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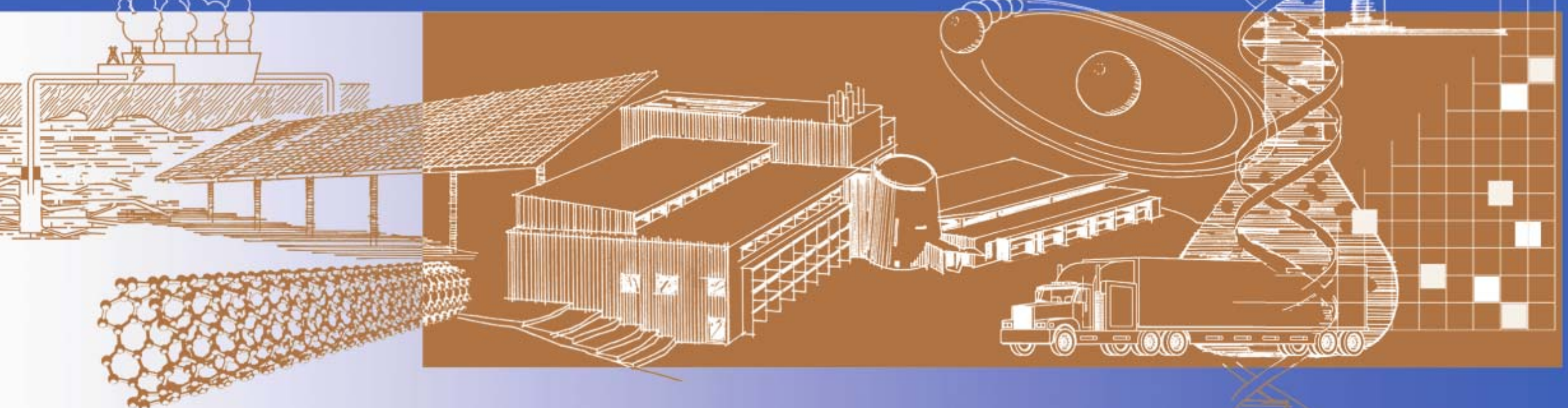

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Solar Technology and Policy Analysis to Support the Systems-Driven Approach

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ABSTRACT

The primary focus of the Systems-Driven Approach (SDA) analysis team is to improve the analytical basis for understanding the system and policy drivers of solar technologies in various markets. Analysis activities during the past year have focused in three inter-related areas: 1) developing long-term market penetration projections for the full set of technologies funded within the Solar Energy Technologies Program, 2) reviewing the Program's out-year cost and performance targets for photovoltaic (PV) technology, and 3) evaluating policies, as well as other factors, that impact the value of solar energy technologies in various markets. This paper will summarize the results of these activities and describe how they relate to the overall SDA effort.

1. Objectives

The main objective of the SDA analysis team is to establish a sound analytical basis for understanding the system and policy drivers of solar technologies in various markets. Results from our analysis activities are linked to the broader SDA process and provide a market context for the benchmarking and modeling efforts. In our analysis work, we draw on expertise of analysts and scientists at the laboratories, U.S. Department of Energy (DOE), and the broader solar community. And we strive to strengthen the SDA process, as well as to increase the awareness of the market potential and the extended value stream for solar technologies.

2. Technical Approach

The analysis team has focused its initial efforts on three main tasks. The first task is to develop long-term market penetration projections for solar technologies. This effort involves examining both the *system* and *policy* drivers of solar technologies in various markets in both the short-and long-term, as well as improving the analytical basis for projecting the Program's economic and environmental benefits. Here, our emphasis is on models and modeling: using existing models—such as the Energy Information Administration's (EIA's) National Energy Modeling System, MARKAL[1], and others—to carry out analysis, examining the structure of various models and providing feedback on how to improve the representation of solar technologies to modelers, and developing new models that will help meet the needs of the broader systems-driven approach modeling effort.

The second task is to review the feasibility of achieving the Program's technical and economic targets. This task draws on both internal and external experts to examine the proposed research goals given technical, funding, and other constraints. Here, our emphasis is on reviewing the existing literature on cost and performance projections, drawing on experts from both within and outside the solar community to review detailed technology cost models, and grounding the Program's targets in real-world experience.

The third task is to evaluate policies, as well as other factors, that impact the value of solar energy technologies in a variety of markets. This task involves using existing models (such as the Clean Power Estimator), spreadsheets, and other tools. Here, our emphasis is on using analytical tools to quantify how changing policies, rate structures, system designs, and other factors will impact the value of solar technologies to consumers, utilities, governments, and other actors.

3. Results and Accomplishments

This section will briefly discuss the analysis team's results and accomplishments for the three tasks discussed above. First, with respect to long-term market penetration projections, we carried out a detailed analysis of the potential role of central and distributed solar energy technologies in the United States over the long-term, i.e., through 2050. In carrying out this analysis, we developed and used a modified version of EIA's National Energy Modeling System (NEMS), and produced a range of solar energy technology and policy focused scenarios. Our main conclusion was that solar energy is well suited to become a major contributor to the U.S. national energy portfolio over the next 25–50 years; however, achieving this vision will require setting aggressive but realistic R&D goals, as well as implementing policies aimed at increasing the penetration of solar energy technologies into the marketplace. Further details about this analysis can be found in Margolis and Wood [1].

A benefit of using NEMS in our analysis of the long-term market potential for solar has been that we have gained considerable insight into how NEMS models the various solar energy technologies. This insight has enabled us to provide feedback to EIA about how to improve the

[1] For details on the MARKAL (MARKet ALlocation) model see the International Energy Agency's Energy Technology Systems Analysis Programme (ETSAP) website: http://www.etsap.org.

representation of solar technologies in NEMS. This is particularly important given that NEMS is used to produce EIA's annual energy outlook, which is widely used in policy discussions, and the DOE/Energy Efficiency and Renewable Energy (EERE) benefits estimates, which are required under the Government Performance Results Act (GPRA).

We have also begun to examine how MARKAL (another model used in the DOE/EERE GPRA benefits assessment) represents solar and to develop our own PV market penetration model. The goal of this effort is to improve the representation of solar technologies in existing models and to develop an alternative model that will inform the work of other analysts, as well as meet the internal needs of the Program.

Second, with respect to reviewing the Program's technical and economic targets, our initial focus has been on PV technology. This approach makes sense given the recent work carried out by Sargent and Lundy [2] on concentrating solar power (CSP), as well as the size of the PV Subprogram relative to the other solar subprograms. The Program's recently published *Multi-Year Technical Plan* [3] set the following target for PV: to reduce the levelized energy costs (LEC) of PV systems to $0.06/kWh by 2020. Although our work in evaluating the feasibility of achieving this target is still in a relatively early phase, we have laid out a logical approach: begin with a review of PV *module* cost and efficiency projections, then carry out a review of *inverter* costs and performance projections, and finally, assemble a complete review of PV *system* cost and performance projections. At this point, we are working with researchers at the University of California–Berkeley to conduct a literature review of PV *module* cost and performance projections.

Third, with respect to value analysis, our emphasis has been on quantifying the reliability, security, and time-of-use value of PV. Two examples of the types of analysis that have come out of this effort include Perez et al. [4] and Hoff and Margolis [5]. Perez et al. used satellite images to examine the availability of dispersed PV during the August 14, 2003, Northeast power outage. They concluded that had a local dispersed PV generation base amounting to at most a few hundred megawatts been on line, power transfers would have been reduced, point-of-use generation and voltage support would have been enhanced, and uncontrolled events would not have evolved into the massive blackout. This type of analysis helps to build the foundation for understanding the potential for solar technologies to play a role in making the electricity grid more robust and secure.

Hoff and Margolis compared the value of PV systems to residential customers under time-of-use (TOU) rates and standard rates (i.e., non-TOU rates). They found that the value of switching from a standard to a TOU rate and then adding a PV system is highly dependent on the customer's original load profile and the size of the PV system installed. For example, for the case of a typical residential customer in PG&E's service territory in California, they found that bundling PV with a TOU rate switch would increase the value of the PV system by 20 to over 100 percent. They also examined existing TOU rates across the United States and found that they would increase the value of PV for most locations in the United States, with the increase ranging from negligible to over 50 percent.

4. Conclusions

The analysis team's research agenda focuses on improving our understanding of the long-term market potential for solar technologies, reviewing the Program's technical and economic targets, and carrying out detailed value analysis of solar technologies. Together, these activities strengthen the systems-driven approach by providing market context for the benchmarking and modeling activities, as well as producing stand-alone analysis products.

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REFERENCES

[1] R. Margolis and F. Wood. "The Role for Solar in the Long-Term Outlook of Electric Power Generation in the U.S." Paper presented at the IAEE North American Conference in Washington, DC, July 8–10, 2004.

[2] Sargent and Lundy Consulting Group. *Assessment of Parabolic Trough and Power Tower Solar Technology Cost and Performance Forecasts*, May 2003, SL-5641, http://www.energylan.sandia.gov/sunlab/PDFs/Assessment.pdf

[3] U.S. Department of Energy. *Solar Energy Technologies Program: Multi-Year Technical Plan 2003-2007 and Beyond*, Office of Energy Efficiency and Renewable Energy, January 2004. (Identifier No. DOE/GO-102004-1775) http://www.nrel.gov/docs/fy04osti/33875.pdf

[4] R. Perez, et al. "Availability of Dispersed Photovoltaic Resource During the August 14th 2003 Northeast Power Outage" Paper presented at the ASES2004 Conference in Portland, Oregon, July 11–14, 2004.

[5] T. Hoff and R. Margolis. "Are Photovoltaic Systems Worth More to Residential Consumers on Net Metered Time-of-Use Rates?" Paper presented at the ASES2004 Conference in Portland, Oregon, July 11–14, 2004.

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