THE SOLAR ENERGY TECHNOLOGIES PROGRAM’S SYSTEMS DRIVEN APPROACH to MANAGING THE SOLAR R&D PORTFOLIO

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On Assignment to Solar Energy Technologies Program
What is the Systems-Driven Approach?

As defined in the SETP Multi-Year Technical Plan:
“All technical targets for R&D on the components and systems funded through the Solar Energy Technologies Program are derived from a common market perspective and national goals, and the resultant technologies are tested and validated in the context of established criteria for each market.”
Why a Systems Driven Approach?

- The solar program is an applied research program.
  - Research must be conducted with the end in mind.
- The Systems Driven Approach provides a framework for program planning:
  - **Benchmarking** to document the current state of the technology and to validate model output.
  - **Modeling** to create a common platform for sensitivity studies at the systems-level and below
    - Evaluate benefits of ongoing and proposed R&D
    - Identify new R&D opportunities via parametric studies
  - **Analysis**
    - Of the market impact of achieving program goals
    - Of the feasibility of proposed research tasks
- **Benchmarking** begins with standard system configurations from the multi-year technical plan
  - Residential (with and without storage) and utility-scale PV (with commercial PV to be added)
  - Utility-scale troughs and towers
  - Parabolic dish-engine and concentrating PV
  - Solar water heating and hybrid solar lighting
- **Cost and performance** to be benchmarked
  - At the system level
  - At the component level
  - At the subcomponent level
  - Not currently detailed in the Multi-Year Technical Plan
Modeling begins with creation of a user-friendly platform for systems-level sensitivity studies.

A graphical user interface provides:
- Access to various standard configurations of solar systems
- Ability to change parameters from default values
- Drop-down menus for in-depth drill-down
- Optional or user-defined submodels
  - E.g. spreadsheets or subroutines called by the model
- Results in the form of exportable data and graphics
Analysis provides context

- What is the relationship of key parameters to market penetration
  - If we achieve 6¢/kWh, what market size might result?
- Which markets are key to achieving GW's of installed solar?
- Are proposed research tasks (cost, schedule, performance) realistic?
  - Evaluate in partnership with internal and external experts
  - Study results of comparable R&D
● Where are we now?
  - The team is making progress in all three areas
  - Initial goal is information and tools that can be used by program managers and researchers to evaluate research options
  - Initial focus is on flat-plate photovoltaics
    ● PV is the target of most of the solar program’s resources
    ● Concentrating solar power from parabolic troughs and power towers were evaluated through the Sargent and Lundy study.
Benchmarking of PV system cost and performance is underway
- Team includes Sandia, Florida Solar Energy Center, SW Technical Development Institute and NREL.
- Team is working closely with private and public sector partners
  - Includes component cost and performance, installation, O&M, etc.
  - Protecting proprietary information is essential

Program research teams and industry partners are most familiar with cost and performance information at the subcomponent level
- These sources tapped as increasing detail is required
Over 250 school & home systems in Florida providing data

Detailed breakdown of installed prices

DASs on over 40 systems provide daily performance information

Close tracking of O&M actions allows determination of system reliability, availability, for energy calculations

- **Inverter Workshop Oct 13-14., 2003** Slide 9
• A graphical user interface has been developed and usability sessions have been conducted.
• PV system performance models have been coded
• Coding of PV component models is underway
• Cost models are currently rudimentary
  – They do not yet support some of the desired sensitivity studies
• Capability of sensitivity analysis has been demonstrated, but results have not been validated
Main Interface Screen

- **Results**: Complete
- **Program**: Technology: Photovoltaics, Market: Residential, Application: Electricity
- **Environment**: Climate: CO Boulder, Utility Rates: Flat Rate, Financials: Residential - Mortgage, Loads: Under Development
- **System**: Configuration: Rack, Collector: Siemens SR100 (12V), Array / Field: 1-axis, Converter: Generic FlatPlate w/ sing, Storage: NONE, ESS: Under Development, Costs: $15,300.00

Graph: After Tax Cash Flow versus Calendar Year
- 2001: -$15
- 2002: 4.377977675
- 2003: 5.228696782
- 2004: 4.59376705328
- 2005: 4.25818813411
- 2006: 4.4113598208276
- 2007: 4.2158103736801
- 2008: 4.026216686071
- 2009: 4.13725543351
- 2010: 4.3547561508578
- 2011: 4.526946411696
- 2012: 4.7101042618156
- 2013: 4.89858438882
- 2014: 5.064423704289

Graph elements: Inflation Rate, Discount Rate, BOS Cost, Collector Cost, Converter Cost.
Program Screen

Technology
- Photovoltaics
- Concentrating Solar Power
- Solar Thermal

Market
- Central Generation
- Distributed Generation
- Buildings (grid-tied)
  - Commercial
  - Residential
- Off Grid

Application
- Electricity

Environment
- Climate: CO Boulder
- Utility Rates: Flat Rate
- Financials: Residential - Mortgage
- Loads: Under Development

System
- Configuration: Rack
- Collector: Siemens SR100 (12V)
- Array / Field: 1-axis
- Converter: Generic Flatplate w/ sing
- Storage: NONE
- EDS: Under Development
- Costs: $15,300.00
Cost Screen

- **Costs**
  - **Collector**: $500.00 / unit, 1 unit, 2.00 kW, $3,000.00/unit, $6,000.00, 52.29%
  - **Converter**: $200.00 / unit, 1 unit, 0.00 kW, $3,000.00/unit, $3,000.00, 19.61%
  - **Storage**: $0.00, 0.00%
  - **BOS**: $2,000.00, 13.07%
  - **Installation**: $2,000.00, 13.07%
  - **Marketing**: $0.00, 0.00%
  - **O and M**: $300.00, 1.96%

- **Total Costs**: $15,300.00, 100%

- **Data Type**
  - Default
  - User-Specified
  - From Detailed Calculations
  - Parametric
Example sensitivity study – inverter cost vs. lifetime in a residential system

Data Not Validated – Example Only –

- 5-yr, 50¢/W
- 10-yr, 80¢/W
Example sensitivity study – improving module efficiency vs. inverter lifetime in a residential system

Constraints – Inverter Cost and Module Cost ($/W) do not change

Compares cost of inverter replacement with cost of area-related BOS
- A Solar 2050 study illustrates long-term projections for solar using Energy Information Administration modeling system
- PV market penetration model in development
  - Designed to be compatible with SDA model
- Value analysis underway – 3 papers presented
  - Includes effect of net-metering on PV system value
- Review of program’s technical and economic targets
  - Literature review of PV cost and efficiency projections
  - Planned for next year:
    - Real world experience vs. cost models estimates for PV manufacturing facilities
    - Inverter cost & performance experience and projections
Solar 2050 Project

Key Findings

- Unconstrained, coal continues to dominate.
- Adding a carbon value opens energy markets to all renewables.
- Attaining R&D goals must be done quickly to have a major impact by 2050.
- Policies must augment enhanced R&D to stimulate market entry of solar.
- A robust mix of solar technologies could help lower carbon emissions.
“Are Photovoltaic Systems Worth More to Residential Consumers on Net Metered Time-of-Use Rates?” (Hoff and Margolis)

- 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 size of PV system installed.
- TOU rates increase the value of PV for most locations in the U.S. with the increase ranging from negligible to over 50 percent.
Next Steps

- Modeling will be demonstrated at the Solar Program Review in Denver, October 25-28.
- Initial release of beta version by end of 2004
- Application to PV subprogram in FY-05.
- Benchmarking, modeling, and analysis will continue to evolve as capability is added, driven by program needs
  - Improved inverter model will be incorporated
    - Treat MTTF as a distribution
    - Conduct parametric analysis to look for opportunities for cost reduction related to inverters
- Applying the Systems-Driven Approach to inverters
  - Need to understand the most sensitive cost drivers in inverters
  - Propose analysis that should be done
    - Identify system/component impacts on inverter cost
  - Provide access to relevant models, costs and other data