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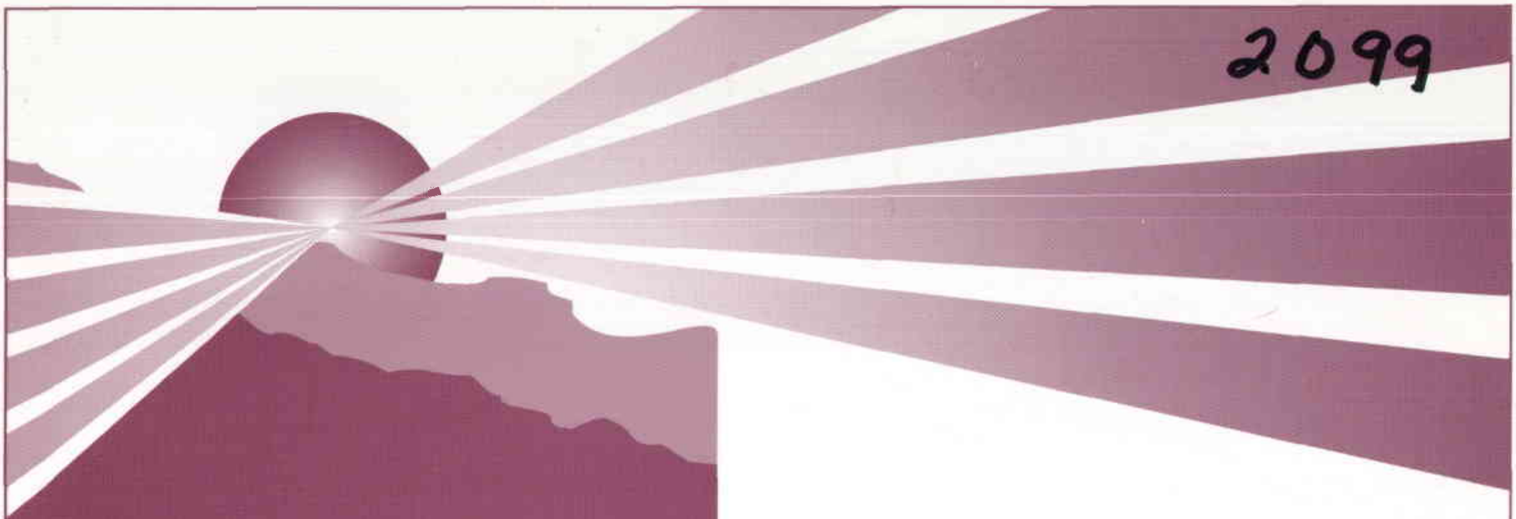

CONCENTRATING
SOLAR POWER
PROGRAM

Peer Review Report

U.S. Department of Energy

CONCENTRATING • SOLAR • POWER

Sun•Lab

Sandia National Laboratories, Albuquerque, NM
National Renewable Energy Laboratory, Golden, CO

Operated for the United States Department of Energy

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Concentrating Solar Power (CSP)
Peer Review
December 2001

The Department of Energy requires periodic peer reviews of its programs. The Concentrating Solar Power (CSP) Program, which is part of DOE's Office of Power Technologies, underwent a detailed 2-day review by a panel led by the MIT Energy Laboratory. The review was held in Albuquerque, NM, on November 7 and 8, 2001.

As described in the Government Performance and Results Act, GPRA, PL 103-62, four criteria were applied when reviewing five specific parts of the CSP Program (Program Management, Distributed Power Systems, Dispatchable Power Systems, Advanced Components and Systems, and Test and Research Facilities) and for rating the overall program. The four criteria are

1. the quality of technology and engineering;
2. programmatic performance, management, and planning;
3. relevance to national and industry needs; and
4. other considerations.

The results of the Review are used by CSP Program managers to determine future direction and to improve the quality and effectiveness of the program.

Anyone interested in seeing the detailed presentations made to the Review Panel may access them at the SunLab website at the following URL.

http://www.energylan.sandia.gov/sunlab/peerreview.htm

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December 7, 2001

Frank Wilkins
Team Leader, Concentrating Solar Power
Office of Power Technologies
Renewable Energy and Energy Efficiency
US Department of Energy
Washington, D.C.

Re: CSP Peer Review

Dear Tex:

The letter is designed to provide an overview of the CSP Peer Review Panel's approach, findings, and recommendations following the 3-day meeting held in Albuquerque on November 7-9, 2001. In addition to this short summary letter we have attached final version of our report, which is in the form of a two per page set of 70+ powerpoint slides. Although the essential content of this information was presented to you at the debrief on Friday afternoon, November 9th in Albuquerque, there has been some minor editing and rearranging of the material contained in the attachment.

First of all, the panel appreciated the care and organization that went into the presentations made at the meeting. In the two full days of briefings we were exposed to both the breadth and depth of the CSP programs in sufficient detail to allow us to provide an informed evaluation.

After much discussion among panel members we decided on the following approach for our review. As you know, we were asked to evaluate the overall CSP program and to examine five specific components:

1. Program Management
2. Distributed Power Systems
3. Dispatchable Power Systems
4. Advanced Components and Systems
5. Test and Research Facilities

In each case, we have provided you with a detailed set of findings and specific recommendations, which are documented in the attachment.

Overall, the Panel felt that the CSP program was addressing important issues needed to meet US deployment goals for renewable energy technologies. In general, the quality of the technology being developed both within the DOE SunLab system at NREL and SNL and with its industry partners is very good. Although the Panel chose not to use a numerical ranking of each program element, they all would fall into the excellent to good category, particularly given their reduced levels of support.

With proper funding the DOE CSP program can play an important role in catalyzing further CSP technology advances, which will further improve CSP economics and market penetration. Ultimately, CSP technologies could contribute significantly to the US supply of electricity from domestic resources. In the short term, CSP could make a difference for the US by adding diversity and security to our energy supplies, particularly in the high-grade areas of the Southwest.

It is the Panel's view that all current DOE-supported R&D being conducted on the CSP technologies -- including dishes, power towers, troughs, concentrating photovoltaics (CPV) and other advanced receiver, heat transfer, and storage components -- are of high quality and deserve continued support as they address a complementary set of applications for both dispatchable and distributed power over a range of scales. In addition, the SunLab's facilities at SNL and NREL represent an important national asset both for critical testing, standardization, and performance verification as well as advanced R&D that need to be sustained and upgraded in the years ahead.

The panel noted that support for the CSP program is significantly below the level needed to contribute to the goals and objectives of the National Energy Policy. Many Panel members believe the program is underfunded by about a factor of 2 to 4 times.

Given the substantial decreases that have occurred in the program's budget over the past decade, the Panel felt that the program management has already responded with considerable restructuring to remove any unessential components, including, of necessity, a number of promising activities. Therefore, we did not feel that major changes in current priorities or further specific cuts or deletions of projects are needed at this time. Nonetheless, as you will see in the attachment, we have not hesitated to make substantive recommendations for the program in general as well as for each of the five elements you asked us to examine.

In view of new DOE priorities articulated recently by Secretary Abraham, we would be happy to provide our perspectives on how CSP technologies might contribute to increasing America's energy security as well as to address goals associated with the President's climate change initiative.

We appreciate the opportunity to comment on this important DOE program and look forward to receiving feedback. As we mentioned in Albuquerque, the Panel chair and other members are available for further discussions of our review with Assistant Secretary Garman, Bob Dixon, Jim Rannels, and other Federal officials who may wish to be directly briefed on the Panel's findings and recommendations.

Sincerely,

Jefferson W. Tester, Chair
on behalf of CSP Peer Review Panel 2001
Herbert Hayden
Glenn Hamer
Rose McKinney-James
William Peters
William Stine

Cc with attachment.
Robert Dixon
Jim Rannels

Concentrating Solar Power Peer Review
Final Report

Panel members

Jefferson Tester, chair
Meissner Professor of Chemical Engineering, MIT

Glenn Hamer
Executive Director, Solar Energies Industries Association

Herbert Hayden
Solar Program Coordinator, Arizona Public Service

Rose McKinney-James
President, Brown and Partners, Las Vegas, Nevada

William Peters
Principal Research Engineer, MIT

William Stine
Professor Emeritus, California State Polytechnic University

Overall CSP Program Findings and Evaluation

Overall CSP Program

- The Concentrating Solar Power Program is an important part of DOE's portfolio of Renewable Energy options that has been severely undervalued in terms of the contribution it could make to meeting DOE RE deployment objectives.
- All CSP technologies – dishes, power towers, troughs, concentrating photovoltaics (CPV), and other advanced concepts deserve continued support.
- In general, CSP Program seems underfunded by a factor of 2x to 4x but not more.

Overall CSP Program

- The R&D costs of maintaining US capability in CSP are very modest in terms of the impact CSP could have for the nation in the long term.
- CSP provides an indigenous and substantial alternative to decrease our flux of greenhouse gas emissions and particulates in the face of increasing concerns over their impact.
- CSP directly addresses energy security concerns by diversifying our national portfolio of energy sources and helps buffer the U.S. against price volatility and deliverability concerns.

Overall CSP Program

- CSP provides energy from a large domestic and environmentally attractive resource.
- CSP complements other RE resources in the US with its high grade in the Southwest where other resources, such as biomass and hydro, are not as attractive. CSP should not be viewed as a competitor with other solar energy systems, such as PV or buildings.
- In the longer term, other regions of the U.S. should be considered for CSP applications as the cost of the technology is lowered.

Overall CSP Program

- CSP can deliver electric power for $0.10-0.20/kWh today, with potential for under $0.10/kWh. Though these costs are higher than wholesale prices in US, they are significantly lower than PV, and could become competitive in the near-term future if resources, environmental, or national energy independence factors constrain fossil usage.
- Continued emphasis on price per kWh comparisons with existing technologies do not include value of externalities, such as low pollution and CO_2, energy security, cash flow out of country, price stability of resource, job creation.

Overall CSP Program

- The excellent correlation between population growth and power expansion needs in the Southwest and the location of the U.S. high-grade direct insolation resource represents a short-term deployment opportunity for CSP. This is consistent with a recent Congressional mandate:

  " ... to develop and scope out an initiative to fulfill the goal of having 1,000 MW_e of new parabolic trough, power tower, and dish engine solar capacity supplying the Southwestern United States by the year 2006."
- To meet this 1000 MW_e goal will require a vigorous and focused DOE/Lab effort.

Overall CSP Program

- The CSP program needs to tell its story better to policy makers in Congress so that the intrinsic values of CSP are realized. Trying to meet the generating costs of combined cycle natural gas fired or existing baseload coal fired electric plants is not going to be possible in the short term for CSP, PV, or virtually any other renewable or new nuclear option. Therefore the other positive attributes of CSP systems should be highlighted to get a complete picture. For example, their non-CO2 and emissions-free operation, the range of scales for CSP from large dispatchable central station (troughs and towers) to small, distributed and off-grid (dishes) systems are very attractive features.

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Overall CSP Program

- CSP has significant environmental benefits: no greenhouse emissions, no NOx, SOx, particulates, or solid wastes, and aids in meeting state, federal, and regional air-quality standards.
- CSP enhances energy security as we attempt to immunize the nation to fossil energy price instabilities and energy deliverability constraints.
- Policies such as green pricing, renewable portfolio standards, tax incentives (e.g., extending production tax credits to include solar, boosting investment tax credit from 10 to 20%, and equalization of capital tax treatment), governmental procurement programs, etc., are necessary in the short term but may not be enough to meet DOE's aggressive deployment goals.

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Overall CSP Program

- Industry and the marketplace, not DOE or CSP, control extent of technology commercialization.
- The CSP has an appropriate role in supporting industry through R&D to improve reliability and reduce costs.
- The CSP strategic plan is dominated by near-term objectives owing to programmatic pressures.
- There is considerable opportunity to increase research aimed at identifying and advancing long-term (10-20 years) CSP technologies.

Overall CSP Program

- CSP management is clearly engaged in a comprehensive effort to support the technological advancement of a range of solar thermal options. Continued funding for these programs is essential to ensuring maximum optimization of the technologies.

Overall CSP Program

- SunLab restructuring appears highly successful.
- The SunLab facilities represent an important national asset for crucial R&D to advance CSP and other technologies. They include an approximate $200 million replacement cost of hardware at Sandia alone.

Overall CSP Program

- The industry partners in CSP technology did an excellent job articulating the value that SunLab brings to their commercialization efforts.
- Given that these companies do not have well-developed infrastructures and resources for conducting advanced R&D, performance reliability, and durability testing, the NREL/SNL SunLab collaboration is essential to push the technologies toward commercialization.

Overall CSP Program

- Federal procurement is a key factor to move the dish program forward.
- There should be increased emphasis on concentrating PV, Power Roofs, Zero Energy Buildings (ZEB), in general.
- CSP has significant economies of scale and multiple unit manufacture cost benefits. There is a need to commercialize to get costs down. Chicken and Egg problem.

Overall CSP Program

- DOE must help industry look for commercial opportunities here or abroad.
- DOE should maintain and increase its involvement in the international CSP community.
- Significant leveraged benefits can be obtained by sharing in domestic and international advancements. Specifically, senior DOE and SunLab management should actively participate in SolarPACES and similar international organizations.

Overall CSP Program

- CSP Program includes several designs and valuable electric generation attributes, such as high efficiency, rapid industrial production, long life, energy storage.
- CSP technologies have proven capabilities and known characteristics. Various constructions exist ranging from large technologies of MW size down to small technologies of kW size, both grid-tied and off-grid. Energy storage can be integrated in most CSP systems at nominal cost and high efficiency.
- Several near-term pathways for further improvements are being pursued for cost reduction and performance increase. Many opportunities for cross-cutting application of know-how between designs exist.

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Overall CSP Program

- CSP using troughs and towers is generally well suited only for installations 50 MW or larger, which prevents it from competing in PV markets where higher prices are paid for smaller 1 MW installations.
- Dish engine and CPV systems have potential for smaller power markets but need to be further along in their commercialization to be competitive (e.g.,10,000, 10-25 kWe units per year production).

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Overall CSP Program

- CSP can provide strategies which offer incremental compliance with the 2006 goals. Investigating opportunities to enter into collaboration with wind may prove beneficial
- Commercial deployment will require the ability to ensure efficient volume production to support mass manufacturing. Little, if any, current emphasis has been placed on supporting commercial-scale manufacturing.

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Overall CSP Program

- The future of CSP and other new energy technologies depends in part on building our National capacity to develop and implement new technologies. A key element in achieving this is to attract and nurture the country's best and brightest young minds into the RE arena. One policy instrument for doing this would be to enhancing the current university partnership initiative.

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Overall CSP Program Recommendations

Overall CSP Program Recommendations

- Develop strategies to support phased CSP deployment in the SW US of appropriate magnitude to support its efficient advancement. Such strategies must address the competitive nature of wholesale power, and the need to attract private capital and expertise, and public appreciation of its strategic benefits.
- Assess the material resources and energy requirements for alternative CSP technologies to deploy 1000 MW_e of CSP.
- SunLab and the DOE should develop a streamlined way to inform policy makers of the strategic component, assets, and plans for CSP; the web page is too detailed for this purpose.

Overall CSP Program Recommendations

- Detailed plans for market penetration should be used as an appropriate metric to justify future funding.
- Improve communication of program strategic vision, accomplishments, and potential benefits to National energy goals to higher-level decision makers
- CSP management needs to develop a focused message which includes three to four key points as an introduction to the web page.
- Industry partnerships represent a strategic opportunity. These partnerships have been expanded over the past few years. CSP should develop additional initiatives to spur further expansion.

Overall CSP Program Recommendations

- The DOE should provide enhanced support of the core capabilities of SunLab to carry out optical characterization and performance, durability, and reliability testing of critical components, including reflectors, receivers, heat transfer devices, and energy converters.
- Optical modeling and analysis tools are currently supported at approximately a 2 FTE level which is about a factor of 2 to 3 too small to support the DOE deployment objectives.
- Such characterization and testing capabilities are absolutely essential to support the US industry and aid diffusion of new technology into the marketplace.

Overall CSP Program Recommendations

- The DOE should consider providing funding to create and implement a peer-reviewed, long-range CSP research program.
- The CSP program should evaluate and, where promising, implement R&D opportunities to advance hybrid CSP technologies; e.g., with other renewables and with fossil energy.

Overall CSP Program Recommendations

- Find additional opportunities to deploy CSP on a smaller scale (100s of kWe to a few MWe) in the SW U.S.
- Programs are making progress, but need to do a better job of succinctly quantifying and articulating success.
- Recommend that the CSP Program develop a list of critical enabling technologies to achieve cost reduction and reliability goals.
- Routinely communicate the accomplishments of CSP to the public and political community in simplified terms that can be readily appreciated by the audience.
- A compelling example would be the very low-cost 80 MW_e upgrade of an existing California solar trough system.

Overall CSP Program Recommendations

- Continue to include CSP vendors and add potential CSP purchasers to the mix of industry collaborators.
- Initiate a National Energy Security Fellowship Program that would support graduate students at U.S. universities. The program would be nationally competitive and should include an internship at a national lab or in a company carrying out government-supported energy R&D[3].

Program Management Findings and Evaluation

Program Management

- The focus on past deployment as a key performance metric of high-level DOE management is shortsighted in view of the long-term potential of CSP. CSP is inherently different than other RE resources in that unit sizes are larger and thus capital investments are higher.
- CSP Program has benefited from continued congressional support.
- Excellent management at the SunLab and DOE program level.

Program Management

- Potential for export sales to developing countries.
- Emphasis on Southwest is an excellent strategy for market entry but program should look to entire U.S. to build constituency.
- Instability of DOE R&D budget drives good workers away.
- Lack of effective public outreach.
- Web page assets are impressive as they provide access to the details of the CSP program.
- Electronic management tools are great for the direct program managers but they may not be really helpful to inform the policy makers and upper level managers.

Program Management

- Responding to DOE/Congressional mandates for rapid penetration of commercial markets.
- Supporting industry efforts to commercialize CSP.
- Useful R&D to diversity portfolio of indigenous US options for supply of central station and distributed electric power to consumers.
- CSP website is a great asset for outreach.
- University involvement in research and demonstration projects is valuable.
- Asking universities to cost share research projects is inappropriate and may exclude many applicants.

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Program Management

- Management has demonstrated a consistent willingness to plan for most program areas. It has excelled in the area of providing the necessary flexibility to address the challenges of fluctuations in funding.
- There is a significant threat of technology flight overseas due to limitations in R&D funding for these programs.
- The area of storage optimization requires clearer and convincing justification.

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Program Management Recommendations

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Program Management Recommendations

- **Institutionalize the CSP peer review process.**
- **Internally at DOE, CSP should participate in portfolio analysis and planning exercises.**
- **Government Performance and Results Act (GPRA) implementation and the metrication of programs needs to account for the fact that not all program elements and milestones are comparable.**
- **The strategic program evaluation process is a step in the right direction, the Peer Review Committee hopes that there is sufficient time and dialogue for carrying out an even-handed, objective treatment of the CSP program.**

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Program Management Recommendations

- Better communicate strategic vision in light of various program constants.
  - Budget
  - Push to commercial demonstration
  - Role of time scales for technological innovation and market penetration by new technologies
- Work closely with other parts of DOE; e.g., fossil energy, to produce synergistic technologies; e.g., natural gas/SDE hybrids.

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Program Management Recommendations

- Think of new ways to communicate CSP values to the legislative and executive branches using their "language."
- Increase amount of university involvement, but eliminate cost share requirement.
- Develop public outreach capabilities so that when people think of solar-generated electricity, they don't just think of PV.

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Program Management Recommendations

- Make greater use of state-of-art modeling and simulation capabilities
  - To guide systems design, integration, performance evaluation
  - To reduce dependence on large-scale hardware testing to achieve technology innovations
- Expand use of innovative science and engineering to help create new generation of CSP technologies that will be
  - Lower cost
  - More reliable

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Program Management Recommendations

- Come up with some way of attaching cents/kWh or $/kW values for externalities.
- Build CSP as means for lowering greenhouse gas emissions.
- Emphasize resource diversity, not just the SW.
- Emphasize export potential.
- Increase effort on component and system validation.
- Develop CSP insurance program (like FDIC) to cover losses should failures occur in order to engender confidence of investors.

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Program Management Recommendations

- Commission a high-level expert study of innovative science and engineering opportunities for a new generation of cost-competitive high reliability CSP technologies responsive to existing and emerging markets. Ask study to identify and rank opportunities for new science and engineering to advance all CSP technologies.
- Continue assisting industry developers with supporting science, engineering, components testing AND R&D[3] on novel concepts.
- Evaluate and possibly restructure current programs to address intermediate and especially longer range opportunities to innovate CSP technology.

Distributed Power Systems Findings and Evaluation

Distributed Power Systems

- Overall the supporting research and development in the distributed power program is of high quality and focused on improving the performance of critical components which would either lower costs or increase reliability to lower risks for commercial adoption of dish engine technologies.
- Modular (5-25 kWe) dish systems provide "entry" opportunities with low capital investment.
- Ease of installation, modularity, and mobility can follow demand.
- High-efficiency means less materials and land area.
- Individual component shutdown has little effect on field power output.

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Distributed Power Systems

- Based upon input from industry, it appears that the CSP Program provides exceptional engineering support. This support, however, could be increased with the identification of more current systems for testing and validation.
- The program performance is outstanding considering available resources and offers significant relevance to industry. However, use of new technology would assist the Labs in offering the guidance necessary to insure greater system efficiency and reliability.
- Dishes have shown progress on reliability but further improvements are needed.

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Distributed Power Systems Recommendations

Distributed Power Recommendations

- Increase number of operating systems to gain better data base for characterizing and lowering MTBF
- Need program to study seal materials and sealing concepts because of uncertain reliability.
- Need program on combined receiver/heater head development.
- Address reliability issues through greater use of state-of-art modeling and simulation and new scientific/engineering concepts.
- Reduce need for "100s of systems" to provide insight on system reliability.

Distributed Power Recommendations

- Use innovative science and engineering pro-actively.
- The use of CPV concepts in distributed power applications should be pursued.
- The CSP Program should take full advantage of the Nevada 1 MW_e initiative.
- Opportunities afforded by building integrated roof-top trough systems for distributed systems should be pursued as part of the DOE's Zero Energy Buildings (ZEB) initiative.

Dispatchable Power Systems Findings and Evaluation

Dispatchable Power Systems

- Familiarity of power cycle by utilities.
- Ease of extending operating hours with thermal storage.
- Most developed of CSP technologies.
- Troughs easily used as preheat for combined cycles.
- Large sizes require large investments.
- Visual impact of high bright towers is a siting issue to be taken seriously.
- A clearer, more crosscutting analysis of the effects of storage on both capital and operating costs is needed, and the value of having dispatchable power needs to be analyzed.

Dispatchable Power Systems

- Trough program has made considerable progress with respect to concentrator and reflector development to further increase performance in terms of capture efficiency and robustness. All of these advancements help reduce both capital and operating costs. The work on the storage elements of trough systems is appropriately focused on critical issues that address the temperature cycle and heat transfer characteristics.
- The 5+ year operating history of the U.S. Luz plants is encouraging with respect to availability and total kWh generated. This clearly demonstrates the viability of trough systems for wider deployment in the Southwest consistent with the DOE's goal of 1000 MWe of CSP by 2006.

Dispatchable Power Systems

- SunLab offers a critical service through its program that validates components. This work supports efforts to increase and stabilize the reliability of systems and offers credible data on performance.
- Many good cost/performance improvements underway, good industry participation, very relevant to large scale where $.10-.20/kWh can be supported.

Dispatchable Power Systems

- Solar 1 and 2 helped set the stage for Solar Tres and other [international] power tower opportunities.
- Clearly a market – at least internationally – for these technologies. Nothing wrong with using American expertise to export a valued product.
- Large-scale troughs most mature technology. Salt Storage R&D is an important component that needs continued attention.

Dispatchable Power Systems Recommendations

Dispatchable Power Systems Recommendations

- The trough roadmapping exercise is an important process that should be continued. The 1998 study needs to be updated to reflect current programmatic goals and objectives and progress that has been made with engineering and system components.
- SunLab can and should play a large role in testing and validating the performance of components for trough systems.

Dispatchable Power Systems Recommendations

- The potential application of trough systems for combined heat and power application in buildings should be investigated further and more actively supported by the DOE.
- Continue to pursue a combined cycle plant for adding solar trough preheat.
- Develop U.S. sources for receiver tubes and mirrors.

Advanced Components and Systems Findings and Evaluation

Advanced Components and Systems

- Focused on innovation and revolutionary change to more than incrementally lower the costs of CSP.
- Heat pipe and hybrid heat pipe receivers critical to dish/Stirling development (efficiency improvement and failure reduction) excellent engineering approach.
- Heat pipe development work looks promising as it could increase receiver performance by 20%.

Advanced Components and Systems

- Hybrid receiver - Stirling engine work is a 6+ year project at $700K investment that could lead to a 20% improvement in performance and substantial reduction in costs, especially with the avoidance of storage.
- Hybrid systems using concentrated solar energy should be looked at aggressively by the CSP program as partnerships with fossil programs are timely.

Advanced Components and Systems

- Resource assessment of solar resource is a key feature for matching the resource to the solar converter to the end use. The effects of particulates and other aerosols on the direct normal radiation (both spatially and temporally) it has a measurable effect on reducing CSP performance and could affect plant siting.
- Energy analysis efforts in SunLab are small and not completely integrated into the EIA-NEMS modeling. The methodology used in the NEMS model does not accurately predict market penetration. Furthermore, the EIA model does not include uncertainty in their predictions of costs, etc., in a very transparent way. The actual value of having dispatchable CSP capacity has not been quantified correctly.

Advanced Components and Systems

- The concentrating photovoltaics program (CPV) represents an exciting opportunity for providing an alternative converter concept with comparable efficiency and performance to Stirling engines and may offer additional advantages of lower costs and higher reliability.
- There appears to be an impending loss of SunLab capability in the optical component testing and development areas because of a shortfall of funding. This is unfortunate because of the large impact that improved reflectors have on lowering costs.

Advanced Components and Systems

- DNI insolation maps highlight high insolation areas, and show that most of US has at least 50% of maximum insolation as the SW, indicating a large potential for other CSP sites.
- Important comparison numbers for CSP technologies are being generated by other government agencies, e.g., EIA, with insufficient input from the CSP Program.

Advanced Components and Systems Recommendations

Advanced Components and Systems Recommendations

- A more complete analysis of the impact of advanced system components should include the value of such things as avoiding storage needs to be more dispatchable, the tradeoffs between lower cost components and increased capture efficiency and reliability. Increased staff effort and funding support for this area are needed.

Advanced Components and Systems Recommendations

- CPV testing results show promise and should continue to be funded. There is a strong opportunity for collaboration with the PV program.
- Accelerate on-sun testing of concentrating PV panels to determine lifetime potential.
- The CPV development work should be managed as a collaboration of the NCPV and SunLab with industrial partners and not use redirected funds out of the CSP program.

Advanced Components and Systems Recommendations

- Resource assessment needs more support. With the reorganized, more holistic approach to managing the solar R&D budget perhaps the DOE could increase the support of resource assessment for all of solar.
- Emphasize that insolation maps show high insolation in most of US, not only the SW.
- Develop more expertise to evaluate DOE/EIA single-number generating programs to ensure proper CSP input and provide evaluation commentary.

Advanced Components and Systems Recommendations

- Long term reliability and performance testing of heat pipe conventional and hybrid receivers should be accelerated to reduce time for development of a commercially acceptable product.

Advanced Components and Systems Recommendations

- Dish hybrid program should evaluate; e.g., by power cycle and total systems simulation studies, opportunities for scale-appropriate synergisms with expected advances in gas-fired turbines, gas-fired combined cycles, and other advanced power cycles firing coal, biomass, and coal-biomass mixtures.
- Storage techniques which increase dispatchability and, therefore, increase the value of CSP power should continue to be a major R&D component.

Test and Research Facilities Findings and Evaluation

Test and Research Facilities

- World class capability. Vital as we move forward on 1000 MW_e project that SunLab expertise is preserved and enhanced.
- Demonstrated ability to validate and test parts.
- Responsive to industry needs.
- Over $200 million of equipment investment at Sandia and NREL provide a unique national asset that is without equal.
- Essential for cost-effective advancement. Good relevance and use.

Test and Research Facilities

- Excellent test facilities for dishes and troughs, central receiver components, optical components, and extremely high-flux testing.
- SunLab testing facilities cut across all CSP technologies.
- UNLV solar test facility is visible, accessible, and trains students to understand CSP.

Test and Research Facilities

- Because of insufficient funding, SunLab test facilities are underutilized by program, delaying updating and requiring searching for contracting from outside.
- Public visibility and access to NSTTF (Sandia) test facility is limited because of its location in a restricted area.

Test and Research Facilities Recommendations

Test and Research Facilities Recommendations

- **Resources for integrating testing at field sites in the SW to SunLab activities should be provided in support of the 1000 MW initiative.**
- **Study impacts of combining NREL and SNL solar test facilities.**
- **Increase public visibility of CSP through the test facilities (PR program, site tours, etc).**
- **Encourage more experimental work by SunLab staff to develop new concepts.**

CSP Peer Review Panel Members

Professor Jefferson Tester, Chair Peer Review Panel: Dr. Tester is H.P. Meissner Professor of Chemical Engineering and Director of MIT's Energy Laboratory. His formal educational training was in chemical engineering at Cornell University (BS '66 and MS '67) and at MIT (PhD '71). For three decades, he has been involved in various aspects of chemical engineering process research as it relates to energy extraction and conversion and environmental control technologies and has coauthored eight books and more than 120 papers on various topics in these areas. Research topics have ranged from geothermal reservoir and drilling technologies, power conversion system design and economics, assessing local, regional, and global environmental effects caused by energy supply and use, to using supercritical fluids as reaction media to replace toxic solvents.

Dr. Tester is a member of the American Institute of Chemical Engineers, American Chemical Society, the Society of Petroleum Engineers, Tau Beta Pi, Sigma Xi, and the Geothermal Resources Council. He currently teaches graduate and undergraduate subjects in thermodynamics and has won several teaching awards including the Department's Outstanding Faculty Member Award in 1986, 1987, and 1990. He is a member of the National Research Council and has served as an advisor to the USDOE and its National Laboratories in areas related to geothermal energy technology and waste minimization and pollution reduction. He recently served on a federal panel advising President Clinton on Energy Technology R&D. Dr. Tester also serves on the editorial boards of the Energy and Fuels Journal, Journal of Supercritical Fluids, and Annual Reviews of Energy and the Environment.

Professor William Peters: Dr. Peters is the Associate Director of the MIT Energy Laboratory. He received his advanced degrees (B.Sc. McGill, '67, Ph.D. MIT, '72) in physical chemistry and performed post-doctoral work at Yale ('72 – '74) before joining MIT as a Research Associate in 1974. The primary mission of the Energy Lab is to develop and perform externally-funded, single- and cross-disciplinary research in energy and energy-related environmental topics. As Associate Director, Dr. Peters' responsibilities include identifying and marketing new research initiatives, expanding participation by MIT faculty, students, and research professionals, and partnering with the Laboratory's other three senior management officers in tactical and strategic planning of the Lab research agenda and operations. Dr. Peters' research is primarily concerned with applications of thermal processing and electro-thermal processing to energy and the environment. His current interests are sustainable utilization of fuels and other resources (forests, minerals, water), fuel conversion, extractive metallurgy, industrial chemistry, and environmental cleanup (contaminated soil, aqueous wastes, human toxicants, and various military hazardous materials). Dr. Peters has authored or coauthored over 75 technical publications and holds four U.S. patents.

Mr. Glen Hamer: Mr. Hamer received a Bachelors Degree in Industrial and Labor Relations from Cornell University ('91) and a Doctorate of Jurisprudence from Arizona State University ('94). Mr. Hamer worked with Congress as a legislative assistant for Senator Jon Kyl and legislative director and chief of staff for Representative Matt Salmon. In January 2001, Mr. Hamer became Executive Director of the Solar Energy Industry Association where his responsibilities include directing the legislative agenda and testifying before Congress in addition to all internal operations.

Ms. Rose McKinney-James: Ms. McKinney-James is a graduate of Olivet College and received her Juris Doctorate from Antioch School of Law. Ms. McKinney-James has a broad-based background of management experience, much of which is in government. A few of the jobs she's held that are more relevant to her post on the Review Panel are President and CEO of the Corporation for Solar Technology and Renewable Resources, Director for the Department of Business and Industry State of Nevada, Nevada Public Service Commissioner, and Staff Assistant to Congresswoman Shirley Chisholm. Ms. McKinney-James has also served on a number of boards including the Desert Research Institute and the National Association of Regulatory Utility Commissioners (NARUC) for which she is a past Secretary-Treasurer and President. She is currently the President of Brown & Partners, a business consulting group specializing in advertising, public relations, and public affairs. Ms. McKinney-James is also currently a member of the Energy Foundation, the Coalition to Advance Sustainable Technologies, and Chair of the Regulatory Reinvention Committee. She has received numerous awards including the League of Women Voters Leadership Award (1998) and the Federal Energy Management Program Solar Commendation (1997).

Mr. Herbert Hayden: Mr. Hayden works for Arizona Public Service (APS) in the Technology Development Department. He graduated from Arizona State University in 1983 with a Bachelors Degree (with honors) in Electrical Engineering. Prior to APS, he worked for Motorola Government Electronics in the development of advanced electronic systems, and served in the US Army in tactical telecommunications. Prior experience at APS includes the development of specialized 800Mhz radio and data communications networks, microwave links, and standby power systems. Mr. Hayden is currently Solar Program Coordinator for APS where he is responsible for solar technology development and the initiation of new solar-based services at APS, including the use of photovoltaic and solar thermal electric power systems for off-grid and grid-connected applications. Several notable accomplishments of the APS Solar Program under his leadership include: the installation and operation of over 1 MW of solar generation, with an additional megawatt under construction; the development of a high-concentration PV tracking system, including structure and controls; currently 500kW of the high-concentration PV system are being constructed and operated; development of Remote Solar Electric Service, providing and maintaining small hybrid PV systems for service to remote homes and ranches in Arizona; and the installation of two Dish Stirling systems in Arizona. He is a former Vice Chairman of the Arizona Solar Energy Association and member of the American Solar Energy Society. Mr. Hayden is an Arizona native and has lived in Tempe since 1981.

Professor William Stine: Dr. Stine received his formal educational training in Mechanical Engineering (BS West Virginia '58, USC MBA '63 and MS '67, PHD USC '72). Professor Stine has had a distinguished professional career starting with 10 years at North American Rockwell Corp. working on propulsion systems. In 1973, he joined the Mechanical Engineering Department of California Polytechnic Institute at San Luis Obispo and, from 1983 to the present, he has been in a similar position at Cal Poly, Pomona. Dr. Stine's areas of expertise are energy and the thermal sciences, specifically: solar energy, heat transfer, fluid mechanics, combustion, and measurement systems. He is a member and past Chair of the ASME Solar Energy Division, a member of the American Solar Energy Society and the International Solar Energy Society, and a past Associate Editor for Solar Thermal Power of the Journal of Solar Energy Engineering. Dr. Stine has authored and coauthored six books and more than 50 technical papers, articles, and reports on solar and renewable energy topics. He is currently Professor Emeritus at Cal Poly at Pomona. Dr. Stine and his equally-accomplished wife continue to teach classes at Cal Poly while sharing time between homes in Santa Fe, NM, and Almeria, Spain.