

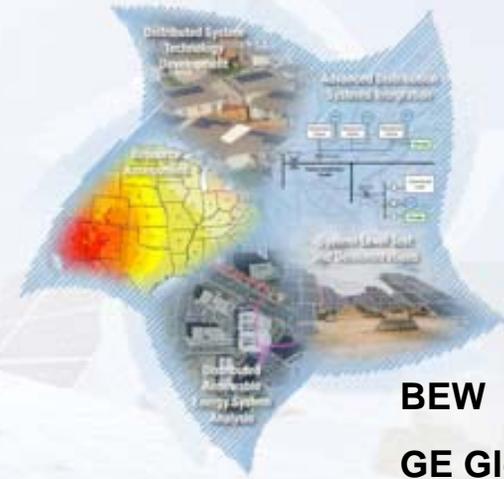
# Renewable Systems Interconnection Study

**Juan Torres**

**Manager, Energy Systems Analysis**  
Sandia National Laboratories



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- BEW
- GE Global Research
- Navigant Consulting
- Norris Energy Consulting
- Northern Plains Power Technologies

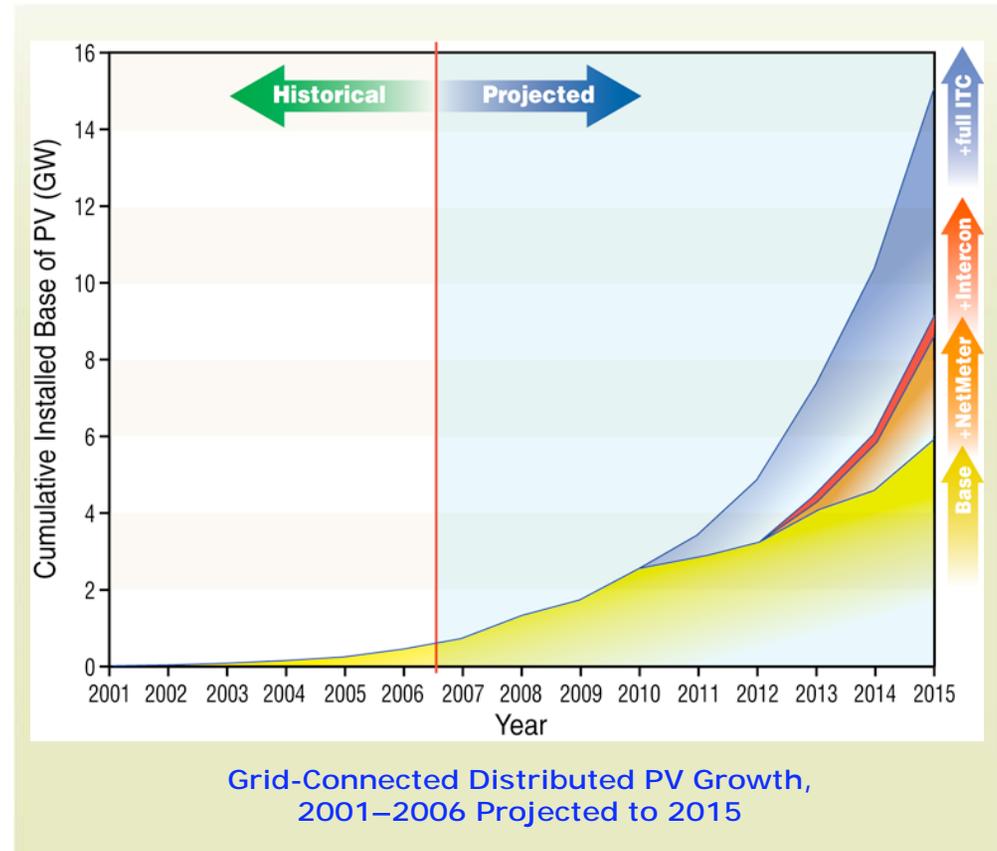
# Significant growth projected for Distributed Renewable Integration



## Driving the market:

- Climate change
- Cost reductions

**Market Risk:** As PV production approaches ~5% of installed generating capacity, grid impacts could create barriers to future growth.



# Renewable System Interconnection Study seeks to remove barriers and reduce risks

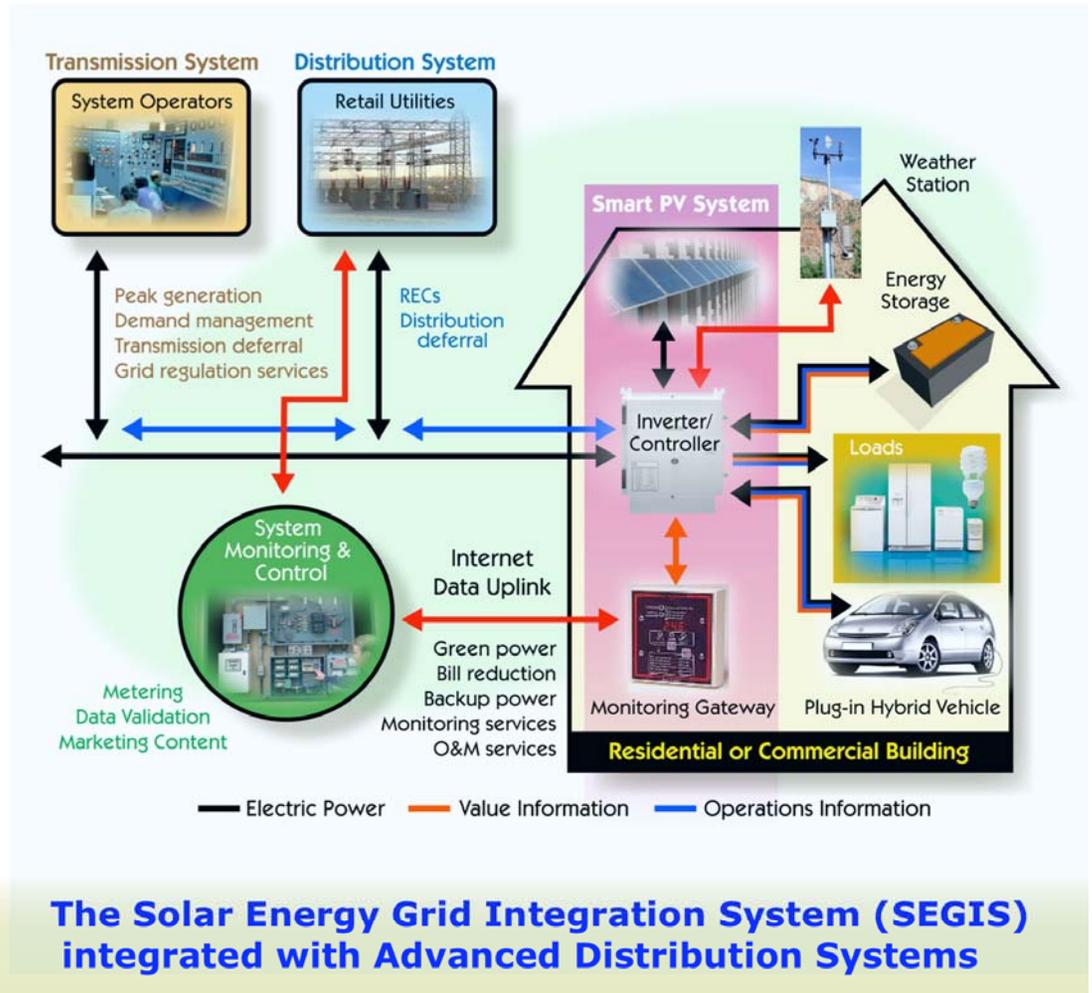


- 📁 **Distributed PV System Technology Development**
- 📄 **Advanced Distribution Systems**
- 📄 **System Level Test and Demonstration**
- 📄 **Distributed Renewable Energy System Analysis**
- 📄 **Solar Resource Assessment**
- 🕒 **Codes, Standards, and Regulatory Implementation**

# Objectives for Distributed PV System Technology Development



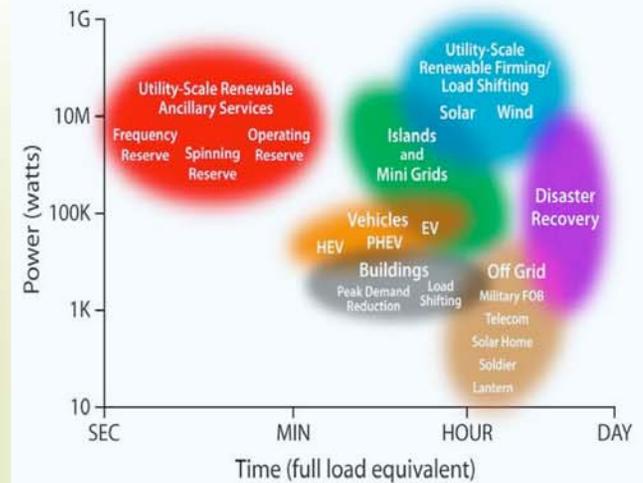
- **Solar Energy Grid Integration Systems (SEGIS)** -- inverter/controllers, energy management.
- More reliable inverter/controller hardware.
- Embed voltage regulation in inverters, controllers, voltage conditioners.
- Investigate new DC power distribution architectures.



# Objectives for Distributed PV System Technology Development (Continued)



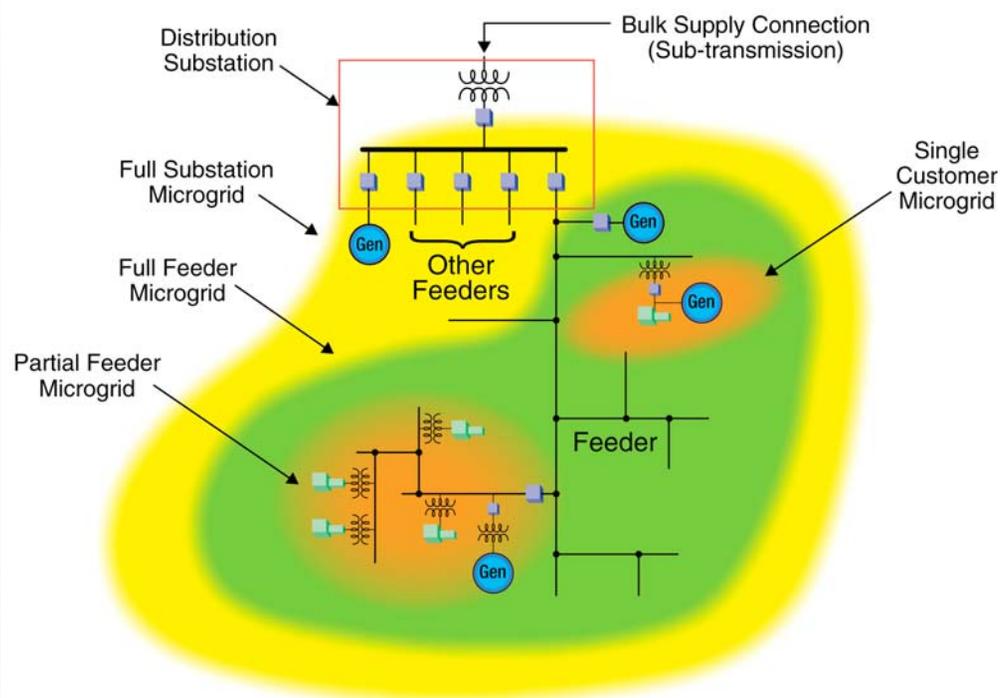
- Integrate communications and control concepts with *SEGIS*.
- Communications protocols to prevent accidental or unauthorized tampering.
- Inverter-tied storage systems to allow intentional islanding (microgrids) and system optimization (demand control).
- Energy system controllers to monitor solar resource, utility pricing, building loads and occupant data.





# Objectives for Advanced Distribution Systems

- Increased automation.
- Emphasize ***“market-driven response”***
- PV-friendly distribution systems.
- Multi-scale microgrid technologies.



# Objectives for System Level Test and Demonstrations



## Laboratory Based Testing

- Models for specific PV system equipment, especially inverter performance.
- Laboratory capabilities for testing high penetration scenarios.
- Establish test protocols for emerging communication methods.
- Evaluate control schemes for autonomous VAR compensation under conditions of multiple inverters.



# Objectives for System Level Test and Demonstrations



## Field Testing and Demonstrations

- Test voltage regulation support, frequency regulation support, spinning reserve, customer peak load reduction.
- Test integration of energy management systems with PV and storage.
- Evaluate impact of high PV penetration on distribution.
- Investigate voltage impacts, SEGIS effectiveness, faults, fuses.
- Investigate PV installed in sub-optimal situations.



**Premier Gardens Subdivision, Rancho Cordova, CA**

Source: Sacramento Municipal Utility District



**15 MW PV Installation, Nellis Air Force Base, NV**

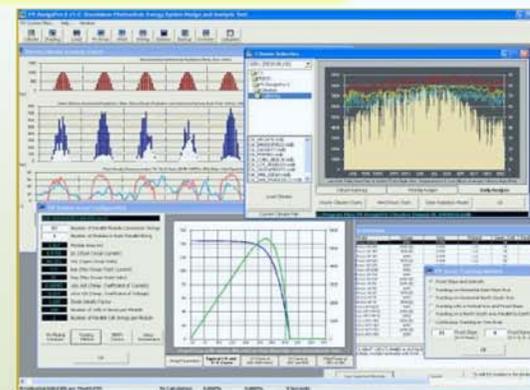
Source: SunPower Corporation



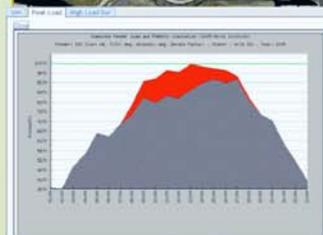
# Objectives for Distributed Renewable Energy System Analysis

## Technical Analysis

- Solve ground fault over-voltage on sub-transmission.
- Adapt distribution system protective systems to handle PV.
- Develop new voltage regulation schemes.
- Solve PV grounding compatibility problem.
- Create benchmark cases for testing models and software.
- Develop automated tools to evaluate impact of PV on distribution.
- Update commercial load flow and fault current calculation software for multiple distributed energy sources.



Improving voltage profile of distribution feeder with PV

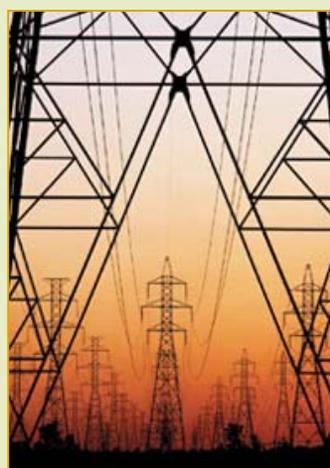
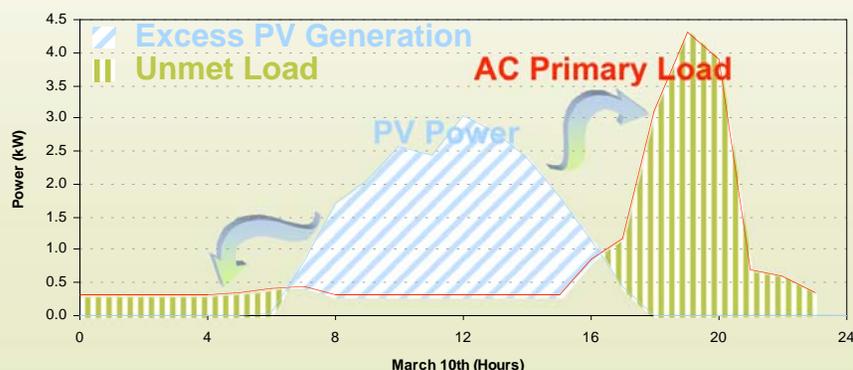


Peak Load Reduction



# Objectives for Distributed Renewable Energy System Analysis

## Economic Analysis

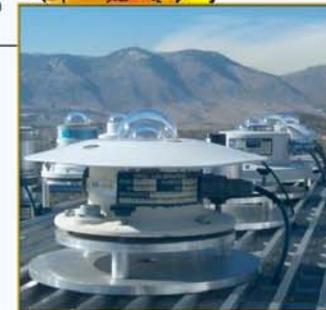
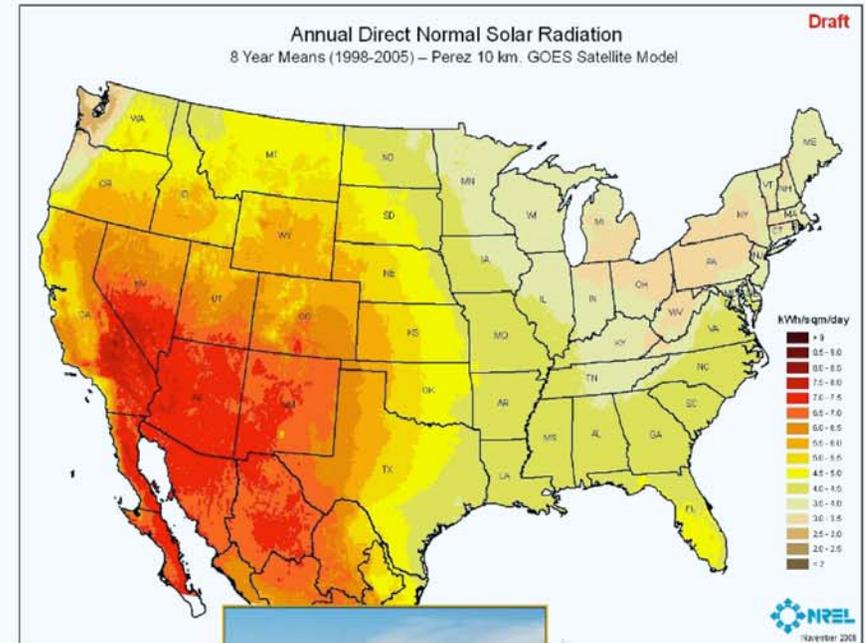


- Develop best practices for quantifying PV benefits.
- Evaluate how geographical diversity mitigates PV output variability.
- Evaluate costs due to unit commitment errors and impacts of increased forecasting quality.
- Examine enabling technologies and techniques, e.g. spatial diversity, orientation, and market-based.
- Examine electric or plug-in hybrid vehicles as PV enablers.
- Second-generation business models with whole or partial, utility ownership of PV.

# Objectives for Solar Resource Assessment

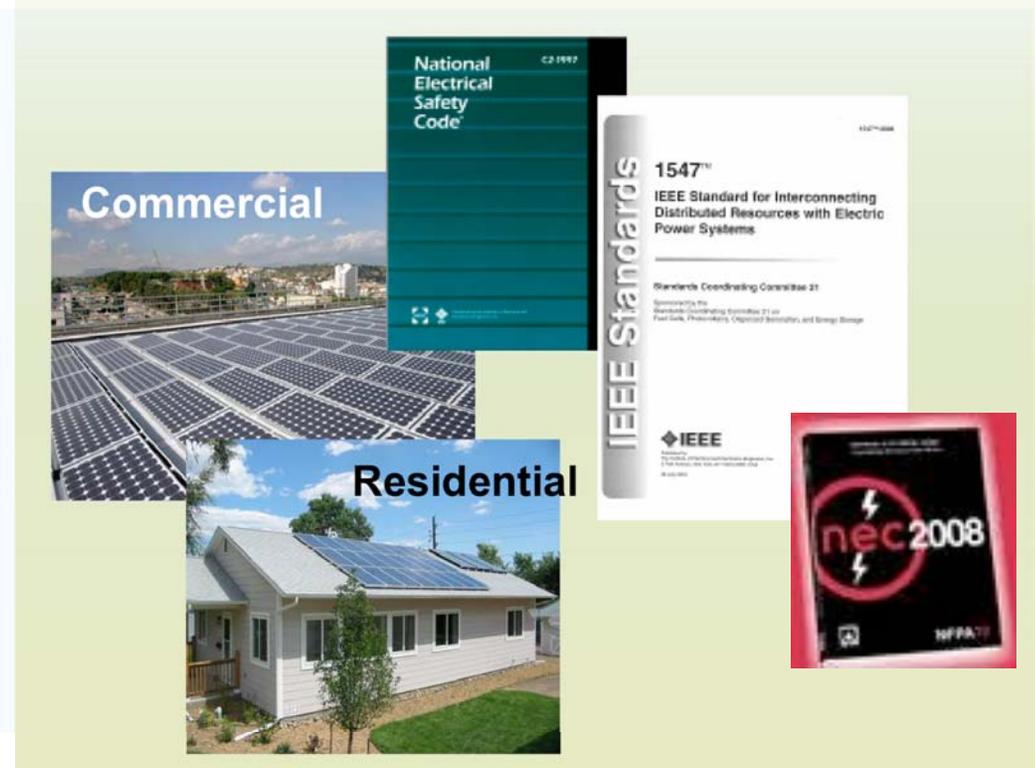


- Resource forecasting over various time steps, (1-3 hour), day ahead, seasonal, inter-annual
- Reliable, sub-hourly data sets
- Improve the spatial resolution of data sets
- Develop a user-interactive data archive.
- Focus new solar radiation products to support RSI requirements





# Objectives for Codes, Standards, and Regulatory Implementation



- Coordinated operation of all distribution equipment.
- Best practices for modeling renewables and energy storage.
- Best practices for T&D system planning and operation.
- Recommendations for enhanced regulatory implementation and practices.
- Improve methods/agreements for siting, permitting, & inspection.