



Solar Interconnection Issues

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Overview

- ❑ This presentation is intended to be a brief discussion of the impact of the interconnection of large amounts of solar generation on a utility's distribution system.
- ❑ The presentation will also discuss typical utility planning concepts, codes and standards, and federal vs. NJ interconnection procedures.
- ❑ Finally, dealing with the challenges, and where we need to be heading.
- ❑ Many thanks to DOE and NREL (proceedings from the High Penetration PV Workshop - <http://www.nrel.gov/docs/fy10osti/48378.pdf>), and others for some of the information in this presentation!

Interconnection Standards



Federal (PJM) Jurisdictional Interconnection Standards

- ❑ Applies to generators participating in PJM's wholesale market, regardless of size and interconnection voltage level, and follows standard FERC-approved procedures developed under the authority of the PJM OATT
- ❑ Procedures and requirements are based on size
 - Large Generating Facilities (>20 MW)
 - Small Generating Facilities (20 MW or less)
- ❑ PJM's Small Generator Interconnection Standards use a streamlined process for smaller generators
 - Fast Track Study Process for small generators
 - 10 kW Inverter Process for certified inverter based generators no larger than 10 kW
 - Small generators must meet IEEE 1547

State Jurisdictional Interconnection Standards

- ❑ In NJ, regulations currently apply to small generators which are connected to the distribution system
 - Net Metering, PURPA or similar arrangements for “retail sales” of electricity to the host utility only, are State jurisdictional
 - Distribution interconnections of “wholesale sales to PJM” projects on non-PJM jurisdictional distribution facilities are State regulated
 - Covers all customer classes
- ❑ NJ’s regulations generally conform with the FERC SGIP, but have some significant differences
- ❑ Technical standards focused on IEEE 1547, and for inverters, requires UL 1741 certification for most applications

IEEE 1547 Interconnection Standards

1547- 2008 Standard for Interconnecting Distributed Resources with Electric Power Systems

1547.1 - 2005 Conformance Test Procedures for Equipment Interconnecting DR with EPS

1547.2 - 2008 Application Guide for IEEE 1547 Standard for Interconnection of DR with EPS

1547.3 - 2007 Guide for Monitoring, Information Exchange and Control of DR

P1547.4 Guide for Design, Operation, & Integration of Distributed Resource Island Systems with EPS

P1547.5 Guidelines for Interconnection of EPS >10 MVA to the Power Transmission Grid

P1547.6 Recommended Practice for Interconnecting DR With EPS Distribution Secondary Networks

P1547.7 Draft Guide to Conducting Distribution Impact Studies for DR Interconnection

Current 1547 Projects

Microgrids

P1547.8 (new)
Extend use of 1547,
e.g. grid support, energy
storage, ride-thru, etc.

NREL High Penetration PV Workshop

IEEE P1547.8

- This **“Recommended Practice for Establishing Methods and Procedures that Provide Supplemental Support for Implementation Strategies for Expanded Use of IEEE Standard 1547”** is needed to address industry driven recommendations related to shortfalls of IEEE 1547, and NIST smart grid standards framework recommendations (e.g., NIST SGIP Priority Action Plan - “PAP 7”)
- Example considerations include: low voltage ride through (LVRT) of PV; VAR (reactive) support; grid support; two-way communications and control; advanced interactive grid to DG operations; high penetration of DG; area EPS with multiple DG interconnections; interactive inverters; energy storage; electric vehicles; etc.

PV Impact Studies, Analysis, Challenges and Goals



Key Areas of Focus for PV Interconnection Impact Studies

- ❑ Voltage Regulation
 - Steady state conditions, fluctuating conditions (flicker), cap bank and tap changer cycling issues, reverse power flow issues, voltage unbalance
- ❑ Fault Currents and Protection Coordination
 - Impact on fault levels, device coordination, interrupting ratings, ground fault current detection desensitization
- ❑ Ground Fault Overvoltages
 - Important especially for non-effectively grounded DG, which is how PV devices are often configured
- ❑ Islanding
 - Important especially in complex situations with multiple DG present, or with fast reclosing and no live-line reclose blocking

PV Interconnection Issues and Barriers

- Key issues/barriers for interconnecting PV
 - Lack of data, and system analysis techniques and tools to sufficiently model and simulate specific impacts of solar on the grid (Voltage effects, GFP, Islanding, PQ, etc.)
 - Need for intelligent bundling of PV with demand side management, communications and controls, and storage technologies
 - Need to enhance system protection and coordination capability through the use of advanced instrumentation, measurement and controls devices
 - Must develop methods, equipment and technologies to effectively mitigate the intermittency of solar
 - Development and investigation of codes and standards to determine limitations on grid integration equipment capabilities and to establish stakeholder consensus

PV Inverter Technical Challenges

- ❑ Implementing VAR Control, LVRT, and Dynamic Control – is technically achievable (IEEE 1547.8 issues)
- ❑ Most inverter modifications can be done through software upgrades
- ❑ Minor hardware changes at minimal additional cost would include:
 - Additional sensors
 - UPS for LVRT capability
- ❑ In VAR Control mode inverter will operate at higher current levels when not at unity power factor – will also have impacts on efficiency and reliability, especially if running at night for regulation purposes.

PV Interconnection Goals

- ❑ Ensure safe and reliable two-way electricity flow
- ❑ Develop smart grid interoperability
- ❑ Develop advanced communication and control functionalities of inverters
- ❑ Integrate renewable systems models into power system planning and operation tools
- ❑ Integrate with energy storage, load management, and demand response to enhance system flexibility
- ❑ Understand high-penetration limiting conditions
- ❑ Understand how various climates and cloud transients affect system reliability

U.S. Department of Energy Solar Energy Technologies Program Goals

Conclusions

- ❑ The rapid expansion of solar generation on the distribution system, has stressed the grid in high penetration areas due to voltage issues as much as line loading.
- ❑ The variable nature of solar, and other renewable resources like wind, is a particularly complex planning and modeling problem. Cloud cover and the associated ramp up of inverters can play havoc on devices such as reclosers, cap banks, tap changers and system protection devices. We need data gathering equipment and modeling programs that can help us manage this resource.
- ❑ Lack of fully developed/updated US standards, and lack of consistency among international standards organizations, hinders inverter product development efforts.
- ❑ Until much of the solar generation in the pipeline is actually in operation, we will not really know how it will impact the system!