Presentation to the PJM NEMSTF
Interconnection Issues

Interconnecting Solar Projects on the PSE&G Distribution System

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- This presentation is intended to be a brief discussion of the effects of interconnecting of large amounts of solar generation on the distribution system.

- The presentation will also discuss typical utility planning concepts, codes and standards, and federal vs. NJ interconnection procedures.

- My thanks to NREL (proceedings from the High Penetration PV Workshop from 2010) - http://www.nrel.gov/docs/fy10osti/48378.pdf), DOE, and others for some of the information in this presentation!

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- In NJ interconnection regulations only apply to generators connected to the distribution system
  - Net Metering, or a "retail sale" of electricity to the host utility under a FERC Qualifying Facility (QF) tariff
  - Distribution interconnections of "wholesale sales to PJM" projects on non-PJM jurisdictional distribution facilities are State regulated
  - Typical projects are renewables (solar predominantly) and other small generators, in all customer classes
- NJ's regulations generally conform with the FERC Small Generator Interconnection Procedures (SGIP), but have some significant differences
- Technical standards focused on IEEE 1547, and for inverters, UL 1741 for connection to the grid

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Net Metering

- Net metering interconnections in NJ follow a specific regulatory process for accepting customer-generator requests for connection of Class I renewable generators under NJ's net metering rules.
- The following flow chart, although somewhat out of date, shows parts of the process, beginning with the application by the customer-generator, and going through inspection.
- There are 2 screen shots from our work management system (DWMS) to show some of the steps involved.
- The second flow chart shows the Level 2/3 process, for projects > 10kW, or that require Level 3 review.

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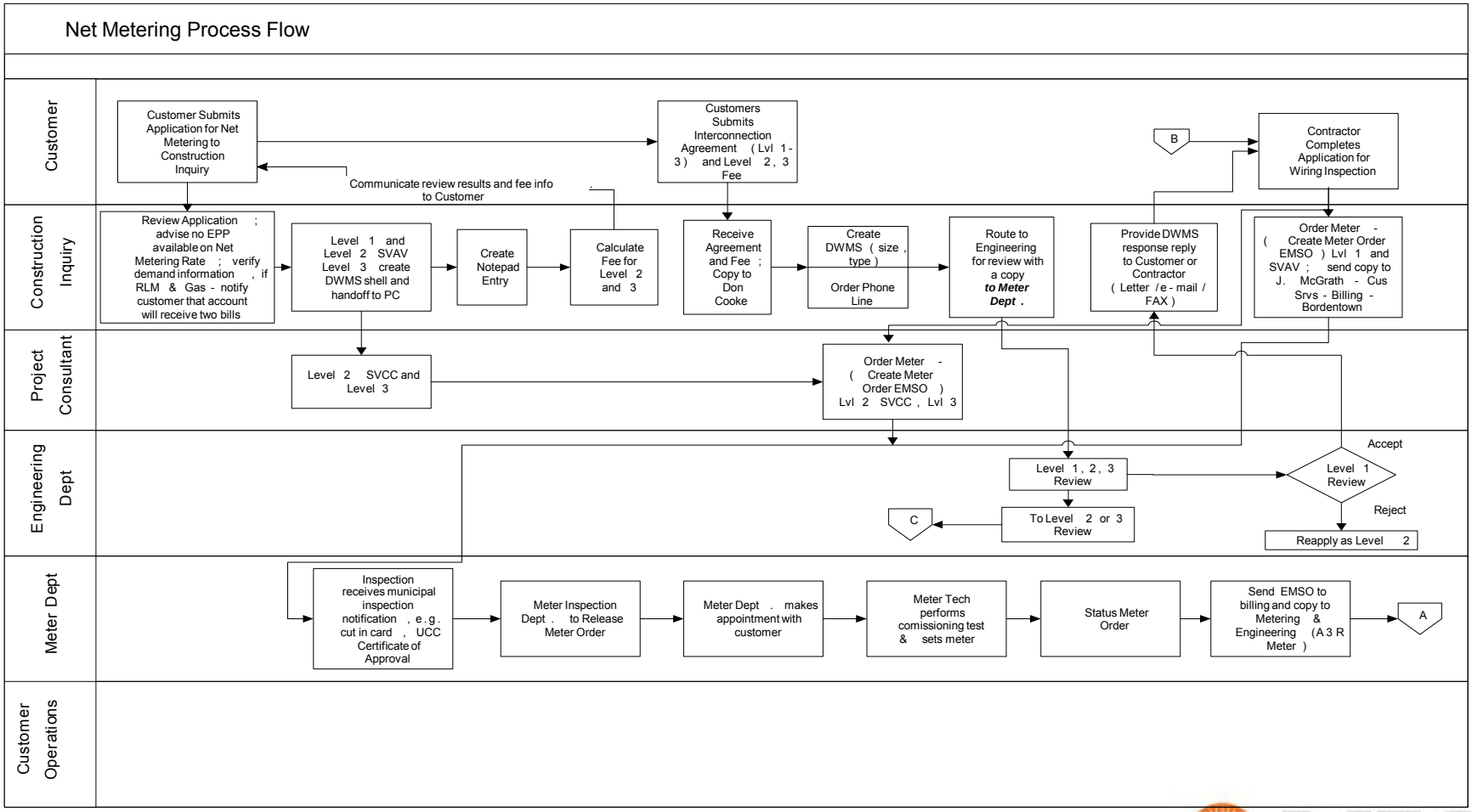

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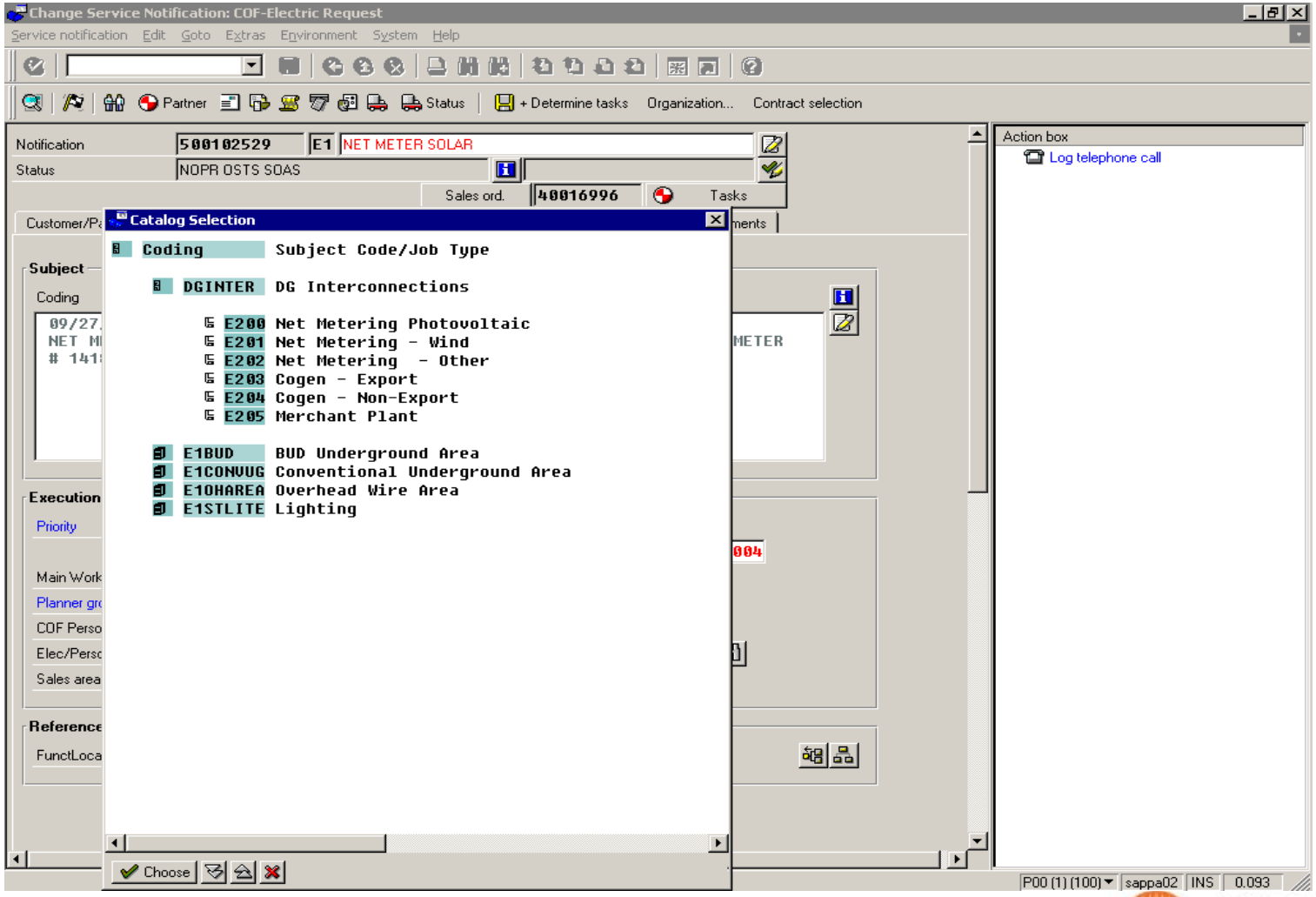

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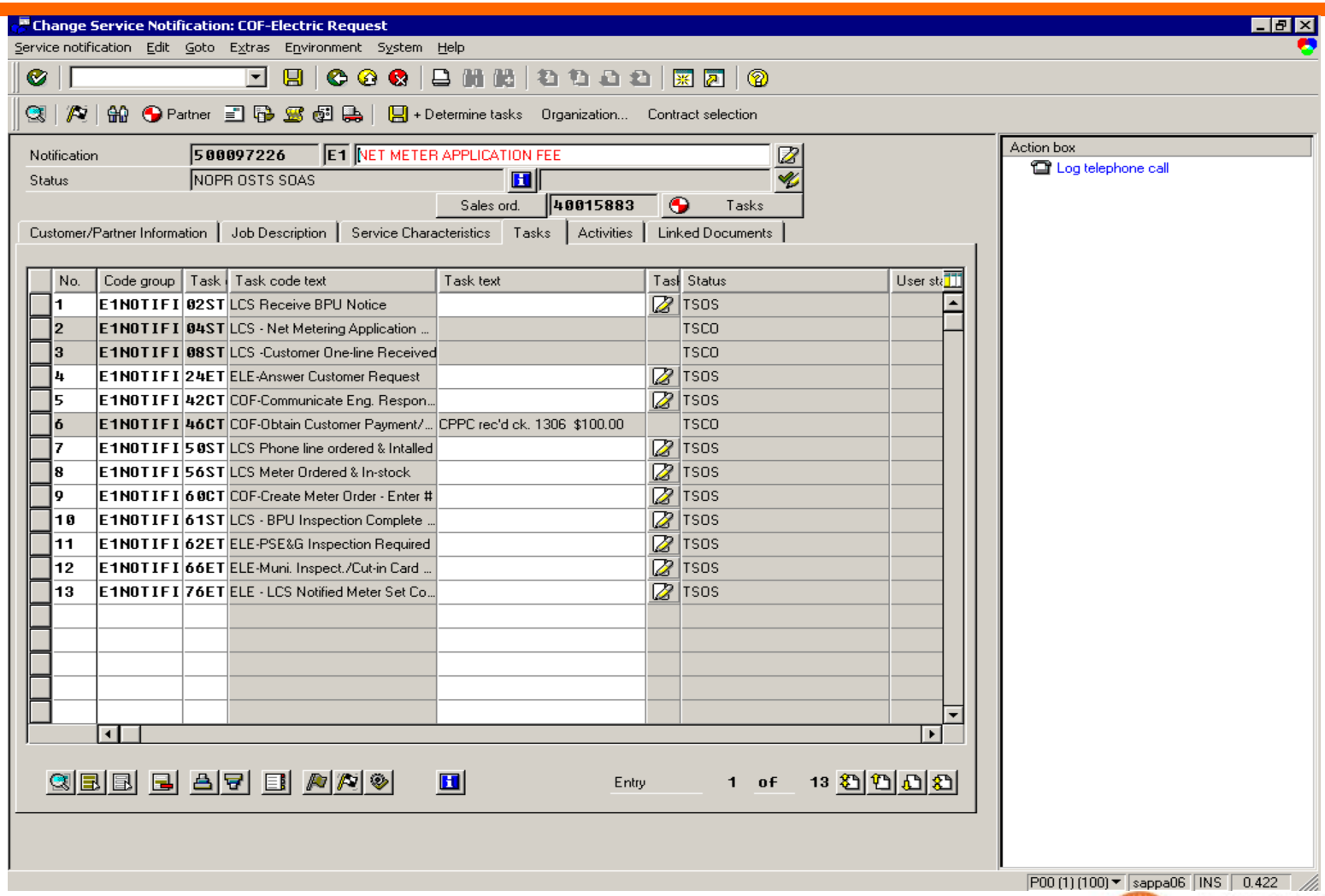

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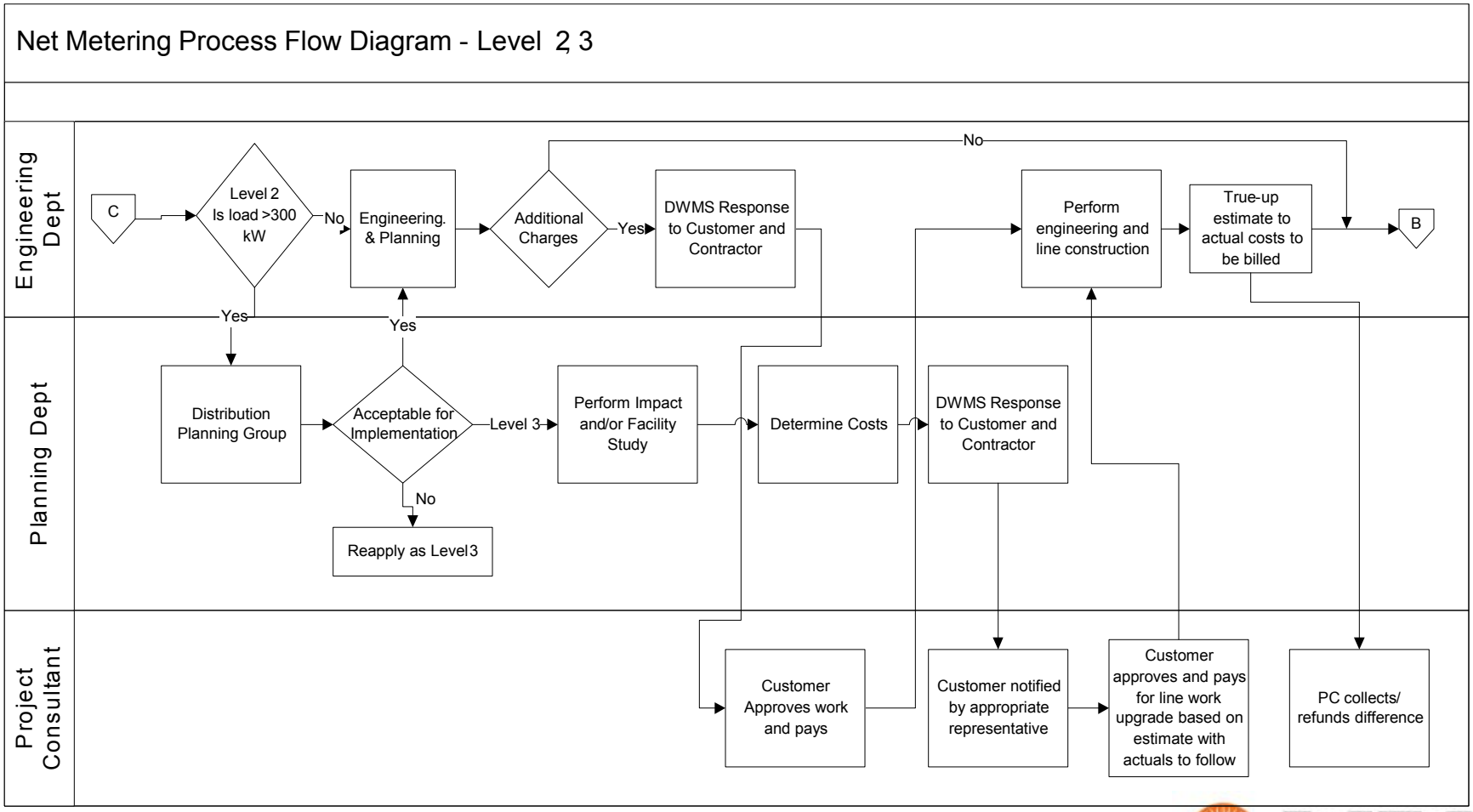

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New Study Request from PJM

- Distribution Planning develops plan of supply options, and sends “Request for Estimate” to local electric division to develop estimate
- DWMS notification created, updates to settlement rule table made, and Division informed
- Engineering Technician creates engineering work order, completes estimate, and sends to Division Staff Engineer
- Division Staff Engineer reviews estimate and sends to Planning
- Metering submits metering estimate to Planning
- Planning submits completed Feasibility/Impact Study to PJM

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- PJM Agreement (WMPA or ISA/CSA) signed and executed
- If a WMPA, or a PSE&G retail tariff for QF purchases, then a PSE&G Interconnection Agreement (IA) is executed
  - If an IA, Generator releases project and makes first payment
- If a PJM ISA/CSA, then PJM is project manager
  - Generator submits 3 months security deposit to PJM
- Electric Division where project is located holds project kick-off meeting for implementation phase
- Construction/Commissioning of interconnection complete
- Project Closeout – same for PJM ISA/CSA or PSE&G IA
  - Division complete DWMS work orders
  - Complete reconciliation with generator (refund or payment)

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Planning Criteria

- A utility's planning criteria are intended to be a guide to provide for the safe, reliable and low cost development of the utility's electrical system as loads increase and reinforcements and/or new facilities are required.

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- With all facilities in service:
  - Loads on the system must be within normal equipment ratings
  - Must provide acceptable voltages to connected customers

- With the outage of any single piece of equipment (N-1 Criteria Violation):
  - Affected load must be within the emergency rating of the remaining facilities
  - System must provide minimum emergency voltages

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- Load Forecasting
  - Substation
  - Feeder
- Distribution Circuit Reinforcement
  - Ratings
  - N-1 Criteria
- New Business
  - Connected vs. Estimated Loads
  - Load Build-up Schedules and Load Shifting
  - Distributed Generation

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- **Substation & Area Capacity**
  - Firm N-1 Criteria
  - Includes Automatic 13-kV ICT Transfers
- **Capacity Processing**
  - Load vs. Capacity Analysis
- **Load Relief Modeling**
  - Power Factor Correction
  - Load Transfers
  - Distributed Generation
- **System Reinforcement Modeling**
  - Interstation Capacity Ties (ICT)
  - Station Reinforcement
  - New Station
  - Generation

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Effects of Distributed Generation (DG) on Distribution System

- 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

NREL *High Penetration PV Workshop : Defining High Penetration PV –Multiple Definitions and Where to Apply Them - Phil Barker, Nova Energy Specialists*

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Key Issues for Solar Photovoltaics (PV) Projects

- Lack of data, and system analysis techniques and tools to sufficiently model and simulate specific impacts of solar on the grid (Voltage effects, Ground Fault Protection, Islanding, Power Quality, 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

DOE – EE&RE, *HPPV Systems into the Distribution Grid Workshop* – Feb 2009

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PV Inverter Technical Challenges

- Implementing Reactive (VAR) Control, Low Voltage Ride Through (LVRT), and Dynamic Control – are technically achievable
- Most inverter modification can be done through software upgrades
- Minor hardware changes at minimal additional cost would include:
  - Additional sensors
  - Uninterruptible Power Supplies (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.

NREL *High Penetration PV Workshop: PV Inverters with VAR Control, LVRT, and Dynamic Control* - Ray Hudson –BEW Engineering

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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

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Any Questions?

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