

# **Solar PV Integration**

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**Electric Transmission Planning**

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# **Dominion Profile**

# Primary Operating Segments Overview

## Dominion Virginia Power



### Electric Transmission

- ❖ 6,455 miles of transmission lines
- ❖ Favorable regulatory environment

### Electric Distribution

- ❖ 57,100 miles of distribution lines
- ❖ 2.5 million franchise retail customer accounts in VA and NC

## Dominion Energy



### Gas Transmission

- ❖ Together with Gas Distribution, operates one of the largest natural gas storage systems in the U.S.
- ❖ 12,200 miles of pipeline in eight states
- ❖ Well positioned in Marcellus and Utica Shale regions

### Gas Distribution

- ❖ 21,900 miles of distribution pipeline and 1.3 million franchise retail natural gas customer accounts in OH & WV

## Dominion Generation



### Utility Generation

- ❖ 20,400 MW of capacity
- ❖ Balanced, diverse fuel mix
- ❖ Favorable regulatory environment

### Merchant Generation

- ❖ 4,200 MW of capacity, including nuclear, gas and renewable power
- ❖ Active hedging program for energy revenue/margins

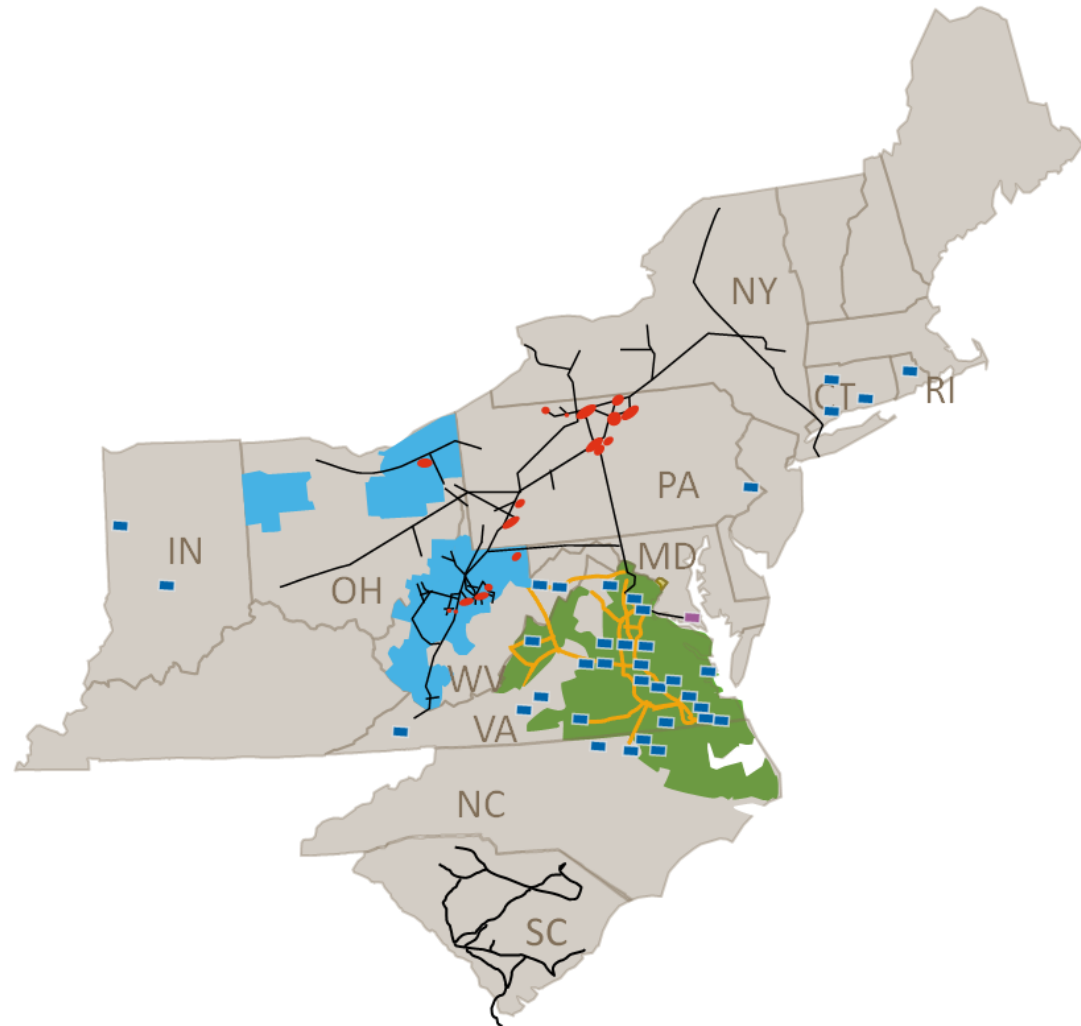
### Dominion Retail

- ❖ Retail Gas & Products/Services
- ❖ 1.2 million non-regulated customer accounts in 13 states

# Dominion Profile

## Power and Natural Gas Infrastructure

- 24,600 MW of electric generation
- 6,455 miles of electric transmission
- 12,200 miles of natural gas transmission, gathering and storage pipeline
- 928 billion cubic feet of natural gas storage operated
- Cove Point LNG Facility
- 2.5 million electric customers in VA and NC
- 1.3 million natural gas customers in OH & WV
- 1.2 million non-regulated retail customers in 13 states (not shown)
- 252 MW of contracted solar generation in 6 states (not shown)



# Research at Dominion

- **System Studies for Dominion**
  - Group members with PhD and Master Degrees
  - Software and hardware available for research activities





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# Renewable Portfolio

# Wind Generation

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- **Ned Power in West Virginia**
  - 50% Owner
  - 264 MW
- **Indiana Wind Power Project**
  - 50% Owner
  - 301 MW
  - Commercial Operation began in 2009
- **Offshore wind in Virginia**
  - Research Continues
  - Up to 2,000 MW
  - Economics is still a challenge in US



# Solar Projects

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- **Utility Scale Facilities in:**
  - **Virginia**
  - **Connecticut**
  - **Georgia**
  - **Utah**
  - **Indiana**
  - **California**
  - **Tennessee**





# Fuel Cell Technology

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- **Bridgeport CT (Clean non-renewable)**
  - 14.9 MW
  - Commercial operation started on December 2013
  - 15 year contract with local utility

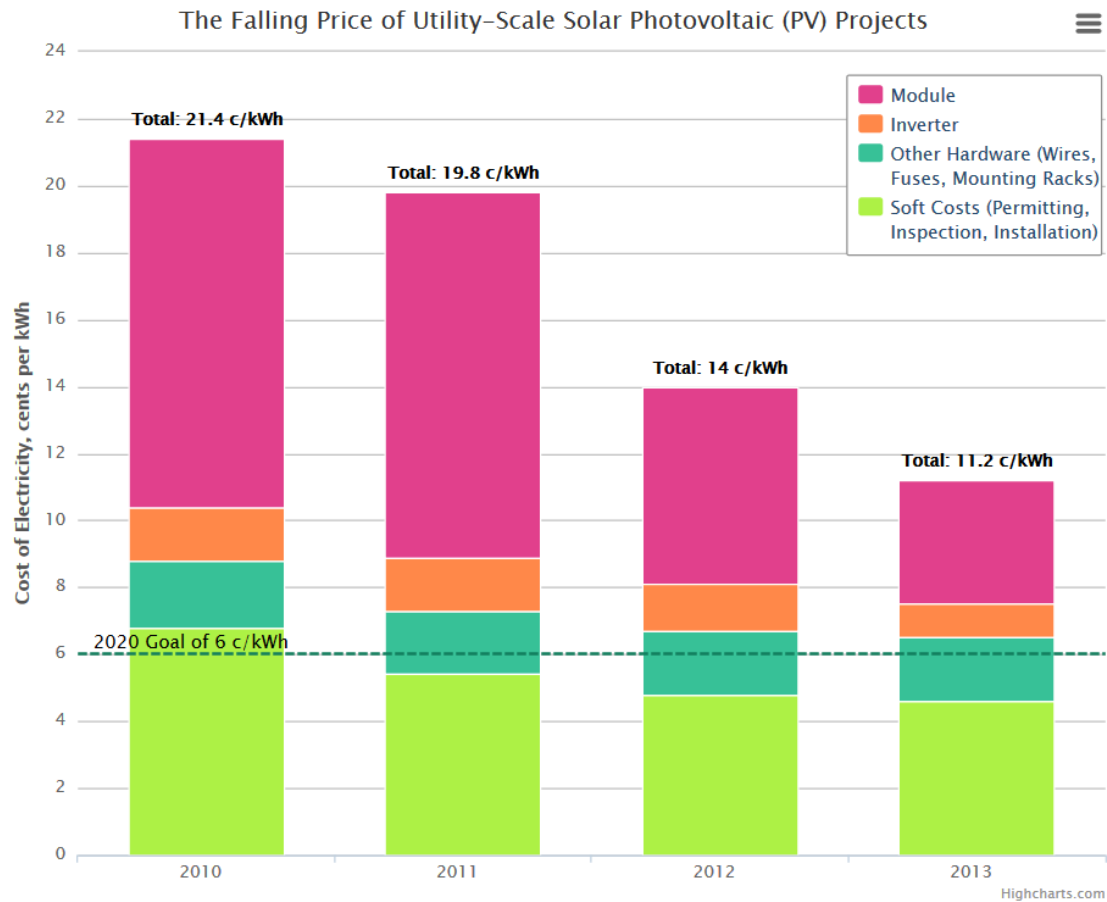


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# **Solar PV Generation in Dominion Service Territory**

# Utility Scale Cost

- DOE Sunshot



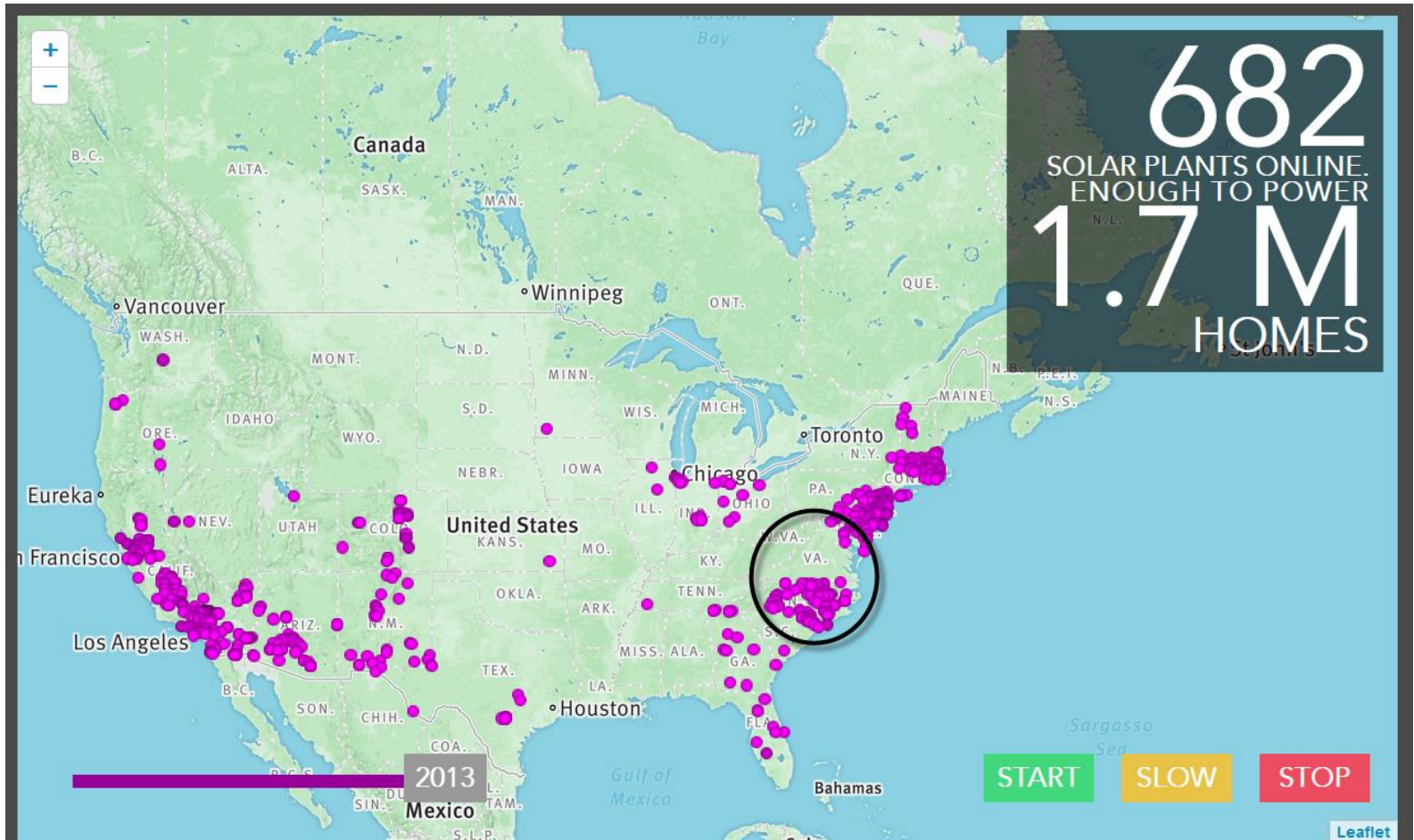
# Federal and State Incentives

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- **North Carolina Tax Credit (2009)**
  - **35% Tax Credit for renewable installations**
  - **Up to \$2,500,000 for non-residential applications**
  - **Up to \$10,500 for residential applications**
  - **Must be installed before January 1, 2016**

# Utility Scale Solar in US

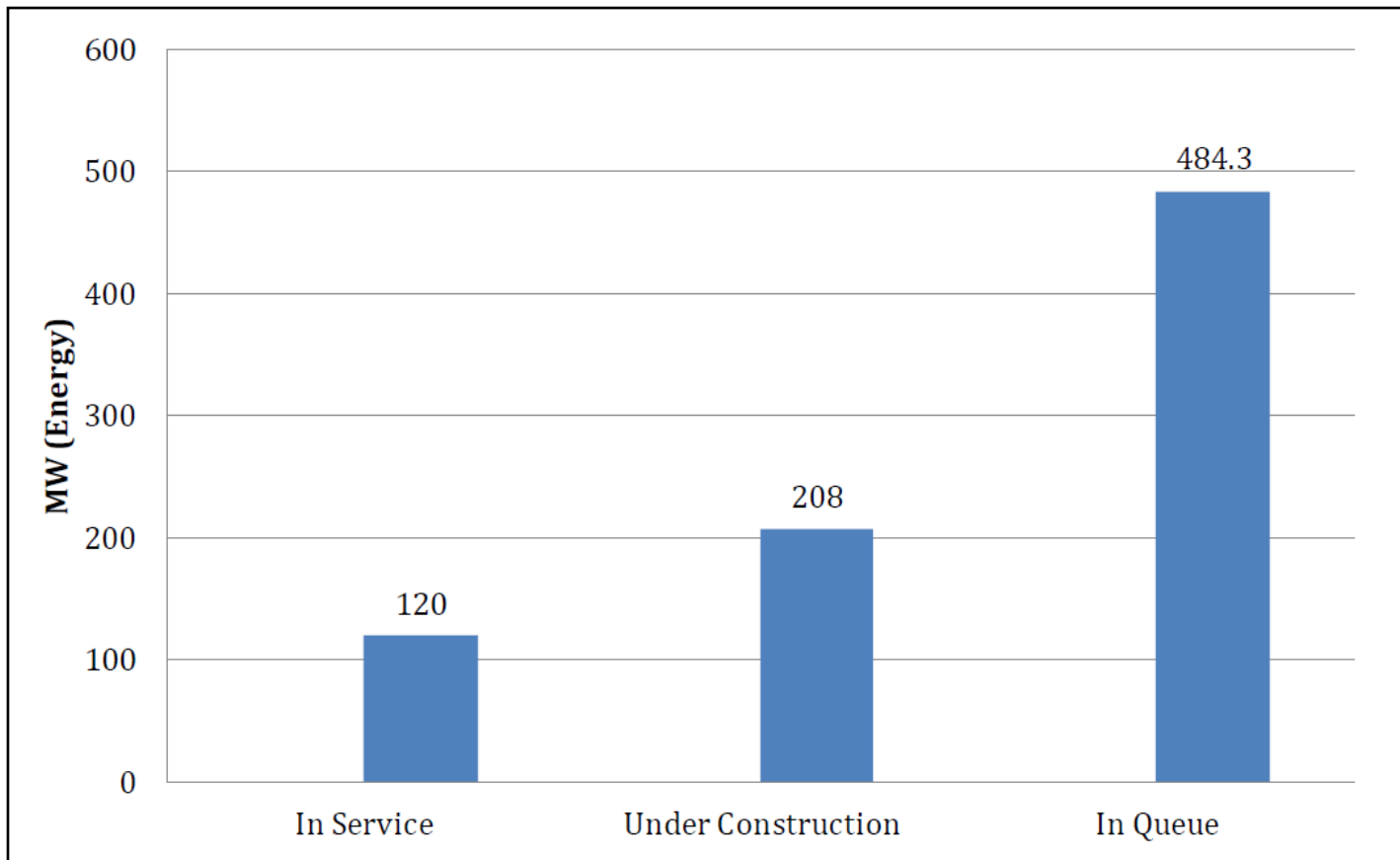
- Energy.gov



Source: Preliminary data from the 2013 EIA-860 report.

# Dominion North Carolina Solar (5/15)

- ~1,000 MW Peak Load



# Generation Interconnection Process

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## PJM process

- **Feasibility Study**
  - High level system impact study
- **System Impact Study**
  - Detailed system impact study
- **Facility Study**
  - Detailed engineering estimates and timelines to construct
- **ISA/ICSA Finalized**
  - Primarily a FERC Document

# **PV Impact on GI Process**

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## **Non Traditional Scenario**

- **Greenfield Projects in Queue**
  - Traditional Projects 80% dropout rate (includes wind)
  - PV Projects 80-90% success rate
- **Construction timelines**
  - Traditional Projects 3-5 years
  - PV 1-2 years



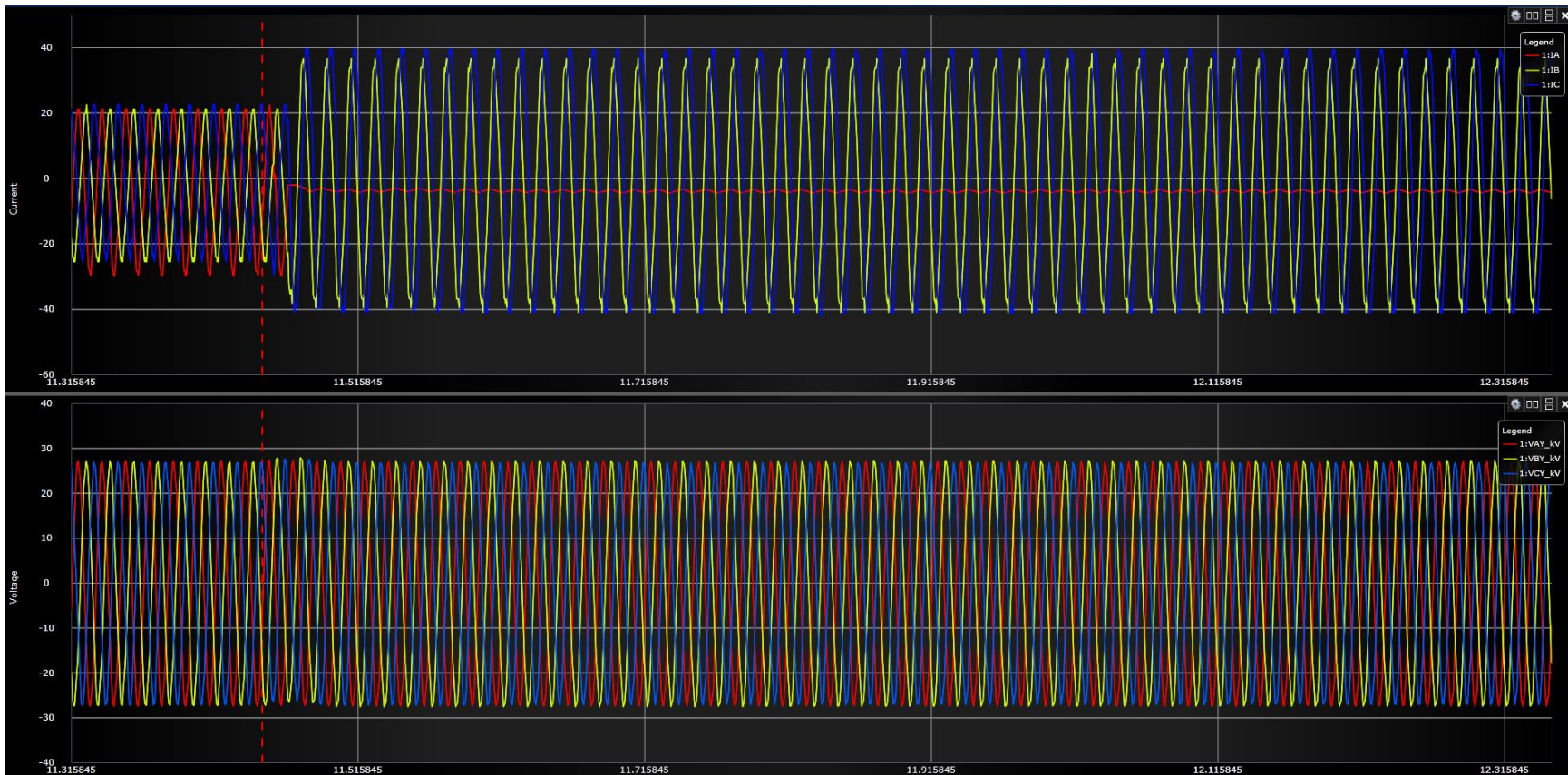
# Solar Integration Experience

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- **Additional Resources to manage**
  - Short installation deadlines
- **Anti-Islanding Vs Ride Through Capabilities**
- **Transfer Trip**
  - Expansion of Fiber Network
- **Harmonic Distortion**
  - THD
  - TDD
- **Effective Grounding**
  - Overvoltages
- **Open Phase**
  - Personnel Safety

# Open Phase Test

- **Protection failed to identify open phase**
  - Facility was not allowed to start operations



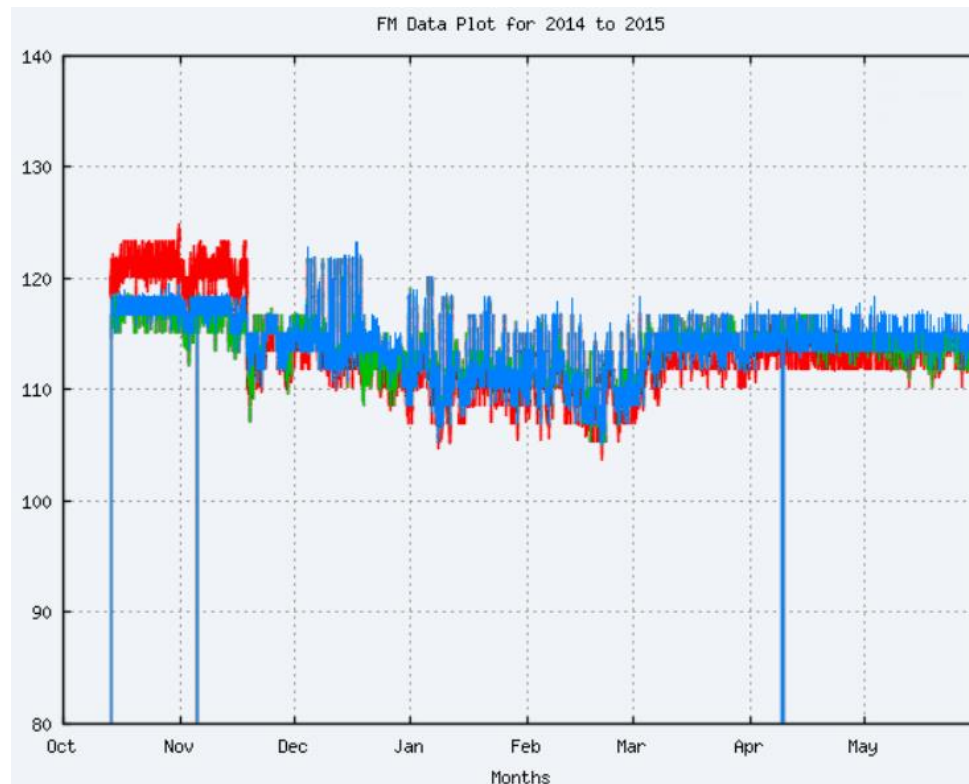
# Change in Inverter Philosophy

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- **Previous Idea**
  - Disconnect during abnormal conditions
    - Low/High Voltage
    - Low/High Frequency
  - Unity Power Factor
- **New Grid Support Functions – Smart Inverters**
  - Low/High Voltage Ride Through
  - Low/High Frequency Ride Through
  - Real/Reactive power control
  - Ramp Rate Control
- **PJM**
  - Enforce grid support capabilities after 05/2015

# 5 MW Solar Site in North Carolina

- Plant went online end of November 2014
- Inverters were adjusted to have fixed Q of 0.95 Absorbing beginning of March 2015
- Utilize Volt/Var control in the future



# Steps Taken to Improve Process

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- **Develop solar interconnection standard for transmission level projects**
- **Advance monitoring at POI**
  - **PMU**
  - **Power Quality Meter**
- **Request for inverter models**
  - **EMTP**
  - **Load Flow**
- **Developing standards for Dominion own inverters**
- **Third party certification for testing and commissioning**

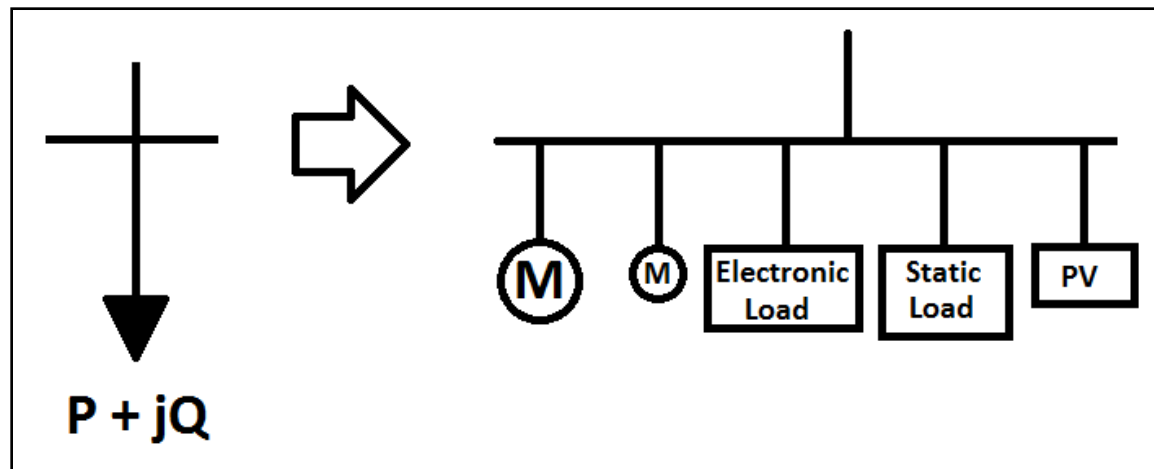
# Transmission Planning

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- **Identify possible infrastructure requirements to accommodate solar generation**
- **Diverse number of contingency and operation scenarios that need to be evaluated**
  - **N-1**
  - **N-1-1**
  - **N-1-1 security constrained**
  - **Bus outage**
  - **Tower Outage**
  - **Intermittency**

# Load Modeling and Behind the Meter PV

- **Large Scale System Analysis**
  - Traditionally loads have been modeled as constant power, constant current and constant impedance.
  - New NERC standards require composite load models that represent the dynamic behavior of load



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**Questions?**