Transforming Distributed Solar Generation
Program Goals

• Continue driving solar technology innovations to improve grid interoperability under high penetration PV.

• Leverage partnerships to develop scalable solutions to meet today’s and future electrical needs

• Drive “system cost” to grid parity with existing energy sources
Partners

- Schweitzer Engineering Laboratories Inc.
- Northern Plains Power Technologies
- Portland General Electric
- Potomac Electric Power Company
- International Battery
Industry Insights and Market Direction

• High Penetration PV
  • Defined herein as effects based
  • Voltage stability, power quality impacts

• Functionality
  • Fixed VAr / power factor
  • Scheduled VAr / power factor
  • SCADA controlled inverters

Market Direction
• Lower cost system solutions
• Long term reliability
Project Objectives

1) Deploy and drive adoption of synchrophasor-based island detection
2) Develop feeder level optimization control strategies for DG
3) Explore economics and impacts of energy storage solution

Increased Confidence under High PV Penetration
**Project Scope**

<table>
<thead>
<tr>
<th>PMU-Islanding</th>
<th>Feeder Level Optimization</th>
<th>Storage-Based Solution</th>
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</thead>
<tbody>
<tr>
<td>Integration of PMU-based island detection solution into commercial meters and relays.</td>
<td>Instrument 2-3 high penetration feeders with PMU-capable dispersed meters / relays</td>
<td>Assessment of economic cost / benefit of applying storage to limit cloud induced transient effects on installed PV systems.</td>
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<tr>
<td>Deploy technology at 2-3 problematic sites (economically and technically challenged installations)</td>
<td>Explore opportunities to increase penetration / improve overall system response through use of fast Volt/VAr management.</td>
<td>Architecture includes site location(s) as well as system size for storage application</td>
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<tr>
<td>Study system response and performance over extended time period</td>
<td>Apply optimization control strategy to improve overall feeder level efficiency, power quality, and voltage stability.</td>
<td>Optimization of storage inverter functionality to meet future installation requirements.</td>
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Technical Approach

• Instrument feeders with time synchronized measurement technologies
  • Inverter locations
  • Voltage regulation equipment
  • Critical nodes throughout feeder

• Build simulation tool-set for rapid analysis and development
  • Central data storage for analysis
  • Detailed feeder level models (East and West Coast)
  • Incorporate “measured” data and events into model for validation

• Model and simulate feeder response under transient conditions
  • Loading scenarios (daily / weekly / seasonal)
  • Irradiance and temperature scenarios (weather station inputs)
  • Location and size of storage solution “optimization”

• Deploy developed technologies
  • Long term demonstration and analysis
  • Voltage stability and power quality analysis
  • Economic validity $$
Leveraging Time Synchronized Measurements
Expected Outcomes

• Increased distribution system voltage awareness

• Improved distributed resource interoperation with existing VR equipment

• Increased grid capacity for intermittent generation

• Understanding of storage based integration opportunities to mitigate system wide cloud induced transients

• Economics of deployment for the created technologies

• Increased awareness of alternative island detection approach that addresses critical industry need
Path Toward Commercialization

- Technology Innovations
- Field Deployment
- Partnership Creation
- Standards Alignment
- Function/Feature Optimizations
- Economic Impacts
- Demonstrations / Long Term Studies
- Data Security
- Widespread Integration / Deployment
- Dispatchable Energy Resource
Closing Remarks

• AE led program addresses 3 barriers to high PV penetration
  • Safety (island detection)
  • Intermittency (storage-solution)
  • Interoperation with existing voltage regulation equipment

• End solutions will be a mix of technology based on need
  • Physical location
  • Electrical characteristics

• Partnerships created will continue to drive developments
The technology proposed to be developed under this opportunity directly targets improving the operational characteristics of PV inverters using system wide awareness to impact the greater electrical utility system. Intermittency of the PV plants, system safety, and inter-operation with utility electromechanical voltage regulation equipment are all addressed and improved upon. Synchrophasors are leveraged for time synchronized system state awareness, as well as control optimization at the point of generation. Energy storage is used in an economical sense to moderate the cloud induced transients and induced voltage affects of high penetration PV. Lastly a novel island detection technique is introduced which overcomes false nuisance trips due to real grid events (large motor starts, etc.) while reliably detecting true island events without causing power quality issues.

Transformer PV systems from intermittent power sources to reliable sources of schedulable energy for improving distribution feeder control, power delivery, power quality, and reliability aspects under high PV penetration scenarios.