SMART-GRID FUNCTIONALITY: Where We Are Today

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for
EERE SEGIS-AC WORKSHOP
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References:
http://www1.eere.energy.gov/solar/systems_integration_program.html
http://www.sandia.gov/solar/

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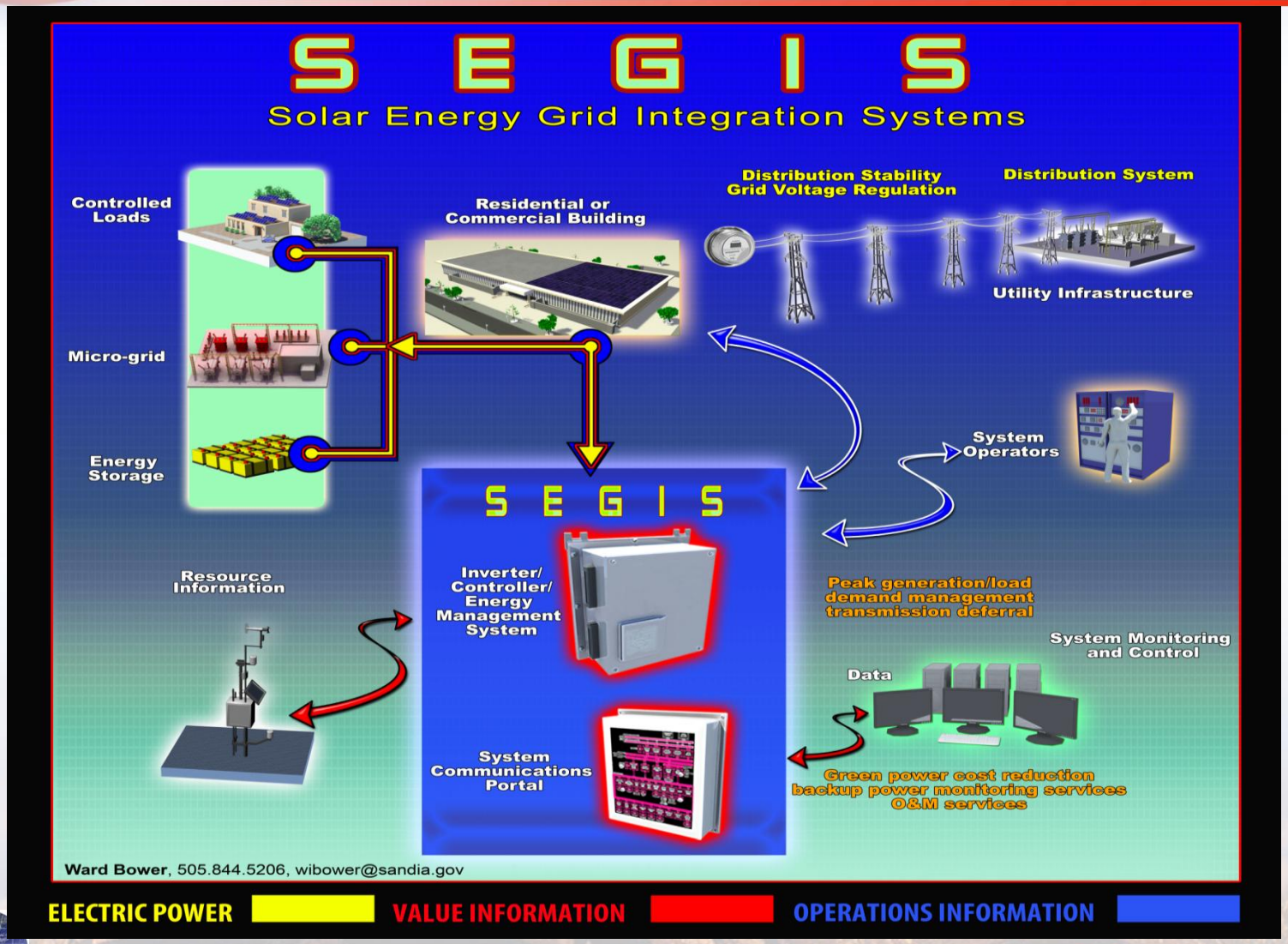
Introduction

- **Where We Are Today**
- **Current SEGIS Work**
- **SEGIS Awards/Advances**

  Added Values,Performance, Economics, Manufacturability, Lifetimes, Communications, Safety

- **Public Aspects of the SEGIS Projects**
- **What's Changed (Barriers Remain!)**
- **Focus for the Future**

SEGIS is the First SETP Step Toward Intelligent PV Grid Integration



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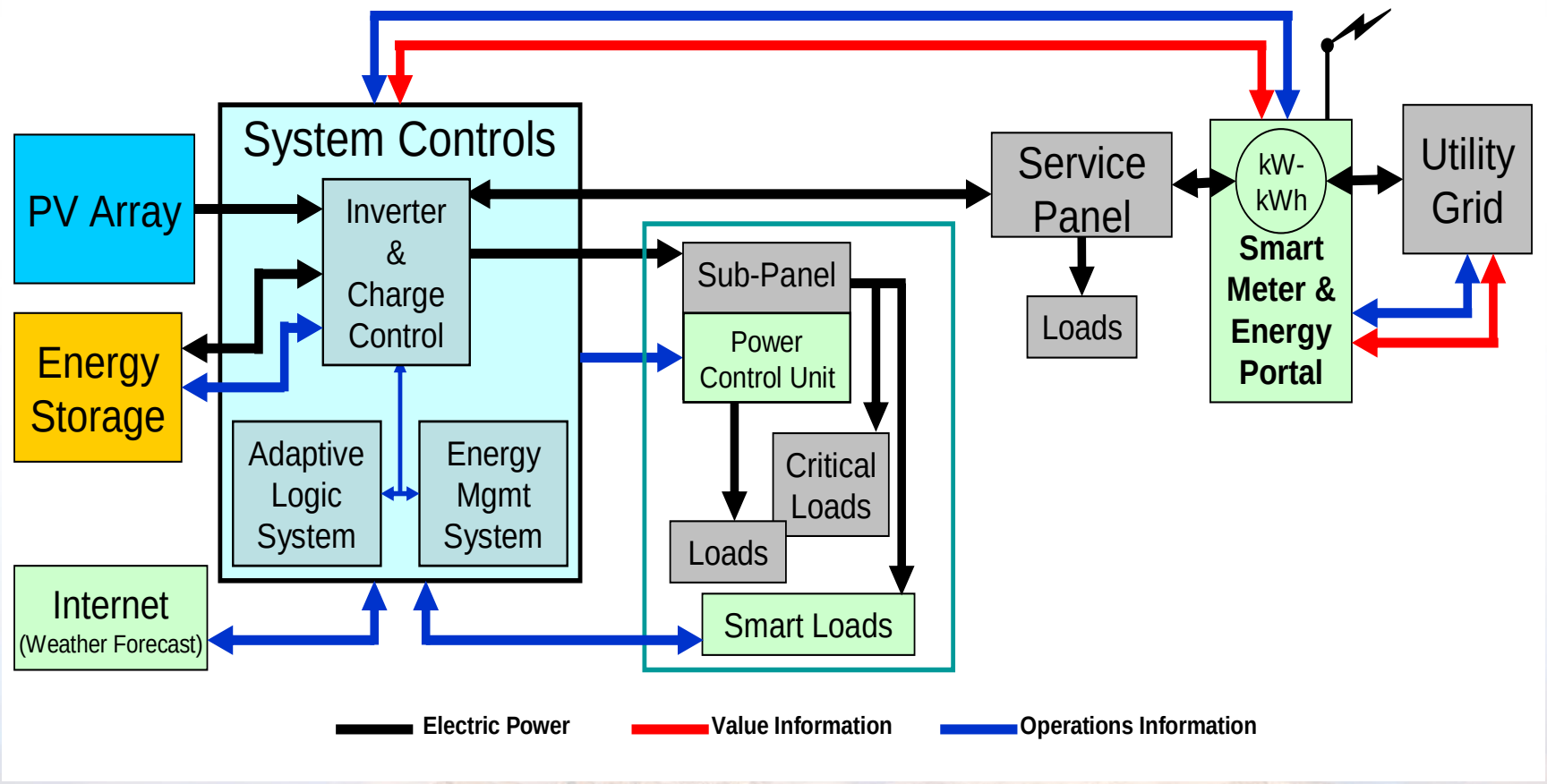
SEGIS Goals

- ***SIGNIFICANTLY*** **Advance Inverters, Controllers & Energy Management Systems to maximize value to Utilities and Consumer**
- **Scope**
  - PV Systems for High-value Residential and Commercial Applications (100W – 250kW)
  - PV Systems using Advanced Energy Management, Utility Interaction, Technology Advances and Communications
  - Building Energy Management + PV Systems AND Hybrid/Micro-grid Applications that Utilize Energy Storage
  - Did NOT Include Development of PV Cell/ PV Module or Energy Storage Technology.

Intelligent Utility Interconnects Are Beginning



Petra Solar: Economically Viable, Highly Integrated, Highly Modular SEGIS Architecture

Technologies Addressed

Smart Grid Interconnection, System Cost, Modularity, System Reliability, Safety, and Advanced Scalable Inverters. AC PV modules aimed at utility ownership and control.

Description

Smart Grid Interconnection, System Cost, Modularity, System Reliability, Safety, and Advanced Scalable Inverters. Low cost, easy-to-install, modular/scalable inverter architectures. Advances in multi-layer control, communications, monitoring and controlling a cluster of AC module inverters, and a strategic EMS switch junction box.

Advances

New circuits to add a new 240V SEGIS system to 120V models. All functionalities operated in prototype testing, communication advances progressive, meets UL today AND transitions from legacy to SEGIS mode. Potential to greatly improve cost and reliability with advanced integrated circuits. No thermal issues. Stated a utility marketing plan with partners ID'ed for demo. US manufacturing in place and expanding.

Participants

Petra Solar, Florida Power Electronics Center, Florida Solar Energy Center, Lakeland Electric, Echelon, PSE&G, First Energy, Pepco Holdings

Princeton Power: Demand Response Inverter

Technologies Addressed

Demand Response Inverter, Load Control, Energy Storage, High Efficiency Components, Grid Integration. Simultaneous multi-port operation for load and resource controls.

Description

Demand Response Inverter, Load Control, Energy Storage/Management, New High Efficiency Components, Grid Integration. Design a new 100-kW inverter based on Princeton's unique inverter technology. Optimize for low-cost, high-quality manufacture, integrated control capabilities with dynamic energy storage and demand response through generation and load control.

Advances

Innovative 4-port demand-response inverter topology w/smart functionality, central resonant link galvanic isolation alternative to transformers, nano-crystal magnetics & central capacitor long-lifetime self healing capacitors resulting in a smaller, much lighter inverter. Demonstrated simultaneous 4-port control of demand response/multi-generation inverter system w/galvanic isolation. System provides flexibility for energy management/micro-grids. ID'ed partners for demonstraton.

Participants

Princeton Power, TDI Power Corp., Gaia Power Technologies, PSE&G, Virginia Tech Center, International Battery, Inc., United Silicon Carbide, Inc., Process Automation.

PV Powered: Maximum Power Point Tracking, Advanced EMS, Advanced Communication, Utility Integration

Technologies Addressed

Optimized Performance Algorithms, Advanced Data Collection, Communications/Energy Management Systems(EMS), Optimized MPPT, Advanced String Monitoring, BEMS.

Description

New maximum power point tracking (MPPT) algorithms to optimize energy harvest for all available and emerging PV technologies. Develop components, smart string combiner hardware, and BEMS to optimize system performance, value and safety. Integration of multilevel communications with facility energy management systems and utility grid management networks.

Advances

MPPT enhancements promise optimize energy delivery. Major commercially available EMS, string level monitoring-meter string currents and disconnect, advanced utility communication and unique use of synchro-phasors shown feasible, and a platform integration/database. Manufacturing/demo sites are ready & partners ID'ed. Plans for SEGIS in product line in progress.

Participants

PV Powered, Portland General Electric, Northern Plains Power Technologies, Schweizer Engineering Laboratories (SEL), Sensus

Florida Solar Energy Center at UCF / Satcon: Development, Validation and Commercialization of Grid-Smart Inverters for Wider PV Technology Utilization

Technologies Addressed

Utility Control of Enhanced Inverter Features, Disturbance-tolerant Anti-Islanding, Shared Inverter, Energy Storage, Building Interaction

Description

Develop new concepts and enhance “Smart Grid” interconnections. Develop “Shared” inverter/controls that serve multiple PV arrays. Include battery storage, utility control, communication, monitoring, and building energy management systems (BEMS). Develop interactive “anti-islanding” strategy keeping PV on line during when necessary.

Advances

PV emerging into smart grids with utility controls of islanding and under voltage ride thru. Dc-dc conversion and dc bus adds flexibility for energy storage and micro-grid. The string combiner can improve performance, safety and reliability while enabling mixed PV technologies, optimal energy harvest, reduced BOS costs, and optimal inverter performance. Utility permissive control allows LVRT, VAR sourcing, constant PF control. Demo plans in place with ID’ed partners,

Participants

UCF/FSEC, SatCon, Sun Edison, Northern Plains Power Technologies, Lakeland Electric, Cooper Power Systems EAS, SENTECH Inc.,

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Important SEGIS Advances

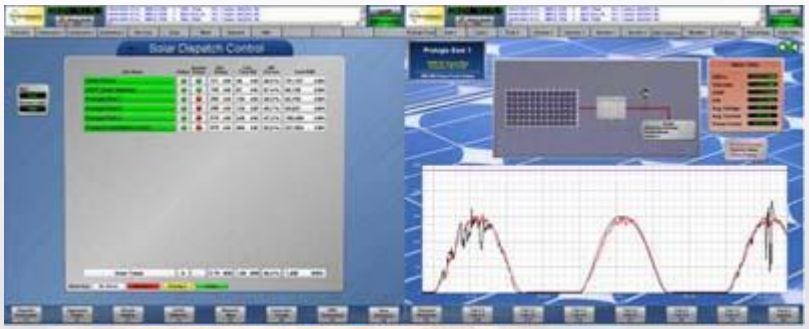
- **Systems Integrations**
- **Smart String Combiners**
- **VAR Support**
- **Maximum Power Point Tracking**
- **Low Voltage Ride-thru Functions**
- **Performance Predictions**
- **Intermittency Mitigation**
- **Component Utilization**
  - Nano-crystal magnetics, Film Capacitors, Integrated Circuits,
- **Communications Integration**
  - Synchrophasors, Mesh Network, PLC, Wireless,

Important SEGIS Advances

- Curtailment
- Anti-Islanding and Intentional Islanding Controls
- Micro-Grid Enablement
- Energy Management/Storage
- Building Energy Management
- Performance/Economic Optimizations
  - Utility support (Value Added)
  - System Optimization (Economics)

Impacts and Public Aspects of SEGIS

- New System Architectures Increase Types/Numbers of PV Applications
- Utility Dispatch Makes PV Look Like a Generator, NOT a Negative Load
- Utility Needs are Being Addressed
- Communications Add Value for Owner Economics and Utility Grid Stability
- Developments are Validating the Sanity of New Interconnect Standards
- System Integrations Improve Reliability and Functionality



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What's Changed?
Many Challenges and Barriers Remain

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A Focus for the Future

- **Coordinated Teaming Projects that BRING the Collective Expertise of Utilities, PV Module Manufacturers, BOS Manufacturers, Academia and Communications Experts TOGETHER with a COMMON Goal.**
- **Enable Sustained Acceleration of PV Grid-tied Installations**
  - PV System Sizes Ranging from Micro-inverters - Large Commercial Installations with Expandability keeping $1/W as a new goal.
  - Intelligent PV-Grid Interoperability (Higher Penetration) Advances
  - PV System Integration for:
    - PV System Performance Enhancement
    - Value Added for Improved Economics to Owner and Utility
    - Features that Improve Manufacturability/Reliability/Lifetimes
    - Integration of Advanced Safety Features (i.e. Arc-fault Detection/Mitigation)
  - Micro-grid Controls and Functionality Integration that Optimize PV and Energy Management Values

A Focus for the Future

- **System Topologies – (Low V to 1000V)**
  - Modularized/Compatible Components
  - Large Area PV Module System Optimization
  - International Functionalities
  - Intelligent Control and Power Interfaces
- **Longer System Lifetime (30y goal)**
  - Higher temperature components
  - Large-scale IC and Power IC applications (ADEPT)
  - Vertically Integrated Manufacturing
  - New Power Semiconductors (Wide Bandgap devices) (ADEPT)
  - Materials Corrosion/Wear-out Improvements (Optimize Costs/Lifetime)
- **Optimized Levelized Cost of Energy**
  - Model developments that include energy storage and alternative methodologies to optimize economics
  - Models that perform LCOE/Value comparisons to assess the metrics used for today's systems

A Focus for the Future

- **Energy Management Optimizations**
  - Minimize Wear-out Mechanisms for Grid-tied PV systems (e.g. VAr generation can replace a lot of energy storage)
  - Optimize Energy Storage Types in PV applications (Economics/lifetime)
  - Integrate Energy Management (Load Controls) with Energy Storage
  - Address Safety with Energy Storage in Accessible Locations
  - Integrate System Controllers (ties PV to utility needs)
- **System and Component Reliability (ADEPT)**
  - Use of Advanced Technologies
    - More efficient and advanced magnetic materials
    - Self-healing capacitors and capacitor application improvements
    - Improved Packaging and Cooling
  - Component remaining lifetime indications
    - Improved sensing for damage to internal circuits
    - Thermal sensing and system profiling
    - Self-protection built into the power conversion hardware

A Focus for the Future

- **Communications for PV Grid Interoperability**
  - Team with Communications experts to implement nested communications to:
    - Perform and report safety related functions
    - Perform economic adjustments to optimize PV system values for owners and interconnected utilities
    - Perform resource predictions and adaptive functionality of PV systems
    - Perform performance monitoring and reporting
    - Participate in and implement best choices of methods, protocols, standards, speed, dependability, etc.
  - AMI/AMR Interaction Development
    - Determine best methodologies and system limitations
    - Interface with developed interface controllers/inverters for maximum benefits for the owner/utility.s
  - **Safety**
    - Arc-fault Detection and Mitigation
    - Smart String Combiners

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