Session 8: Distributed Energy Resources
Utility Concerns, Grid Impacts
and Mitigation Strategies

October 21, 2015 – Santiago, Chile

Michael Coddington
National Renewable Energy Laboratory
Golden, Colorado, U.S.A.
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Problems Associated with “Too Much” Customer-Sited DG

• Voltage control – High or Low voltage
  • Much greater risk for larger DG systems that export power to the grid
• Excessive voltage regulator tap operations
• Power quality (customer flicker, etc.)
• Risk of unintentional islanding
• Protection/fuse miscoordination, relay desensitization, etc.
• Load masking affecting planning & operations
## Utility Concerns about High PV Penetration

<table>
<thead>
<tr>
<th>Identified Issues</th>
<th>Relative Priority</th>
<th>Identified Issues</th>
<th>Relative Priority</th>
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<tbody>
<tr>
<td>Voltage Control</td>
<td>High</td>
<td>Equipment Specs</td>
<td>High</td>
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<tr>
<td>Protection</td>
<td>High</td>
<td>Interconnection Handbook</td>
<td>Medium</td>
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<tr>
<td>System Operations</td>
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<td>Rule 21 and WDAT</td>
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<td>Power Quality</td>
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<td>IEEE 1547/ UL 1741</td>
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<td>Monitoring and Control</td>
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<td>Application Review</td>
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<tr>
<td>Feeder Loading Criteria</td>
<td>High</td>
<td>Clarification of Responsibilities</td>
<td>High</td>
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<tr>
<td>Transmission Impact</td>
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<td>Integration with Tariffs</td>
<td>Medium</td>
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<tr>
<td>Feeder Design</td>
<td>Medium</td>
<td>Coordination with Other Initiatives</td>
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<tr>
<td>Planning Models</td>
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</table>

Source: Russell Neal, Southern California Edison
Renewable Energy Interconnection Technical Concerns

Wind and Large Solar (Central Station Generation)
Steady state and transient stability analysis
Quantifying variability (impacts on ramp rates and operations)
Load/Generation Coincidence (Peak Load and Variability of Source)
Regulation Requirements
Integration with Automatic Generation Control (AGC)
Incorporation of renewable resource forecasting
Examine current operating practice and new concepts to enable high penetration;
  – frequency responsive (create regulating reserves)
  – demand side coordination

Distributed Solar and Small Wind (Distributed Generation)
Issues listed above at scale, plus
Voltage Regulation
Grounding
Protection design and coordination (short circuit, recloser, etc.)
Unintentional Islanding
Power Quality (Harmonics, Flicker, DC Injection)

Most technical concerns at the transmission level have been solved with modern wind turbines and grid codes
Focus is on grid planning and operations

Technical concerns at the distribution level have been identified (details at end of presentation), but small RE have not been fully integrated into planning and operations

Interconnection concerns are real and solvable
Voltage Control – Global Utility Concern

ANSI C84.1
Standard for Electrical Power Systems and Equipment-Voltage Ratings (A 60 Hz standard, but the concept is universal)

- Service Voltage – Voltage at the point of delivery
- Range A (+/-5%) is favorable
- Range B (+/- 10%) is tolerable
Voltage Control Concerns

Substation Transformer

Voltage Regulator

Voltage Regulator

Upper ANSI Limits

Nominal Voltage Level

Lower ANSI Limits

Distance in Miles
Voltage Control Concerns

Substation Transformer

Current Flow

PV Large Exporting PV System

Voltage

Upper ANSI Limits

Nominal Voltage Level

Lower ANSI Limits

Distance in Miles
Voltage Control Concerns

- Substation Transformer
- Voltage Regulator
- Current Flow
- Large Exporting PV System

Voltage vs. Distance in Miles
- Upper ANSI Limits
- Lower ANSI Limits
- Nominal Voltage Level
Voltage Control Concerns

Distributed Generation Concerns

May need to re-evaluate settings and scheme:

- Switched capacitor settings may especially be vulnerable to adding to DG voltage rise
Switched Capacitor Banks

– Defined by kVAr rating of bank
– Voltage rise proportional to rating
Short-circuit current coordination

Distributed Generation can provide a variety of levels of short circuit current

This may impact the short-circuit coordination between fuses and circuit breakers in the distribution system.

In the example to the right, the DG increases short-circuit current seen by the fuse and is no longer coordinated with the breaker CB-1 opening.
PV Hosting Capacity Study

“Alternatives to the 15% rule (of-thumb)”

PV Hosting Capacity in Distribution Systems
Development of Alternative Screening Methods
Interconnection Study of 21 Utilities

- PG&E
- SCE
- SDG&E
- SMUD
- NSP
- Com Ed
- Detroit Edison
- Nashville Electric
- PSCO
- PNM
- APS
- Tri County Electric Coop
- Austin Power
- SPS
- NSTAR
- National Grid
- Con Ed
- O&R
- Central Hudson
- LIPA
- PEPCO
Areas of Focus for PV Interconnection

• Application Process and Timeline
• Fast-Track Screens and Supplemental Screens
• Utility Concerns of PV Grid Impacts
• Types of Impact Studies & Software Tools
• Mitigation Strategies Employed
There are significant differences amongst Electric utilities in practices, processes, tools & models and mitigation strategies.
Screening DG Applications

Most North American utilities follow a version of FERC SGIP screens
Some used a minimum daytime load for penetration screen (prior to FERC SGIP 2013 order)

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

- Voltage Regulation 16
- Reverse power flow 11
- Protection system coordination 10
- Increased duty of line regulation equipment 8
- Unintentional islanding 8
- Secondary network protection 6
- Variability due to clouds 5
- Increased switching of capacitors 4
## Mitigation Strategies Considered

<table>
<thead>
<tr>
<th>Type</th>
<th>SW (5)</th>
<th>Central (3)</th>
<th>California (4)</th>
<th>NE (7)</th>
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<td>Upgraded line sections (16)</td>
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<td>2</td>
<td>4</td>
<td>6</td>
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<tr>
<td>Modify protection (16)</td>
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<td>3</td>
<td>3</td>
<td>6</td>
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<tr>
<td>Voltage Regulation devices (13)</td>
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<td>3</td>
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<tr>
<td>Direct Transfer Trip (12)</td>
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<td>3</td>
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<tr>
<td>Advanced inverters (11)</td>
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<td>3</td>
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<tr>
<td>Communication/Control Technology (11)</td>
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<td>Power factor controls (8)</td>
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<td>Grounding transformers (8)</td>
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<td>Reclosers (3)</td>
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<td>Static VAR Compensator (SVC) (1)</td>
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<td>Capacitor control modifications (1)</td>
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<td>Volt/VAR Controls (1)</td>
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<td>x</td>
<td>x</td>
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</table>
Best Practices by Experienced Utilities

• Open communication between utility & developer
• Online interconnection applications
• Ease of tracking project status
• Rational screening approach
• Supplemental screening options
• “Safety Valve” approach to solve simple problems and avoid impact studies
• Standard impact study approach, software
• Cost-effective mitigation strategies
• Supportive regulatory organizations
• Uniform state rules/processes for all utilities
• Overall streamlined, transparent processes
• Apply for Interconnection prior to construction!
Electric Distribution Planning
Past, Present and Future Considerations

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Safety – Design and maintain an electric system that does not place the general public at risk

Reliability

• Provide the power that the consumers need
• Maintain a stable, nominal voltage
• Provide a stable frequency
• Maintain power quality
• Reduce Outages (short or sustained)
• Measures
  • Frequency of outages (S.A.I.F.I.)
  • Duration of outages (S.A.I.D.I.)

Cost - Supply energy at an acceptable price
EDP Focus of the 1990s (Universal)

- Load Forecasting
- Reliability (SAIDI, SAIFI)
- Feeder-Level protection
- Capacitor placement
- Voltage regulator placement
- Secondary network design
- Annual budget for division projects
- Voltage support (+/- 5% - +/- 10%)
- Regulatory complaint resolution
- Power Quality support
- Under Frequency Load Shedding Schemes
5-STEP ELECTRIC PLANNING APPROACH

1. Identify the Problem
   Forecast where demand exceeds present capacity

2. Set Goals
   This distribution system must meet all necessary criteria at minimum cost

3. Identify Alternatives
   Different reinforcement of alternative plans

4. Evaluate Each Option
   For electrical and reliability performance and cost

5. Select the Lowest Cost Alternative
   Performance must meet all criteria
MY FIRST DG PROJECT (1993)
MY RESPONSE!

- Lack of standards and codes
- No experience on grid-tied DG
- No state policy in place
- Policy driven
- Many utility departments involved

NO!!!
THE PLANNING PROCESS

1. Project the **conditions, requirements and situation** the company may face
2. Estimate the consequences and the results they will cause and determine which are unacceptable
3. Identify actions or plans needed to handle or change the situation, mitigate its effects, or achieve desired goals
4. Decide upon, approve, and initiate Actions
INTEGRATED DISTRIBUTION PLANNING

- Forecast DG growth on each circuit
- Establish the hosting capacity and allowable “penetration level”
- Determine available capacity on each distribution circuit
- Plan upgrades and expedite interconnection procedures based on IDP
- Publish the results
Questions for Consideration

- Should distribution utilities PLAN for DG?
- Who should pay for distribution upgrades that increase Grid Hosting Capacity (GHC)?
- What are the best types of distribution system investments?
- Who should pay for the distribution system?
- How should DSOs recover investments?
- Can we “Rate-Base” GHC investments?
GRACIAS!