DER Interconnection Puzzle Pieces

Technical Codes & Standards

Smart Inverters

Power Electronics

Advanced Modeling Tools

Interconnection Rules & Processes

Each Puzzle Piece is Very Important!
Applications vary based on:
- System size
  - <10kW
  - 10kW-100kW
  - >100kW
  - Synchronous Machines
- Technology type

Normalized Utility Interconnection Process

**Standards & Codes**
- IEEE 1547
- UL 1741
- NEC
Technical Screens – Not All are Helpful & Useful

1. Is the application subject to the utility tariff?
2. Aggregated DG <15% of Peak Load on line section
3. For connection to a spot network: DG is inverter-based, aggregated DG capacity is <5% of peak load & <50 kW
4. Aggregated DG contribution to maximum short circuit current is <10%
5. Aggregated DG does not cause protective device to exceed 87.5% of short circuit interrupting capability
6. DG interface is compatible with type of primary distribution line (wye/Delta)
7. For a single-phase shared secondary, Aggregated DG capacity <20kW
8. Resulting imbalance <20% of service transformer rating of 240 V service
9. Aggregated transmission connected DG capacity <10 MW for stability-limited area
10. Construction not required for interconnection

Takeaway: The 15% Capacity Penetration metric has been shown to be far too strict in most cases
Common Utility Concerns for DERs

- Voltage Regulation
- Protection coordination
- Reverse power flow
- Unintentional islanding
- Increased equipment line duty
- Secondary network reliability
- Variability due to clouds
- Capacitor switching
- Impacts from multiple technologies
# Common Mitigation Tools & Strategies

## The Interconnection “Toolbox”

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Description</th>
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<tbody>
<tr>
<td>Modify protection settings/fuses</td>
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<tr>
<td>Advanced Inverter function use (e.g. absorb VAr to lower local voltage levels)</td>
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<td>Voltage Regulation Devices &amp; Controls</td>
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<td>Direct Transfer Trip (DTT)</td>
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<td>Upgrade a feeder or line section</td>
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<tr>
<td>Communications &amp; Controls</td>
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<tr>
<td>Grounding transformers</td>
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<tr>
<td>Limiting DER system size</td>
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</tbody>
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Costs for each strategy vary greatly!

https://www.nrel.gov/docs/fy19osti/72102.pdf
Smart Inverters – An Important New Strategy for Distribution Systems

- Power electronics that offer many additional features for control and grid support than the earlier inverters
- Many new smart inverter functions offer “Grid Support” features to help utilities
- The goal is to maximize the amount of inverter based DERs on the grid
- Utilities need all DERs to be “Grid Friendly”, and support voltage & frequency
- These inverters can provide future communication and control functions

Señor Smart Inverter
Major Achievements in 2018 Revision

- Consensus standard: 120+ industry experts in working group, 4-year effort
- Robust public balloting: 389-member public ballot pool, 1,500+ comments resolved
- 93% approval (75% required).

- More coordinated operation under normal conditions
- Maintain grid safety
- Grid support under abnormal conditions
- New guidance for interoperability and open communications
- New guidance for intentional islands
- Strikes a balance between needs for large and small installations.
Final Observations – What Have We Learnt in the U.S.?

- Distribution Systems are generally able to absorb high amounts of PV and other DERs
- Potential challenges for PV (etc.) are related to size of DER system, DER location, voltage level of distribution system
- New technology, such as “Smart Inverters” and System Controllers will help increase “Grid Hosting Capacity” and allow greater DER penetration
- Monitoring and control for more DER systems will become necessary, but also autonomous controls will be critically important as distributed energy resources will become “Good Citizens of the Grid”
- Regulatory reform to support both DERs AND the utilities will be very important over the next few decades
Thank you

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