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United States Senate
Committee on Energy and Natural Resources

Field Hearing in Albuquerque, New Mexico
2 July 2008

Concentrating Solar Power

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Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC0494AL85000.

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INTRODUCTION

Concentrating Solar Power (CSP) describes a suite of solar technologies that use mirrors and thermodynamic processes to develop grid-ready electricity. Mirrors on tracking structures concentrate sunlight, producing high temperatures, which then drive conventional or novel engine cycles that in turn drive a generator to develop electricity. CSP technologies do not depend on strategic or high-tech materials, but rather are based fundamentally on glass and steel structures. The collected energy can be stored as thermal energy—an inherent advantage of CSP over photovoltaic solar and wind electrical generation. While CSP technologies are not as recognizable as photovoltaic power (PV) technologies, there are nearly 450 MW of CSP generation currently operating in California and Nevada, with additional planned deployments of over 3000 MW in the Southwest United States.

CSP has the potential to supply a large fraction of the energy needs of the United States, although prime generation sites exist primarily in the Southwest. Working in conjunction with other renewable resources established in other parts of the country, and with improvements to the grid infrastructure, the future of CSP in the nation's energy portfolio is indeed bright. The current cost of electricity generation by CSP trough plants is about $0.16/kWh. Other CSP technologies may produce lower cost electricity due to higher system efficiencies. With further technology development and increased deployment, the cost of CSP-generated electricity projected in several studies to reach $0.06/kWh. In addition, the high-temperature capabilities of CSP make possible highly efficient chemical processes that can lead to solar fuels production.

The DOE national laboratories, specifically Sandia National Laboratories and the National Renewable Energy Laboratory (NREL), have played a crucial role in existing CSP deployments, and we continue to work closely with industry to optimize and improve the designs and plans for upcoming deployments. The historical and ongoing technical achievements at the laboratories have been and will continue to be a cornerstone of successful cost reduction, performance enhancement, and deployment success. Key laboratory-developed technologies are deployed to the field by industry. The test capabilities at Sandia are unmatched worldwide, and provide a great resource to industry partners.

CSP DESCRIPTION

CSP converts the sun's energy into heat and then uses that heat to power an engine-generator unit. The sunlight is concentrated with mirrors—similar to concentration by a magnifying glass. The resulting heat is intense enough to create steam to drive a conventional turbine or to heat a working fluid in a smaller engine, similar to burning gasoline in an automotive engine. CSP technologies are large-scale, providing utility-scale generation of power, with near-term planned plant sizes ranging from 100 to 1000 MW. (A typical coal or nuclear plant may be 500-2000 MW.) CSP consists of three basic technologies: (1) parabolic troughs, (2) power towers, and (3) dish-engine systems. Each of these technologies uses a parabolic array of mirrors, on different scales, to create intense heat.

CSP is already being deployed, with 384 MW of capacity in nine plants in California and a new 64 MW plant in Nevada. Combined, these plants represent more than 140 plant-years of commercial operation. The national laboratories have continued to develop the CSP technology and have also helped improve the deployed plants. In 1998, the nine plants in California increased their rated capacity from 354 MW to 384, in part because of performance and operations and maintenance improvements pioneered by the laboratories. Over the last two decades, new deployments have been limited by the relatively low cost of electricity generation by natural gas. The recent dramatic increases in fuel cost, coupled with the Renewable Portfolio Standards (RPSs) in some states, have driven renewed interest in CSP deployment. The addition of the 30% Investment Tax Credit (ITC), as opposed to the 10% level, offsets some of the financial risks inherent in initial scaled-up deployments.

A key advantage of CSP is dispatchability (that is, the ability of a generating unit to increase or decrease generation, or to be brought on line or shut down at the request of a utility's system operator). Because the energy conversion process is a thermal action, the solar input can be supplemented in two ways. The first is through thermal storage, in which a working fluid is stored hot and then used when needed to drive the turbine. This process is very efficient, with over 98% recovery. The second is that systems can be "hybridized"—where an alternate fuel such as natural gas can be burned to supplement the solar collection. This method is not as desirable as storage, but it does present an option that photovoltaic and wind energy sources do not provide.

A second advantage of CSP is the inherent "low tech" of the materials involved. The collection structures are typically steel or aluminum, with glass reflector surfaces. The resulting structures have been likened to "a funny-looking car." Indeed, several industry partners who work with Sandia have already leveraged the manufacturing capabilities of the Detroit-area automotive companies, as well as other basic American manufacturing companies.

TECHNOLOGY DESCRIPTIONS

Parabolic Troughs

The parabolic trough system is a line-focus mirror array, as opposed to a point focus system. At the focal line, a specialized tube carrying a working fluid (such as a thermal oil or a molten salt) is heated. The working fluid reaches temperatures in the range of 500°C. The collected heat can then be stored or directly passed through a heat exchanger to generate steam for a conventional turbine.

This technology is the most widely deployed CSP approach, and existing deployments help in obtaining funding and approvals for new installations. The state-of-the-art systems are solar-only (no storage), with an annual efficiency in the 12-14% range and a peak efficiency of about 16-18%. Typical plants in the past were sized under 50 MW due to power purchase agreement limitations. The newest plant, in Nevada, is a 64 MW installation. Proposed plants for Arizona are as large as 280 MW with storage. The larger size plants bring down the cost of the electricity generated through economies of scale.

Current trough research includes thermal storage development and testing, higher temperatures (which leads to higher performance), and lower cost designs. Key laboratory optical modeling and systems development approaches are helping industry to reduce costs without reducing performance.

One key component of trough systems is the receiver tube, a glass and metal structure that includes some laboratory-developed sealing technology. The Schott Solar Company is planning to build a plant in Albuquerque to fabricate this critical component.

Dish Engine Systems

Dish-engine systems consist of a tracking dish that concentrates sunlight to a single point, and a heat engine at that point which converts the intense heat to electricity through a rotating shaft and generator. Current designs center on a Stirling cycle engine, which is similar in many respects to automotive engines. Dish systems currently range from 3 to 25 kW capacity each, although larger systems are envisioned by some companies. Most companies currently developing dish systems intend to deploy fields of dishes, with aggregated capacities up to 1000 MW (for example, 40,000 25 kW dishes in one field). This deployment approach is seen as key to cost reduction.

Because of the point focus at each dish, the dish system is capable of very high temperature operation, typically in the 800°C range (glowing red to orange). These high temperatures lead to very high system efficiencies for conversion of sunlight to grid-ready electricity. The current world record solar conversion efficiency is 31.25%, held by the Stirling Energy Systems 25 kW Dish-Stirling system located at Sandia National Laboratories. The annual efficiency of such a system is in the range of 22-25%.

Stirling Energy Systems has announced two large power purchase agreements in California. The first is with Southern California Edison for the energy from a plant with 20,000 dishes producing 500 MW, with potential expansion to 850 MW. The second is with San Diego Gas and Electric for the energy from a 12,000-dish system producing 300 MW, with possible expansion to 36,000 dishes and 900 MW. With recent investment, the prognosis for successful deployment is very good.

Current efforts in dish-engine deployment center on cost reduction and large-scale manufacturing. The role of the national laboratories in this effort is in technology transfer and design support. In particular, as non-solar entities are engaged to provide manufactured parts and systems, Sandia's experience is leveraged to be sure that solar performance is not compromised. Additional development is centered on alternate engine advancement that could lead to lower operation and maintenance costs. The large number of dishes deployed in single locations help ramp up the production rates, which also leads to lower costs.

Power Towers

The power tower is also a point-focus technology that allows for higher temperatures than those in trough systems. In the tower system, a field of steerable mirrors reflects the sun's energy to a large point at the top of a tower, where a working fluid is heated and then either stored or directly used to drive a conventional turbine. A commercial power tower is likely to be sized in the range of 100 MW electrical output, although both smaller and larger plants have been proposed.

Tower systems can directly generate steam at the receiver location to drive a turbine. Such plants, on a 10 MW scale, have been demonstrated in Spain, where they have achieved annual efficiencies in the 12% range. A second approach is to heat a molten salt working fluid to a higher temperature, then store this hot salt until the generation of electricity is needed. A small-scale pilot plant, operated in the 1990s, demonstrated the feasibility of this approach. Larger molten salt plants are expected to lead to 18-20% annual efficiency. The higher temperatures of the tower systems make the possibility of thermal storage more economically feasible than with trough systems.

Although no US power tower plants are currently in production or deployment, several US companies have recently announced plans to pursue and develop various power tower technologies. Additional research and development will concentrate on cost reduction of the tracking mirror systems (development which is likely to support all the CSP technologies) and on the development of robust, efficient receiver assemblies.

Storage

Thermal storage of energy is unique to the CSP technologies, and it represents a significant advantage over other intermittent renewable technologies such as wind and photovoltaics. The large-scale storage of thermal energy is highly efficient, with over 98% recovery of stored energy. (Compare this to the battery storage of electricity, typically in the 60-70% range.) In addition, the storage containment equipment and fluids are quite cost effective compared to batteries, and they are more environmentally benign.

The thermal storage uncouples the collection and generation phases of the CSP cycle. Energy can be collected throughout the day, with actual generation of electricity deferred until needed (for example, evening peak periods). With enough storage, CSP technologies will be able to provide baseload (continuous, around-the-clock) power generation in the future. In the shorter term, storage can firm up capacity during peak parts of the day as well as shift the generation to better match the utility's needs. Some utilities (for example, Arizona Public Service) have indicated they will not consider solar technologies without storage, as their peak period extends well into the evening. Other utilities do not see the need for storage in the immediate future, but begin to see the need as renewables reach toward 20% of the regional generating capacity. The use of substantial storage will allow CSP to provide greater than 20% penetration in the electric generation arena.

Trough and tower technologies are well suited to molten salt storage, a technology demonstrated in the 1990s on the Solar 2 pilot plant in Barstow, California at a 10 MW electric generation level. The demonstrated systems used a nitrate salt (which is essentially fertilizer) to collect and store the heat. Sandia National Laboratories is presently examining salts with the potential for a lower melting point (reduces parasitic loads and losses) and a higher operating temperature (improves total system efficiency). Sandia is also testing components and materials for durability in long-term exposure to the salt working fluids.

DEVELOPMENT NEEDS

The current public interest, high energy prices, and state renewable portfolio standards are driving unprecedented interest in CSP technologies. Deployment proposals and plans, as well as private investment in solar technologies, have grown exponentially over the past few years. More than 3000 MW of known Power Purchase Agreements (PPAs) are now on the books, with many more reported to be in progress. These deployments are investor-driven, so risk must be minimized to support return on investment. The national laboratories are continuing to play a key role in technology deployment and personnel training. The accumulated knowledge and experience in the laboratories is being leveraged through partnerships, Cooperative Research and Development Agreements (CRADAs), and other mechanisms. This leveraging helps the commercial sector deploy effective technologies and minimize the waste of capital investment. However, the laboratories also need to revive a research and development role that will develop next-generation systems with the potential to meet long-term cost targets.

Support and development needs lie in three key areas. First, continued technical support of near-term commercial deployments is needed to leverage the DOE investment in CSP development. Second, supply chain development is necessary to bring US industry capabilities to bear on this key strategic resource. Third, the laboratories must continue advanced development, leading the CSP technologies to more cost-effective solutions that bring us to mainstream power generation.

Industry technical support has been and continues to be the cornerstone of the laboratory involvement with CSP. Tools, methods, and technologies developed at the laboratories are directly responsible for the feasibility of the proposed deployments, as well as for ongoing improvements of operational systems in the field. The CSP personnel base at the laboratories has been very stable when compared to other missions of the laboratories, providing a continuity and experience base unmatched anywhere in the world. We have demonstrated an ability to provide significant value to industry partners during design, development, testing, and qualification phases of these technologies. However, there are limited "experts" in the solar field, so the rapid expansion of CSP firms has led to a severe shortage of engineers with solar experience. Working hand-in-hand with the laboratories has proven a viable method to add to the "solar expert" ranks. Sandia National Laboratories has also made use of its expertise in other areas of the laboratory, including manufacturing, failure analysis, materials research, Supervisory Control and Data Acquisition (SCADA) system and controls development, information security, and systems engineering. With the large planned deployments, this aspect of CSP development is reactive to industry needs.

Supply chain development provides for a transition of US manufacturing capabilities to these new technologies. The CSP technologies are presented to potential cross-cutting suppliers to develop a manufacturing resource for use across the CSP spectrum. This approach allows the leveraging of existing US nonsolar suppliers, particularly in the automotive sector, rather than reinventing the manufacturing wheel. This approach has proven successful in several areas for the Stirling Energy Systems team. The engine is being "productionized" by a Detroit engine production firm. Very significant enhancements have been proposed that will reduce the cost of the engine, increase reliability, and improve the performance potential. There are unique capabilities in American industry, developed for other sectors, which will impact all areas of the CSP designs. Supply chain development also includes development of solar engineers through development of university programs and curricula. This aspect of CSP development must be cooperative with industry to leverage both laboratory and industry experience.

The laboratories must revitalize a thrust in advanced development for CSP technologies. Rapid deployment and substantial private investment make the CSP industry partners focused on near-term sales and deployments. Thus the laboratories must continue to develop next-generation systems, components, and tools. Industry is neither able to take on the risk of advanced development nor the distraction it would inject into the deployment process. Although industry has proposed approaches that will initiate large deployments, laboratory technology breakthroughs will lead to cost reductions that will make CSP technologies cost-competitive with conventional fossil-fuel power generation. The laboratories need to focus on development of disruptive technologies that will impact the cost and performance of CSP systems. Increases in system performance (efficiency) will directly impact electricity generation costs because the majority of the cost in these systems is in the collection apparatus (steel and glass). The laboratories must be proactive in the development of advanced technologies.

The laboratories have often developed new approaches that industry did not anticipate. These approaches often become part of the baseline technology that industry is prepared to deploy. Sandia has developed closed-loop tracking sensors and algorithms that substantially reduced the assembly accuracy requirements of dish systems. Rather than "perfect" installations, the closed-loop sensors and algorithms allow the system to learn and adapt to any imperfections, resulting in a substantial reduction in installation costs. Sandia-developed mirror facets have a substantially higher accuracy than prior "commercial grade" facets, and for about the same price. This development has changed the entire design paradigm for point-focus systems, as the improved performance has a substantial effect on the cost of electricity generated. These improvements are now entering the parabolic trough arena as well: Sandia-developed heat pipe receivers demonstrated a 20% improvement in system performance on one Dish-Stirling system. Further development is expected to bring this disruptive technology to the market. Systems models, tools, and development hardware have led to a better and more realistic understanding of system performance and costs. Spin-off technology and algorithms from Sandia's Advanced Dish Development System (ADDS) are being incorporated into the near-commercial products of Stirling Energy Systems, Infinia Corporation, and Eurodish.

Sandia's new "TOP" (Theoretical Overlay Photographic) alignment system for troughs has demonstrated the benefit of optical alignment of existing trough plants, and it provides a tool to economically perform the alignment.

The high temperatures possible with the point focus systems (dishes and towers) make possible high-temperature chemical processes for the development of transportation fuels. Several processes have been proposed and are under development for splitting water using high-temperature processes, creating a reliable and cost-effective stream of hydrogen. Similar processes can be used to split CO_2 into CO and O_2. The CO can then be easily combined with hydrogen to create liquid fuels, which can then be distributed using the existing fuels infrastructure. The CO_2 could be supplied from sequestration at coal plants or, in the long run, through atmospheric scrubbing.

CSP Market Potential

CSP technologies are enjoying unprecedented interest and development, both in the US and worldwide. This interest is driven by a variety of factors creating something of a "perfect storm." Respected US and international companies are entering the CSP field, and significant private investment is flowing into CSP. In the US, there is significant solar resource in the Southwest states, primarily in areas with otherwise undesirable land.

Market Drivers

A variety of drivers have led to the current unprecedented commercial interest in CSP. The first is the Renewable Portfolio Standards (RPSs), primarily in the Southwest states, that mandate certain significant percentages of electricity generation must come from renewables. Although wind power has made significant deployments driven by the RPSs, utilities particularly like solar because of the match of the generation profile to the load profile. Therefore, as renewables have started to provide a notable fraction of the energy in some regions, the utilities have desired to balance wind generation with solar generation.

The second driver is the rapid and recent increases in fuel costs for conventional power generation. This factor is particularly applicable to natural gas plants, which were installed as "peakers" when natural gas was abundant and cheap just a few years ago. Currently the costs of CSP generation are very competitive with peak natural gas generation, even at relatively small deployment levels.

Third, the cost of all energy, especially gasoline, has driven public sentiment and support for solar energy. Not only is solar seen as a stable, US-grown energy source, but it is also "green," satisfying additional public sentiment concerning global warming and greenhouse gasses. The extraordinary public interest is demonstrated to me each day as I field numerous calls from the media and private citizens.

Finally, the investment by DOE and private industry over the last 20-30 years has provided a level of technology readiness suitable for significant investment in large deployments. Although technical and financial risk is still apparent, the technical risk has been reduced through the laboratory and cooperative projects, demonstrations, and technology development. Modern design, manufacturing, and analysis tools applied to CSP allow rapid movement from concept to feasible hardware while reducing costs and risk.

Solar Resource

Presently, CSP technologies require approximately 6 acres per MW of installed capacity, compared to non-tracking PV at nearly twice that requirement. This translates to a 500 MW plant using about 5 square miles of desert land. CSP technologies require "direct normal insolation," which is a measure of the brightness of the light coming directly from the sun, rather then reflected off clouds and sky. Therefore, CSP technologies work best in clear, dry environments like the Southwest United States. Figure 1 shows the tremendous resource available in the southwest states of New Mexico, Arizona, California, and Nevada, with some areas in Colorado. Obviously not all of this land is available for CSP deployments.

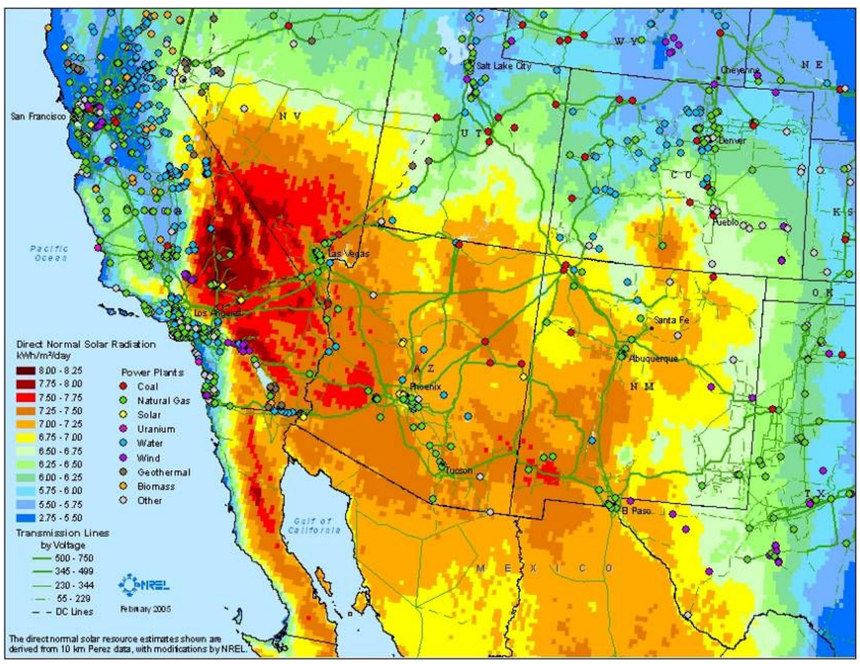

Figure 1. Direct Normal Resource Assessment (NREL data).

An NREL study filtered this data to exclude land already in use, environmentally and culturally sensitive land, and land with significant slopes. The remaining lands were only considered when contiguous areas were greater than 10 km² (or 4 mi²) and a solar resource over 6.75 kwh/m²/day. Figure 2 shows the filtered data. If the minimum direct normal considered is 6.0 kWh/m²/day, a still very good resource, considerable additional land becomes available, particularly in the State of Utah.

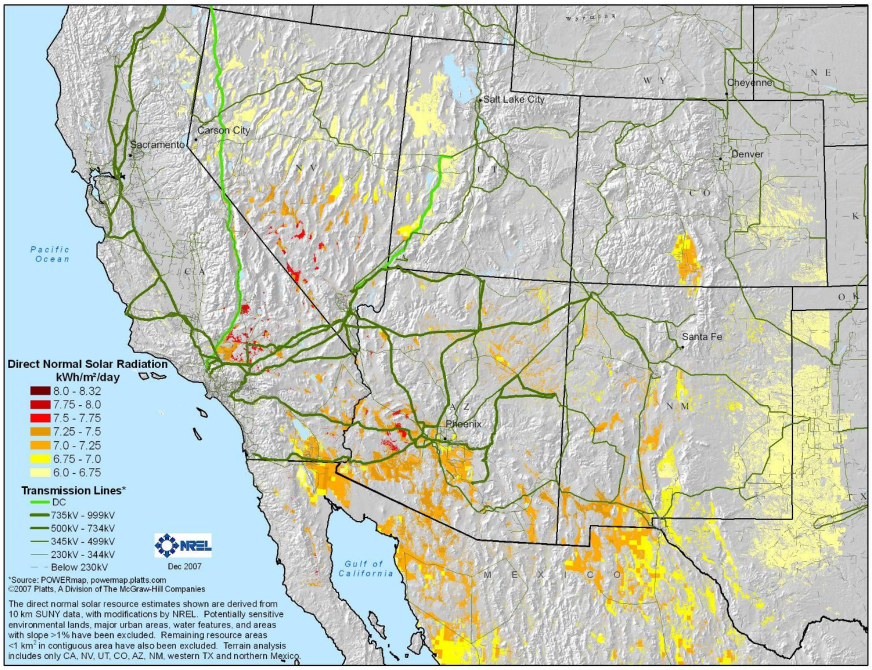

Figure 2. Filtered Direct Normal Resource (NREL data).

Although the vast majority of prime land has been filtered out, there are still more than 53,000 mi² of land available for CSP projects. Table 1 shows a breakdown of potential land, filtered as noted, on a state-by-state basis. This analysis shows an available resource that is 7 times larger than the total nameplate generating capacity of the US electric grid. These data and maps are available from the Renewable Resources Data Center at NREL.

Table 1. CSP generating capacity by state on filtered land.

State	Land Area (miles^2)	Solar Capacity (MW)	Solar Generation Capacity (GWh)
AZ	19,279	2,467,663	5,836,517
CA	6,853	877,204	2,074,763
CO	2,124	271,903	643,105
NV	5,589	715,438	1,692,154
NM	15,156	1,939,970	4,588,417
TX	1,162	148,729	351,774
UT	3,564	456,147	1,078,879
Total	**53727**	**6,877,054**	**16,265,609**

CSP Cost

Renewable resources are best compared on the basis of "Levelized Energy Cost" (LEC). This is the present value of the total cost of building and operating a generating plant over its entire economic life, which is then spread across all the energy generated during the life of the plant, resulting in an average cost per kWh of energy produced in present-day dollars. CSP plants do not have ongoing fuel costs, which represent a significant fraction of the LEC of electricity from conventional fueled plants. However, the CSP plants are highly capital intensive, essentially buying 20-30 years of fuel up front in the form of collection equipment. Therefore, the LEC of CSP energy is highly dependent on financing and tax structures, as well as the rate of production of the equipment being fielded. The value of CSP is impacted by the cost, but also by environmental considerations that may or may not have a financial value, such as carbon footprint. Policies in this area can impact the value of CSP substantially. The cost of conventional generation is influenced by the current high cost of fuels, which also helps the relative value of CSP.

Figure 3 shows the anticipated LEC reduction for CSP projects compared to the cumulative deployment of CSP projects. This projection is taken from the Western Governors' Association (WGA) Solar Task Force Summary Report of January 2006.[1] This model uses a trough plant with 6 hours of thermal storage as a surrogate for all CSP technologies, and includes continuation of the ITC. Significant reductions in cost are expected through manufacturing improvements resulting from the sheer volume of deployed concentrators. However, significant supporting policy and financial assumptions are included as noted in the figure.

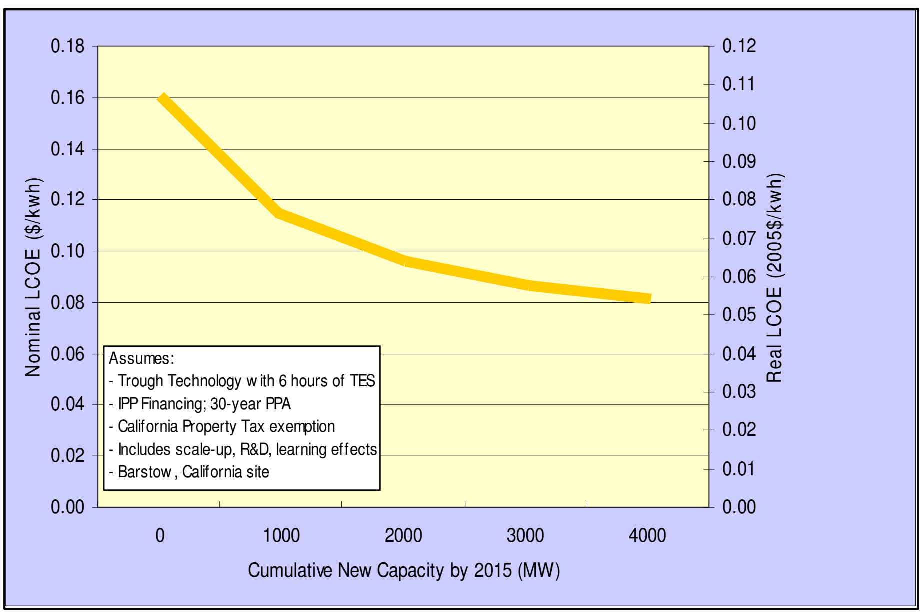

Figure 3. Cost reduction of CSP through deployment and development (WGA Solar Task Force Summary Report, Jan 2006).

Private industry is leading the way on current deployments. As expected, the exact terms of the contracts with the utilities are closely held secrets, so it is difficult to obtain accurate current costs of CSP generation. However, the 2003 Sergeant and Lundy report is an excellent resource on the prognosis for cost reduction of trough and tower systems.[2]

[1] Report available at: http://www.nrel.gov/csp/troughnet/pdfs/kearney_wga_overview.pdf.
[2] Sergeant and Lundy LLC Consulting Group, "Assessment of Parabolic Trough and Power Tower Solar Technology Cost and Performance Forecasts", Chicago, IL: NREL/SL-5641, October 2003.

This report is scheduled to be updated to include modern technology improvements and financial considerations, and extended to include the dish-engine systems.

The current LEC for trough plants is estimated at $0.16/kWh. Industry experts have indicated that near-term deployments can be expected to produce an LEC in the $0.12/kWh range (DOE semi-annual review conference, Austin TX, April 2008). Further technological developments and very large deployments are needed to reach the predicted $0.06/kWh range. Several trough manufacturers have also indicated that the near-term deployments planned are highly dependent on a stable ITC policy.

The contract price for Stirling Energy Systems dish-system electricity is also a closely protected corporate secret. However, if one reviews current policy in California, it is clear that the base price for these near-term plants is likely at or below $0.10/kWh.[3] The high efficiency of the dish-engine technologies makes $0.06/kWh a feasible target. Again, the LEC is strongly impacted through large deployments leading to highly automated manufacturing. In addition, successful early deployments will lead to more favorable financing terms for later deployments, similar to the pattern seen in trough deployments.

No large tower projects in the US are far enough advanced to evaluate modern costs. However, the Sergeant and Lundy report indicates that towers can reach the range of $0.055/kWh. Towers have the inherent advantage of simple storage combined with higher temperatures than troughs, leading to higher efficiency and therefore lower cost.

The current energy environment is encouraging substantial interest in CSP. More than 3000 MW of deployment has been announced in the Southwest United States, and additional large deployments are in the planning and exploratory stages. Table 2 lists the publicly announced deployments planed for the Southwest US. In the near term, we expect an ITC extension would facilitate these deployments and accelerate the cumulative deployment of CSP in the United States.

[3] California CPUC Resolution E-4118 Adopting the 2007 MPR (Market Price Referent), 4 October 2007. Document available at: http://docs.cpuc.ca.gov/published/Final_resolution/73594.htm.

Table 2. Known planned deployments in the US as of Spring, 2008

Deployment	Size	Status
Trough/ORC in Arizona	1 MW	(APS Acciona, operating)
Trough electric project in Nevada	64 MW	(Nevada Power, Acciona, commissioned June 2007)
Dish-Stirling plant in Southern California	500 MW Option to 850 MW	(SCE, SES, Aug 2005)
Dish-Stirling plants in Southern California	300 MW Options to 900 MW	(SDG&E, SES, Sept 2005)
Trough plant	553 MW	(PG&E, Solel, July 2007)
Linear Fresnel Reflector	177 MW	(AUSRA, PG&E, Nov 2007)
Parabolic Trough with storage	280 MW	(Abengoa, APS, Feb 2008)
Arizona PS Consortium RFP	250 MW	(issued Dec 2007)
Parabolic Trough	250 MW	(FPL Energy, AFC filed)
Power Tower	900 MW	(BrightSource, PG&E, April 2008)
Other RFPs issued but not announced		
Total	**3,275-4,225**	

Figure 4 shows the expected impact of ITC extensions on the near-term deployment of CSP technologies, based on NREL projections published in the 2008-2012 Multi-Year Program Plan.[4] These plants take a number of years for design and development, permitting, and financing. Thus the importance of a stable, long-term taxation and credit policy cannot be stressed enough.

In summary, the cost of CSP is likely to be competitive with conventional generation processes. The cost reductions will come through a combination of technology improvement (performance improvement), design for manufacture (cost reduction through design), volume manufacturing (cost reduction through automation and stable factory orders), favorable financing (through investor confidence) and equitable taxation (recognition that the capital investment is comparable to fuel investment in a conventional plant). In the short term, the ITC will promote deployment to accomplish these cost reductions.

[4] 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.

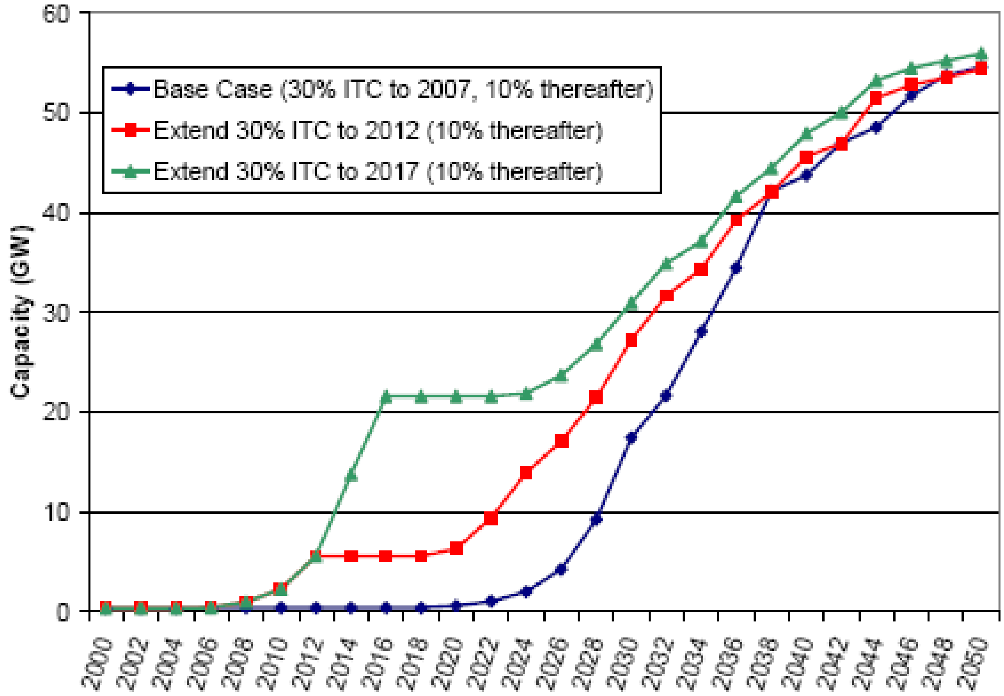

Figure 4. Impact of ITC extension on near-term deployments.

Market Barriers

While we enjoy an unprecedented renewal of interest in CSP, there remain several market barriers. If these barriers can be addressed, CSP deployments will accelerate more rapidly, moving the balance of our energy infrastructure toward a sustainable domestic resource.

The first barrier is financial risk. CSP plants are not consumer items; rather they are very large industrial complexes. The up-front cost is high, and it is paid back over long periods of successful operation. The lack of large deployments, particularly in dishes and towers, leads to uncertainty and therefore a higher cost for financing these projects. As plants are deployed, the financial risk is reduced, and the cost of financing is proportionally reduced. The current very high interest in troughs in part results from the ability to finance these projects based on the success of the over 400 MW in the Southwest United States. This is one area where the ITC can significantly reduce the cost of the plant to offset the high cost of financing due to the perceived risk.

Similarly, taxation policies impact the financial feasibility of CSP plants. The high amount of capitalization results in a significant tax burden when compared to conventional-fuel power plants. A state policy to exempt these plants from property taxes will help level the playing field, making CSP competitive with conventional technologies.

As we work with companies in planning large deployments, we find that available transmission capacity is a much larger consideration than land cost. Despite high public interest in renewable energy, the public tends to be very opposed to new transmission capacity. A good example is the Sunrise Powerlink, proposed by San Diego Gas and Electric. Current transmission capacity can handle the introduction of the 300 MW Stirling Energy Systems dish-engine power plant in the Imperial Valley. However, the proposed extensions will need the Sunrise Powerlink, which is currently opposed by several activist groups. Beyond California, if we anticipate the Southwest United States supplying CSP-generated power to large portions of the country, substantial changes to the nation's electrical grid will need to be considered. Any new large-scale transmission lines will also face challenges in ensuring minimal environmental impact.

Many of the proposed plants are on federal government land, primarily BLM land. The permitting process for these lands, though necessary to protect various national interests, is a cumbersome and slow process. The shear size of these plants, several square miles each, presents unique environmental approval challenges that must be considered in detail. Streamlined permitting and approval processes for lands in the "CSP hotspot" could accelerate development and deployment.

BLM recently announced a two-year freeze on new solar projects on BLM land while they study environmental impacts.[5] This freeze forces the consideration of environmental impacts to be performed in series with other site considerations, rather than in parallel, effectively delaying new installations by another two years. A coordinated federal streamlined permitting process could significantly shorten the process leading to deployment, rather than the current patchwork approval process that adds significant delays.

Beyond the land-use permitting, site development and planning takes years in order to meet many state and local requirements. The technologies are substantially different than conventional technologies from a utility perspective. This is particularly true with systems that do not incorporate storage. Large intermittent sources have not been previously addressed by the utilities, so there is substantial uncertainty. There are no applicable codes and interconnect standards for such systems. All these significant technical and policy issues slow the approval process and add financial uncertainty to the project developer. We need sustainable energy policies, economic conditions, and permitting processes that motivate private investment in new technology deployment.

CONCLUSIONS

CSP has the potential to meet a very large fraction of our nation's energy needs, starting with grid-based electricity and expanding to transportation fuels production. The resource available in the Southwest United States on easily useable land is nearly 7 TW, or 7 times the current electrical generation capacity of the US. Cost-effective and efficient storage sets CSP technologies apart from key intermittent renewables of photovoltaic solar and wind. This is especially important as intermittent renewables begin to generate significant fractions of our national energy supply.

CSP leverages existing US manufacturing capabilities. The fundamental building blocks of CSP are glass and steel, materials common to the automotive and building industries.

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[5] Frosch, Dan. "Citing Need for Assessment, U.S. Freezes Solar Energy Projects," *New York Times*, 27 June 2008. http://www.nytimes.com/2008/06/27/us/27solar.html

Current market drivers—including global climate change, high fuel prices, and technology readiness—have led to unprecedented interest in CSP technologies. A number of US and International companies are poised to deploy large CSP plants in the Southwest United States.

Significant deployment acceleration requires policy improvements, including a stable taxation and regulatory environment and streamlined land use and interconnect approvals and policies.

The support of the national laboratories has been crucial to the technical success of CSP projects, and the laboratories' role will not diminish with the advent of large deployments. The partnerships developed between the laboratories and industry have been extremely valuable in the feasibility and success of new CSP deployments. Although the technical support of the deployments is critical, the laboratories also need to promote supply chain development leading to cost reduction, and they need to enhance long-term research and development of disruptive and advanced technologies that will dramatically impact the cost and performance of future plants.

Continued industry support, supply chain development, advanced technology research, and stable policies will allow us as a nation to take advantage of this tremendous energy resource identified in our own backyard.

WITNESS BIOGRAPHY

Charles E. (Chuck) Andraka has worked for Sandia National laboratories in the Concentrating Solar Power area for over 23 years. He has supported all areas of CSP as a systems engineer, specializing in optics, heat transfer, controls, and systems modeling. He has concentrated his efforts in dish-engine technology, but has worked on many cross-cutting technologies. Chuck has earned the level of "Distinguished Member of Technical Staff" at Sandia. He currently is the project lead for dish engine work at Sandia under the DOE Solar Thermal Electric program.

Chuck received a BSME in 1983 and MSME in 1984 from Virginia Tech. He has authored and co-authored over 50 conference and journal papers in the CSP area. He chairs the Solar Thermal Power technical track for the American Society of Mechanical Engineers.