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Comments from Sandia National Laboratories

In Response to Written Questions Posed by Senate Committee on Energy and Natural Resources

Follow-up after Concentrating Solar Power Field Hearing
Albuquerque, New Mexico, July 10, 2008

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Questions from Senator Domenici:

Q: According to Sandia, it is possible to lower the CSP costs from today's 16 cents per kwH, to 12 cents in the near-term and even 6 cents in the long-term. How long do you estimate it will be before CSP drops to 12 cents? 6 cents?

A: The cost reductions for CSP technology, as for any emerging power system, are largely dependent on deployment. The costs to which you refer are from a 2003 report done by the DOE for the National Research Council,[1] commonly referred to as the "Sergeant and Lundy Report." While the costs of all technologies, especially fossil-fuel-based, have increased in the interim, this study reports that the cost reductions for trough and tower systems will result about equally from three sources: deployment, learning-curve cost reductions related to financing; and R&D of new components. The study indicates that cost reductions as low as 10 cents could be achieved with as little as 3 to 5 GW of deployment of CSP systems. (Note: there are currently 4 GW of CSP projects planned for deployment in the southwest.) The lower end of the scale, in the 6 cent range, requires aggressive technical advancement as well as deployment, as stated in the Sergeant and Lundy report:

> "The specific values will depend on total capacity of various technologies deployed and the extent of R&D program success. In the technically aggressive cases for troughs / towers, the S&L analysis found that cost reductions were due to volume production (26%/28%), plant scale-up (20%/48%), and technological advance (54%/24%)".

The net of these aggressive reductions reaches the 6 cent range. The original Sergeant & Lundy study is currently being updated and new number should be available late in the Fall. It should also be noted that the 6 cent range was seen in 2003 as the level needed to be competitive with conventional fossil technologies. The current market conditions will likely raise this competition level closer to 10 cents.

While it is not possible to say exactly when the cost of CSP systems will drop below 12 cents per kWhr, it was reported that a recent large US trough project was bid at 14 cents per kWhr.

Q: To date, there are no Power Tower CSP projects in this country, although an 11 MW project just came on-line in Spain. What are the advantages/disadvantages to this technology? Why aren't we seeing any Power Tower projects developed in the U.S.?

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[1] Assessment of Parabolic Trough and Power Tower Solar Technology Cost and Performance Forecasts, prepared for the Department of Energy and National Renewable Energy Laboratory, SL-5641, May 2003.

A: An 11 MW power tower project was built in Spain because of the favorable CSP incentive structure that will pay 47 UScents/kWhr for power from CSP; because a large company (Abengoa Solar) recognized a worldwide business development opportunity; and because of an additional government subsidy for the project.

As noted in the Sargent & Lundy report, the power tower has a longer-term cost advantage relative to solar trough systems. This is largely due to the fact that a power tower is a higher efficiency system and can more readily integrate thermal storage, thereby improving the capacity factor (yearly hours of operation) and potential value to the utilities.

So far we have not seen the deployment of power towers in the U.S. because of the perceived technical and financial risks. Due to the large initial capital investment needed for these projects, it has been difficult to obtain power purchase agreements and financing for higher risk projects. However, there is one power purchase agreement for a power tower in California between Pacific Gas & Electric and BrightSource energy. At least two other companies, eSolar and Solar Reserve, are actively developing projects in the southwest U. S.

The fact remains that we must find a way to enable the deployment of higher-risk, technologies at the utility-scale of solar power.

Q: I understand that Sandia is studying the new 64 MW CSP project in Nevada. What are you learning from that project? Why didn't that project include a thermal storage component?

A: The Nevada Solar 1 project was funded by private industry. Sandia is familiar with the technology and has worked with the developer, Solargenix, in the past but we do not have access to the data on the operation of the plant.

This system does not include thermal storage for two reasons: the utility, Nevada Power, did not value thermal storage to increase the capacity factor of the plant and they wanted the lowest cost solar option.

It should be noted that, even though two trough plants with storage are under construction in Spain, thermal energy storage for trough systems is not well established and some utilities and financial institutions consider it to be a higher risk technology. The announced 280 MW trough plant for the Phoenix area also includes thermal storage. While extending troughs to include storage cost effectively is a current area of intense DOE and industry research, the potential for storage in towers appears to be much greater. This is because of the higher temperatures inherent in tower systems, which leads to less storage volume for a given level of storage. In addition, current storage proposals for troughs have a separate storage medium, requiring an expensive heat exchanger, whereas towers store the energy in the operating fluid (salt). We expect that current DOE development will support an increase in the number of plants, both towers and troughs, that incorporate thermal storage.

Q: Currently, a CSP project requires approximately 5 acres of land per megawatt. Is there room for improvement?

A: There is a small difference in the area required for a trough, a tower, and dish/Stirling systems. The size of the solar field for all three of the technologies is driven by shading issues in the morning and evening, as well as mid-day in the winter when the sun is lower in the sky. Any reduction in the area required for the concentrators will be incremental because it depends on the fundamental optics of concentrating sunlight. The plant concentrator area could be reduced by tradeoffs that the developer would make between energy production at certain times of year and plant foot print.

Transmission

Q: In the 2005 Energy Policy Act, Congress sought to address the critical issue of transmission siting through the National Interest Electric Transmission Corridor process. Even though these provisions haven't been fully implemented, and no line has been sited pursuant to EPAct, the NIETC process has proven controversial. Still, everyone here today has highlighted the critical need to bring more transmission on line to transport these renewable resources to load. Just this past weekend, the Albuquerque Journal ran an Op-Ed criticizing environmental groups – who want the "green" power but not the infrastructure that goes with it – for opposing needed transmission lines.

What more should Congress do in this important area? Some have called for Congress to provide FERC with exclusive jurisdiction to site new transmission for a renewable project. Please comment.

A: There are two approaches to address the nations growing electricity demand, through centralized generation and through distributed generation. Centralized generation includes coal, nuclear, wind farms, concentrated solar power plants, photovoltaic arrays, geothermal energy and other generation sources that produce electricity on the megawatt through gigawatt scale. Most of this centralized generation connects to the grid at the transmission or subtransmission voltage level. Much of the available renewable resources exist in locations where transmission is not available to transport the energy to the loads. In this case, new transmission lines are needed to make large quantities of renewable power available where it is greatly needed. The 2006 National Electric Transmission Congestion Study identified critical congestion areas based on current and projected growth. There are many barriers to get the needed transmission sited and installed including regulatory, cost recovery, and technical issues. Giving FERC exclusive jurisdiction in siting new transmission for renewables does not solve the problem about who pays for new transmission. A technical challenge that has not been addressed with the high penetration of renewables is grid stability. Utilities are now running into problems with maintaining frequency stability with large amounts of intermittent generation such as wind and solar. This is primarily due to the fact that currently deployed versions of these renewable resources are not dispatchable, in other words we only have wind energy when the wind blows and photovoltaic energy when the sun shines. This is unlike fossil, nuclear, and geothermal generation that we can dispatch as needed because we have control of the fuel source at the generation plant as needed. Utilities have compensated by running dispatchable fossil generators as "spinning reserve" to compensate for renewable intermittency, which is not always cost effective. There is concern that increasing the penetration of renewables on the electric grid will increase stability problems. A key technology that will enable the dispatchability of renewables and help alleviate the stability problem is energy storage. Significant additional research is needed in this area. Concentrating solar power is one renewable technology that can incorporate storage technology through molten salt.

The second approach to meeting the nations growing electricity demand is through the use of more distributed generation. This includes rooftop photovoltaic panels, photovoltaic arrays at distribution voltages, distributed wind, fuel cells, and other small generation resources that can be placed at or very near the load. This approach is attractive for remote load sites and where new transmission is not a viable option. There are numerous challenges that have been identified by increasing the penetration of renewables at the distribution level through the DOE Renewable Systems Interconnection (RSI) initiative . This set of studies completed in December 2007 outline the challenges for distributed photovoltaics in the categories of 1)Distributed PV System Technology Development, 2)Advanced Distribution Systems, 3)System Level Test and Demonstration, 4)Distributed Renewable Energy System Analysis, 4) Solar Resource Assessment, 6)Codes, Standards, and Regulatory Implementation. However, these studies only identify some of the problems and funding is not in place to address the identified challenges. While these studies focus on distributed photovoltaics, the concepts are applicable to most renewables.

In summary, transmission siting is just one element of the renewable interconnection challenge. Further research in renewable systems interconnection is needed to address the technology needs, codes and standards, business models, and regulatory issues to assure that we maintain a secure and reliable electric grid as we increase the penetration of renewables in the US. The National Laboratories are well situated to take the lead in these areas of policy and technical development.

ITC

Q: One of the most important issues facing the solar industry today is that the tax credits we passed in a bipartisan manner are set to expire. We must enact a long-term ITC extension as soon as possible. However, for the first time in the renewable tax credit history, the House Majority is insisting that the tax credits be “offset” by tax increases on other industries.

Many of you have submitted testimony highlighting the tremendous economic boost the ITC provides the solar industry. According to Dr. Marker from SHOTT, solar capacity additions in 2007 contributed $2 billion to the U.S. economy, creating 6,000 new jobs.

And, it's forecasted that if the ITC is extended, 62,000 manufacturing and distribution jobs will be created.

Do you agree that these tax credits "pay for themselves" and therefore don't need to be paid for by raising taxes on other industries? Is the renewable industry concerned that this new "pay for" requirement can set a troubling precedent in that offsets will be required each time the existing tax credits expire.

A: We do not have the data to document the net "value" of the Investment Tax Credit. However, analysis for states in the southwest has shown that the development of CSP projects has a positive value to state and local economies over the lifetimes of the projects. Specific examples have been sited in several reports.[2][3][4]

Solar Resource Potential

Q: We currently have just over 400 MW of CSP installed capacity in this country, at a rate of about 16 cents per kilowatt-hour. A recent study suggests that solar energy could grow to 10% of the nation's power by 2025. Do you agree with that assessment? If so, what percentage will CSP contribute as opposed to Photovoltaic? Also, how long will it take to get solar power costs on parity with conventional power sources?

A: With the sustained incentive of the 30% ITC through 2017, the study results presented at the hearing predicts a deployment of 22 GW by 2025[5]. If the ITC were extended through 2025, the total deployment could be 40 GW as predicted by the same methodology presented in this reference. To reach 10% of the current U. S. grid capacity or about 100 GW by 2025 would require more aggressive incentives, significant streamlining of approval processes, and aggressive expansion of transmission capabilities.

CSP and photovoltaics are primarily focused on different market sectors. CSP is focused on the wholesale, utility-scale power market and photovoltaics are currently being applied to the "higher value" distributed, retail power market. The very large CSP installations are centrally sited, permitted, and maintained, but compete at utility generation rates. The bulk of current PV installations are distributed, either at the rooftop level or in relatively small power plants, are sited, permitted, and maintained by the owners, and compete financially on the customer side of the meter (retail pricing). The deployment scenarios and incentives are very different to reflect the needs and unique

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[2] The Economic Impact of Concentrating Solar Power in New Mexico, The University of New Mexico, Bureau of Business and Economic Research, December 2004.

[3] The Potential Economic Impact of Constructing and Operating Solar Power Generation Facilities in Nevada, Final Report, R. Keith Schwer and Mary Riddel, Center for Business and Economic Research, University of Nevada, Las Vegas, July 2003

[4] Economic, Energy, and Environmental Benefits of Concentrating Solar Power in California, Deliverable 3 Final Report, Black and Veatch, Prepared for National Renewable Energy Laboratory Under Subcontract AEK-5-55036, September 2005

[5] Department of Energy Solar Energy Technologies Program, *Multi Year Program Plan, 2008-2012*, April 2008. Plan available at: http://www1.eere.energy.gov/solar/pdfs/solar_program_mypp_2008-2012.pdf.

characteristics of these two markets. U. S. deployment of photovoltaics is predicted to be 20 to 25 GW by 2025 in the photovoltaics roadmap[6]. If the cost of photovoltaics falls as some think it may, it is possible that in the future PV may also compete in the utility-scale markets, as it currently does in Spain.

Even with the increase in the cost of commodities, CSP costs are projected to continue to decrease. The current cost of conventional pulverized coal power continues to increase with anecdotal costs indicated to be in the 5 to 7 cents/kWhr range. More importantly, uncertainty over future carbon regulation is resulting in the cancellation of orders for new pulverized coal plants. Carbon capture is projected to increase the cost of coal by an additional 5.4 cents/kwhr[7], perhaps more if gasification technology is utilized. This means that the gap between the cost of generating a kWhr of electricity using pulverized coal and CSP and other sources of renewable electricity is growing smaller. As discussed during the testimony, once a solar plant is installed, the cost of electricity generated is relatively stable over the life of the plant, while conventional technology energy costs are highly dependent upon the cost of fuel.

[6] Solar Electric Power, The U.S. Photovoltaic Industry Roadmap, May 2001, available at http://photovoltaics.sandia.gov/docs/PDF/PV_Road_Map.pdf
[7] Reducing U. S. Greenhouse Gas Emissions: How Much at What Cost?, U. S. Greenhouse Gas Mapping Initiative, Executive Report, December 2007. (aka, the McKinsey Report)