Challenges Integrating DER

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APS System Overview

**ITEM**

- Counties: 1
- Square miles: 34,646
- Customers: 1.2 million
- Substations: 43
- Distribution line miles: 29,148
- Transmission line miles: 6,068
- Generation units: 65

**STATISTICS**

- Peak demand: 7,350 MW (06/20/2017)
- Previous peak: 7,236 MW (07/21/2006)
Considering Utility Models

• Deregulated market entity
  – T&D companies
  – Wholesale generation market
  – ISO/RTO for transmission, balancing and market clearing

• Vertically integrated utility
  – Generation, T&D, customer interconnection

• ‘Wires’ companies
  – T&D
System Layer DER Impacts

- Anything that happens in one area affects the others
- Generation
  - IRP and resource adequacy
  - Balancing, flexibility and ramping
  - Bulk grid /wholesale impacts
- Transmission/Sub-transmission
  - Masked load: line and transformer flows
  - N-1 reliability criteria and disturbance response
  - Operating flexibility
  - Capital infrastructure planning
- Distribution
  - Monitoring, control and operational flexibility
  - Hosting capacity, high penetration impacts
  - Reliability (voltage, thermal, protection) impacts
  - Locational value of customer technology
- Customer meter
  - Technology adoption drivers and needs
  - Retail rates and impacts
  - Changing customer behaviors
## DER Interconnection Impacts

### Penetration

<table>
<thead>
<tr>
<th>Impact</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal</td>
<td><strong>Green</strong></td>
<td><strong>Yellow</strong></td>
<td><strong>Red</strong></td>
</tr>
<tr>
<td>Voltage &amp; PQ</td>
<td><strong>Green</strong></td>
<td><strong>Yellow</strong></td>
<td><strong>Red</strong></td>
</tr>
<tr>
<td>Protection</td>
<td><strong>Green</strong></td>
<td><strong>Yellow</strong></td>
<td><strong>Red</strong></td>
</tr>
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- **Potential benefits**
  - Some benefits – highly dependent
  - Negative impacts
Interconnection Processes

• At the meter
  – Safety and reliability
  – Interconnection drawings, certified equipment, protection coordination
  – NEC, NESC, NFPA

• At the transformer
  – Sizing electrical equipment
    • To serve load (ie. PV production = 0 at night)
    • To back-feed the grid (production >> load)

• On the grid
  – Aggregate impacts of all interconnected systems
  – Thermal capacity of transformers, wires, devices
  – Voltage and power quality impacts
  – Protection equipment impacts
DER Integration Costs

• Hard costs
  – Infrastructure
    • Required to maintain safe, reliable operation, and maintain power quality
  – Upgrades required due to existing/emerging issues
  – DG application that causes the grid upgrade

• Soft costs
  – Application interface portal
  – Administrative and engineering resources to determine impacts and conduct analysis

• Other costs
  – Tools, technology, data
  – Operational modifications that affect other assets
- At the meter
  - Inverter, controls & communications
  - Switches
  - Protective devices

- At the transformer
  - Panel
  - Service conductor
  - Transformer

- On the grid
  - Primary conductors
  - Voltage regulating equipment
  - Substation (relays, breakers) or line (reclosers, fuses) protective devices
Other Considerations

- Integration costs are but a piece of the pie
- Utility structure
  - Vertically integrated? Wires Only? Deregulated Market?
  - Bulk grid and generation impacts
- Investment recovery mechanisms
  - Net metering?
  - Rate structure (kWh only charges)?
  - Billing reflective of infrastructure vs. energy?
- Operational impacts
  - Production alignment with consumption?
  - Challenged existing balancing and operations
    - Seasonal (spring/fall vs. summer)
    - Infrastructure deferral possible (sensitive to assumptions)
Conclusions

- Utility structure matters
- Costs of integrating DER
  - Hard costs (infrastructure)
  - Soft costs (support)
- Other considerations are significant
  - Rate structure
  - Investment recovery
  - Customer benefit and grid benefit
- DER grid benefits
  - Needs proactive planning and awareness
Peak Day Generation Stack June 19, 2016

Max = ~7400 MW @ 5:30PM

Min = ~2400 MW @ 3:30AM