Solar Energy Grid Integration Systems (SEGIS): Goals, Processes and Impacts

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for
Distribution Grid Codes for High Penetration DER
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References:
http://www1.eere.energy.gov/solar/systems_integration_program.html
http://www.sandia.gov/solar/

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(SEGIS) Goals

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  - Princeton Power
  - PV Powered
  - University of Central Florida/Satcon
- **Administrative**
  - Carolyn David, Sandia Purchasing
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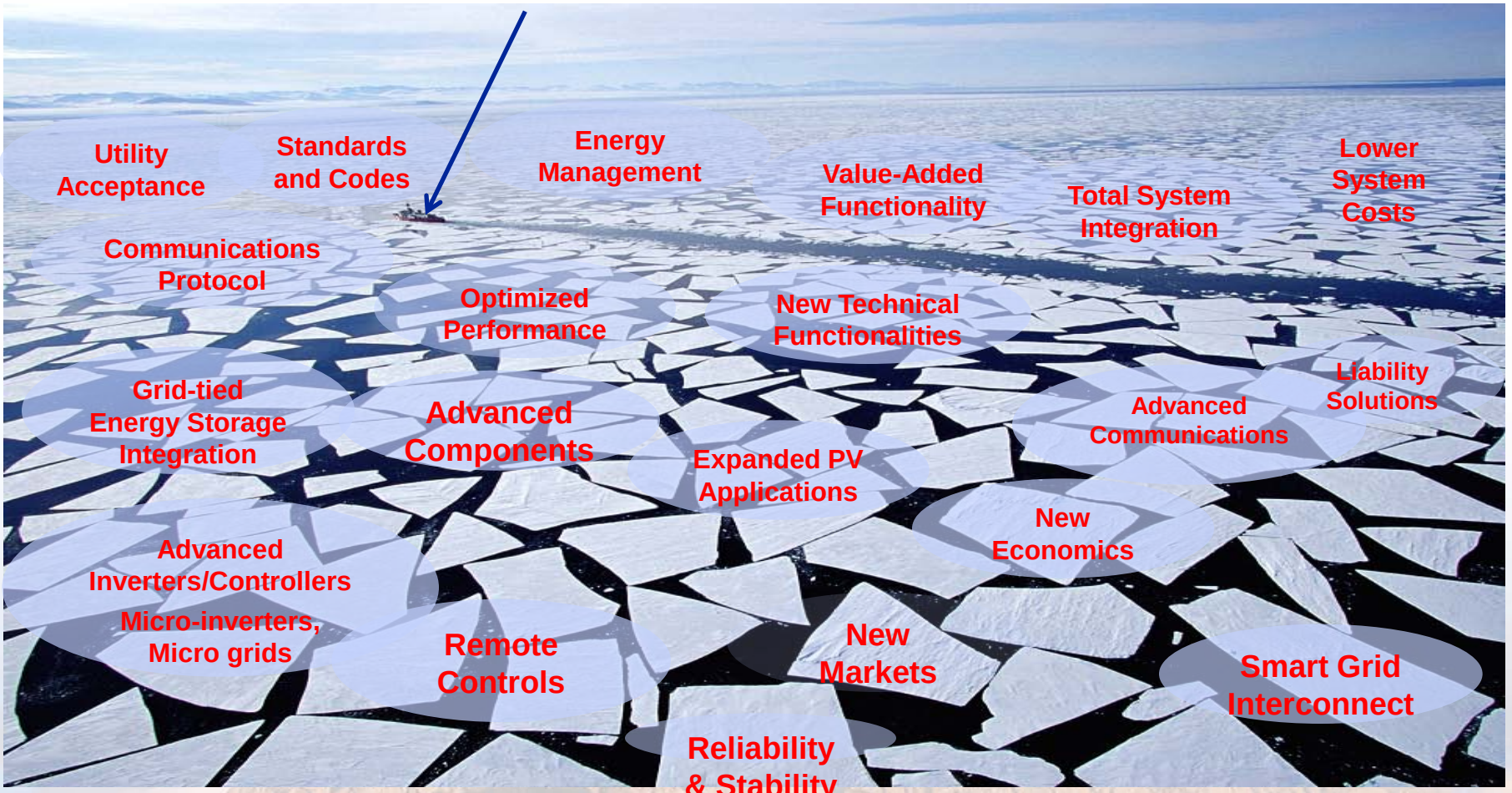
Introduction

- **Goals**
  - Proactive Research and Developments
  - Revolutionary Changes
  - High Penetration Methodologies and Advances
- **Processes**
  - Project Timeline and Status
  - Project Topics and Scope
  - Project Deliverables (3 Stages)
  - Legacy versus Smart Grid Functionality
- **Impacts**
  - Technical Advances versus Enabling Progress
    - Short-term
    - Long-term
  - Towards Lower Costs

SEGIS – The Initial SETP "Integrated PV System for Intelligent Interconnect" Icebreaker





SEGIS

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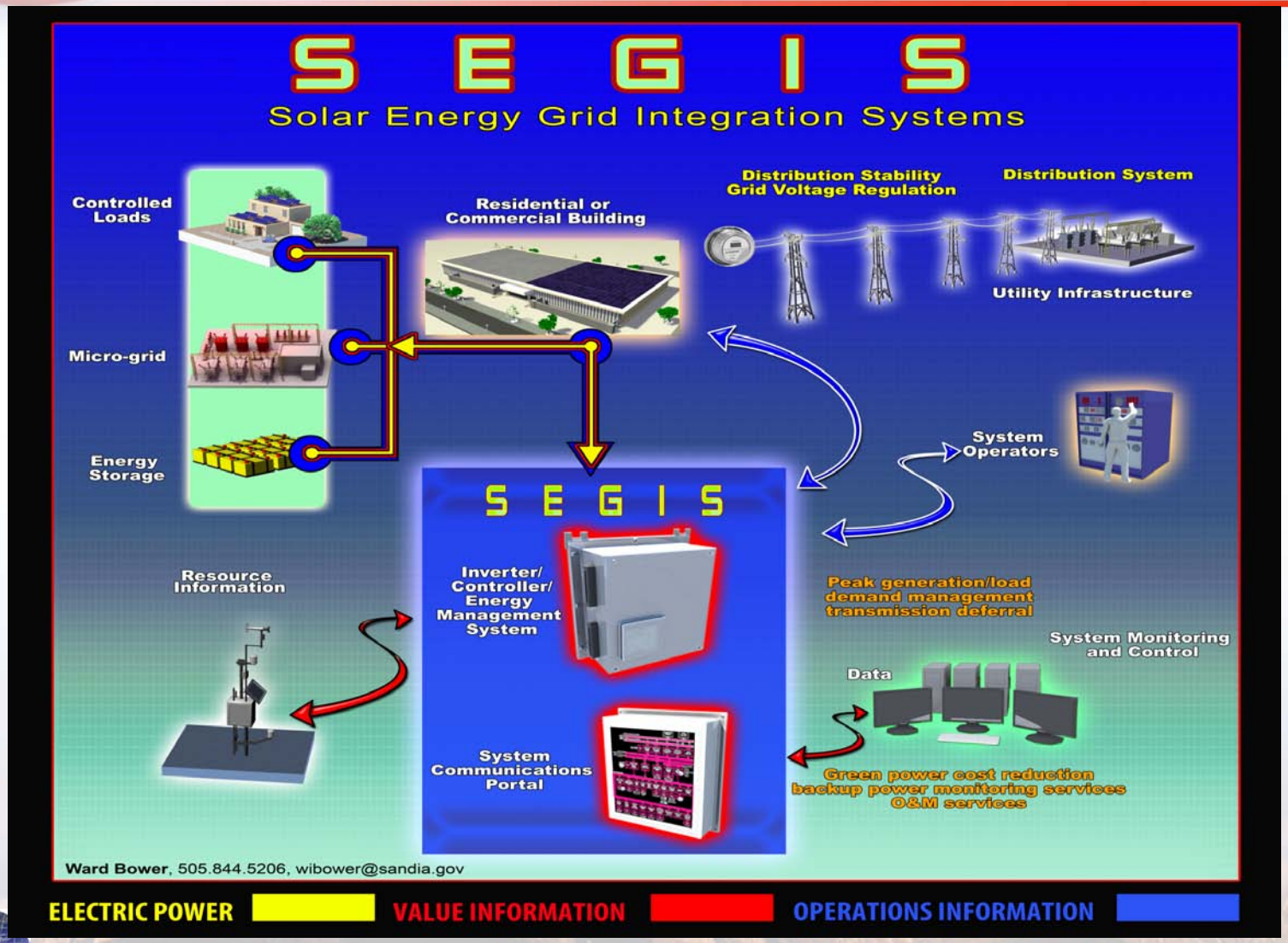
SEGIS is the First SETP Step Toward Intelligent PV Grid Integration



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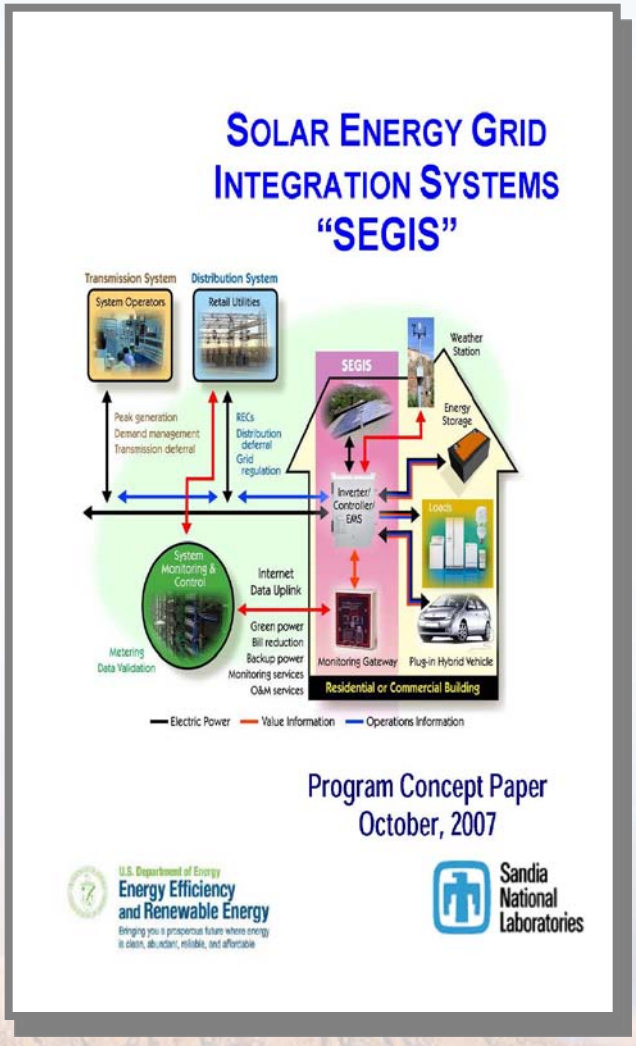
The SEGIS White Paper Goals for PV and DG

- Prepare for high-penetration PV and DG in the context of the future “Smart” utility
  - Develop integrated and advanced inverters/controllers/BOS
  - Integrate energy management, energy storage control, building energy management systems.
  - Introduce advanced communications, sensors, total system for optimized PV economies
  - Modeling for system designs
- Improve power electronics, BOS and systems costs, reliability and lifetimes
- Develop “Integrated Advanced Concepts” for
  - Micro-inverter, micro-grid, communication, and electrical grid/infrastructure support
  - Grid stability & reliability is necessary
- **Team with utility, communication, industry experts for bottom-up system designs.**



(SEGIS) Processes

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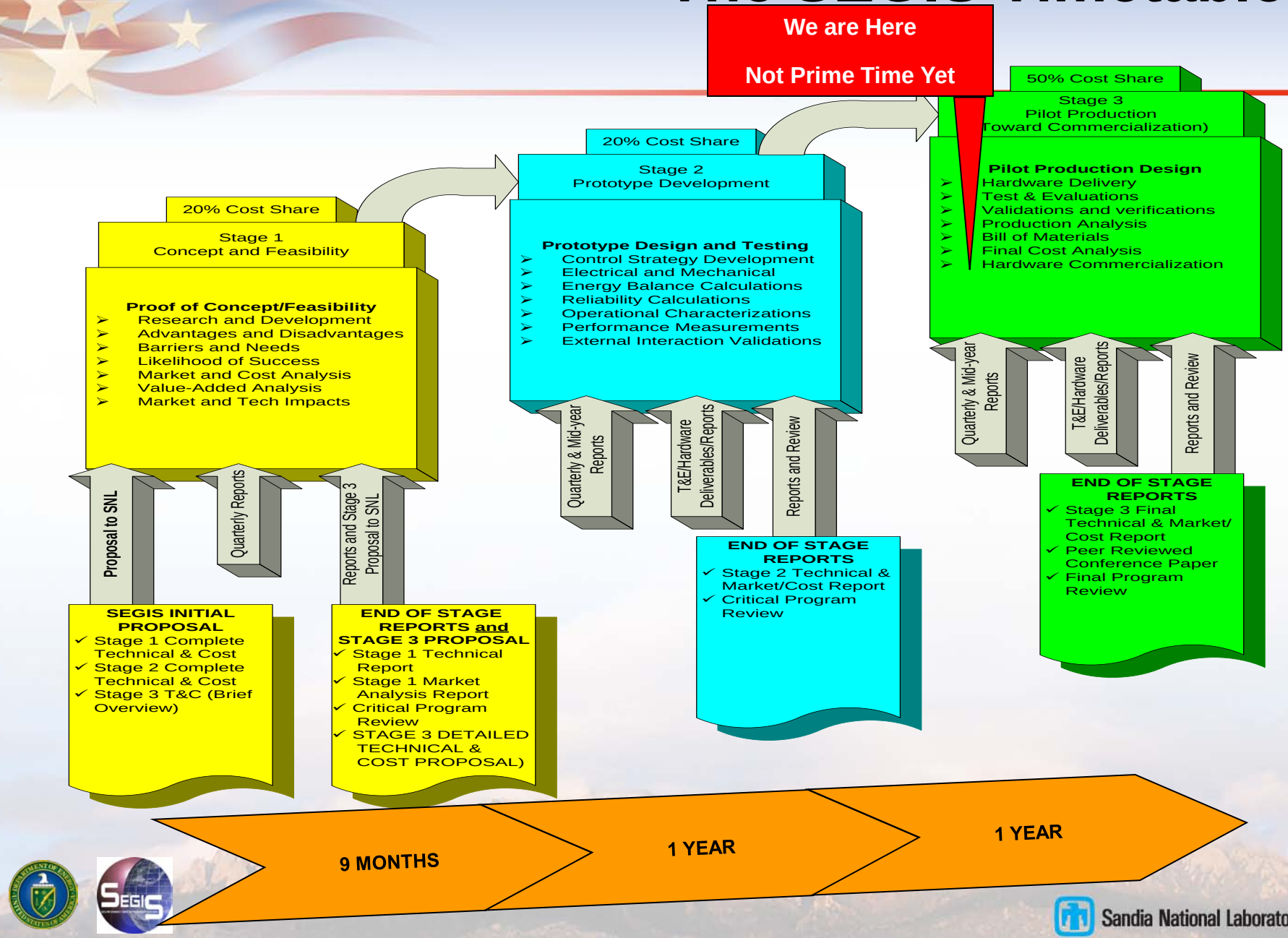
Background for SEGIS Solicitation

- **"Revolutionary" not just "Evolutionary" advances were goals**
- **Contractors proposed SEGIS features that had the highest likelihood of success for their products and the industry**
  - Profitable near-term commercialization was an important goal
  - All Stage 1 contractors provided market analysis and concept designs
  - Modeling was important for component and system analysis
  - *Contractor resources varied - cost share, staffing, expertise, partners*
- **All Stage 1 and Stage 2 contract start dates were synchronized**
- **Stage 3 selections were based on witness testing results, Stage 2 final reports, Stage 3 updated proposals and critical design reviews**
- **Likelihood of success and positive system cost, system performance and industry growth impacts were critical "Stage-gate Type" criteria with a "Best Value" selection criteria.**

The SEGIS Timetable



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SEGIS Solicitation Status

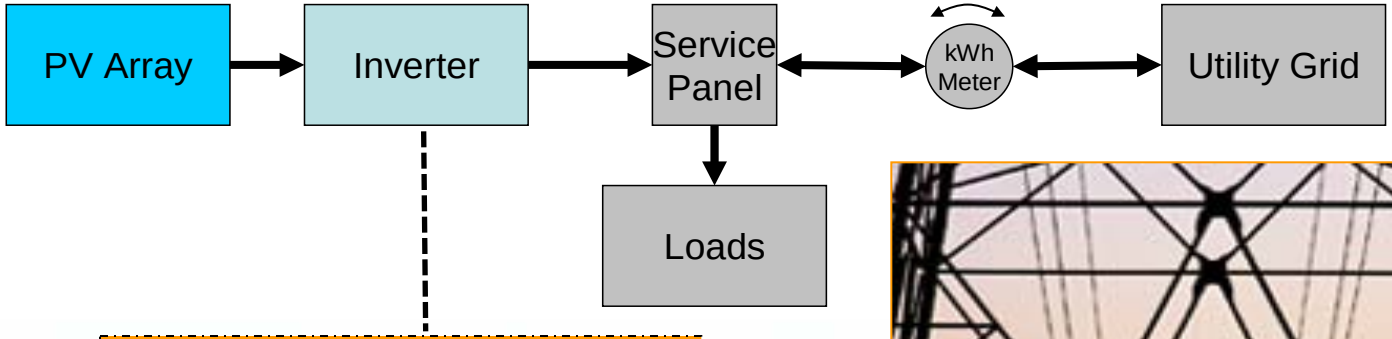
- **Stage 1**
  - "12" Contractors completed with conceptual designs and market analysis for their concepts
- **Stage 2**
  - "5" Contractors completed with prototype designs delivered as functional hardware
  - Witness testing completed 5/21
  - "Stage Gate Review" in early June, 2010 for Stage 3 awards
- **Stage 3**
  - "4" contractors will move SEGIS designs into commercialization

Stage 3 Contractors

- **Petra Solar**
- **Princeton Power**
- **PV Powered**
- **University of Central Florida/Satcon**

Today's Typical PV - Utility Interconnection

Duh!



Autonomous Functionality

Anti-islanding

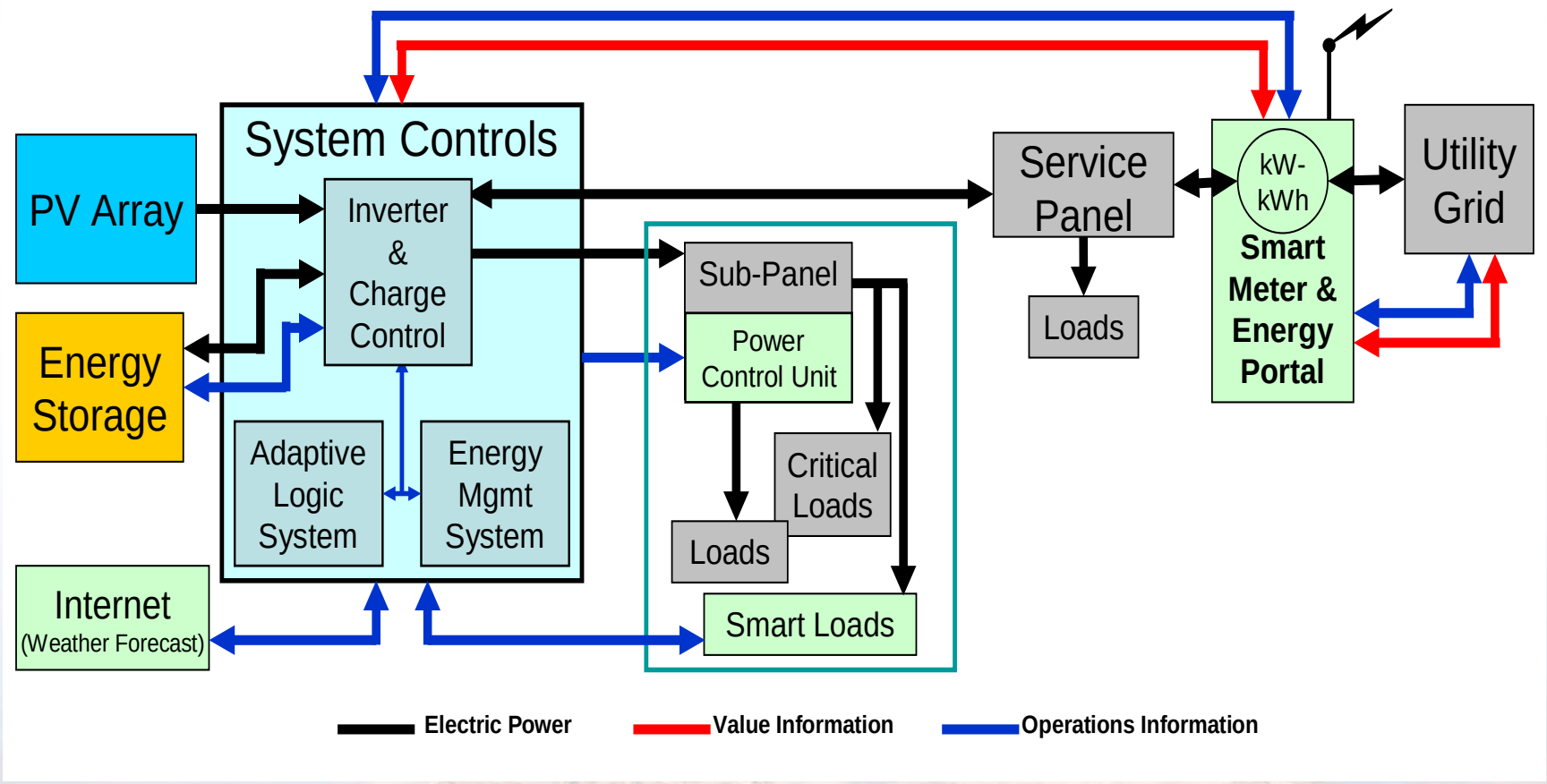
AC and DC Voltage Trips

Over- & Under- Frequency

Power limit

Over Temperature

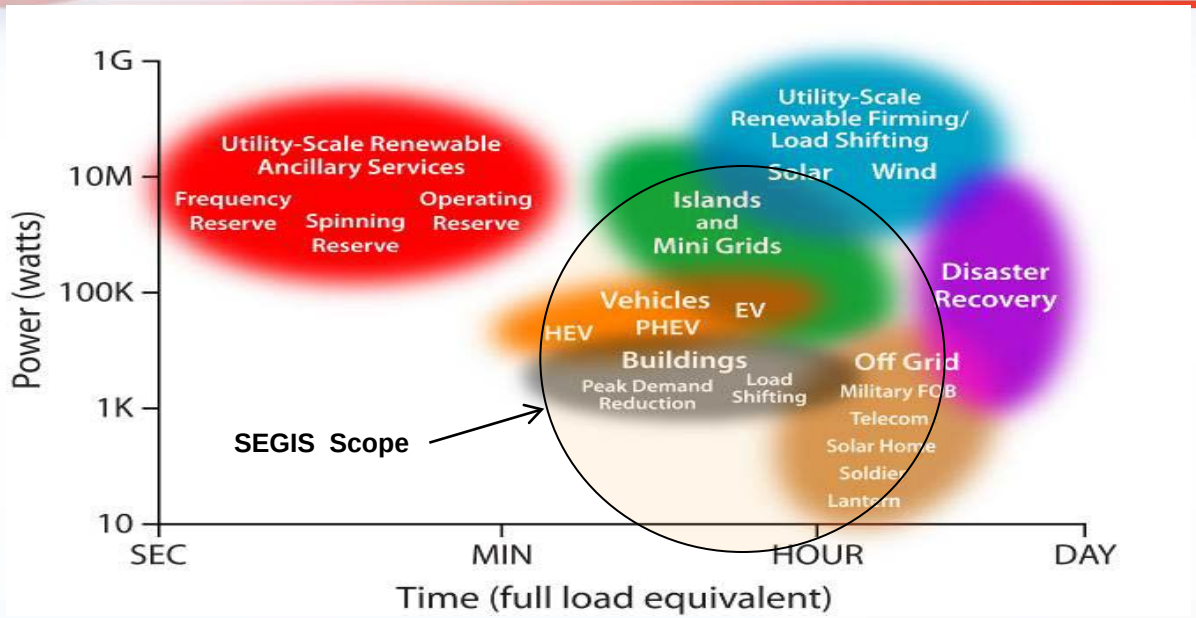
A Future Conceptual Intelligent Utility Interconnect



Important Topics of SEGIS Stage-2 Advances

- **Intermittency Mitigation**
- **Maximum Power Point Tracking**
- **Low Voltage Ride-thru Functions**
- **Performance Predictions**
- **Communications Integration**
- **Performance Optimizations**
- **Value Added**
  - Utility support
  - Metering
  - Optimization

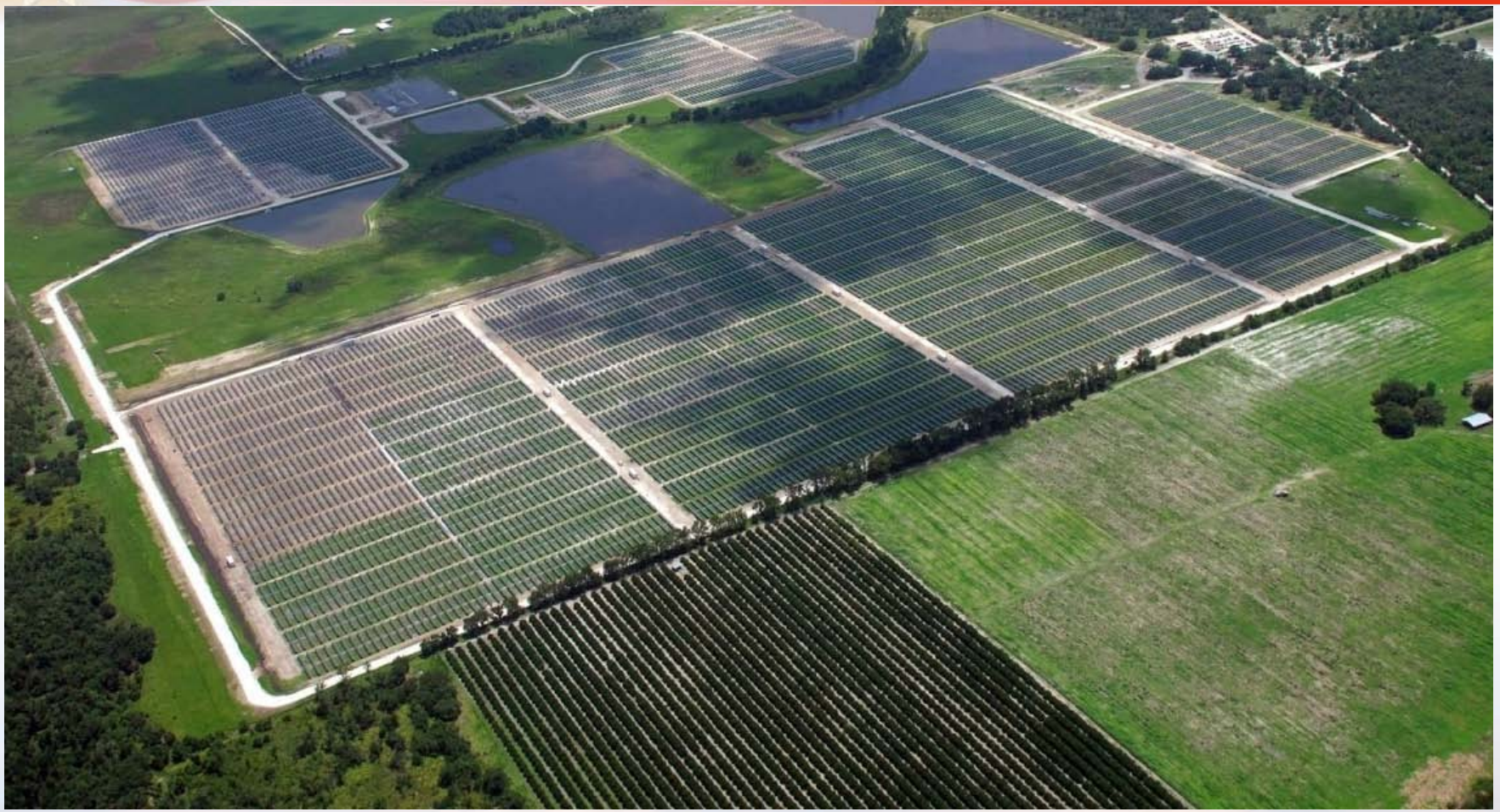
SEGIS Includes: A Broad Spectrum of Applications for PV System Technology Development



- Inverter-tied storage systems to use dc bus, allow intentional islanding (microgrids) and system optimization (demand control).
- Energy system controllers to monitor solar resource, utility pricing, building loads, occupant data and then provide safe switching.
- Embed voltage regulation in inverters, controllers, voltage conditioners.
- Integrate communications and control concepts with *SEGIS*.
- Communications protocols to prevent unauthorized tampering.

(SEGIS) Impacts

SEGIS Developments Include Several Methodologies to Mitigate Intermittent Power Production



Potential Issues for Intermittency, String Combiners, MPPT, System Stability

25-MW DeSoto PV Plant, Arcadia, FL

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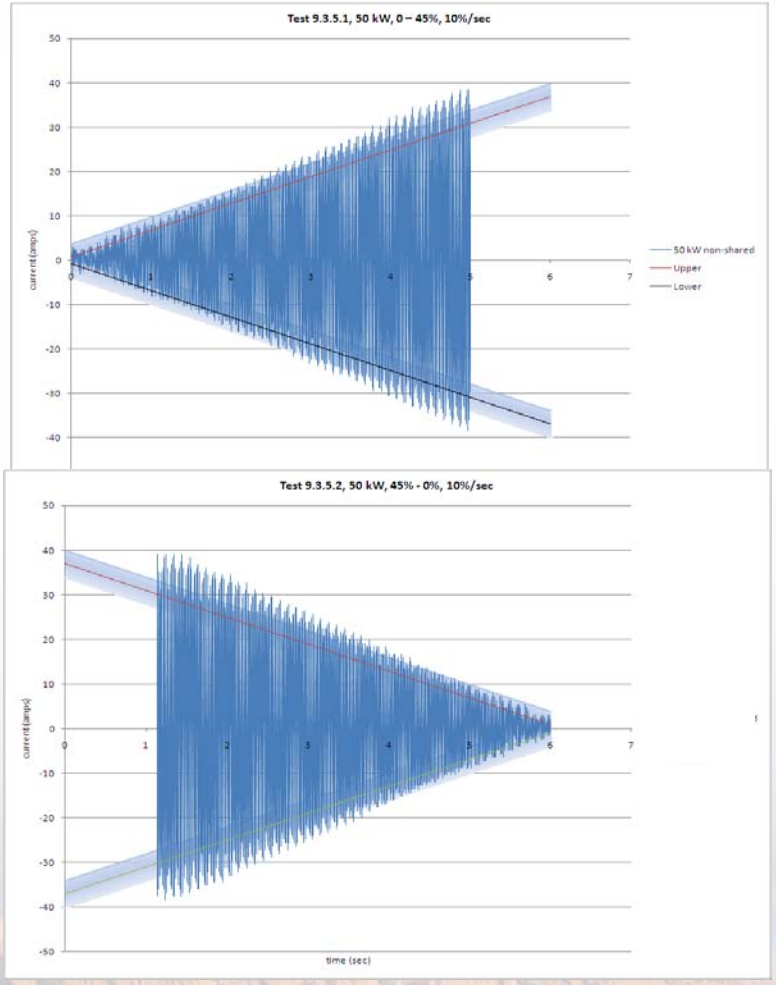
SEGIS Developments Include Several Methodologies to Mitigate Intermittent Power Production

- **Ramping the output of the PV inverter**
  - Ramps for PV Reconnect relieves transients on the grid
  - Ramps for loss of PV may required energy storage
  - Ramps may be controlled by the utility



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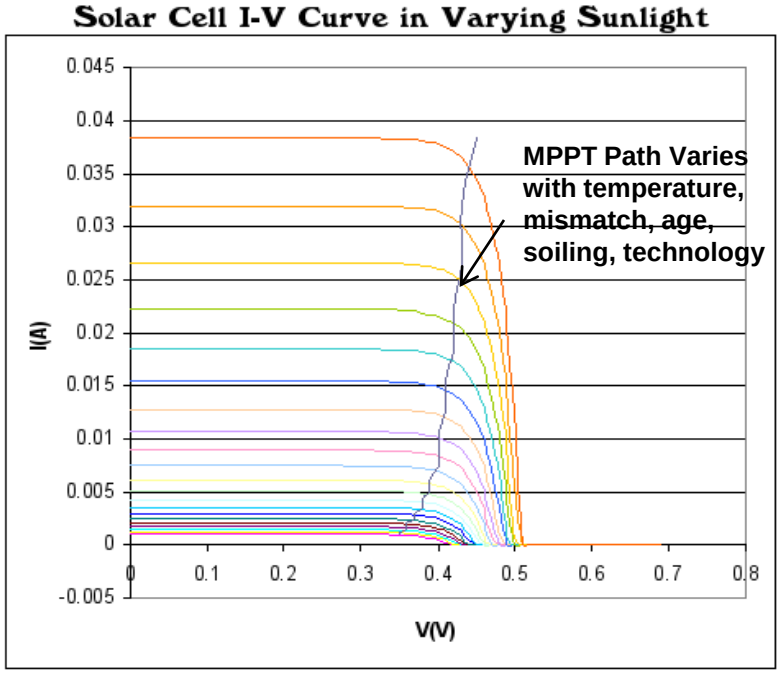
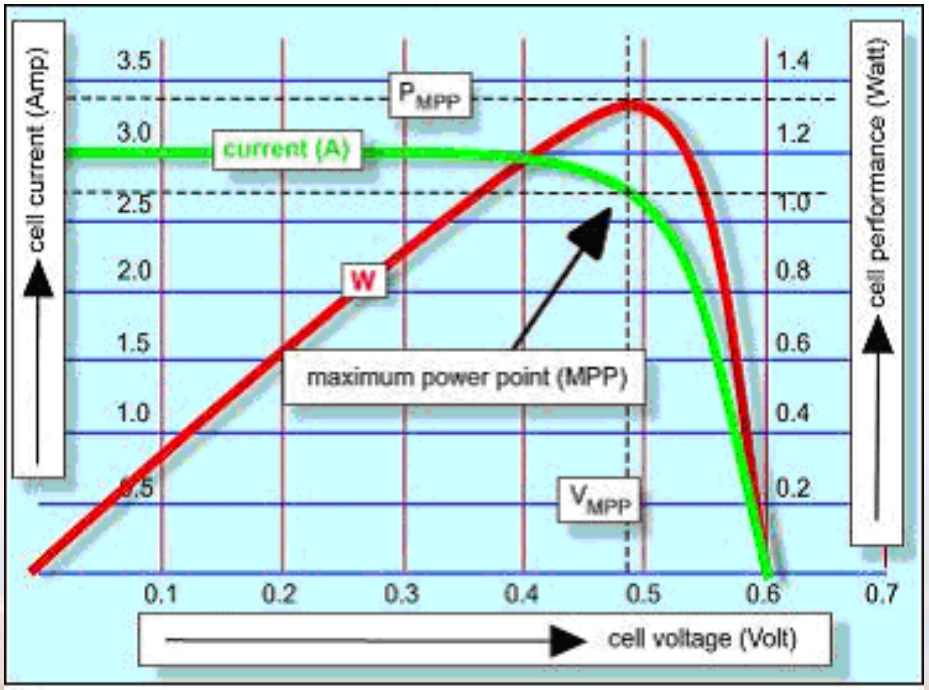
SEGIS Developments Include Maximum-Power-Point-Tracking to Optimize Power Production

- **Maximum Power Point Characteristics Vary with PV Module Technology, Tracking, Concentrators**





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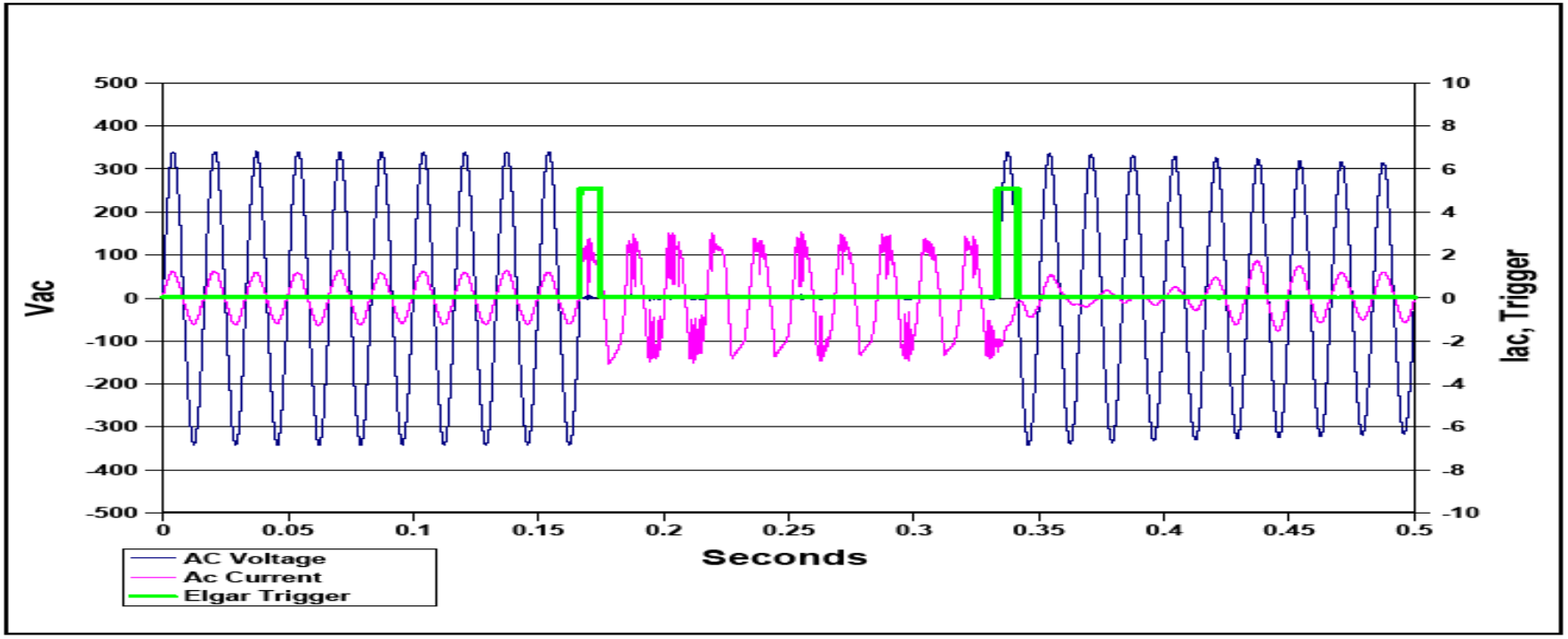
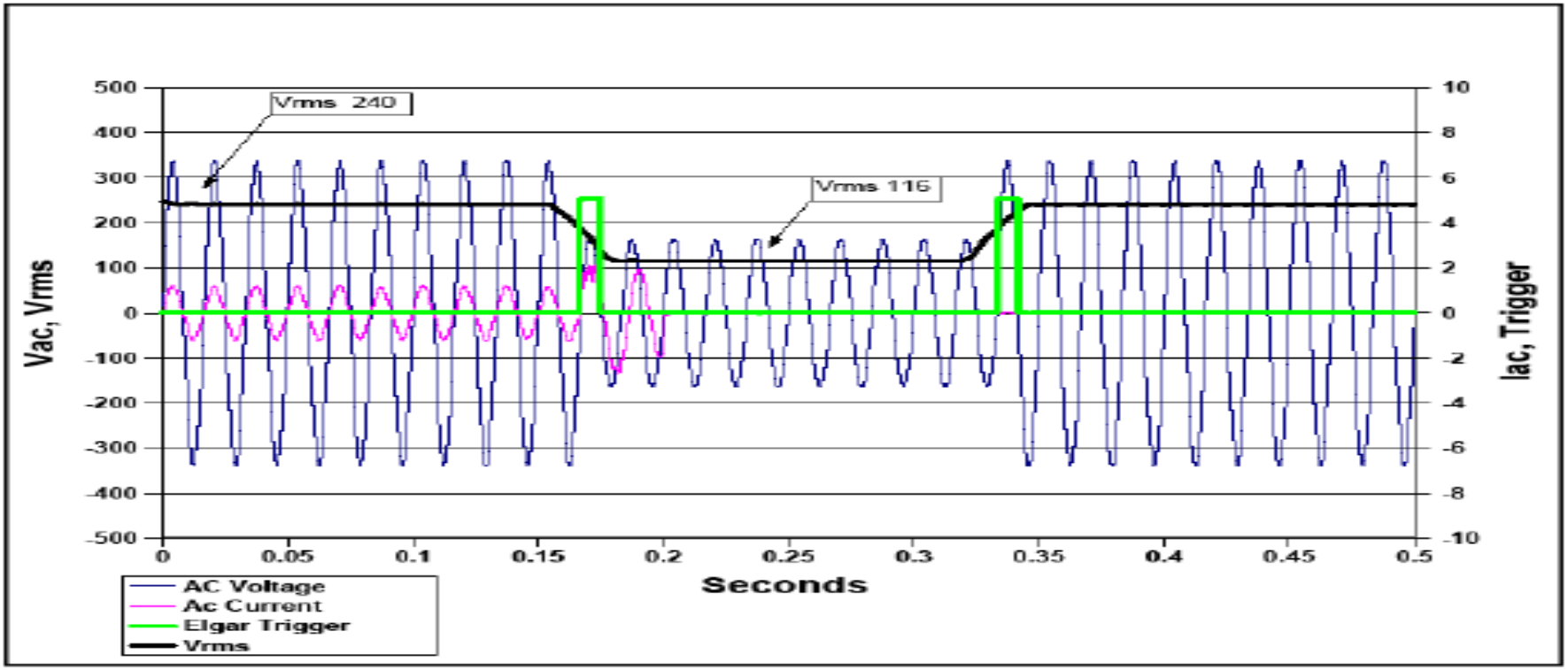
SEGIS Developments Include Utility Low-Voltage Ride-Through to Assist a Failing Grid

- Zero Volt Ride Through Test on a SEGIS System



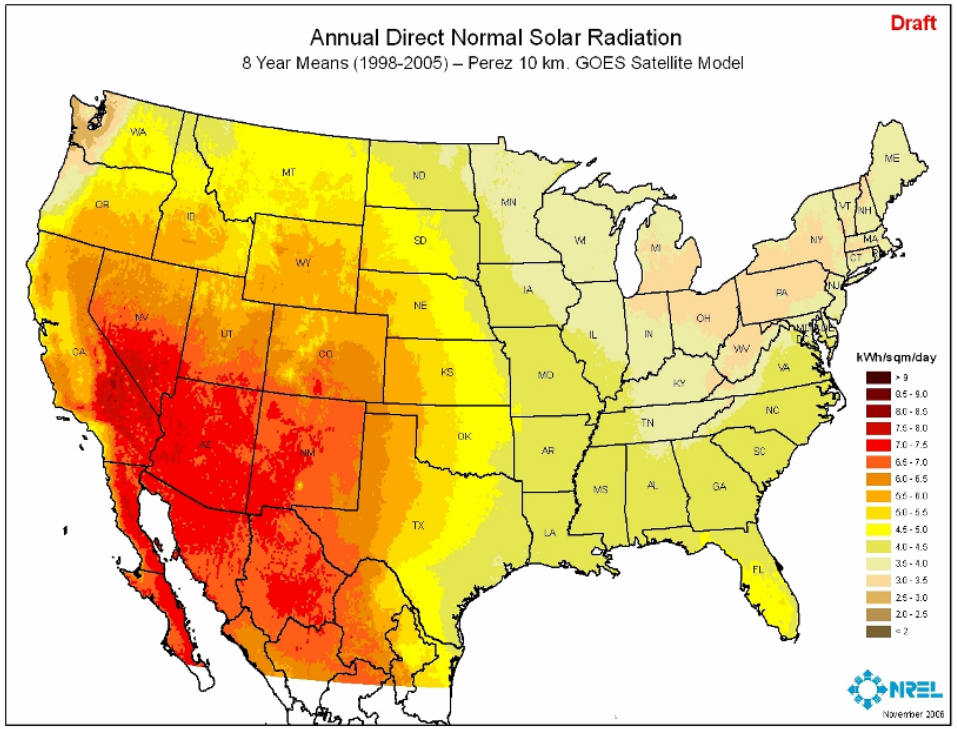
SEGIS Developments Include Utility Low-Voltage Ride-Through to Assist a Failing Grid

- **This one didn't help the stressed utility!**
  - Inverter stopped producing power with voltage sag
  - Inverter didn't return until after 5 minutes *(IEEE1547)*



SEGIS Includes Resource and Performance Predictions

- Resource forecasting over various time steps, (minutes, 1-3 hour, day ahead, seasonal, annual)
- Reliable, sub-hourly data sets
- Improved spatial resolution of data sets
- User-interactive data portals
- Utility grade hardware for automated and utility-controlled functionality



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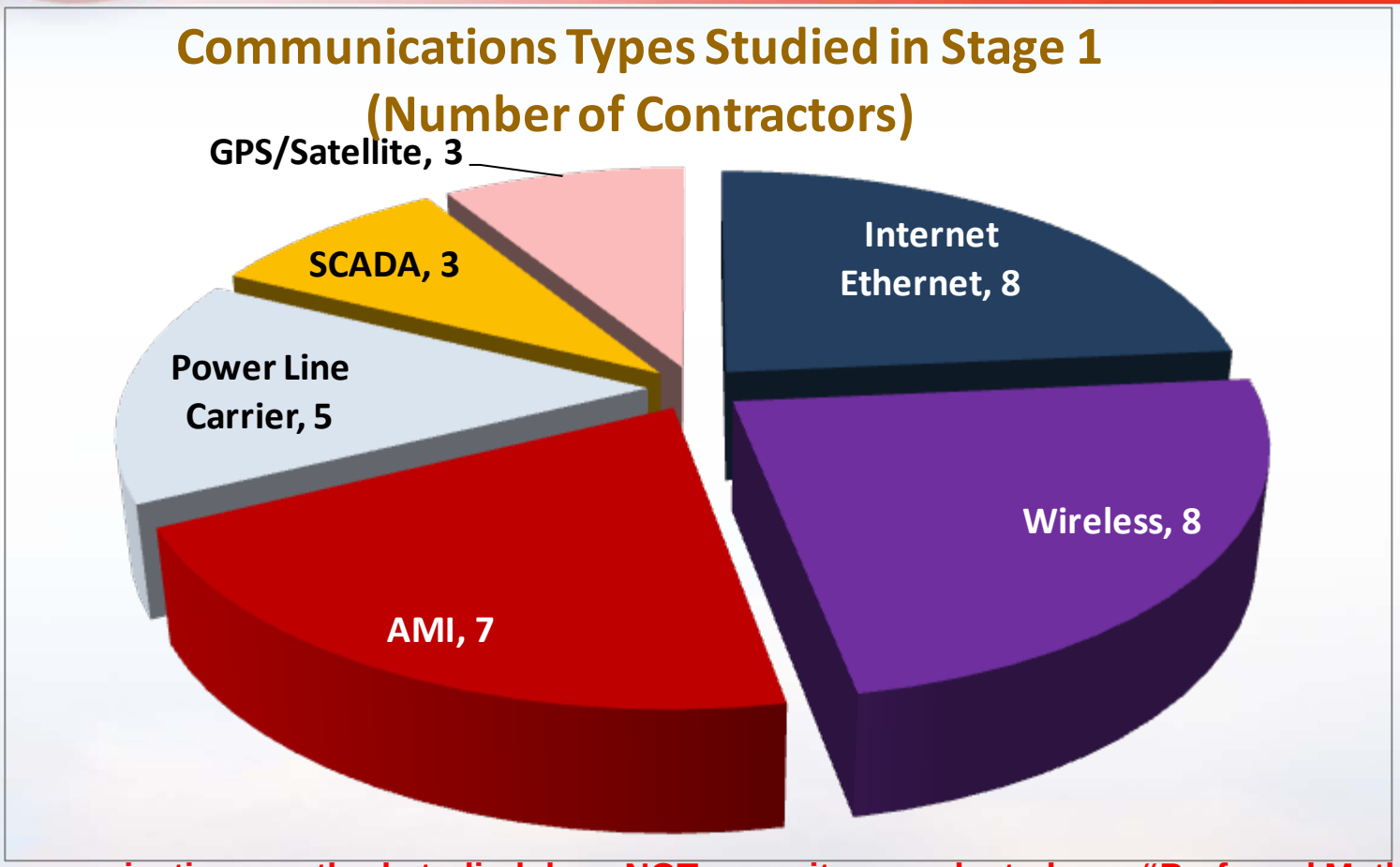
SEGIS Includes: Most Communications Methods and Combinations of Communications

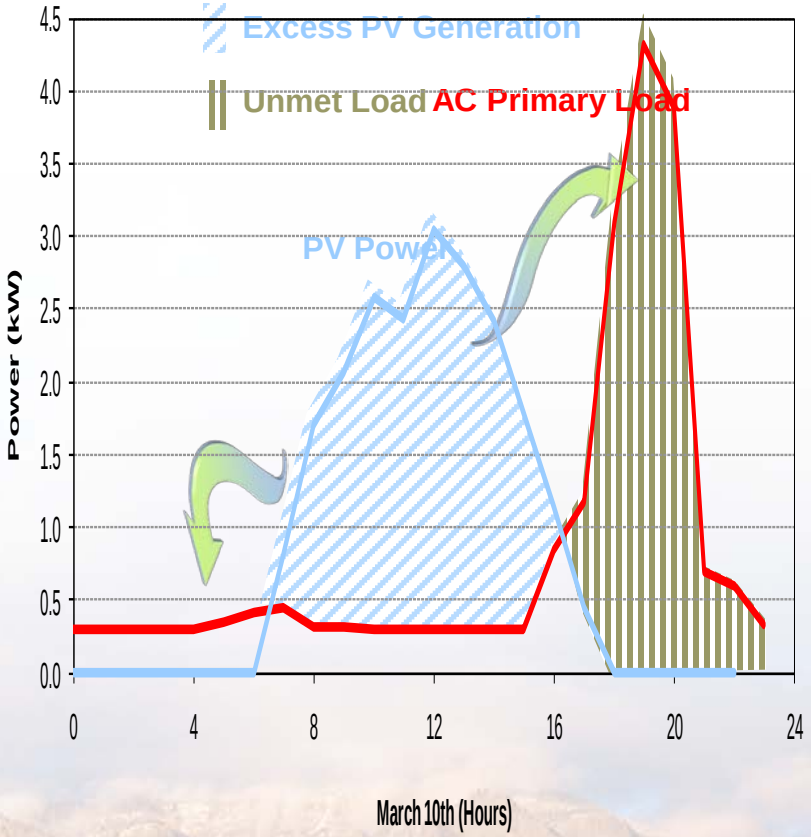


Communications method studied does NOT mean it was selected as a "Preferred Method"

Numerous Communications Pitfalls and Incompatibilities were Uncovered - Communication from internal controls to utility interactive controls, speed of response and communication reliability are main issues

SEGIS Includes: Advanced Methodology Applications

- **Energy Management and Communications Methods**
  - Integration with energy storage & other generation
    - Power shifting and optimization
    - Protocol, Wireless PLC Ethernet
    - Safe switching, isolation
  - Integrated sensors & detection
    - Improve system reliability
    - **Initiate** utility acceptance
  - Advanced communications devices, sensors & methods



Summary: Critical Aspects of Next-Generation Logistics

- **Focus on Costs to Enable DOE $/W Targets**
- **Device & System Self-protection/Reliability**
  - Hardware and software advances to protect the inverter and components for higher reliability/longer lifetimes
  - Advanced systems to “Predict System” status, health and remaining lifetime
- **Improved Inverter AND Complete System Modeling to Facilitate Adaptive Controls and Advanced Power Electronics**
- **Customer/Utility Friendly PV Systems**

Thank You

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