Distribution Planning with DER: Distribution System-Wide Impact Assessment Methods

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Evolving Planning Tools

- Vendor tools advance at the rate their customers require additional functionality
  - Sequential time-series analysis

- Open-Source tools like OpenDSS advance more quickly as needed for research
  - Smart inverter controls
  - System-wide planning (Distribution Resource Plans)
  - Distribution System Management (DMS) applications
System-wide began years ago…

Detailed Feeder Hosting Capacity

Baseline – No PV
PV Penetration 1
PV Penetration 2
PV Penetration 3
Beyond…

Increase Penetration Levels Until Violations Occur
- voltage
- protection
- power quality
- thermal

Process is repeated 100’s of times to capture many possible scenarios
Detailed Analysis led to…

What matters most?

- DER technology and impacts
- DER size and location
- Feeder design and operation

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**Voltage**

**Protection coordination**

**Thermal capacity**

**DER Technology and Impacts**

**DER Size and Location**

**Feeder Design and Operation**

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Impact Below Threshold

Impact Depends

Impact Above Threshold

Uncontrolled DER Deployment

Optimal DER Deployment

Impact Threshold

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0 1 2 3 4

Hosting Capacity (MW)

0 5 10 15 20 25

Feeder
The Question Arose… How to Analyze System-Wide?

- Detailed system analysis requires significant time/resources
- “Work-arounds” have included:
  - Detailed analysis on select feeders and extrapolating results to others
  - Simplified screening analysis on all feeders

Extrapolation Problem:
Two similar feeders with different results

Screening Problem:
Under and over conservative results

Current Analysis Methods Aren’t Sufficient
To go System-wide, New Methods are Needed

- Captures what matters most
  - DER technology and impacts
  - DER size and location
  - Feeder design and operation

**EPRI’s Streamlined Hosting Capacity Method**

- **Granular**
  - Capture unique feeder-specific responses
- **Repeatable**
  - As distribution feeders change
- **Scalable**
  - System-wide assessment
- **Transparent**
  - Clear and open methods for analysis
- **Proven**
  - Validated techniques
- **Available**
  - Utilize readily available utility data and tools
Streamlined Hosting Capacity Method – What is it?

Input
- Database of feeders from distribution planning software (CYME, Milsoft, Synergi)

The Method
- Developed from years of detailed hosting capacity analysis
- Works within existing planning tools
- Considers voltage, thermal, and protection impacts
- Considers DER technology impacts
- Considers DER size and location

Output
- Effectively and efficiently analyzes each and every feeder in system
- Provides Node-level, feeder-level, and system-level hosting capacity
- Issues found at X penetration
- Locations where DER is more/less likely to cause grid issues

Details on Streamlined Method: EPRI Report 3002003278, 2015
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On Feeder-by-feeder, step ranges of distribution locations to determine ranges of hosting capacity
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Power System Criteria Evaluation

**Power System Criteria**

- **Thermal**
  - Substation transformer
  - Primary conductor
  - Service Transformer
  - Secondary Conductor

- **Power Quality/Voltage**
  - Sudden (fast) voltage change
  - Steady-state voltage
  - Voltage regulator impact
  - Load tap changer impact

- **Protection**
  - Relay reduction of reach
  - Sympathetic tripping
  - Element fault current
  - Reverse power flow

- **Reliability/Safety**
  - Unintentional islanding
  - Operational flexibility
Distribution System-Wide Hosting Capacity
Sample Results from One Utility Application

System Hosting Capacity
(~ 300 distribution feeders)

*Hosting Capacity
- lower
- higher

*Initial analysis results from TVA/EPB study, results not finalized
Distribution System-Wide Hosting Capacity

Sample Results from One Utility Application

System Hosting Capacity
(~ 300 distribution feeders)

Substation-level Hosting Capacity

Inform transmission studies

Identify feeders

*Hosting Capacity

- lower
- higher

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Distribution System-Wide Hosting Capacity

Sample Results from One Utility Application

System Hosting Capacity
(≈ 300 distribution feeders)

Substation-level Hosting Capacity

Feeder-level Hosting Capacity

*Hosting Capacity

lower
higher

Inform transmission studies

Identify feeders

*Initial analysis results from TVA/EPB study, results not finalized

Identify issues and locations
Graphic Visualization of System-Wide Results

Hosting Capacity
- lower
- higher

Substation-Level **Minimum** Hosting Capacity

Substation-Level **Maximum** Hosting Capacity
Distribution of Feeder Hosting Capacity Values
Large-Scale Centralized PV

Distribution of Feeder Hosting 12kV Feeders

Feeder Count

Cumulative Distribution

Min Hosting Capacity
Max Hosting Capacity
Applications For Streamlined Hosting Capacity Method

- Improving interconnection screening (accuracy and efficiency)
- Identifying optimal locations for locating DER
- Mapping DER impacts across system
- Identifying issues/mitigations needed to accommodate higher penetrations
- Establishing the cost/benefit of DER
- Informing distribution resource plans
- Informing bulk system studies
Advancing the Core Analytical Method (Streamlined Hosting Capacity Algorithm)

- Implemented separate from DSA platform interface/output
- Further advancements are underway – and will be ongoing thru R&D and utility implementation
- Near-term capabilities to be added
  - Mitigation: accommodating higher than existing hosting capacity
  - DER Value: thermal capacity and energy
  - Smart inverters: guidance for settings and determining higher hosting capacity values
  - Energy storage: constrained and controlled
Wrap-Up

- Existing methods aren’t sufficient to address today’s challenges
- New methods are needed
- Advancing open-source tools is first step (OpenDSS)
- Applications/methods can then be implemented in commercial tools
- Streamlined Hosting Capacity Method Currently Developed in
  - CYME
  - Synergi
  - Milsoft
- Current Applications
  - DOE SUNRISE Project (TVA + Southern Co)
  - EPRI Project (SRP, XCEL, SCE, Central Hudson, HydroOne)
  - > 3000 feeders analyzed
Together...Shaping the Future of Electricity
References

Detailed Hosting Capacity Method


Streamlined Hosting Capacity Method


General