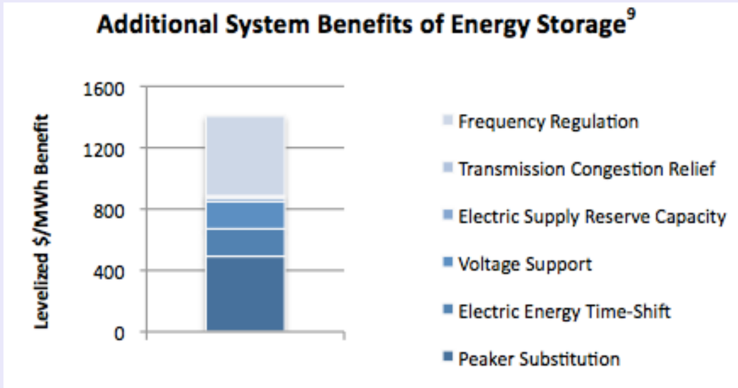
Source: California Energy Storage Alliance –Does not include pumped hydro storage

Until variable renewable energy sources become a bigger portion of grid energy, storage will serve many other applications than just being a tool to store kilowatt-hours for another time ("time-shift"). A 2010 report for Sandia National Laboratory provides a categorization of major energy storage applications, ranging from "voltage support" to "transmission congestion relief."[63]

This variety of applications for energy storage is also relevant to the cost of storage. While the cost of advanced batteries and other storage technologies is relatively high, the California Energy Storage Association notes that storing electricity like a battery is only a fraction of the full potential value of an energy storage system.

If an energy storage system (e.g. a big battery) were used to replace a natural gas "peaker" plant (used when electricity demand peaks), the adjacent chart illustrates the many other valuable benefits the battery system would provide.[64]

Energy Storage is More Than Big Batteries



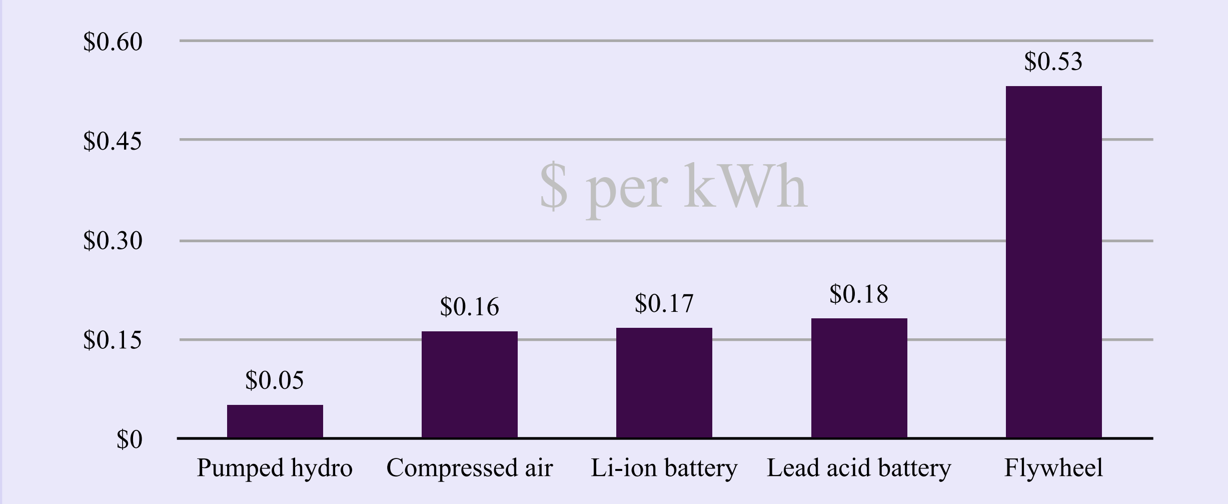
The high value of energy storage in a variety of applications means that it can be worthwhile even at relatively high cost per kW compared to new fossil fuel or renewable energy generation. Costs (and benefits) can vary quite a bit even for a given technology (e.g. batteries, compressed air energy storage, flywheels) as well as for a given application (e.g. voltage support, energy time shifting, firming renewable energy).

The following table shows energy storage costs from the Electric Power Research Institute, comparing that to installed costs for renewable energy and natural gas combined cycle power plants.[65]

Technology	Cost per kW
Compressed air	$810 to 1,045
Lead-acid battery	$2,000 to 3,000
Lithium-ion battery	$1,200 to 4,000
Solar PV	$3,500
Onshore wind	$2,000
Natural gas	$1,000

Translated to a per kWh cost, the following chart illustrates the incremental cost of storage (added to the initial cost of generating a kWh of electricity) as estimated by Glenn Doty of Doty Energy.[66] Pumped hydro, for example, adds about 5 cents to each kWh that is stored. Other technologies are more expensive.

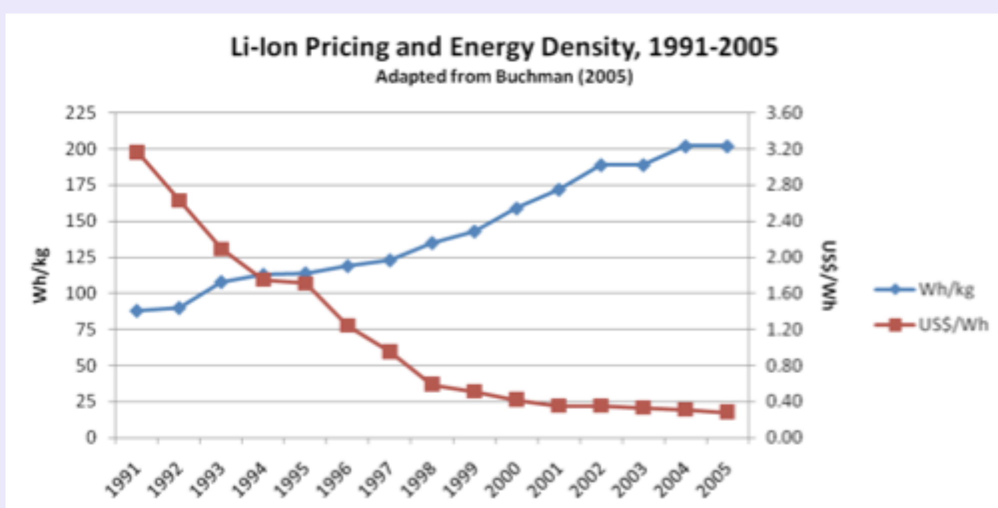
Incremental Cost of Popular Utility-Scale Storage Technologies



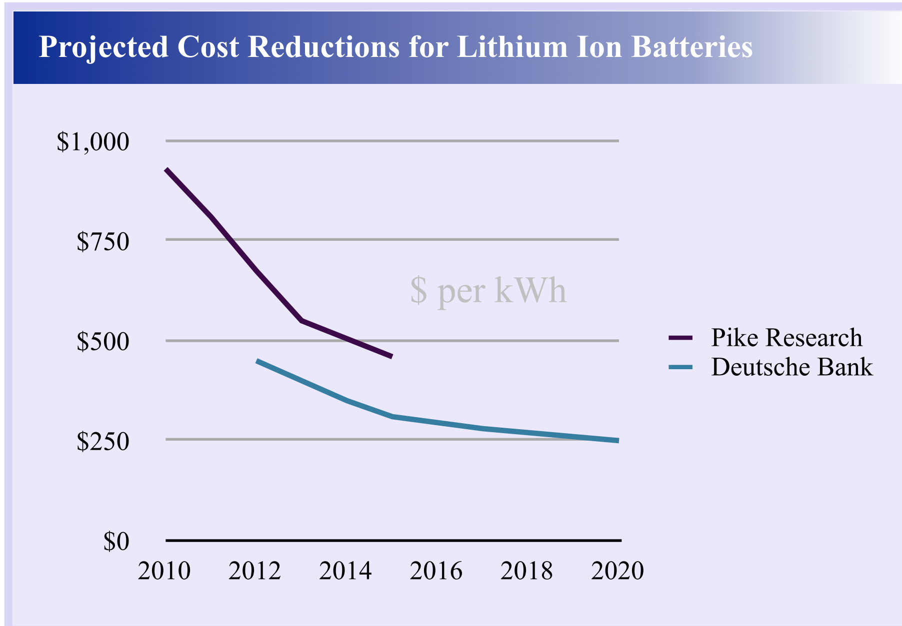
Utilities are gaining practical experience managing variable generation with storage. Denmark relies heavily on pumped hydro storage in Norway to help them manage their wind power that can at times generate more than 100% of current demand. Alabama's Electric Cooperative has been operating a 110 MW compressed air energy storage system since 1991.[67] Xcel Energy has been testing a 1-MW (7.2 MWh) sodium-sulfide battery that is integrated with a 11.5-MW wind energy project in Luverne, MN. The Long Island Power Authority in New York is considering a 400 MW battery storage facility to meet new demand by shifting excess night-time generation to daytime load.[68]

In the near term, some storage technology costs will decrease significantly, according to the Electric Power Research Institute (EPRI).[69] Their forecast is reinforced by the history of price reductions of lithium ion batteries in consumer electronics (below).[70] The red line (with square markers) illustrates the falling cost of consumer lithium ion batteries per Watt-hour and the blue line (with diamond markers) shows the increasing energy density of the batteries, in Watt-hours (Wh) per kilogram (kg).

Historical Cost Reductions for Consumer Lithium Ion Batteries



EPRI anticipates that larger-scale lithium ion battery costs will drop, too, as the electric vehicle industry ramps up. Other industry experts are also forecasting significant decreases in lithium ion prices. The following chart shows the price forecasts for lithium ion batteries for use in electric vehicles from Pike Research[71] and Deutsche Bank.[72]



Also in the near term, underground compressed air storage and pumped hydro systems should see lower costs on a per kW basis as additional projects come online. However, there is also uncertainty in compressed air cost projections with the primary constraint being identifying developable sites, environmental permitting, and available nearby transmission assets.

As costs fall and renewable energy grows, energy storage will play an increasingly important role in smoothing integration of distributed generation into the electricity grid.

Smart grids

Smart grid is a poorly defined term, but the basic concept is a grid that maximizes information and automation to operate at peak efficiency. The improvements range from the central and distributed generator through the high-voltage transmission network and the distribution system, to industrial users and building automation systems, to energy storage installations, and to end-use consumers and their thermostats, electric vehicles, appliances, and other household devices.[73]

The technologies of smart grid are grid paradigm neutral. Tools like advanced meters, robust real-time price signals, and two-way power flow control could democratize the grid so that energy consumers could become more energy efficient and also be energy producers. The tools of the smart grid could also make a top-down grid operate more efficiently. For example, a citywide smart grid rollout by the Chattanooga, TN, public utility uses smart meters and automated switches and is forecast to reduce outage time by 40% and provide demand side reduction of 15%, as well as improve power quality.[74]

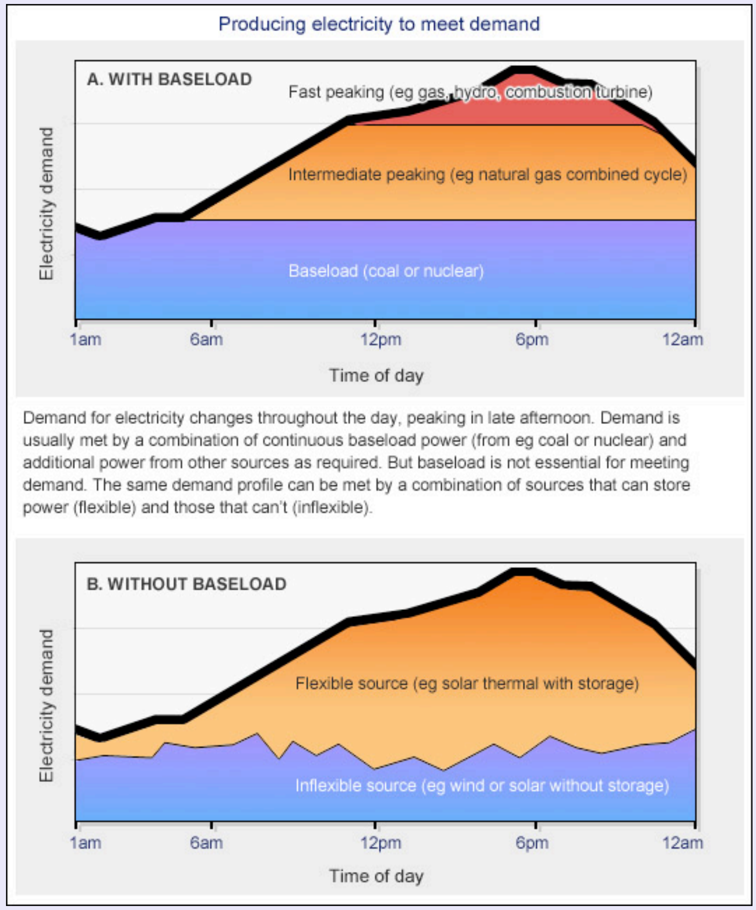
Smart grid information flow could clearly be an advantage in integrating distributed generation, but so far few U.S. utilities are seeing this technology upgrade in that light.

A Long-Term Paradigm Shift

Electricity planning is based on 20-30 year predictions. Today, distributed generation is a very small part of our electricity presence. But assuming that current growth rates continue, within 20 years it will be a significant presence. Today planners are grappling with the question of how to integrate growing amounts of DG into grid system based on centralized generation and long distance transport of electricity. Future planners may grapple with the reverse: how to integrate centralized generation into a grid comprised primarily of distributed generation and storage.

Right now, the grid is based on meeting electricity demand by stacking power plants, as shown in the adjacent graphic.[75] The lowest layer are coal and nuclear power plants. They are called "baseload" because they are run almost all the time at the highest possible capacity. The next layer are called intermediate because they ramp up production as demand (load) increases and ramp down as it decreases (e.g. up in daytime, down at night), but not as quickly as the top layer. The top layer of power plants are called "fast peaking" because they respond on short notice to peaks in power demand (such as air conditioners running overtime on very hot summer days).

A Paradigm Shift in Electricity Supply



One problem for distributed generation integration is that long term power supply contracts from centralized baseload resources (e.g. coal) can cause variable (solar and wind) resources to be curtailed if there is no local load and no excess capacity on the grid. Thus today and in the short run, new renewables displace intermediate and peaking plants such as hydro generators or natural gas plants.

As more and more variable resources are interconnected, they will compete more directly with central station, baseload power plants in supplying our instantaneous energy needs. At this point, engineering challenges begin. Nuclear power plants can change output by up to 5% of total capacity on a minute-to-minute basis, but only if the power plant is already operating at a minimum of 50 to 60% of full capacity.[76] For any baseload power plant, there are increased operations and maintenance costs associated with frequent adjustments to output.

As the nature of the grid changes, it will make more sense to change the nature of electricity planning rather than cramming variable, distributed generators into a centralized baseload plus peaking paradigm. For example, long-term planning processes need to effectively differentiate variability based on weather (clouds and wind) from variability based on time of day or season. As noted above, in a proceeding before the California Public Utilities Commission, one intervenor noted that without differentiating seasonal from daily variability, utilities will overestimate the amount and cost of backup generation needed to support distributed generation.[77]

Solar and wind have no fuel cost, so they can always outbid fossil fuel power on the spot market. Instead of matching demand by stacking intermediate and peaking plants on top of baseload power plants, the new grid will take all available renewables first and then use demand management, storage, and intermediate/peaking fossil fuel power plants to match supply with demand. Unlike the current system of primarily inflexible generators, the new flexible grid will more easily accommodate the electricity generated at any given moment as wind and solar output changes based on wind speed and/or cloud cover.

In Germany, the tension between distributed and centralized electric paradigms has become intense as renewable energy – primarily distributed generation – has reached 17% of supply (up three-fold in a decade), peaking at over 30% at times.[78]

Dr. Norbert Rottgen, German Federal Minister for the Environment, thinks Germany and in the future the United States, will have to make a choice.[79]

> *It is economically nonsensical to pursue two strategies at the same time, for both a centralized and a decentralized energy supply system, since both strategies would involve enormous investment requirements. I am convinced that the investment in renewable energies is the economically more promising project. But we will have to make up our minds. We can't go down both paths at the same time.*

When we make additional investments in the electricity grid, we should no longer be spending money on the 20th century grid system, but should instead focus on the 21st century paradigm of distributed generation. The centralized model no longer fits the inherently decentralized nature of renewable energy supply and the economic and democratic advantages of distributed generation. The grid must change.

Regulatory Roadblocks / The Political System

Despite technology's march toward more efficient and distributed energy production, there's a substantial tension between the decentralized opportunity and the institutional and policy inertia generated from a century dominated by the paradigm of centralized generation. Motivated by the urgency of global climate change, many renewable energy advocates hope to transform the electricity grid by building ever-larger wind farms and solar power projects in remote regions, and sending power across the super grid to cities. These competing visions for the grid will compete for limited resources for clean energy development.

The tension between decentralized and centralized is most clearly seen in the battles over the construction of a new high voltage transmission network. In 2005 Congress gave the Department of Energy and the Federal Energy Regulatory Commission (FERC) new authority to accelerate the construction of this network. The new law allowed FERC to approve a new transmission line if the state utility commission had not done so in one year after submission of the request. FERC then asserted its authority to overrule states that disapproved of the request for a new transmission line. The federal courts twice ruled that FERC did not have this authority.

States have actively expressed their opposition to being forced to pay for a new transmission infrastructure that assumes they will be importers rather than generators of renewable energy. Ten East Coast governors signed a letter to Congress in 2009 asking them to reconsider proposed legislation pre-empting state authority over new transmission.[80] Editorials in the Detroit Free Press in 2011 decry the cost to Michigan ratepayers of expanding high-voltage transmission that largely uses Michigan as a waypoint between windy points West and big cities to the East.[81]

The existing electricity system – and the rules that govern it – privilege money and power, and punishes people and communities of the 21st century paradigm.

The vision of a distributed electricity system requires designing policies that can overcome a number of roadblocks.

Roadblock 1: Federal Energy Regulatory Commission (FERC)

There is an inherent tension between federal and state and local energy regulatory agencies. FERC sees its primary goal as accelerating and enabling the long distance transmission of electricity while in the era of renewable energy many states see their primary goal as maximizing in-state production of energy and the economic benefits that derive from that.

Preempting State Authority

FERC has asserted that it has preemptive powers to impose new, high-voltage transmission lines on recalcitrant states (so far denied by the courts). The claim came from a section of the 2005 Energy Policy Act that gave FERC the authority to approve transmission lines in Department of Energy designated "National Interest Electric Transmission Corridors" if states did not act on proposals within one year. FERC took this to mean that it could approve any transmission line, even one that a state had rejected. The 4th Circuit Court of Appeals disagreed in February 2009, ruling that FERC had overstepped its authority.[82]

FERC has also encouraged a shift in the locus of transmission planning from local and state, to regional and national bodies.

FERC has also undermined state's ability to establish premium prices for renewables in order to accelerate and maximize their use. In particular, FERC has prohibited states from setting prices above the utility's avoided cost – the price the utility says it must pay to get an additional kilowatt-hour of power – generally too low to attract investment in all but the least expensive renewable energy sources. FERC did recently open a loophole in its denial but it remains to be seen whether states are going to be able to do what they want within that narrow wiggle room.[83]

Disproportionately Rewarding Transmission

FERC provides a higher, guaranteed return on investment for high voltage transmission lines than are provided for power plants or lower voltage lines. While the 2005 Energy Policy Act authorized a higher return under exceptional circumstances, FERC has generally extended substantial incentives to every transmission project, with little consideration for the specific benefits the projects bring to ratepayers.[84]

In Their Own Words – FERC

FERC: "There is no requirement in section 219 or Order No. 679 that an applicant must demonstrate that its project is the best of all possible projects, or that it has explored every conceivable alternative before deciding to proceed with a particular project." Docket No. EL08-77-000

FERC: "we note that [American Electric Power] is under no obligation under either FPA section 205 or FPA section 219 to establish that the incentives requested are necessary." Docket No. EL06-50-001

Ignoring Least Cost Analysis and Careful Analysis

FERC's insistence in shifting decisions up the food chain undermines the least cost planning processes that have been painstakingly put in place over the last 30 years in many states. States are usually required to analyze alternatives (e.g. efficiency, renewables, distributed generation) to new power plants or transmission lines. FERC has been insistent that neither it nor the regional transmission planning authorities are required to analyze alternatives while at the same time insisting that FERC can overrule state decisions regarding transmission lines.

Roadblock 2: Federal Renewable Energy Incentives and Guarantees

There are many ways federal incentives for renewable energy have been biased toward large, absentee owned centralized power generation. One of the most pervasive is evident in the two major incentives for renewable energy production: the Production Tax Credit (PTC) and Investment Tax Credit (ITC). The PTC provides a 2.1 cent per kWh incentive for several renewable technologies over 10 years. The ITC provides an up-front 30% tax credit to defray project capital costs. Both federal tax incentives require the renewable energy producer to have sufficient tax liability to absorb the credit.

The use of tax credits for incentives eliminates any non-taxable entity from access to the incentive, including municipal or county governments, tribal entities, non-profit organizations, and cooperatives. In the case of wind power, the limitations on access are particularly profound because each investor in a wind project must either have "passive income" to apply the credit against or be materially involved in the day-to-day operation of the project. This limitation is particularly onerous for wind projects with many owners, such as cooperatively- or community-owned projects.[85]

For solar, the use of tax credits is particularly onerous for homeowners. As many as half of American households do not have sufficient tax liability to absorb the federal solar tax credit before it expires.[86] These households could go solar, but only at a higher price than those who can use the credit. In other words, those with money and income can go solar, while the rest of us stay in the "dark" ages.

In addition to limiting participation in renewable energy development, the federal tax incentives also make renewable energy more expensive than alternative incentive strategies.[87] Providing incentives through the tax code forces project developers to partner with "tax equity investors" such as large investment banks. These banks want a return on their investment, so they add cost to the project, costs that are passed on to ratepayers (and also come out of the pockets of taxpayers). Additionally, the number of such tax equity investors is limited, both constricting the total market and allowing them to set their own price. A recent study found that a cash grant (as was enacted as part of the federal economic stimulus package) could provide the same impact on project finances at half the cost to the government and taxpayers.[88]

Federal tax incentives also make renewable energy more expensive...A recent study found that a cash grant (as was enacted as part of the federal economic stimulus package) could provide the same impact on project finances at half the cost to the government and taxpayers.

Tax credits have also provided an opportunity for financing hijinks. Banks who finance leased residential solar PV projects have taken advantage of rules allowing them to substitute the "fair market value" of the installation rather than the actual project cost. The cost inflation is as high as $4.00 per Watt and can cause million of dollars in overpayments of federal tax credits to bankers.[89]

One other federal incentive is the use of loan guarantees to support large-scale, centralized renewable energy projects. For example, a 250 MW parabolic trough concentrating solar power plant in Arizona received a $1.45 billion federal loan guarantee,[90] which means the federal government will pay the loan back if the developer is unable to, helping the developer borrow at a lower interest rate. Such guarantees skew the playing field when, on the other hand, Southern California Edison is building 250 MW of distributed small-scale PV projects for a levelized cost of 16-18 cents per kWh, with no federal loan guarantee. Big solar gets additional federal support that distributed solar does not.

Roadblock 3: Insufficient Federal and State Oversight of Utility Interconnection Rules

Distributed generation developers can find financing and hardware with ease, but navigating the utility interconnection process is mind-boggling. In most areas of the country, the grid system is a black box and developers only learn about potential interconnection costs once they initiate the arduously slow interconnection process (and have sunk significant money into site development).

Even in California, a leader in distributed solar, the state and federal rules for interconnecting distributed generation projects create a major barrier.

Without basic information about the number of applicants in the utility queue, the prospects for obtaining interconnection, and the eventual costs, current rules remain an enormous barrier to expanded distributed generation development.

For example, while there is supposed "Fast Track" approval for small-scale distributed generation projects (under 3 MW), California utilities managed to insert a "poison pill" into interconnection rules that exposes developers to "uncapped, undefined, and indefinite cost liability." There's little guarantee that a Fast Track application will not morph into a larger "Independent Study Procedure" of grid impact, because any system upgrades trigger this higher standard of review.[91]

To make matters worse, there are no objective criteria for this more complex Independent Study Procedure review so an applicant has little indication of success despite advancing a $50,000 fee. There are also no timelines for completing such studies, and recent interconnection standards approved by the California PUC will result in an average study timeframe of 2-3 years.

Furthermore, a large portion of the data a developer would need to clarify and expedite interconnection is considered proprietary by the utility, sealing it in a black box.

The following list of now-hidden data requested by the Clean Coalition for PG&E's interconnection rule docket highlights the level of obfuscation facing distributed generation developers:[92]

- Number of [Wholesale Distribution Tariff] WDT applications in the PG&E queue, with dates of entry
- Number successfully processed, time for processing, and costs of studies
- Number of Fast Track applications in the PG&E queue, with dates of entry
- Number successfully processed in Fast Track, time for processing and costs of studies. Information on rejected Fast Track applications, including specific screen that was failed (if relevant).
- Actual cost to PG&E of feasibility studies, system impact studies and facilities studies for all interconnection queues, with methodology for determining actual costs
- Cost of required upgrades for each project or cluster (PacifiCorp, for example, posts all of this information online as soon as it is completed)"

Without basic information about the number of applicants in the utility queue, the prospects for obtaining interconnection, and the eventual costs, current rules remain an enormous barrier to expanded distributed generation development.

Roadblock 4: Local Permitting for Wind and Solar

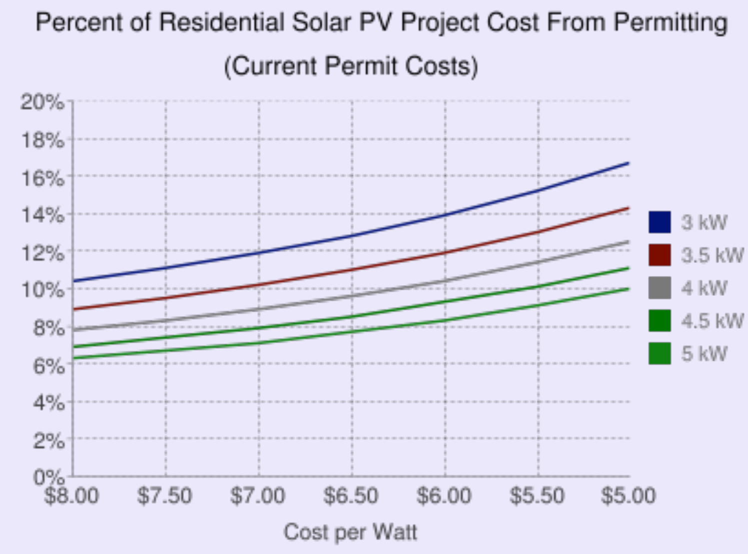
Permitting and siting for wind and solar projects is typically handled at the local (city or county) level. This local authority provides an opportunity for local residents to discuss the merits of sometimes-large renewable energy projects. However, the inconsistency of municipal rules for wind and solar increases development costs and can prove a barrier to decentralized as well as centralized power projects.

For wind power, some counties have instituted complete moratoriums on wind projects and other have established setbacks and other stipulations that create a de facto ban on new wind turbine construction. Sometimes state rules are established to provide a more uniform set of rules for developers, but this process isn't without controversy. The Wisconsin legislature is currently embroiled in a debate over wind siting rules, with some draft rules so stringent – to appease local opposition – that they would effectively close the entire state to new wind development.

For solar power, permitting rules vary widely between municipalities, and costs often far exceed the cost to issue the permit. A recent report found solar permitting costs averaged $2,500 per project. As solar PV costs continue to fall, the portion of project costs devoted to permitting can rise as high as 20 percent.[93]

Proposed best practices for municipal permitting can reduce these fees by a factor of five, reducing the permitting share of project costs to 4 percent or less. In Colorado, the passage of the 2011 Fair Permit Act caps the permit fees that local governments can apply.[94]

Permit Costs Could Stall Distributed Solar PV



Roadblock 5: Net Metering Limitations

A widespread state policy for supporting on-site generation – net metering – allows generation of electricity for a home or business to be deducted from the monthly electricity bill at the full retail electricity rate. This rate is often higher than the wholesale electricity rate that would otherwise be paid for electricity that feeds into the grid.

The major drawback of net metering is that it makes it economically advantageous to optimize the size of a solar array for on-site load rather than maximize it. For example, a homeowner installing a rooftop solar PV system would not want the production from their solar array to significantly exceed their on-site consumption, because they will receive inadequate compensation for that power. However, the overall cost of solar electricity would be lower if the homeowner could benefit from installing as much solar as could possibly fit on their roof.

Another issue with net metering is that utilities credit on-site generators with a deduction equal to the energy charge on the user's bill, just as if the user had reduced on-site consumption by using conservation. Such a practice does not credit the other values of distributed generation to the grid, including voltage regulation or deferral of infrastructure upgrades.

Overcoming the Roadblocks: Democratizing the Electricity System

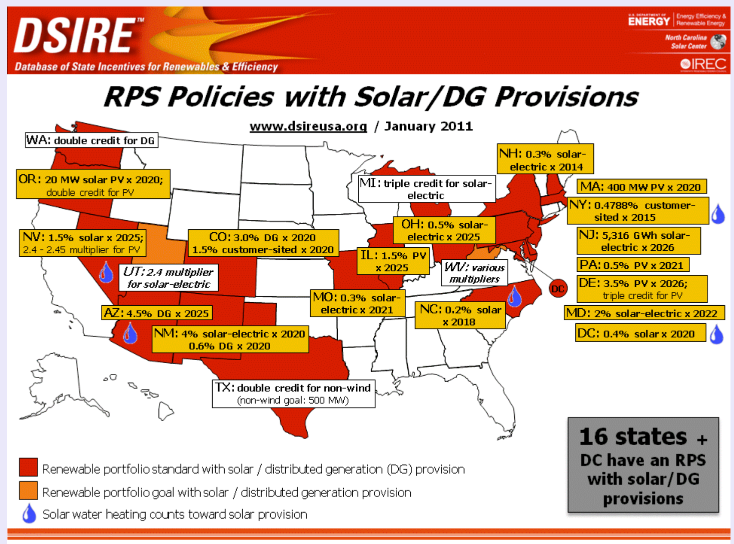
The electricity grid system has become host to a distributed generation phenomenon that has developed in a largely hostile environment. It's possible that distributed generation has enough inherent economic and political advantage to be sustainable, but new policy could significantly expand distributed generation in the electricity system.

The following policies illustrate the many ways that the electricity system can incorporate the benefits of distributed energy generation.

Distributed Generation or Solar Power Carve-Outs

With nearly 30 states already mandating the development of renewable energy, more states should focus on power that can be generated locally and with greater economic returns to the state. Already 16 states have carve-outs in their renewable mandates for either distributed generation or solar power, specifically.[95] These carve-outs reduce competition between large and small projects and create a domestic market for distributed generation that can support more local ownership and in-state economic value.

Sixteen States Specifically Support DG or Solar



CLEAN Contracts

Clean, Local, Energy, Accessible, Now. The CLEAN name highlights the distributed energy potential of a guaranteed, long-term contract and a price for renewable energy sufficient to attract investment (the same deal offered to regulated utilities). This policy (under various names, such as feed-in tariffs) is responsible for half of the world's installed wind power and three-quarters of its solar PV. It's the dominant energy policy in most of Europe as well as a growing number of places in North America (Ontario, Vermont, Oregon, Gainesville, FL).

In Ontario, a robust and comprehensive feed-in tariff is encouraging the development of over 2,500 MW of renewable energy, much of it distributed generation. In Germany, home to some of the most effective renewable energy policies in the world, more than half of its 27,000 MW of wind are in projects 20 MW and smaller.[96] Over 80 percent of the 3,000 megawatts of solar PV added to the German grid in 2009 were put on rooftops, most less than 100 kW.[97]

CLEAN contracts can be used in concert with renewable energy standards but also as a standalone policy for encouraging the development of renewable energy. Their signature success is reducing risk for renewable energy development with a guaranteed and transparent contract, reducing the costs and time to project developers to obtain financing. In general, CLEAN contracts have a lower total cost for renewable electricity than renewable mandates due to fewer stranded costs associated with auctions or solicitations (see below).[98] Every state should adopt a CLEAN contract policy.

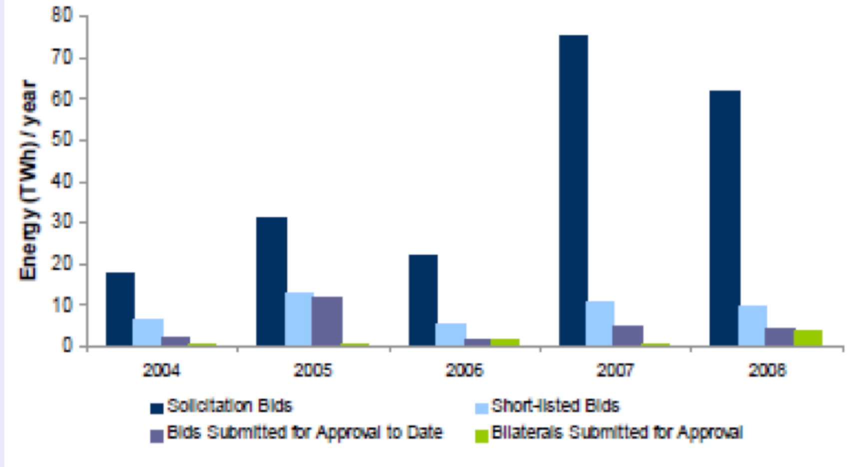
Renewable Auctions

In lieu of a CLEAN contract policy, the California public utility commission (CPUC) recently opted to develop a renewable auction mechanism to encourage the development of 1 to 20 MW distributed generation projects. While this program is admirable for its focus on the distributed generation segment, the auction mechanism has its own liabilities.

Utilities like auctions outside their control no more so than any requirements to purchase third-party generated electricity and have challenged CPUC's implementation order.

Auctions Cause Significant Stranded Costs

Auction Failure rate of 97%



Source: California Public Utilities Commission, 2nd Quarter 2009

According to CPUC data, approximately 97% of projects bid into auctions under the state's renewable energy standard have failed to win a contract from the utilities.[99] This failure rate of 97% represents millions of dollars in stranded costs, costs that developers have to ultimately try to pass on to utilities and their ratepayers. It's an incredible waste of human energy in pursuit of "lowest-cost" renewable energy.

Renewable Energy Incentives (Federal)

The most important change to federal renewable energy incentives, short of adopting CLEAN contracts, would be to transition away from tax credits and toward cash payments. The cash grant program – effective 2009 through 2011 and passed as part of the economic stimulus bill – has significantly increased local ownership of renewable energy projects.[100] But the cash grant program is intended to be temporary, even though President Obama's proposed budget would extend it through 2012.

The cash grant program was adopted because the major renewable energy developers were unable to find tax equity partners to use the tax credits during the recession, but it's a band-aid on a deeper problem with using the tax code for renewable energy incentives.

One alternative for the federal government is to make the tax credits refundable. This would allow anyone eligible for the tax credits to maximize them even if their tax liability was limited. It would also avoid the problem of a shrinking tax liability market during a major recession.

An even better strategy would be for the federal government to permanently shift its incentive payments to cash, and to base them on the output of renewable energy systems (like CLEAN contracts). In addition to opening access to incentives for community-based and nontaxable entities (e.g. municipalities), paying for production would increase the efficiency of government dollars by paying for output, rather than reducing capital costs on potentially low-performing projects. The cash payment option also reduces tax law problems for community ownership. Unless an investor in a wind or solar project takes an active role in project oversight, they can only use their tax credits against passive income (from a business or investment income), and most Americans have no passive income. A cash payment can be used by any investor, in any project structure.

Transmission Incentives and Regulatory Policy (Federal)

A second area of focus at the federal level is regulatory policy, set by FERC. Currently, high-voltage transmission projects are eligible for (and in fact routinely receive) bonuses to their return on investment; bonuses that are not given to power plant construction. The bonus incentives distort a state-based comprehensive planning policy that asks utilities to consider many options, not just transmission, for meeting their reliability and safety goals. Instead, investor-owned utilities and transmission developers have an incentive to encourage the development of transmission at the expense of more cost-effective alternatives. This program should be terminated.

Congress should also clarify that FERC should give great latitude to states in energy planning, that FERC does not have the authority to overturn state transmission related decisions and that FERC's analysis must analyze alternatives to transmission not simply alternative routes for transmission lines.

Renewable Energy Incentives (State)

In addition to a comprehensive policy like CLEAN contracts, there are other renewable energy incentives. States should focus their dollars on projects that provide the greatest economic advantage for the state, and incentives for renewable energy should prioritize distributed generation that has a higher likelihood of local ownership. A good example is Minnesota's now-expired incentive for small wind projects that offered 1.5 cents per kilowatt-hour for wind projects smaller than 2 MW.

Community Choice Aggregation and Municipalization

There are few better opportunities for energy self-reliance than local authority. Community choice aggregation (CCA) allows cities, counties, and collaborations of local governments to govern their electricity supply contracts. In some cases, like California's Marin County, more than three-quarters of the electricity supply to local customers is renewable. Other CCA organizations have succeeded in achieving lower rates for their customers with new local supply and or competitive contracting.

A step further (especially for the 46 states without CCA laws) is municipalization. Over 2,000 municipal and state-owned utilities serve 45 million Americans, and they provide communities with local determination over their electric supply. The power of municipalization is enormous. When Boulder, CO, recently decided not to renew their franchise with Xcel Energy to study municipalization, they found the possibility of enormous economic opportunity (and lower rates), as well as getting a bid from Xcel to provide 90% of Boulder's electricity from wind by 2020.

Communities should consider the benefits of local control of their electricity system to maximize the potential for local, distributed renewable energy development.

Solar Access Laws

One of the biggest barriers to distributed solar in residential areas isn't financial, but rather the obtuse rules of homeowners' associations that bar the installation of rooftop or ground-mounted solar PV systems. States should pass solar access laws giving every property owner the right to put a solar PV system on their roof. Exceptions can be (and are) made for historic areas, but energy self-reliance shouldn't be subject to outdated aesthetic concerns.

Model Net Metering Rules

In most states, customers who generate energy on-site can essentially roll back their electric meter, receiving a 1:1 credit for every kilowatt-hour they generate. Strong net metering laws make grid interconnection simple, allow for systems of significant size (up to 2 megawatts), and ensure customers get reimbursed at the retail electricity rate for each kilowatt-hour of demand they offset (even if production modestly exceeds consumption). In the best case, rules provide compensation for excess energy at premium rates (more like a CLEAN contract).

The cutting edge of net metering laws includes virtual or aggregated net metering. The former allows customers to share the output of a community-based energy installation even if it isn't physically connected to their meter. Essentially, the law requires utilities to replace hardware with bookkeeping. The latter policy – aggregated net metering – allows customers to aggregate their meters (e.g. a college campus with multiple buildings, each with its own meter) so that an on-site electricity source, like a wind turbine, can be credited against the consumption from the entire campus, instead of just one building.

Every state should adopt model net metering rules to encourage more on-site renewable energy generation.

Model Interconnection Rules

With interconnection posing a major roadblock to greater expansion of distributed generation, model rules can provide states with guidance in establishing more effective policy. In their 2010 report, *Freeing the Grid*, the Interstate Renewable Energy Council details the various components of an effective interconnection policy.[101] The following list highlights the more important components:

- Generators up to 20 MW allowed with multiple size "breakpoints" in the interconnection process (e.g. 10 kW, 2 MW, 10 MW, 20 MW) to segregate and fast-track minimal impact projects from those requiring more study.
- Shorter timelines than FERC federal interconnection standards.
- Interconnection fees capped (and waived entirely for net metered customers), engineering fees fixed to prevent uncertainty.
- Safety standards consistent with major electrical safety standards (Underwriters Laboratory and IEEE).
- Use of federal "technical screens" to fast-track review of projects with many similarities.
- Standard interconnection agreement.
- Rules apply to all state utilities.

California Assembly Bill 1302 also provides an example of model legislation for distributed generation. The law requires every major utility to provide maps and other information outlining zones that are optimal for the deployment of distributed generation. The law would also require utilities to take distributed generation into account when making investments in the electric grid, would require a third party audit of the interconnection process, and provide more transparency of the queuing process for renewable energy projects.

States and public utility commissions should adopt these interconnection rules and laws to drastically simplify and remove uncertainty from the process of developing distributed renewable energy projects.

Building Codes

Net zero energy buildings are an increasing part of building codes in Europe, transforming building efficiency codes into a more comprehensive policy for energy balance. These policies require that buildings be operated without using fossil fuels, have a net zero energy balance (by balancing on-site generation with load) or have a positive energy balance. Most would take effect by 2020.

Since even the most efficiently designed building uses some energy (especially in colder or humid climates), a net zero energy building code is a de facto incentive for distributed generation. States and local governments should use the building code to reduce on-site energy consumption, allowing the cost of energy efficiency and distributed generation to be integrated into the first mortgage, one of the most cost effective financing tools.

Identification of Existing Grid Capacity ("Sweet Spots")

Utilities should be required to publish data on their distribution networks to allow distributed generation developers to identify areas with available capacity where interconnection costs may be lower.

Grid-lock: the monopolistic lock on power of existing utilities

Minnesota was the first state to conduct an engineering-level analysis of the capacity of the existing state sub-transmission network to interconnect additional distributed generation. The first study found up to 1,400 MW of additional distributed wind energy could be injected into the existing grid in the West-Central part of the state. The cost for integration was less than 10 percent of an equivalent amount of new, high-voltage transmission line.[102] A subsequent, legislature-ordered state-wide study confirmed the first regional study and suggested that Minnesota had sufficient capacity in its existing transmission system to interconnect sufficient renewable electricity to meet its 25 percent renewable portfolios goal.[103]

California's statewide grid operator is conducting its own analysis of the capacity of the existing transmission network to interconnect significant quantities of distributed generation. At the same time, California's Public Utilities Commission has ordered two of the state's largest utilities – SCE and SDG&E – to provide a map of capacity on distribution level circuits to developers. Every state should require its utilities to do the same.

The Moment for 21st Century Energy Self-Reliance

Distributed generation offers a cost-effective and fast-scaling alternative to centralized generation of electricity, and at a cost competitive with centralized renewable energy development. Most importantly, it offers an opportunity to democratize the electricity system, dispersing power generation and its attendant economic benefits.

The technical barriers to the transformation are surmountable. In the short run, much more distributed generation can be added to the existing grid system without substantial difficulty. In the long run, new technical expertise and cheaper energy storage will transform the static, centralized grid into a dynamic and primarily decentralized renewable energy system.

While the transformation is a technical one, the largest barriers are political. From the federal to the state to the local level, policies shield the legacy electric grid from a democratic transformation.

New policies are needed to level the playing field for local, distributed generators. Rules are needed to change the historic paradigm of a few large-scale, fossil fuel power plants supplying a grid connected by long-distance transmission lines. Rules are also needed to prevent regulators from forcing the same paradigm on inherently distributed renewable energy production. These rule changes range from ending perverse and unnecessary incentives for new high-voltage transmission lines to transforming federal incentives to cash and production-based payments to tearing down interconnection barriers to the democratization of the grid.

The need for new rules is ultimately driven by the need for a new energy model. If new wind and solar power plants are built in the outdated, centralized model with significant new infrastructure, it will preclude local ownership and the spreading of economic benefits. Without these local benefits, the centralized strategy generates more resistance than a distributed system, a bane in both politics and electricity systems.

The urgency of action on global climate change only magnifies the disadvantages of pursuing a centralized model of renewable energy development. Community-based and distributed renewable energy production builds a political constituency to support the expansion of renewable energy and the retirement of fossil fueled generation, helping step away from a carbon-based electricity system.

The political advantage of distributed generation is obvious. The technological and economic dynamics have moved in favor of distributed renewable energy generation, but without new rules the opportunity will be lost.

References

** There's no uniformly accepted definition of distributed generation (DG). The Department of Energy has described DG as generation of 30 MW or less, on or near consumer sites. The California Energy Commission has described DG as less than 20 MW and connected to the utility distribution system. Lawrence Berkeley National Laboratory has defined distributed resources as 5 MW or less.*

We generally agree with such definitions.

For our purposes, distributed generation has two components. We use only renewable energy technologies with the exception of combined-heat-and-power systems (because of their high efficiency).

Additionally, we define distributed generation much like others, in that it must plug in to the distribution or sub-transmission part of the electric grid (e.g. lines on wood poles). This is because it is preferable to have power generation closer to load to more efficiently deliver electricity as well as to ensure that both the impacts of power generation (such as pollution) and its economic benefits accrue to those who receive the electricity. Distributed generation is not necessarily locally owned. However, local ownership of distributed generation is preferable for its ability to connect local renewable resources to their economic benefits.

We also consider projects connected to the transmission network as distributed generation, but only if they are 80 MW or smaller (a limit established in the 1978 Public Utility Regulatory Policies Act for "qualified" independent power producers). Many organizations working on distributed generation focus on 20 MW and smaller projects because then they do not have to "screw with the Federal Energy Regulatory Commission" regulations on projects larger than 20 MW (more on that later).

[1] Fossil fuel energy sources also enjoyed significant federal support when they were new.

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[3] Gipe, Paul. New California Governor Jerry Brown Calls for Feed-in Tariffs. (Renewable Energy World, 1/3/11). Accessed 6/20/11 at http://tinyurl.com/26hxmvy.

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[5] Other events indicating a distributed generation future:

- Vermont has introduced a pilot CLEAN Contract (a.k.a. feed-in tariff) program that offers a long term premium price for wind, solar PV, hydro, landfill gas, farm methane, and biomass electricity generation under 2 MW. Hawaii offers a similar program, but with a project size cap of 5 MW.
- Gainesville, FL, San Antonio, TX, and Sacramento, CA's municipally owned electricity utilities have introduced long term premium priced contracts for distributed solar power.
- The California Public Utilities Commission (CPUC) has required utilities to identify "sweet spots" on their distribution lines to encourage distributed generation that maximizes the benefits to the existing grid.
- In Minnesota, the state legislature required the state's utilities to identify a no-cost and least-cost plan for adding 1,200 MW of distributed wind power.
- In some regions, renewable energy represents over 15 or 20 percent of grid electricity, providing the first field tests for a future grid based on distributed generation.
- Several communities, including San Diego, CA, and many universities have conducted energy independence studies to determine how to get 100 percent of their electricity from nearby, renewable resources. Boulder, CO, is considering municipalization of its electricity system to increase renewable energy production.
- In April 2011, the Distributed Network Protocol (DNP) Users Group issued the first industry standard to allow solar inverters to interact efficiently with other "smart grid" technologies, allowing utilities to "talk" to and control these devices if necessary.
- The Federal Energy Regulatory Commission has proposed that demand response be compensated as if it were actual generation, giving it sounder footing against power generators.
- Electric vehicles are entering the market. More than 100,000 are expected to be on U.S. roads by 2012.
- A number of utilities in Texas, Minnesota, North Carolina and elsewhere are testing energy storage technologies to smooth production from variable renewable energy generators.
- Several European nations have enacted standards for new buildings to be net zero energy consumers--any use of imported fossil fueled electricity is offset by on-site generated energy that is exported to the grid, by 2020.

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