CEC Cancels Gas-Fed Peaker, Suggesting Rooftop Photovoltaic Equally Cost-Effective

Bill Powers

An emerging discussion in the climate-change debate is whether our renewable energy should come primarily from remote utility-scale wind and solar plants, connected to urban centers by a vast new network of transmission lines, or whether local renewable energy should play a much more prominent role. The rooftop solar photovoltaic (PV) array is among the most recognized forms of local renewable energy.

On June 17, the California Energy Commission (CEC) issued a landmark ruling that will undoubtedly figure prominently in this discussion. The CEC denied an application for a 100-megawatt natural gas–fired gas turbine power plant in part because rooftop solar PV could potentially achieve the same objectives for comparable cost.

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This decision implies that any future applications for gas-fired generation in California, or any other type of generation including remote utility-scale renewable energy generation that may require public land and new transmission to reach demand centers, will be measured against using urban PV to meet the power need.

The CEC decision said the following:

> Photovoltaic arrays mounted on existing flat warehouse roofs or on top of vehicle shelters in parking lots do not consume any acreage. The warehouses and parking lots continue to perform those functions with the PV in place. (Ex. 616, p. 11.) . . . Mr. Powers (expert for intervenor) provided detailed analysis of the costs of such PV, concluding that there was little or no difference between the cost of energy provided by a project such as the CVEUP (gas turbine peaking plant) compared with the cost of energy provided by PV. (Ex. 616, pp. 13–14.) . . . PV does provide power at a time when demand is likely to be high—on hot, sunny days. Mr. Powers acknowledged on cross-examination that the solar peak does not match the demand peak, but testified that storage technologies exist which could be used to manage this. The essential points in Mr. Powers' testimony about the costs and practicality of PV were uncontroverted. (CEC Decision, pp. 29–30)

The CEC concluded that PV solar arrays on rooftops and over parking lots may be a viable alternative to the gas turbine project, and that if the gas turbine project proponent opted to file a new application, a much more detailed analysis of the PV alternative would be required. The use of the urban PV alternative as the litmus test that must be passed before a new gas turbine

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plant, or a new remote utility-scale wind or solar plant, can be approved should move the rooftop solar PV option onto center stage of the national renewable energy debate.

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URBAN PV IS COST-EFFECTIVE ALTERNATIVE TO PEAKING GAS-FIRED POWER

The CEC identified the low-end levelized cost of energy (COE) for PV as $114 a megawatt-hour in an August 2008 report that includes the comparative costs of different renewable energy technologies.[1] This $114 a megawatt-hour is based on "thin-film" PV and conservative assumptions regarding the installed cost and the direct-current-to-alternating-current conversion factor. The thin-film PV technology upon which the CEC estimate is based is manufactured by First Solar. First Solar stated an expected COE of $90 a megawatt-hour in its April 2008 comment letter to the CEC.

The thin-film PV capacity factor identified by the CEC and California's investor-owned utilities is 18 percent. Capacity factor is a measure of the amount of power produced by a system compared to its maximum potential output. Maximum potential output would be achieved if the system produced its rated power output 24 hours a day, every day of the year. Operating continuously at maximum output is equal to a 100 percent capacity factor.

The CEC identified the COE of a 50-megawatt simple-cycle gas turbine as $647 a megawatt-hour in its December 2007 report, *Comparative Cost of Electric Generation Technologies*. The turbines proposed for the gas turbine project were two turbines of approximately 50-megawatt capacity. The CEC assumed a 5 percent annual capacity factor for simple-cycle gas turbines in calculating the $647-a-megawatt-hour figure. This level is consistent with the level of operation anticipated by the project applicant. The applicant stated that the expected capacity factor would be 5 percent.[2]

Adjusting the peaking gas turbine COE to reflect an 18 percent capacity factor, equivalent to the annual capacity factor of thin-film PV, gives a simple cycle gas turbine COE of $180 a megawatt-hour.

The local utility assigns PV without storage a capacity factor of 50 percent for peak demand reliability purposes.[3] The reason for this is that PV system output peaks at midday, and the daily summertime demand peaks are typically around 3:00 p.m. or 4:00 p.m. State-of-the-art peaking gas turbines achieve only about 75 percent of their nameplate capacity at 100°F due to the relatively low density of ambient air at 100°F. Older peaking turbines achieve as little as 65 percent or less of nameplate capacity at 100°F.

If only 50 percent of the installed PV capacity is considered available for peaking reliability purposes per San Diego Gas & Electric's (SDG&E's) assumption, then 150 megawatts of PV without storage would have to be installed to assure 75 megawatts of state-of-the-art peaking gas turbine power reliability at 100°F. In other words, 50 percent more PV nameplate capacity must be installed to achieve the same reliable capacity achieved by the gas turbine at 100°F.

If the value of the peaking power available from the PV array is limited exclusively to its ability to provide peaking power (for the sake of argument), it is reasonable to multiply the levelized COE by 1.5 to reflect the relative output compared to a peaking gas turbine on a summer afternoon. Multiplying the base case PV COE range of $90 a megawatt-hour (First Solar) to $114 a megawatt-hour (CEC) by 1.5 gives a peaking power PV COE range of $135 a megawatt-hour to $171 a megawatt-hour.

There is little difference between the COE of a 150-megawatt thin-film PV. . . and 100 megawatts of state-of-the-art gas turbine capacity at the same conditions. This is without considering the . . . renewable energy credits . . . , the elimination of air emissions, or the lack of dependence on a secure supply of natural gas.

Thus, there is little difference between the COE of a 150-megawatt thin-film PV array to assure 75 megawatts of net reliable summer afternoon peaking power at 100°F and 100 megawatts of state-of-the-art gas turbine capacity at the same conditions. This is without considering the green economic benefits of renewable

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energy credits generated by PV, the elimination of air emissions, or the lack of dependence on a secure supply of natural gas.

The addition of limited storage to each PV system ensures that the PV nameplate capacity is firm on-peak capacity. Commercial-scale demonstration projects are under way.[4] The battery systems are fully controllable by the utility as peaking units. The addition of energy management and battery storage allows the PV system to supply the utility grid with its peak output through the late afternoon summertime demand peak. The batteries mean that a 75-megawatt PV array with limited storage can provide the same reliable output at 100°F as a 100-megawatt peaking gas turbine plant. Adding limited storage capacity is a cost-effective approach to assuring the entire PV capacity is available during peak demand periods.

On June 18, Southern California Edison (SCE), California's largest investor-owned utility, received approval from the California Public Utilities Commission to construct a 500-megawatt urban PV project on warehouse rooftops. SCE states in its March 2008 project application that it

> can coordinate generation or storage technologies at the substation level to moderate the inherent weather-caused variability in solar PV production before such intermittency cascades into the higher voltage transmission system. Such coordination will reduce system costs. ([2008, March 27]. SCE application to CPUC for commercial PV program—Testimony, p. 17.)

SCE envisions large-scale storage as a viable and complementary element to its PV program. Maintaining rated power of the PV system through the afternoon peak load with energy storage would only be necessary on hot summer days.

ROOFTOP PV COULD PROVIDE RELIABLE POWER IN MANY PLACES NATIONWIDE

The U.S. solar energy approach to date has been almost completely focused on remote utility-scale solar energy resources and the transmission associated with such projects. This approach had merit in the 1980s when California became the world leader in solar power development using parabolic trough solar thermal technology at a time when solar PV cost $12 to $15 a watt (2008 dollars). However, the world has changed. Commercial PV installations now cost less than $4 a watt.

"Land-Intensive" Argument No Longer Correct

The current national focus on utility-scale desert solar power in the Southwest presumes this solar resource is so much more cost-effective than the urban PV alternative that it justifies the transmission cost, environmental trade-offs, and controversy of such remote solar development. This may have been true in the 1980s. It is not true in 2009.

The least-cost solar resource in 2009 is in California's developed urban and suburban areas, and this resource is vast. Urban solar deployments would be compatible dual use of existing rooftops and parking lots, avoiding the often-cited dilemma that "solar power is very land-intensive, and siting a solar plant means that most if not all of the other uses of that land are precluded."

It is true that some of the largest solar resources are to be found on public lands in the Southwest. However, these large solar resources are only useful to the extent that they are cost-effective in their own right and can be delivered efficiently to population centers. The cost of delivery via new transmission can be very high, without even addressing the environmental compromises necessary to construct the transmission lines or the utility-scale solar plants themselves.

No Line Loss nor Significant Additional Transmission

California's ongoing renewable energy transmission siting process, known as the Renewable Energy Transmission Initiative (RETI), indicates the least-cost solar solution to reaching California's target of 33 percent renewable energy by 2020 would consist predominantly of local distributed PV. Why? Because state-of-the-art PV is more cost-effective than solar thermal, and tens of thousands of megawatts of PV could be added at the local level with little or no upgrading to the existing transmission system required. RETI makes the following points about state-of-the-art PV:

> There is considerable commercial interest in utility-scale "thin film" (PV) systems. This sensitivity tests an alternate thin film technology for solar with capital costs of about $3,700/kWe (AC), roughly half that of tracking crystalline (PV). Notably, these (PV) capital costs are also lower than the large-scale solar thermal projects; therefore thin film solar is assumed to occur both at the distributed scale (20 MW) and also in large scale blocks (150 MW). (California Energy Commission. [2009, January 5]. RETI Phase 1B Final Report, pp. 5-27, 5-28.

PV can be deployed in urban and suburban areas in compatible dual-use applications that require no environmental trade-offs.

Unlike solar thermal technologies, PV can be deployed in urban and suburban areas in compatible dual-use applications that require no environmental trade-offs. Urban/suburban PV is more cost-effective than remote PV because it avoids the (1) high cost of new transmission lines and (2) high line losses, in the range of 15 percent, during peak demand periods.

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Could Fulfill 75 Percent of California's Renewables Target

The RETI report goes on to say that distributed PV at a current state-of-the-art capital cost of $3.70 a watt can provide two-thirds of what California needs going forward to reach 33 percent renewable energy by 2020:

> The results of this sensitivity run are dramatic. More importantly, the cost-competitive in-state (distributed PV resources) increase by more than 20 times to about 45,000 GWh/yr. This figure is over two-thirds of the net short requirement. The large majority of these (distributed) resources are 20 MW solar PV projects assumed to connect to the distribution system.

In February 2009, RETI reduced its estimate of the gap that must be filled to reach 33 percent by 2020, such that 45,000 gigawatt-hours a year (GWh/yr) from distributed PV could meet 75 percent of the need.

The November 2008 Los Angeles Department of Water & Power (LADWP) "Solar Los Angeles" strategic plan is a good real-world example of a renewable energy future that leads with distributed urban PV. The plan consists of 780 megawatts of urban PV and 500 megawatts of remote solar. This is two-thirds urban solar, one-third remote solar. With this urban/remote balance, little if any new transmission will be necessary for Los Angeles to go solar. LADWP is a public utility, and "Solar Los Angeles" reflects the intent of the city of Los Angeles to become a leader in smart and urban renewable energy development.

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San Diego Gas & Electric's service territory offers another example of the large role urban PV could and should play in California's, and the nation's, renewable energy portfolio:

- There are approximately 4,500 megawatts of commercial rooftop and commercial parking lot PV potential in SDG&E territory.
- Peak load in SDG&E territory in 2008 was 4,348 megawatts, and the average load over the course of the year is approximately 2,500 megawatts.
- 4,500 megawatts of PV are equivalent to approximately 900 megawatts of continuous power generation over the course of a year.
- The San Diego area could generate approximately 40 percent of its year-round power demand from urban commercial rooftop and commercial parking lot PV alone.
- That is without considering approximately 2,500 megawatts of PV potential on residential rooftops in SDG&E territory.

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- If the residential PV resource is fully developed in addition to the commercial PV resource, 60 percent of the San Diego area's year-round power demand could be met with urban PV.
- This large solar resource has no land-use requirements, as it is all compatible dual-use, and has no environmental impacts.

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Argument That Insufficient Manufacturing Capacity Exists Is False

RETI has attempted to minimize the distributed PV solution to California's renewable energy goal by stating that there is no way PV manufacturers could mobilize quickly enough to provide 2,000 to 3,000 megawatts of PV per year to realize the potential of the distributed PV alternative for California. This is not a valid concern. Spain, with about the same population as California and a less productive economy, added nearly 2,500 megawatts of PV in 2008.

More than 5,000 megawatts of PV were installed worldwide in 2008.[5] Worldwide thin-film PV production capacity reached 3,600 megawatts a year in 2008. It is projected to reach 7,400 megawatts a year in 2010. Worldwide conventional polycrystalline silicon PV production capacity reached 13,300 megawatts a year in 2008. It is projected to reach 20,000 megawatts a year in 2010. The 2010 projections were made just as the economic slump began in late 2008. It is likely there will be some scale-back on the 2010 capacity projections due to the state of the world economy. However, there is a tremendous amount of available worldwide PV manufacturing capacity.

Worldwide PV manufacturing, either thin-film alone or thin-film and conventional polycrystalline silicon, could readily supply a 3,000-megawatts-a-year PV demand in California and a much higher PV demand for the United States as a whole. The *Wall Street Journal* recently reported that conventional solar panel prices have fallen by $2 a watt since 2008, due to too much solar manufacturing capacity chasing too few solar projects.

New Transmission Line Buildout Could be Minimized

Investor-owned utilities make far more profit on transmission lines than any other types of infrastructure they build. This reality is often lost in the debate over whether it is preferable to generate renewable energy remotely and transmit it to demand centers or generate it locally. For example, a 1,000-megawatt transmission line being proposed by a western utility ostensibly to transmit renewable energy, with an estimated cost of $1.9 billion, will generate at least $1.3 billion in profits (in current dollars) for the utility shareholders over the financial life of the project. A total of $700 million of those profits will be credited to the company in the first eight-and-a-half years. Remote renewable energy generation requires transmission. Local renewable energy generation does not.

The nation has over 527,000 miles of existing high-voltage transmission.[6] This transmission infrastructure serves a declining demand for electricity. U.S. electricity demand declined approximately 2 percent in 2008 and is expected to decline another 1 percent in 2009.[7]

Southern California, with an average electrical demand of approximately 14,000 megawatts, has approximately 20,000 megawatts of import capacity on existing transmission lines. Southern California can already import 100 percent of its average electrical load. There may be some need to upgrade older lines so they can continue to provide decades of reliable service. However, neither California nor the United States as a whole is experiencing a shortage of transmission capacity as a general matter.

The policy challenge is the difficult work of ramping down the existing flow of fossil power on existing lines and methodically replacing it with renewable energy generation. A reasonable proposal of this sort was presented to the California Energy Commission in early 2007 by a major solar thermal developer. Called the Mojave Solar Development Zone, it would preferentially locate solar thermal projects along the rights-of-way of major existing highways with

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existing high-voltage transmission lines in the Mojave Desert. These highway corridors already have a combined 6,000 megawatts of existing transmission capacity.

In reality, the zone identified by the solar thermal developer is far larger than it needs to be to generate 6,000 megawatts, or even 10,000 megawatts of solar power. Solar thermal or PV can produce about 100 megawatts a square mile. One hundred square miles would produce about 10,000 megawatts. One-half mile solar rights-of-way on each side of the highway for only 100 miles would suffice to provide 10,000 megawatts of solar power.

This commonsense proposal predates the RETI process and apparently gained little or no traction within the RETI process itself. One likely reason is that the desert solar land rush had already begun, and restricting solar development to a limited Mojave Solar Development Zone would have inconvenienced developers with more remote and undeveloped properties in some phase of negotiation.

Another likely reason is that it made use of existing transmission and presumed that existing fossil transmission rights would be transferred to the solar projects. This is a reasonable presumption, but it is also a strategy the affected investor-owned utilities have steadfastly opposed. The California Energy Commission and the state of California missed an opportunity in 2007 to gain a measure of control of the desert land rush through some form of the Mojave Solar Development Zone and failed to act.

There is a better, more cost-effective, and less damaging solution that is being ignored or dismissed for reasons of political convenience.

The easiest pathway from a political standpoint—to give investor-owned utilities a mandate to overlay public lands and the United States with new transmission—would result in tremendous controversy and probable gridlock in moving forward on the development of renewable energy generation. The affected citizens and interest groups will oppose many of these projects for the right reasons—that there is a better, more cost-effective, and less damaging solution that is being ignored or dismissed for reasons of political convenience.

It is understandable why an investor-owned utility would see renewable energy solutions through a transmission lens. However, that lens is costly, inefficient, and controversial. The fact that a solar strategy with heavy reliance on remote sites and attendant new transmission would be very costly is positive financial news to an investor-owned utility. Yet it is an unnecessary and largely avoidable financial burden on everyone else.

CONCLUSION

The CEC made the right decision when it identified urban PV as a potentially viable alternative to a conventional peaking gas turbine. The CEC, through the RETI process, had already identified state-of-the-art PV as more cost-effective than utility-scale solar thermal technology. The net effect of these developments is to place more focus on urban PV to carry a much bigger share of the nation's renewable energy load than had been previously contemplated by policymakers.

NOTES

1. RETI Phase 1B draft report. (2008, August). PV cost comparison table, pp. 6–7. Retrieved July 2, 2009, from http://www.energy.ca.gov/reti/documents/2008-08-16_PHASE_1B_DRAFT_RESOURCE_REPORT.PDF.
2. CH2MHill. (2008, February). Response to Environmental Health Coalition Data Requests 1 to 35, p. 11.
3. SDG&E. (2006, August 4). Application A.06-08-010 for 500 kV Sunrise Powerlink transmission line, p. II-32: "This (PV) alternative proposes the installation of rooftop photovoltaic ("PV") technologies on houses, commercial facilities and industrial complexes within the San Diego area. Assuming 10% of the 3000 MW statewide target was achievable in the San Diego area, and—as described below—that 50% of this amount can be reliably assumed to be available during peak load hours, the maximum effective contribution of solar rooftop PV technology in reducing the need for conventional generating sources would be 150 MW."
4. CPUC A.06-08-010 Sunrise Powerlink Phase II proceeding hearing transcript at p. 3943, ln 10–16.
5. Schreiber, D. (2008, December 1–2). PV thin-film markets, manufacturers, margins. presentation at 1st Thin-Film Summit, San Francisco.
6. (2009, February 6). Hurdles (not financial ones) await electric grid update. *New York Times.* Retrieved July 2, 2009, from http://www.nytimes.com/2009/02/07/science/earth/07grid.html.
7. Energy Information Administration. (2009, May). *Short-term energy outlook—U.S. total electricity consumption, 1998–2010* (graph).

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