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

Systems-Driven Approach

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 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

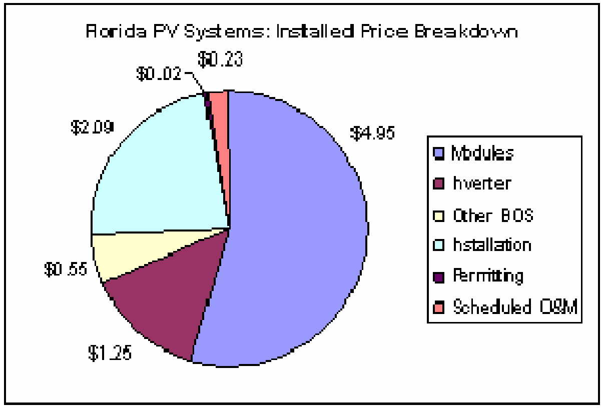
- **Modeling** begins with creation of a user-friendly platform for systems-level sensitivity studies
- A graphical user interface provides:
  - Access to various standard configurations of solar systems
  - Ability to change parameters from default values
  - Drop-down menus for in-depth drill-down
  - 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 Events per Event Mode

Action – Mode	Count	Parts Cost min – avg – max			Labor Cost min – avg - max			Average Down Time
Replaced Component – Inverter-Internal	5	0	340	1700	25	70	100	38.20
Replaced Component – Inverter-Sizing	1	0	0	0	0	0	0	
Repaired – Inverter-Fuse Failure-Unknown Cause	6	0	6.67	10	120	120	120	4
Repaired – Inverter-Internal	5	0	26.6	80	50	50	50	60.40

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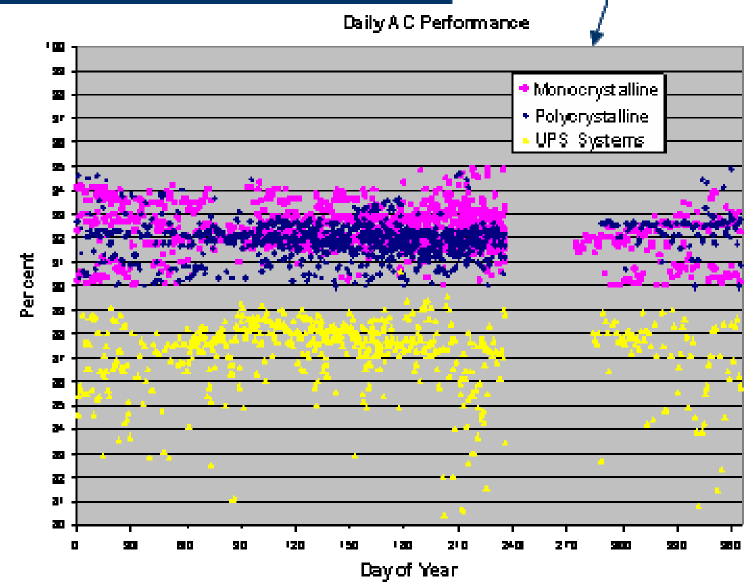
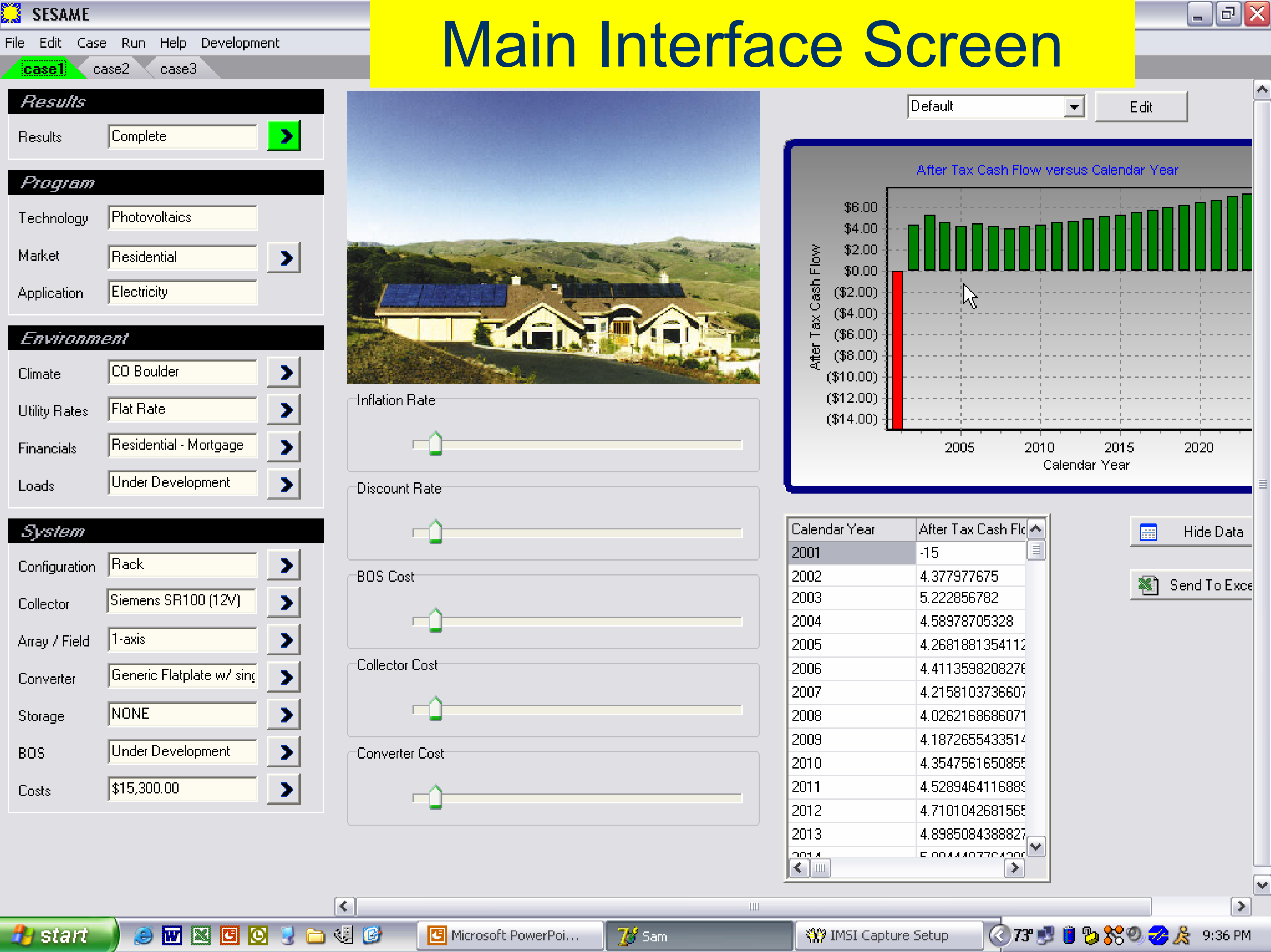


- A graphical user interface has been developed and usability sessions have been conducted.
- PV system performance models have been coded
- Coding of PV component models is underway
- Cost models are currently rudimentary
  - They do not yet support some of the desired sensitivity studies
- Capability of sensitivity analysis has been demonstrated, but *results have not been validated*

Main Interface Screen



Program Screen

SESAME

File Edit Case Run Help Development

case1 case2 case3

Results

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
BOS	Under Development
Costs	$15,300.00

Technology

- (•) Photovoltaics
- ( ) Concentrating Solar Power
- ( ) Solar Thermal

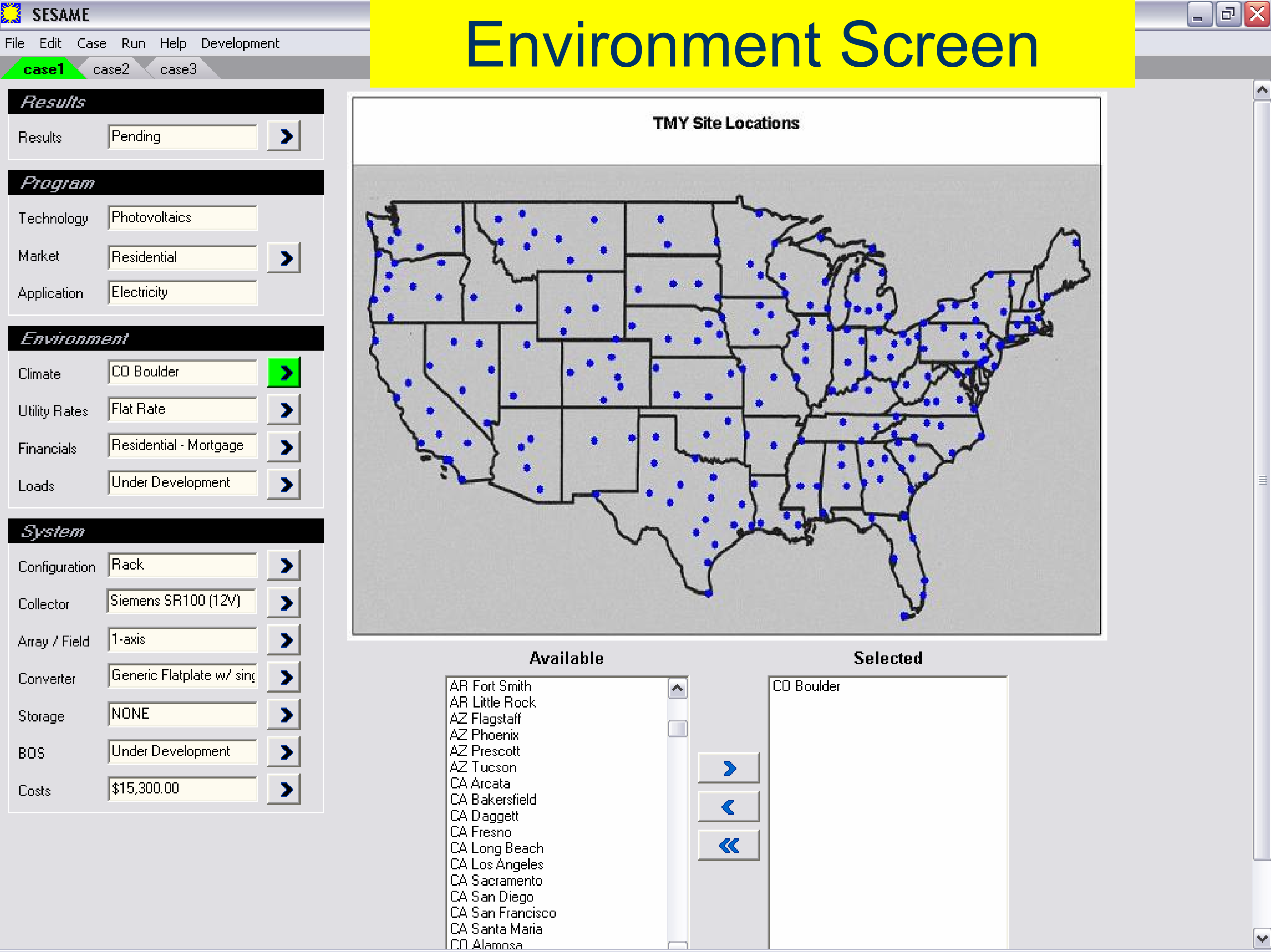
Market

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

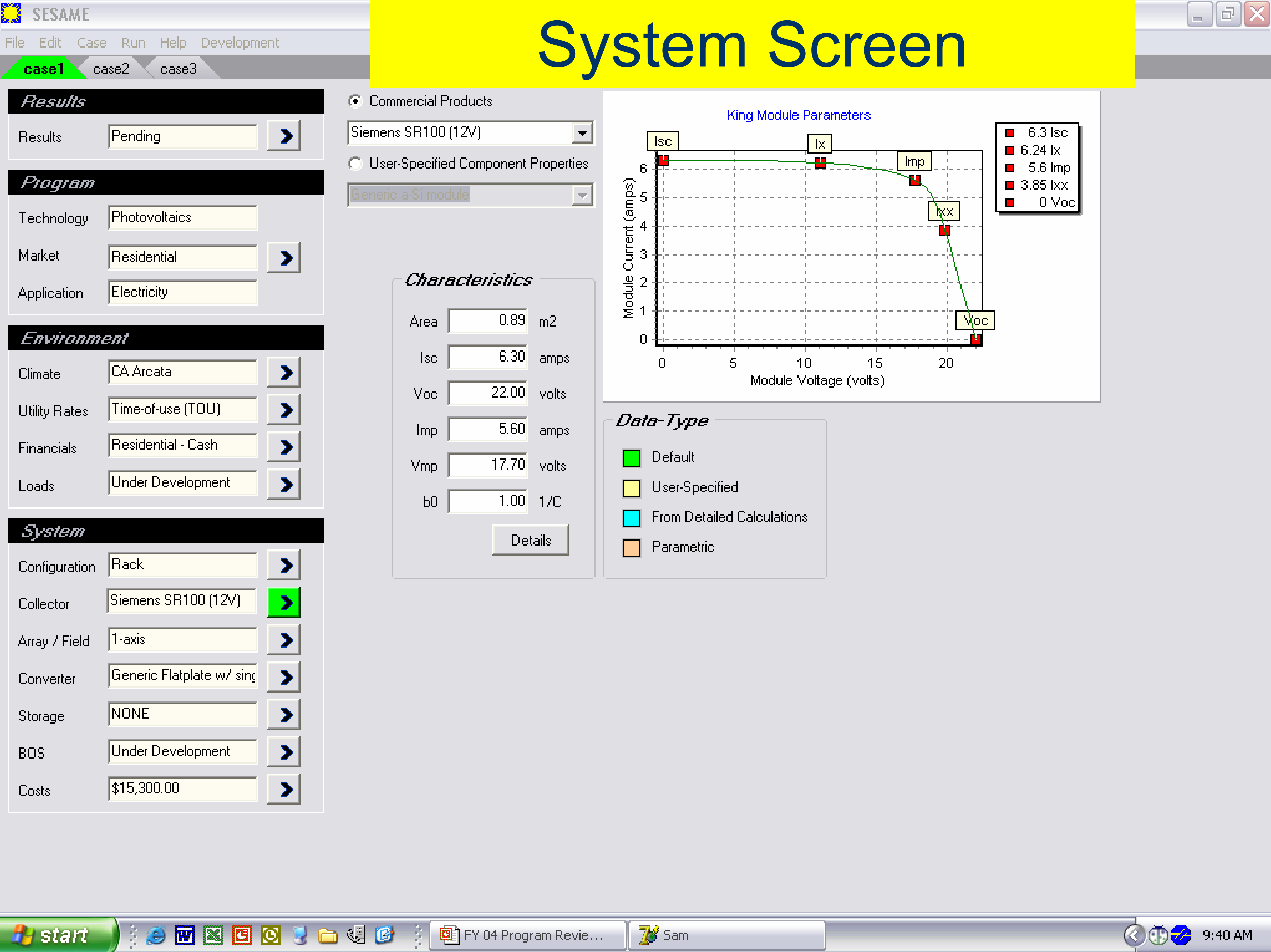
Application

- [x] Electricity

Environment Screen



System Screen



Cost Screen

SESAME

File Edit Case Run Help Development

case1 case2 case3

Results

Results	Pending

Program

Technology	Photovoltaics
Market	Residential
Application	Electricity

Environment

Climate	CA Arcata
Utility Rates	Time-of-use (TOU)
Financials	Residential - Cash
Loads	Under Development

System

Configuration	Rack
Collector	Siemens SR100 (12V)
Array / Field	1-axis
Converter	Generic Flatplate w/ sinç
Storage	NONE
BOS	Under Development
Costs	$15,300.00

Costs

Collector	500.00	W/unit	1	units	2.00	kW	$8,000.00	/unit	$8,000.00	52.29 %
Converter	200.00	W/unit	1	units	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 %
								Totals	$15,300.00	100 %

Details

Data-Type

- Default
- User-Specified
- From Detailed Calculations
- Parametric

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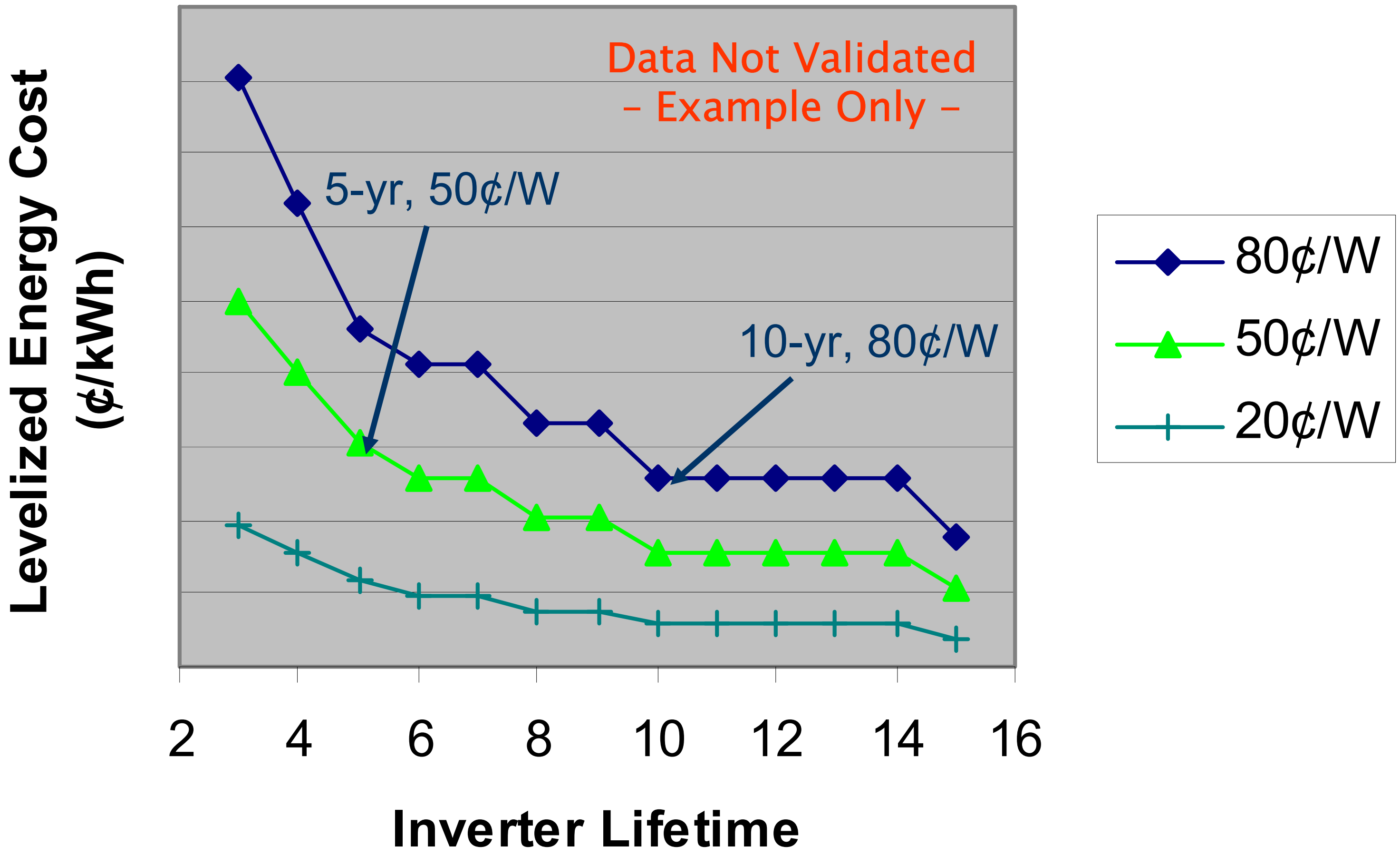
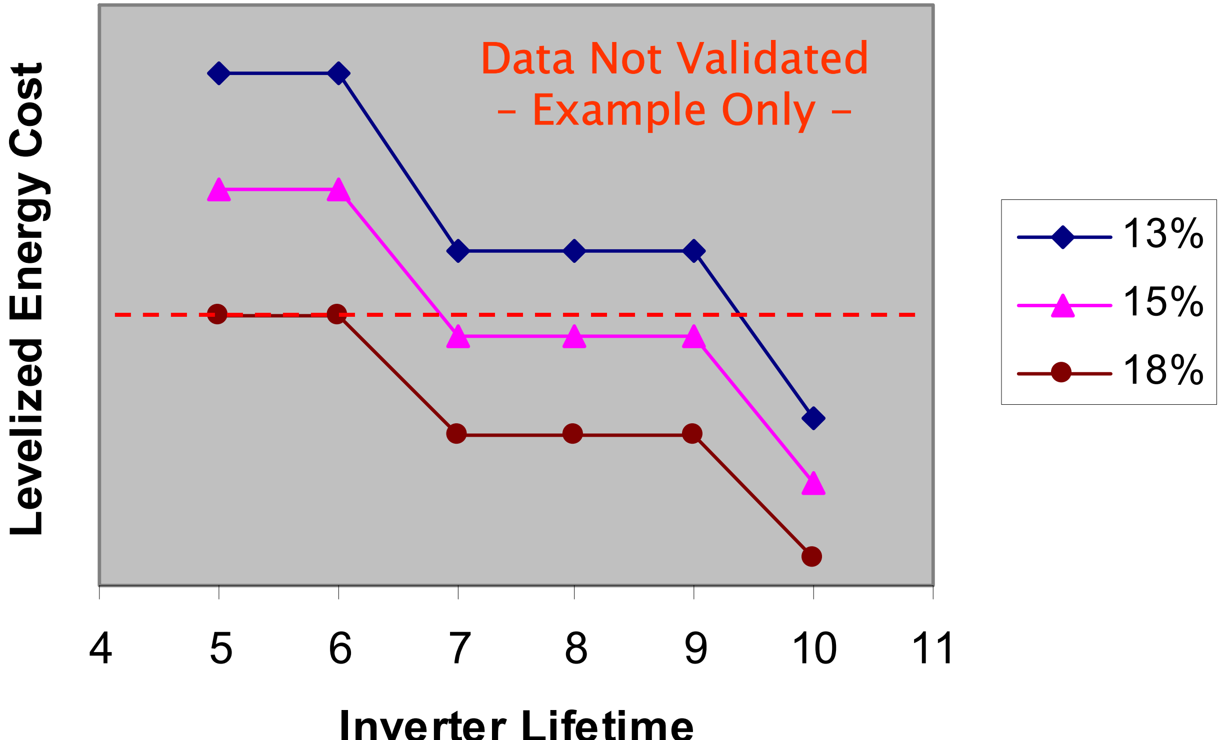
- Example sensitivity study –inverter cost vs. lifetime in a residential system



- Example sensitivity study – improving module efficiency vs. inverter lifetime in a residential system



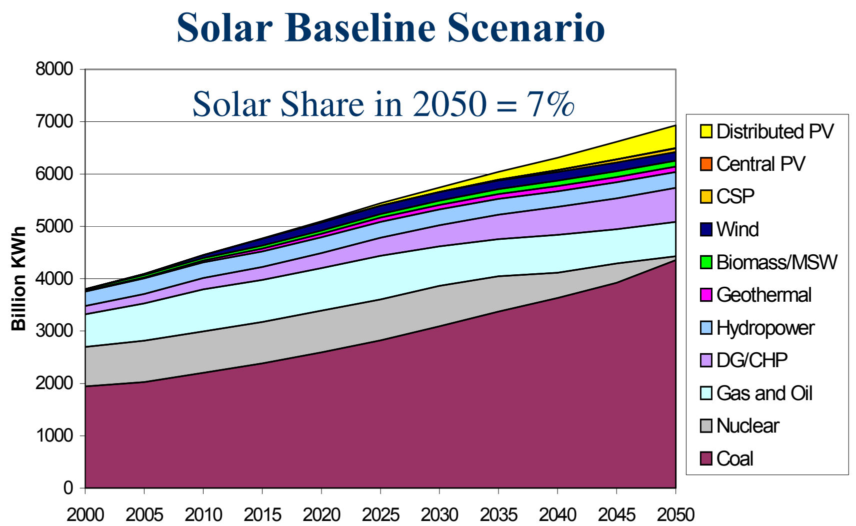
- Constraints – Inverter Cost and Module Cost ($/W) do not change
- Compares cost of inverter replacement with cost of area-related BOS

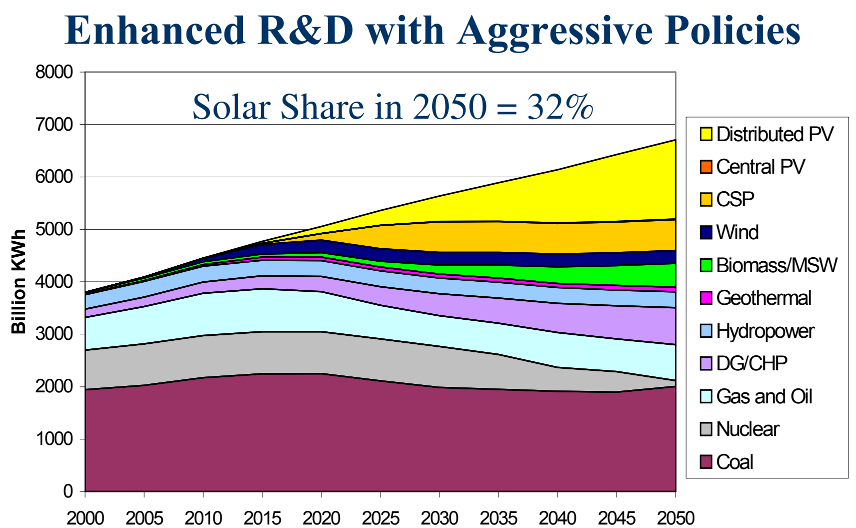
- A Solar 2050 study illustrates long-term projections for solar using Energy Information Administration modeling system
- PV market penetration model in development
  - Designed to be compatible with SDA model
- Value analysis underway – 3 papers presented
  - Includes effect of net-metering on PV system 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.

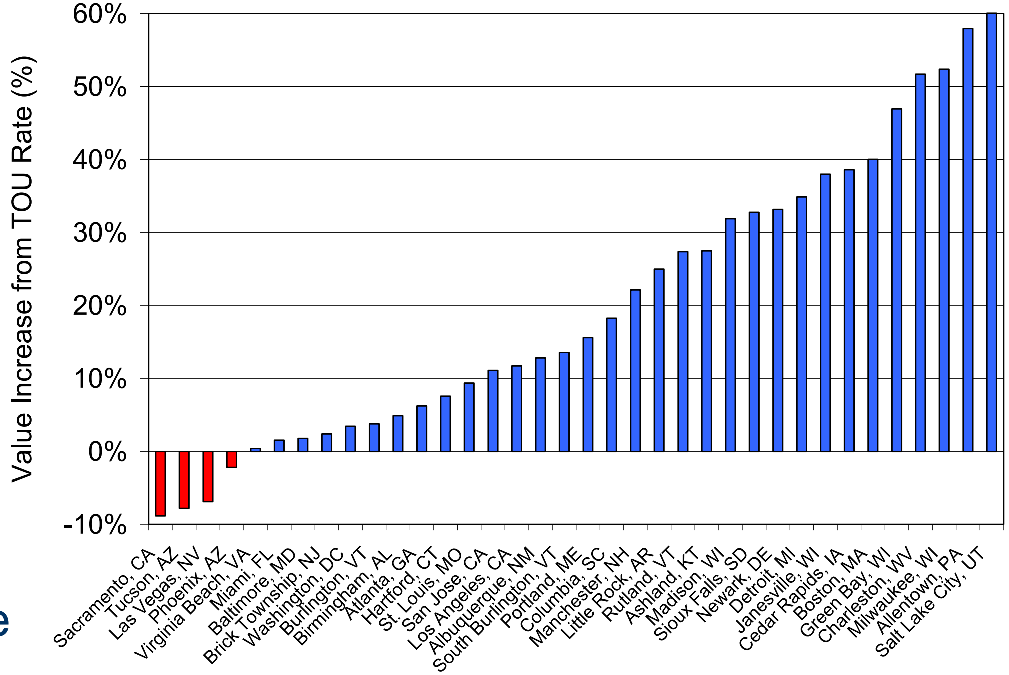




Time of Use Value

- "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.

Percentage Change in Utility Bill Savings for Selected Locations in the U.S.



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

The SDA Team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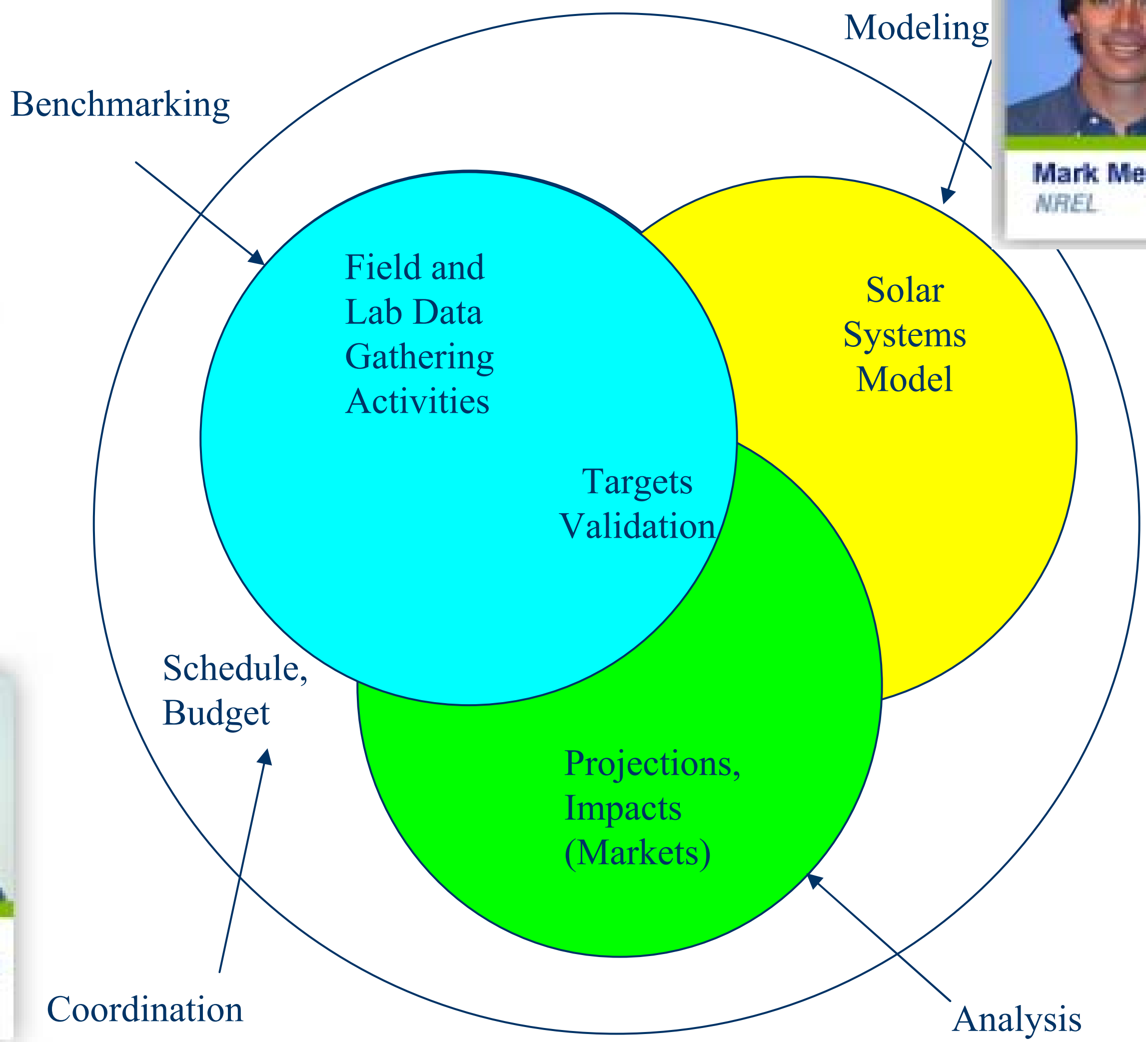
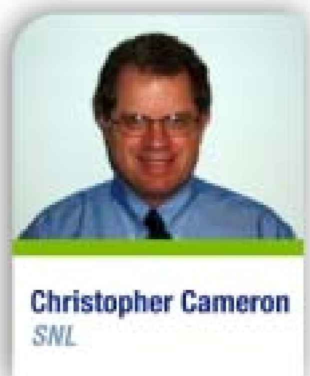

Benchmarking
Modeling
Field and
Lab Data
Gathering
Activities
Solar
Systems
Model
Targets
Validation
Schedule,
Budget
Projections,
Impacts
(Markets)
Coordination
Analysis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NREL - SDA Analysis