Distribution Power Electronics: Utility Perspective

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Thought for the Day…
Are Utilities Keeping Pace?

Circa 1900

Today

Future

Modernization leverages the application of state-of-the-art technologies to meet customer and operational demands.
The Time is Now…
Policy and technology advances are pressuring the current electric infrastructure system.

Policy Driving Shifts
- Federal, state & local policy and community initiatives.
- Aggressive renewable portfolio standards and incentives.
- New investments in electric generation ($1.3 Trillion* by 2035) are changing where generation is located – more local and more distributed.
- New investments in gas infrastructure ($400 Billion* by 2035).

Infrastructure Delivery
- Electric delivery sector is in need of major reinvestment ($1.0 Trillion* by 2035) driven by asset modernization (replacement, cyber-security).
- Climate change is causing more frequent and severe weather events and a need for more resilient infrastructure.
- Critical information for optimization and prioritization to enable policy for market demands.

Technology & Customers Driving Shifts
- Customers are dependent on energy to enable their daily lives and businesses.
- Customers are accustomed to getting more and seeking more value. Affordability and reliability are expected.
- More diverse customers with evolving needs. Technology is reshaping and playing a major role in their lives.
NY-Potsdam UG Microgrid

Legend:
- Interconnection to Overhead Circuit(s)
- Underground Distribution for "Load" (Customer) Only
- Underground Distribution for Generation
- Switchgear with Special Control Equipment
- Padmount Transformer for Secondary Service Customer
- Primary Metered Customer - with load & generation
- Primary Metered Customer - with generation only

Notes:
1. Each of the customer’s services will need to be reworked to accommodate the new underground service lateral(s).
2. The electrical connections are based upon the locations of the various “load” customers in the various “generation” customers to minimize the underground facilities that need to be installed while maintaining the “loop” distribution design.
3. The switchgear was arbitrarily selected for the “interconnection to overhead circuit(s)”. These were shown to remind us that for normal configuration, operation, that the overhead will be supplying the load.

V/O Potsdam
Lawrence Avenue ES976
MicroGrid
Interconnection Diagram (Rev 3.01)
Fault Locating Adventure

9:00 P.M ~ 5:00 A.M (8 hours)

X2 = 16 hours...
Phase II Solar “Integrate vs. Interconnect”

Purchase up to 20 MW’s of turn-key solar sites, implemented with advanced inverters

National Grid’s goal is to use these sites, to further solar development in the commonwealth through advanced technologies

- Advanced Inverter Features
- PLCP DTT
- Construction Optimization

Learn more about impacts of solar on areas by pre-selecting towns with:

- High PV penetration feeders
- Lightly loaded feeders
- Heavy loaded feeders
## Advanced Control Modes

<table>
<thead>
<tr>
<th>Functionality</th>
<th>Modes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Power Control</td>
<td>Real Power Curtailment</td>
<td>Ability to limit the active power production of the PV site to a value below its potential</td>
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<tr>
<td>Active Power Control</td>
<td>Ramp Rate Control</td>
<td>Ability to limit the rate of change in magnitude of active power supplied</td>
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<tr>
<td>Reactive Power Control</td>
<td>Fixed Power Factor: P_{\text{fixed}}</td>
<td>Ability to maintain a power factor at the PV site’s PCC by changing reactive power injection</td>
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<tr>
<td>Reactive Power Control</td>
<td>Fixed Reactive Set-point: Q_{\text{fixed}}</td>
<td>Ability to inject a fixed amount of reactive power (percentage of nameplate) at the PCC</td>
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<tr>
<td>Reactive Power Control</td>
<td>Power factor compensation - Power factor/active power characteristic curve P_{F(P)}</td>
<td>Ability to establish a Power Factor level at the PCC based on actual Active Power production</td>
</tr>
<tr>
<td>Reactive Power Control</td>
<td>Voltage Compensation - Reactive power/voltage characteristic curve Q(U)</td>
<td>Ability to inject Reactive Power at the PCC based on actual Voltage level</td>
</tr>
<tr>
<td>Reactive Power Control</td>
<td>Voltage Regulation – closed loop regulation of the voltage Ramp Rate Control</td>
<td>Ability to establish a Voltage level at the PCC by injecting Reactive Power. Ability to limit the rate of change in magnitude of reactive power supplied</td>
</tr>
<tr>
<td>Frequency Droop Response</td>
<td>Real Power Curtailment</td>
<td>Ability to curtail Active Power during higher than normal frequency at the PCC</td>
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<td>Low Voltage Ride Through (“LVRT”) &amp; High Voltage Ride Through (“HVRT”)</td>
<td>Ride Through or Modulated Power Output</td>
<td>Ability to configure the tripping of the PV site during Under and Over Voltage events at the PCC (beyond what UL1741 specifies)</td>
</tr>
<tr>
<td>Frequency Ride Through (“FRT”)</td>
<td>Ride Through or Modulated Power Output</td>
<td>Ability to configure the tripping of the PV site during Under and Over Frequency events at the PCC (beyond what UL1741 specifies)</td>
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</table>
Example: Inverter Control Impact

Simulation Results
2000 Iterations

Control Strategies

Advanced Inverter Voltage Control Strategies

Total Hosting Capacity [%]

Base Scenario Fix PF PF(P) Qfix Q(U) P(U) Q(U)|P(U)
Secondary Regulation
Thoughts on Implementation

Power Electronics have the promise to increase overall system
- Observability
- Efficiency
- Resiliency
- Power Quality

However, they also have the potential to:
- Introduce new failure mechanisms
- Increase Observability
- Information Overload Operators
- Tax Infrastructure

- Communications bottlenecks
- Fail-out-of-the-way Pilots
- Pilot vs. Integrated into the business
- Security: Physical/Cyber
Potential Applications:
Balancing the Distribution System
Potential Applications:
EMS Visibility: Cable Balancing
Potential Applications: Dynamic Feeder Balancing

Active electronics at Feeder Tie locations:
• Manage Power flow between feeders
• Assist in restoration and FLISR efforts
• Limit or mitigate fault current impacts
• Assist in reconfiguration for construction
• Voltage Support at EOL
• Fault Location
Potential Applications:
Lateral Feeder Balancing

Active electronics at Lateral locations:
• Sustain balanced power flows as load changes
• Supply local VARS as needed
• Provide lateral visibility
• Assist in restoration and FLISR operations
Thoughts?

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