GABRIELLE GIFFFORDS
8TH DISTRICT, ARIZONA

WASHINGTON OFFICE:
502 CANNON HOUSE OFFICE BUILDING
WASHINGTON, DC 20515
(202) 225-2542

DISTRICT OFFICES:
TUCSON OFFICE
1661 NORTH SWAN, SUITE 112
TUCSON, AZ 85712
(520) 881-3588

COCHISE COUNTY OFFICE
77 CALLE PORTAL, SUITE B-160
SIERRA VISTA, AZ 85635
(520) 459-3115

Congress of the United States
House of Representatives
Washington, DC 20515

COMMITTEES:
ARMED SERVICES
SUBCOMMITTEE ON AIR AND LAND FORCES
SUBCOMMITTEE ON MILITARY READINESS
SCIENCE AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY AND ENVIRONMENT
FOREIGN AFFAIRS
SUBCOMMITTEE ON THE WESTERN HEMISPHERE

Written Statement of Mark Mehos
National Renewable Energy Laboratory
Presented to the U.S. House of Representatives
Committee on Science and Technology
March 17, 2008

Madame Chairman, thank you for this occasion to present and discuss information related to opportunities and obstacles for utility-scale solar power. I am the manager of the Concentrating Solar Power Program at the National Renewable Energy Laboratory (NREL). NREL is located in Golden, Colorado, and is the U.S. Department of Energy's primary laboratory for research and development (R&D) of renewable energy and energy efficiency technologies. I am honored to be here and to speak with you today.

I truly believe that solar power—both concentrating solar power and photovoltaic technologies—can provide a significant level of generating capacity in the United States if cost goals established by the U.S. Department of Energy (DOE) can be achieved. Reaching these goals will require a carefully balanced blend of DOE and industry sponsored R&D and government policies.

Introduction to Solar Technologies

Solar energy can be converted into electricity by means of photovoltaic (PV) or concentrating solar power (CSP) systems. Photovoltaics is the technical word for solar panels that create electricity. Photovoltaic material converts sunlight directly into electricity through a device called a solar cell. When sunlight strikes a solar cell, electrons are dislodged, creating an electrical current that can be captured and harnessed to do useful work.

Solar cells are connected together electrically to produce modules, and modules are mounted in PV arrays that can measure up to several meters on a side. **Flat-plate PV** arrays can be mounted at a fixed angle facing south, or they can be mounted on a tracking system, allowing the array to follow the sun in one or two axes to capture more sunlight over the course of a day. About 10 to 20 PV arrays can provide enough power for a household. However, for large electric utility or industrial applications, hundreds or thousands of arrays can be interconnected to form a single, large "utility-scale" PV system.

Higher efficiency solar cells, because of their high cost, are better suited to operate under concentrated sunlight. **Concentrating photovoltaic** (CPV) collectors use lenses or mirrors as optics to focus the sunlight onto the high-efficiency cells. The main idea is to use very little of the expensive semiconducting PV material while collecting as much sunlight as possible with lower-cost concentrating optics. CPV systems are being considered primarily for utility-scale applications.

CSP technologies use concentrating optics to generate high temperatures that are typically used to drive conventional steam or gas turbines. Due to economies of scale, CSP is generally considered a central-generation technology, rather than a source of distributed generation.

The three main types of concentrating solar power systems are parabolic trough systems, power tower systems, and dish/engine systems. Variants of these systems are also being considered, such as the linear Fresnel reflector system, which uses flat, rather than parabolic, mirrors to concentrate the solar thermal energy.

Parabolic trough systems concentrate the sun's energy through the use of long, linear parabolically curved mirrors. The mirrors track the sun, focusing sunlight on a receiver that runs along the focal line of the trough. A heat-transfer fluid, typically a synthetic oil, flows through the receiver, rising in temperature as it flows along the length of the collector. The hot oil is then used to boil water in a conventional steam generator to produce electricity. Alternatively, water can be boiled directly in the receiver using a direct-steam receiver. A key advantage of parabolic trough systems is that they can use thermal storage, giving the systems the flexibility to dispatch electricity coincident with peak utility loads, which often occur late in the evening. Many systems in Spain, as well as the system announced by Arizona Public Service last month, will make use of this feature. Parabolic trough systems are currently the most commercially developed technology.

A **power tower** system uses a large field of mirrors, called heliostats, to concentrate sunlight onto the top of a tower, where a receiver is located. This focused sunlight heats a working fluid such as molten salt or water/steam flowing through the receiver. Similar to oil in a parabolic trough receiver, the salt in a tower receiver is used to generate steam (using heat exchangers) to generate electricity through a conventional steam generator. As with trough systems, tower systems can be integrated with thermal storage. Future low-cost storage options should allow both troughs and towers to operate competitively in the near-term in intermediate load markets and in the future in base load markets, offering a potential alternative to coal-based generation.

A **dish/engine** system uses a mirrored dish, similar to a very large satellite dish. The dish-shaped surface collects and concentrates the sun’s heat onto a receiver, which absorbs the heat and transfers it to a gas within a Stirling engine or gas turbine. The heat allows the gas to expand against a piston (in a Stirling engine) or to power a turbine to produce mechanical power. The mechanical power is then used to run a generator or alternator to produce electricity.

Resource Potential for Solar Energy in the United States

A 2005 study commissioned by the Western Governors’ Association (WGA) looked at the solar resource and suitable land available in seven southwestern U.S. states, including California, Arizona, Nevada, Utah, Colorado, New Mexico, and Texas. Analysis using Geographic Information Systems (GIS) determined optimal CSP sites with high economic potential by excluding regions in urban or sensitive areas, regions with low solar resource, and regions where terrain would inhibit the cost-effective deployment of large-scale plants. Even with this high level of exclusions, the WGA solar task force calculated a capability of generating up to 6,800 gigawatts (GW) using CSP technologies—almost seven times the current electric generating capacity of the entire United States. The WGA study found that, with a build-out of only 2 to 4 GW of CSP, the technology will be competitive with conventional natural-gas-fired combined-cycle plants with a cost approaching 10¢ per kilowatt-hour.

The southwestern United States is not the only area with great potential for CSP. Projects are under way in Spain and Northern Africa, with additional projects planned for Israel, the Middle

East, Northern Mexico, and Australia. In total, more than 60 utility-scale CSP plants are under development worldwide, primarily driven by policies favorable to large-scale deployment of the technology.

Two questions are now addressed that relate to the role of the federal government in the success of utility-scale solar projects in the Untied States.

The first question is: How can the federal government facilitate the deployment of utility-scale solar projects?

At the request of the U.S. Department of Energy, NREL analyzed the impact of policy (both state and federal) and R&D on the penetration of utility-scale solar generating systems in the southwest United States. The Renewable Energy Deployment System (ReEDS) model, developed at NREL, was used to estimate the U.S. market potential of wind and solar energy for the next 20 to 50 years. The model competes these technologies against the more-conventional generation technologies of hydro, gas-combustion turbine and combined-cycle systems, coal, and nuclear. Future sequestration technologies are also included within the ReEDS model.

Results from the model indicate that utility-scale solar technologies can produce nearly 120 GWs of capacity in the Southwest by 2050. Significantly more capacity is possible if dedicated transmission can supply generation to load centers located outside the Southwest. However, a key outcome of the analysis is that initial market penetration is extremely dependent on the continuation of the existing 30% investment tax credit (ITC). According to the analysis, without an extension of the ITC, new capacity will be delayed about 10 to 15 years—until lower CSP generation costs resulting from R&D and international market development allow CSP technologies to compete against future conventional plants.

The federal government can facilitate the deployment of solar power plants by providing access to land. Utility-scale solar projects require considerable acreage. The 280-megawatt (MW) Arizona Public Service project mentioned earlier will cover 3 square miles. That is nearly 2,000 acres to produce the power for 70,000 homes. The federal government owns large tracts of land in the West. Doing an environmental study of those lands and streamlining the process by which industry can lease tracts found suitable for solar power projects will shorten the time it will take to build projects on these lands.

Finally, the federal government can support efforts to relieve transmission congestion throughout the West. Existing transmission lines are operating at near capacity. New lines must be built to bring power from solar plants located in the areas where the solar resource is best, often in remote sunny regions. Our transmission grid is like our highway system, but without the interstate highways. An “interstate” grid system would facilitate the transmission of solar power from the Southwest to load centers throughout the United States. As described earlier, the United States has an enormous solar resource. Once we reduce the cost of the technology, the next challenge will be to distribute the electricity produced to the people who need it.

A second questions is: How does the level of federal investment required to “kick start” utility-scale solar compare with that required by other technologies seeking government support?

NREL scientists are studying a number of renewable energy technologies. The country is entering a period where it must start making the transition to new sources of energy. DOE and NREL are pursuing a portfolio approach of technologies—such as solar, wind, biomass, hydrogen, and geothermal—that could play a role in the future. All these technologies have the potential to become cost competitive with fossil generation.

The price tag of utility-scale solar projects is large. For example, the 280-MW plant mentioned above will cost more than a billion dollars. Fortunately, the federal government does not need to contribute directly to cover the cost of these plants. The southwestern states have established renewable portfolio standards that have created the market for utility-scale power plants. Some states have established price guidelines by which they recognize that they will initially have to pay more for the renewable power. The additional costs are passed along to the ratepayers. Thus, the bulk of the cost for establishing cost-effective utility-scale solar power is being borne by the states. If the federal government were to decide that utility-scale solar power was important, then they could partner with the states, which have already kick-started utility-scale solar.

Most of the money appropriated for solar energy R&D focuses on residential and commercial applications. Utility-scale solar receives about $30 million out of a total solar budget of $170 million. To meet the goals mentioned earlier, the DOE estimates that this funding would need to be doubled. Researchers at NREL work closely with the CSP industry and universities to develop new technologies that are more efficient and less costly. A study commissioned by DOE several years ago showed that reducing the cost of solar technology depends about 45% on R&D and 55% on actually building solar projects. This combination of R&D and deployment could well bring the cost of solar power into alignment with fossil generation in the intermediate power markets. And with low-cost storage, the overall cost may also align with future baseload power markets if carbon constraints are considered.

Summary

Addressing our near-term needs in solar power will require a national strategy that promotes the deployment of solar systems and processes that are ready to serve us today. At the same time, addressing our longer-term needs and achieving a significant contribution from solar power technologies will require a major new commitment to the research needed to deliver the next—and subsequent—generations of CSP, PV. and other new solar technologies.

Thank you.