Advanced Inverter Overview

Renewables on the Distribution Grid
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Overview

Distributed Resources Include:

- ***Efficiency***,
- ***Distributed Generation*** (Solar PV, Combined heat and power, Small wind),
- ***Distributed Flexibility and Storage*** (Demand response, Electric vehicles, Thermal storage, Battery storage), and
- ***Distributed intelligence*** (Information and control technologies that support system integration, including advanced inverters).

Advanced Inverters

Examples of advanced functionality:

- Voltage and Frequency Ride through while still providing anti-islanding
- Reactive Power (var) support
- Ramping rates for normal and emergency scenarios
- Reconnection using “soft-start” capability with either ramping or random starts within windows, in order to avoid sharp spikes when large numbers of I-DER systems reconnect to the distribution system

Impacts on Distribution Systems
Distributed Generation - Feeder Analysis

Evaluation Criteria include:

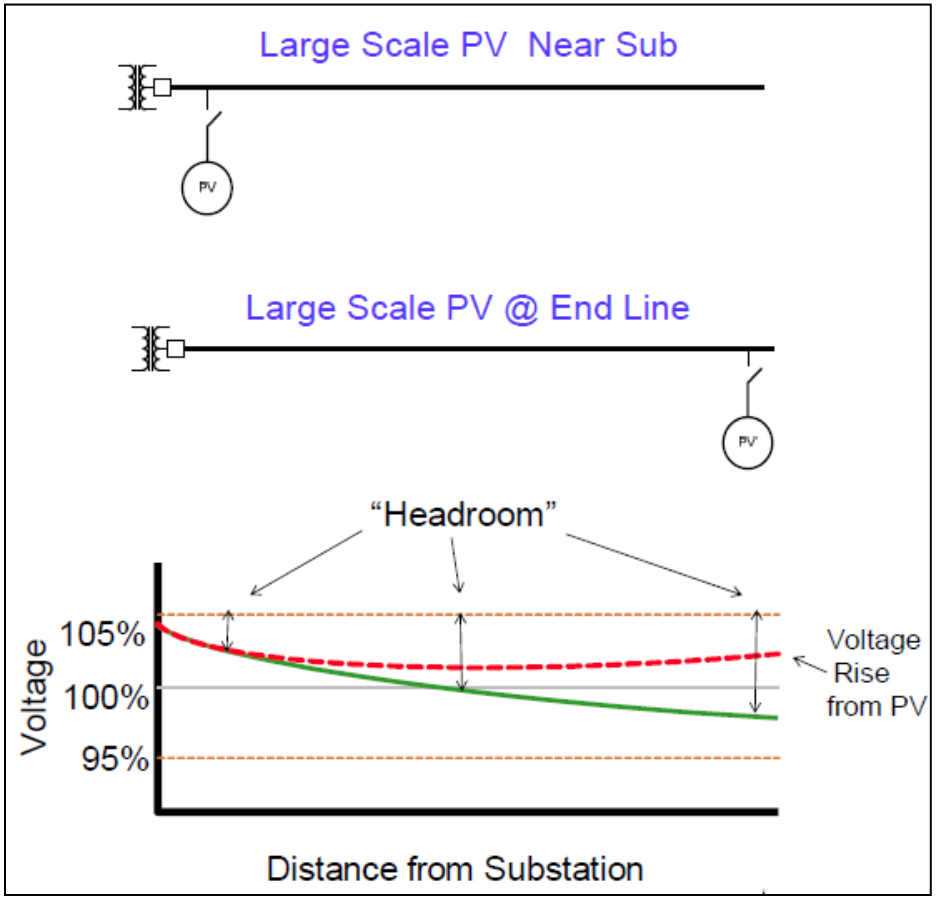
- Voltage
- Protection system
- Power quality
- Loading
- Operations

Solutions include:

- Advanced Inverters
- Demand Response
- Energy Storage (thermal, batteries, Electric Vehicles)

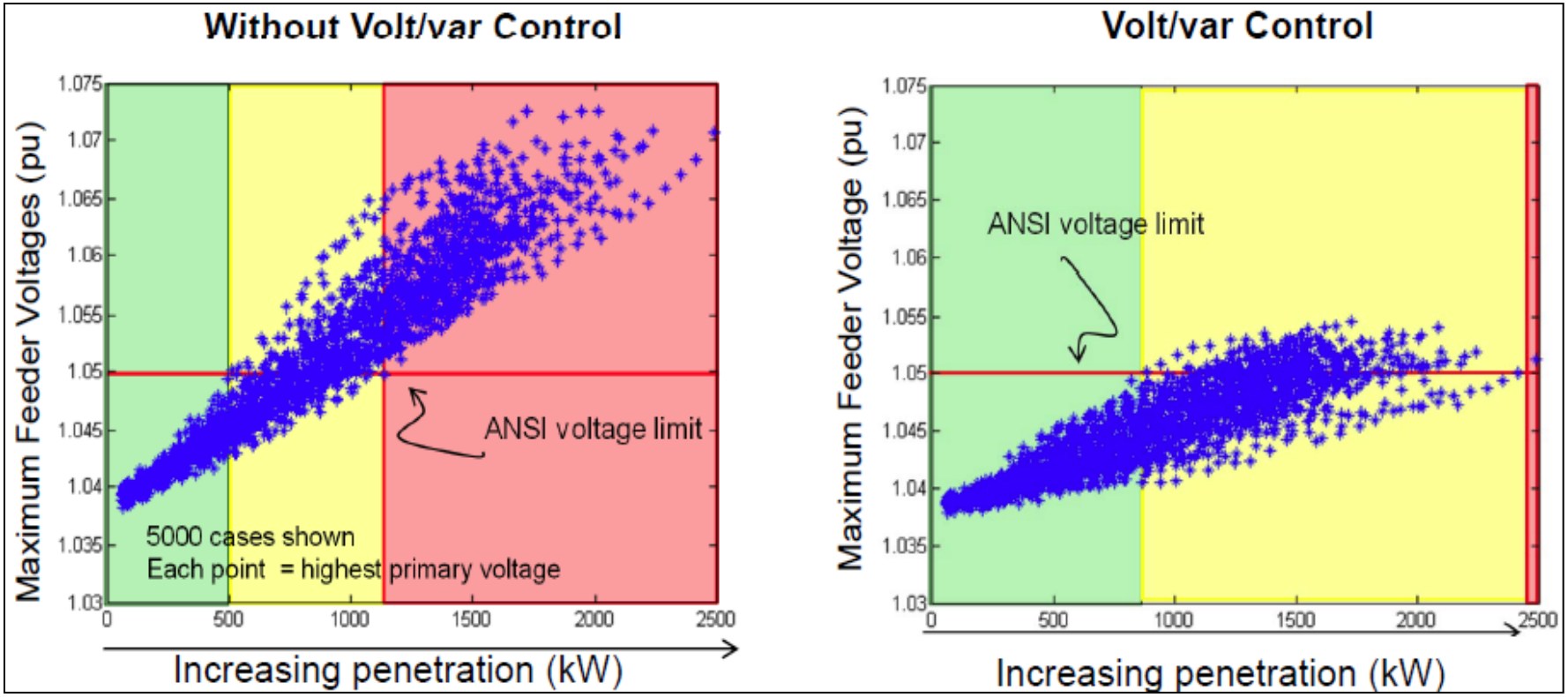
Key Factors that Determine How Much PV a Feeder Can Accommodate (Hosting Capacity)

- Size of PV
- Location of PV
- Feeder characteristics
- Electrical proximity to other PV
- Unique solar resource characteristics in the area
- PV control



Source: EPRI, Daniel Brooks & Jeff Smith. Presentations IEEE PES July 13, Lisbon Nov 12.

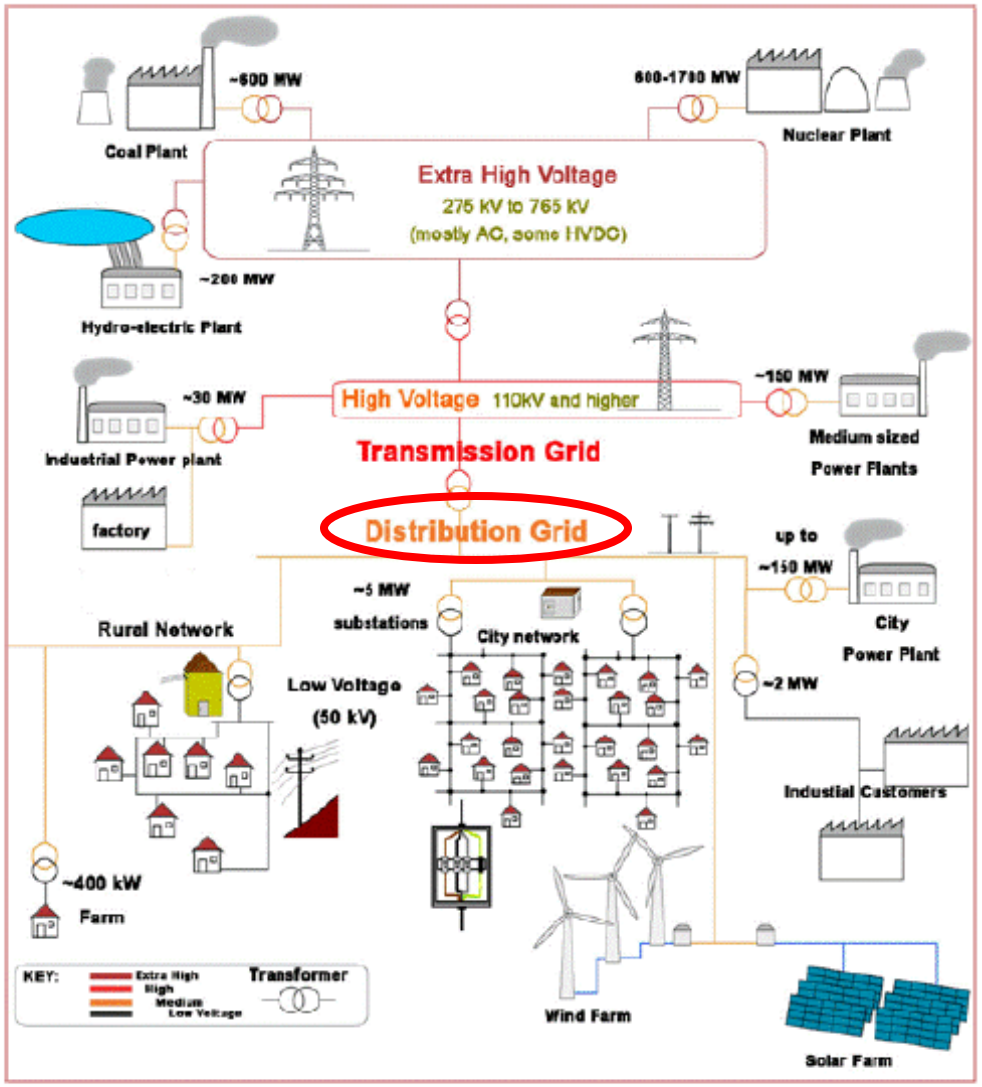
Increasing Hosting Capacity with Smart Inverters



Advanced inverters can generally double the capacity of PV allowed on a feeder.

Graphic Source: EPRI, Daniel Brooks & Jeff Smith. Presentations IEEE PES July 13, Lisbon Nov 12.

Technical Context – Codes & Standards



Bulk System Guidelines
NERC, FERC
IEEE, ANSI, IEC
NESC

Technical and
jurisdictional overlap

Distribution System Guidelines
IEEE 1547, PUC/PRC
IEEE, ANSI, IEC
NEC

Source: NREL Presentation at MN Commerce DG Interconnection Meeting. May 31, 2012

CA Smart Inverter Working Group

In response to California Rule 21, the Smart Inverter Working Group (SIWG) will develop standards for certifying advanced functions.

January 1, 2014 SIWG report to the CPUC*:

- Background
- Recommendations
- Development framework & timelines

* SIWG Rule 21 Recommendations for the CPUC, January 2014.

SIWG - **Proposed Timeline**

- Phase 1: autonomous functions
  - March 2014 – UL to publish test procedures
  - October 2015 – commercial implementation
- Phase 2: communication functions
  - June 2014 - UL to publish test procedures
  - January 2016 - commercial implementation
- Phase 3: additional functions
  - September 2014 - UL to publish test procedures
  - April 2016 - commercial implementation

Source: SIWG Rule 21 Recommendations for the CPUC, January 2014.

Integration with the Distribution Grid

- **DG penetrations in MN are still very low; increases are coming.**
- *Distribution system planning* occurs largely in isolation from planning for other parts of the grid – coordination is needed with other planning work;
- *Distribution system planning* is based largely on historical peak loads – additional drivers should be incorporated;
- *Distributed generation* is capable of providing active grid support but has not historically been allowed or required to do so – both will change;
- *Distributed generation* is often not visible to the system operators – challenging at high penetrations;
- *Distribution management systems* have advanced significantly including sophisticated real time functions – capabilities not yet tapped.

Future Grid

Tomorrow's grid will:

- Be more distributed, flexible, intelligent, real-time controlled, autonomous, open *and* secure;
- Be cleaner and reliable;
- Operate resiliently against attack and natural disaster.

Tomorrow's distribution system will:

- Enable a high level of integrated Distributed Resources, both supply and demand side, with active participation by consumers;
- Manage two way flows of electricity;
- Implement modern distribution management systems (DMS) including advanced control and communications.

Distribution Planning

Increasing need for:

- Transparency
- Forecasting and planning for DG, DSM, and efficiency
- Coordination with other planning work

Distribution Planning

Utilities to watch:

- San Diego Gas and Electric
  - Distribution system available capacity
  - Dynamic pricing
- Con Edison
  - DSM and efficiency forecasting:
  - **Planning for Efficiency**, Con Edison, August 2011, Public Utilities Fortnightly

Thank You.

Questions?

MN DG Resources

Reports, presentations, data, and dockets:

http://mn.gov/commerce/energy/topics/clean-energy/distributed-generation/ or search for: “MN distributed generation”

http://mn.gov/commerce/energy/topics/resources/energy-legislation-initiatives/ or search for: “MN Energy Legislation Initiatives”

https://mn.gov/commerce/energy/utilities/Annual-Reporting-Utility.jsp or search for: “MN Utility Annual Reporting”