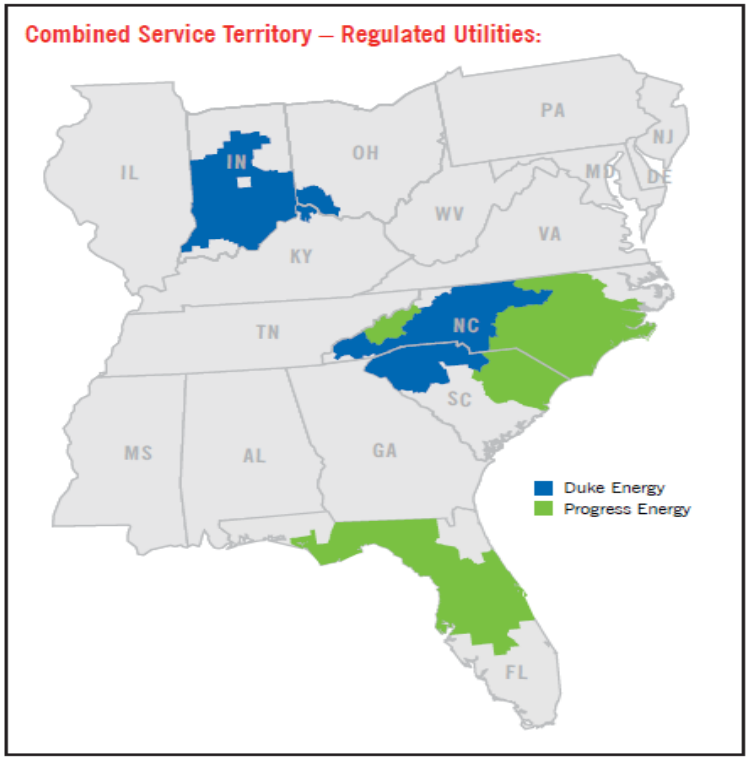
High Solar Penetration Issues and Approaches

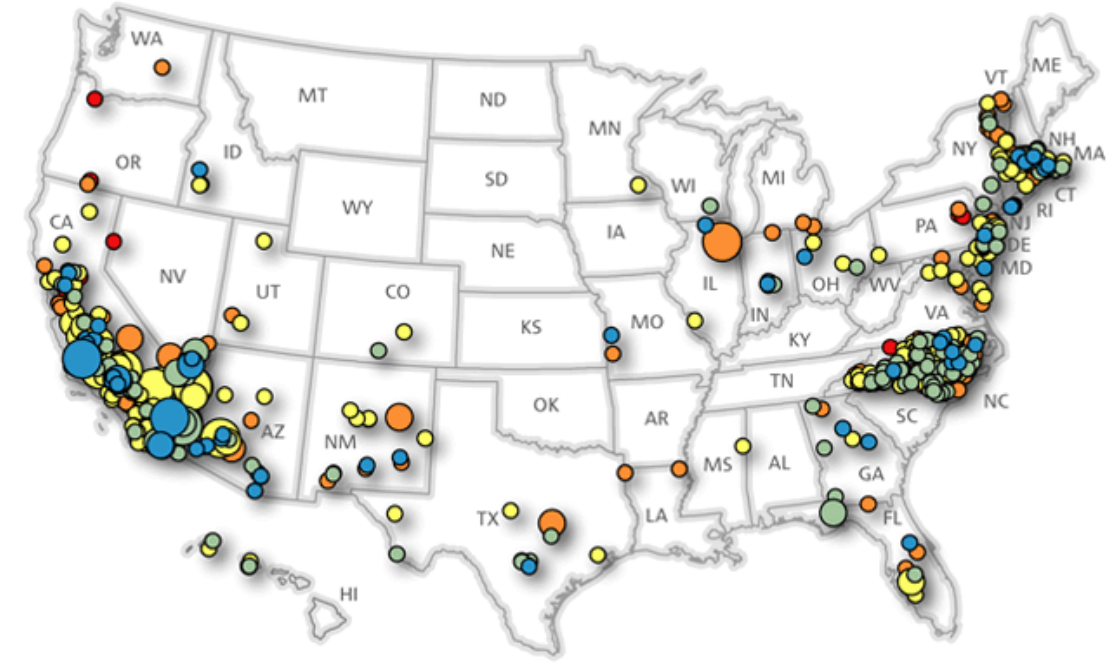
10/22/2015 National Renewable Energy Laboratory Workshop

DUKE ENERGY®

- Electric Retail Customers – 7.3 million
- Gas Customers – 500,000
- Market Cap – $57.5 billion
- Employees – 28,324
- Service Territory – 95,000 square miles
- Total US Generation Capacity – 57,500 MWs
- Transmission Lines – 32,400 miles
- Distribution Lines – 262,900 miles
- Duke Energy International owns, operates or has interest in approximately 4,900 MWs of generation



Policies Fostering Solar Growth



Build phase

- Construction started
- Advanced development
- Early development
- Announced
- Postponed

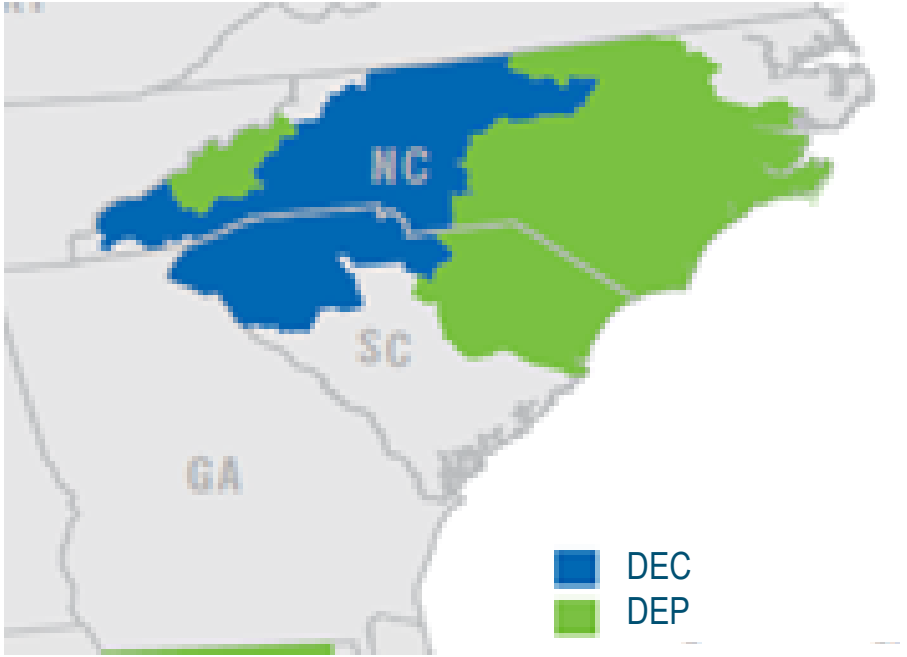
Build net capacity change (MW)

- 0 - 130
- 131 - 450
- 451 - 1,008

Source: SNL Energy

Carolinas Installed Solar Capacity

	Current	Projected YE
DEC	217 MW	350 MW
DEP	389 MW	800 MW

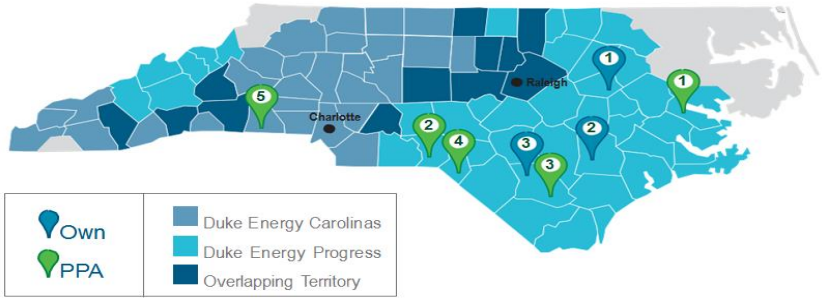


For Reference:
Dan River CC is 620 MW

Committed to Expanding Solar in North Carolina

September 2014

- Announced $500 million investment in solar
- 8 projects; 278 MW
- 3 projects, or 128 MW, owned/operated by Duke Energy
- Targeted in-service date for projects: Late 2015



January 2015

- Announced 13-MW solar project at Camp Lejeune
- Pending NCUC approval, to be owned/operated by Duke Energy
- Targeted in-service date for project: Late 2015

Act 236: The South Carolina Distributed Energy Resource Program Act of 2014

Signed into law by Gov. Nikki Haley on June 2, 2014

- Permits non-utilities and utilities to lease solar panels to homeowners and businesses.
- Requires the Public Service Commission of South Carolina to update solar power interconnection standards and the rate utilities must offer to a customer who installs solar panels at their home or business.
- Allows utilities to invest in or purchase solar power. If a utility adopts solar power, it must include an incentive program for customers who want to install solar at a home, business or a tax-exempt entity's location.

Large-Scale Solar Facilities

- Duke will seek Proposals for solar facilities (1-10MW)
- 1-10 MW solar PV; must be operational by 12/31/2016
- 40 MW Duke Energy Carolinas and 13 MW Duke Energy Progress

Solar Rebate

- One-time rebate to customer upon completion of installation
- Residential rebate $ 1.00/watt DC and Non-residential $0.75/watt DC
- Customer may lease or purchase system; customer may net-meter or sell-all generation. Customer may install up to 1,000 kW and receive rebate

Shared Solar Program

- “Community Solar” is a bill-savings program offered by the utility in which multiple customers subscribe to and share in the economic benefits from one, large renewable energy facility.
- Available to all customers and marketed specifically to tax-exempt and low-income customers

Committed to Expanding Solar in Florida

- Duke Energy recently announced to invest in 500MW of renewable energy in its Florida service territory as part of its 10 year plan. One megawatt of large-scale solar is equivalent to about 200 typical residential rooftop systems

- Since 2003, Duke Energy Florida has provided approximately $8 million for solar installations at K-12 schools and universities.

- Since 2011, Duke Energy Florida has funded more than $8 million to assist residential and commercial customers who install their own PV systems.

- We are leading several research projects in key areas of the state to evaluate impacts of DER on the system
  - Battery storage projects in St. Petersburg to evaluate how to leverage storage in concert with PV
  - $1 million solar PV system at USF to manage and test integration

North Carolina is Somewhat Unique

- Most of the solar capacity installed in North Carolina consists of 1MW to 5MW sites.

- Very little residential rooftop solar in NC currently. This is likely to change as solar installation and panel prices continue to decline or if regulatory policies change to permit 3rd party leasing of solar installations.

Impacts Already Being Seen

- Impacts are being noted across most parts of Duke Energy's business:
  - Distribution
  - Transmission
  - System Operations
  - Generation – Near Future

Scope

Document the current and planned state of distributed resource integration across all Duke Energy Jurisdictions. Document current operational impacts caused by the existing DER penetration level. Identify workable solutions to these current impacts. Project future operational scenarios that will emerge as DER penetration increases. Identify gaps in existing processes, technology, and tools. Prioritize impacts based on consequence, likelihood, and timing of occurrence. Propose solutions for the prioritized projected impacts.

Representatives

System Operations
Grid Management
DER Operation Support
DER Forecasting
Grid Concept Evaluation
Transmission Planning
Distribution Planning
Generation Dispatch and Operations
Transmission P&C Engineering
DPAC/DG
Fossil/Hydro Operation
System Fuels and Optimization
Power Quality

Issues List

- Solar site awareness and visibility
  - Physical/Circuit Location
  - Specifications
  - Data
  - Forecast and Contribution up to the System Level
- Masking of Actual Facility Loading
- Need for Better Meter Data
  - More Granularity
  - Near Real Time
- High Voltage During Light Load and Backfeed onto Transmission
- Impact on Load Shedding (Inadvertently Dropping Generation as Well as Load)

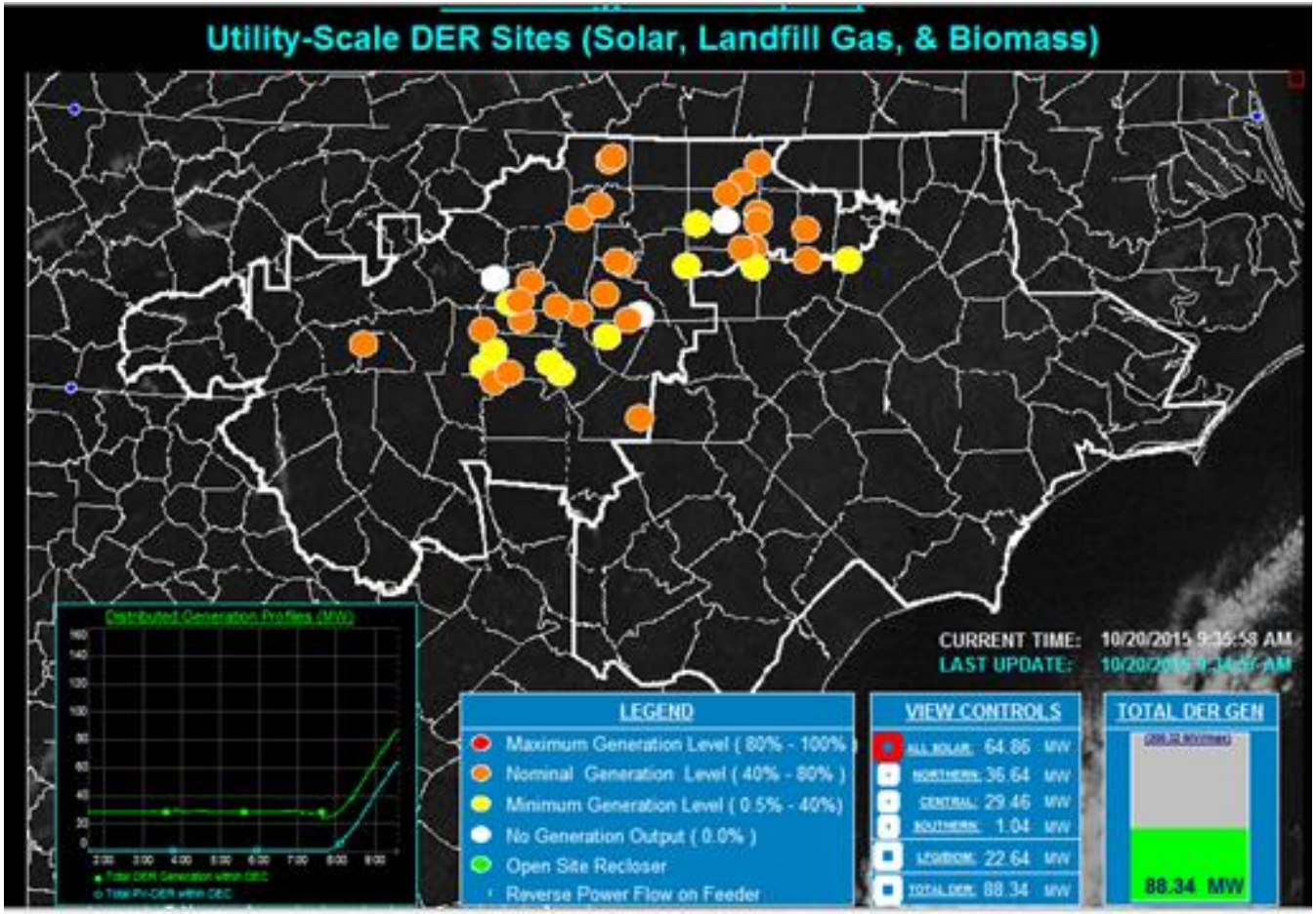
Visualization of Distributed Generation

- Long Term Plan – GIS and DMS will be the systems of record, the preferred visualization tool, and control for all these assets.

- Working with Alstom on Distributed Energy Resource Management System (DERMS)
  - Project to enhance the functionality of the Alstom DMS to track capture impact of DER

- Not quite there yet, so

PI Visualization



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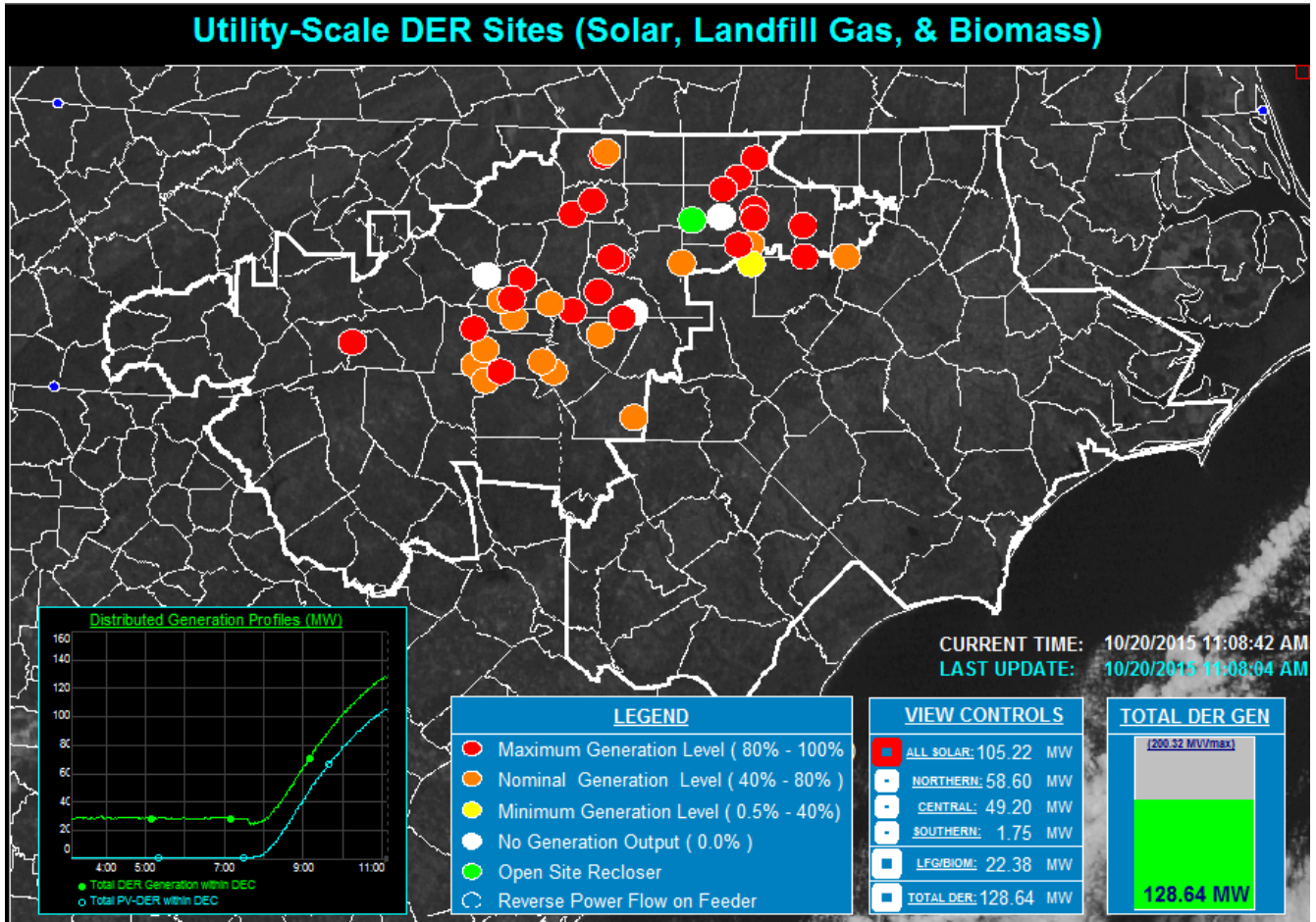
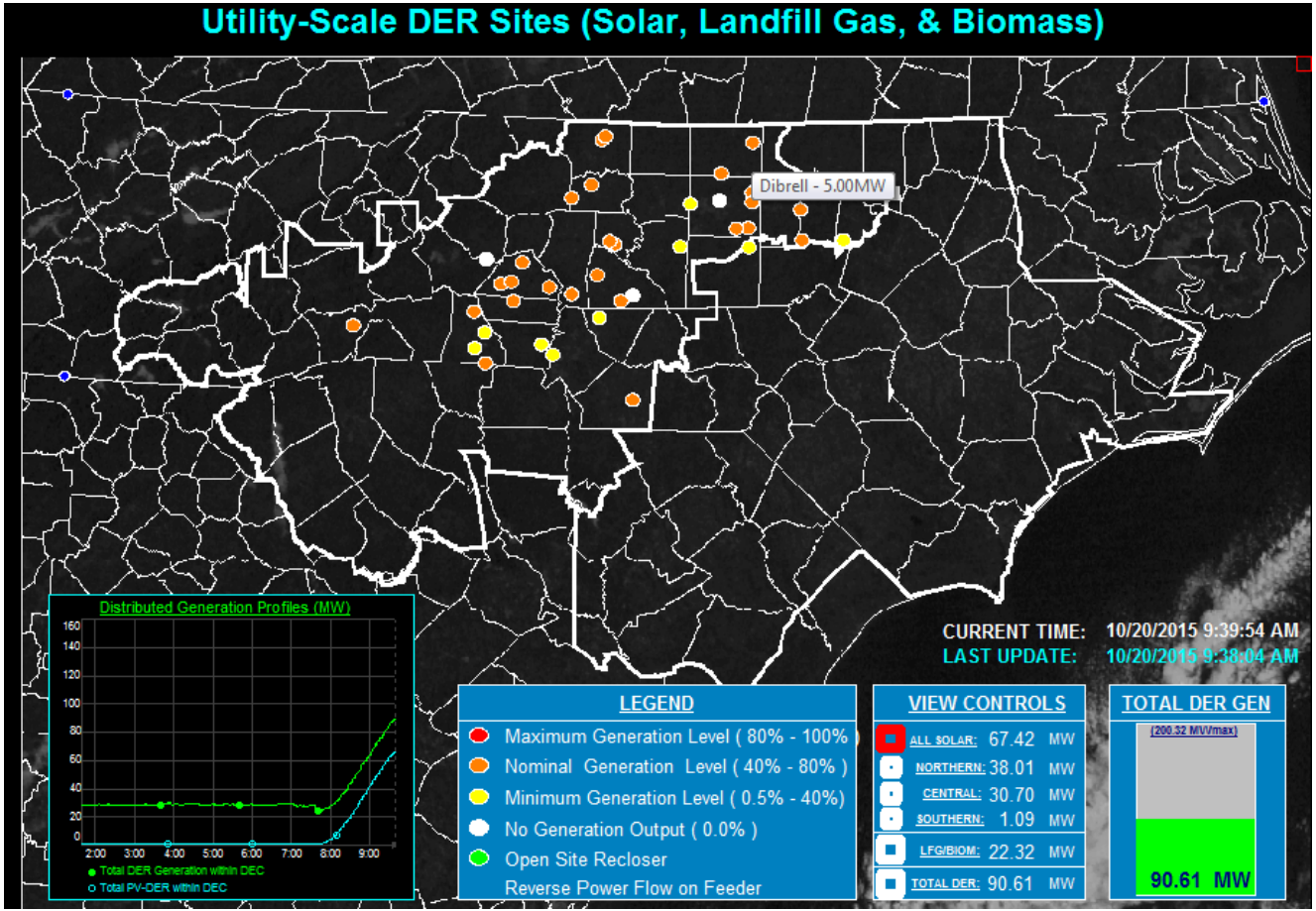


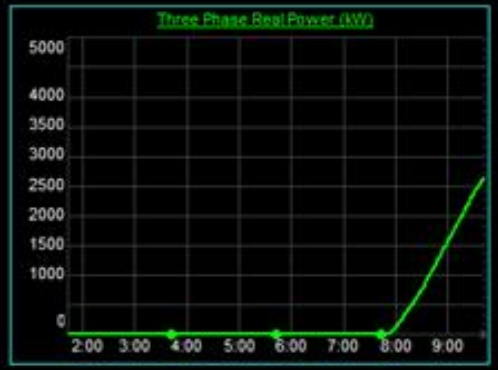
Hover for Site Name and Size

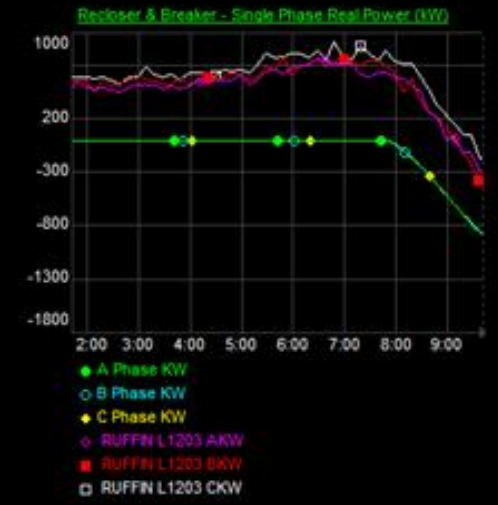


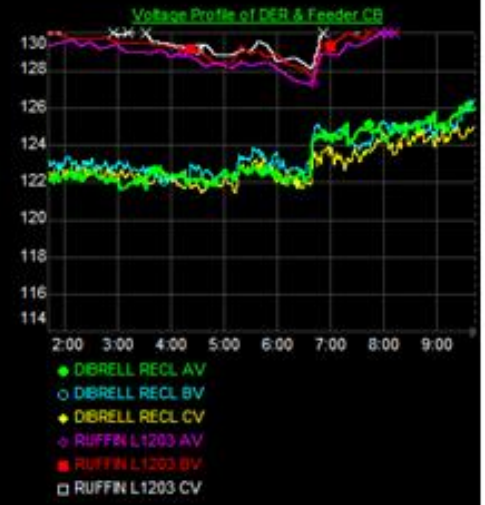
Dibrell Solar Farm

Feeder Name (STA)	
Contractor	
County	
Town	
Operating Area	
Irradiance Forecast:	
Capacity	
Connected Voltage	
Date in Operation	
Collector Tilt Angle	
Collector Azimuth Angle	
#of PV Panels	
Type of PV Panels	
#of Inverters	
Type of Inverters	
Site Contact	
Phone Number	

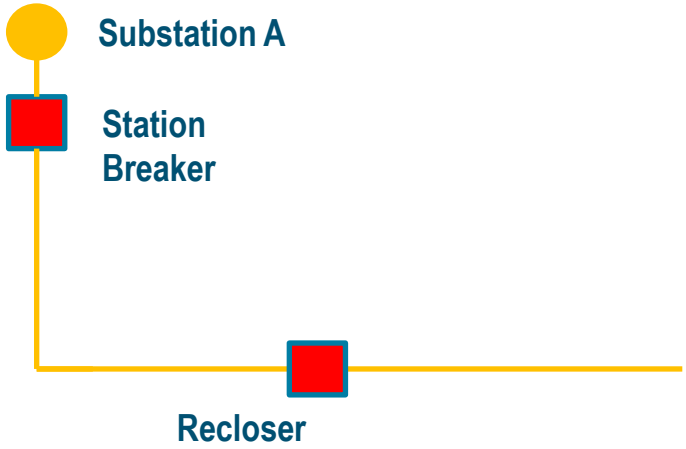
Farm Location: Lat, Lon







- Limitations on “Self-Healing” Networks



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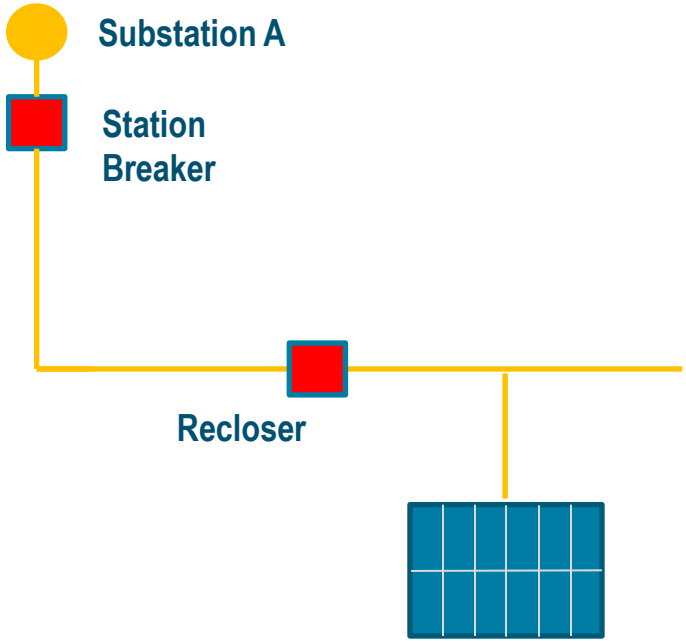

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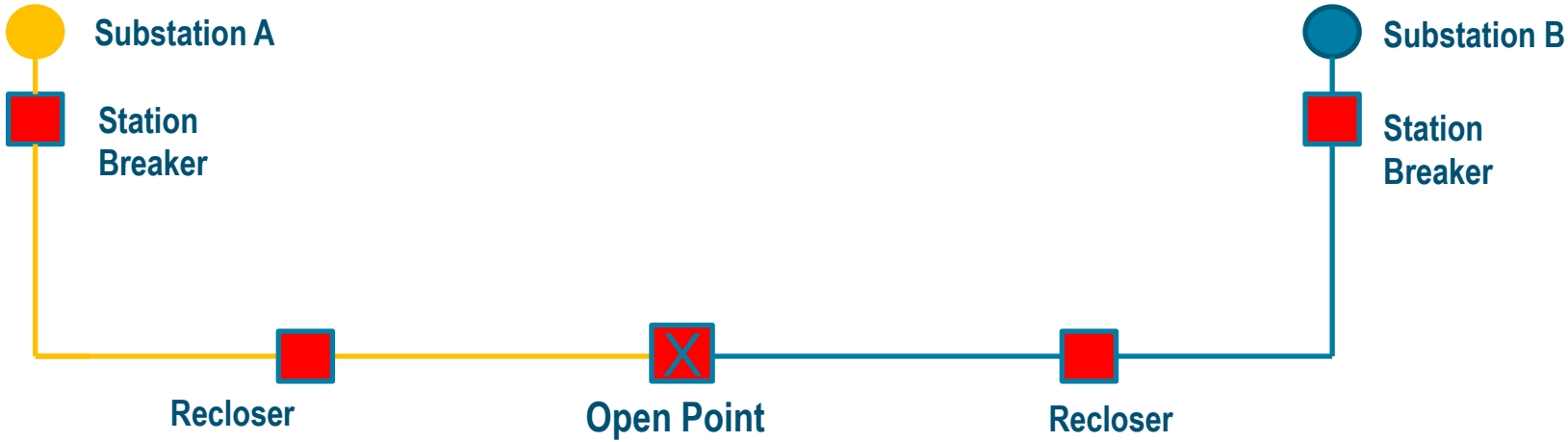

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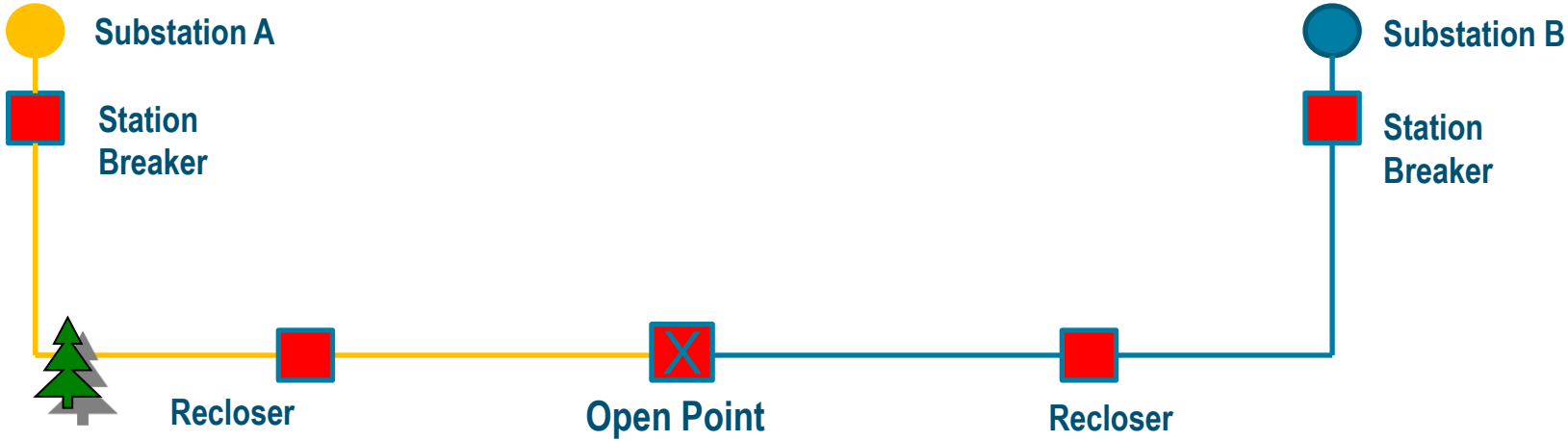

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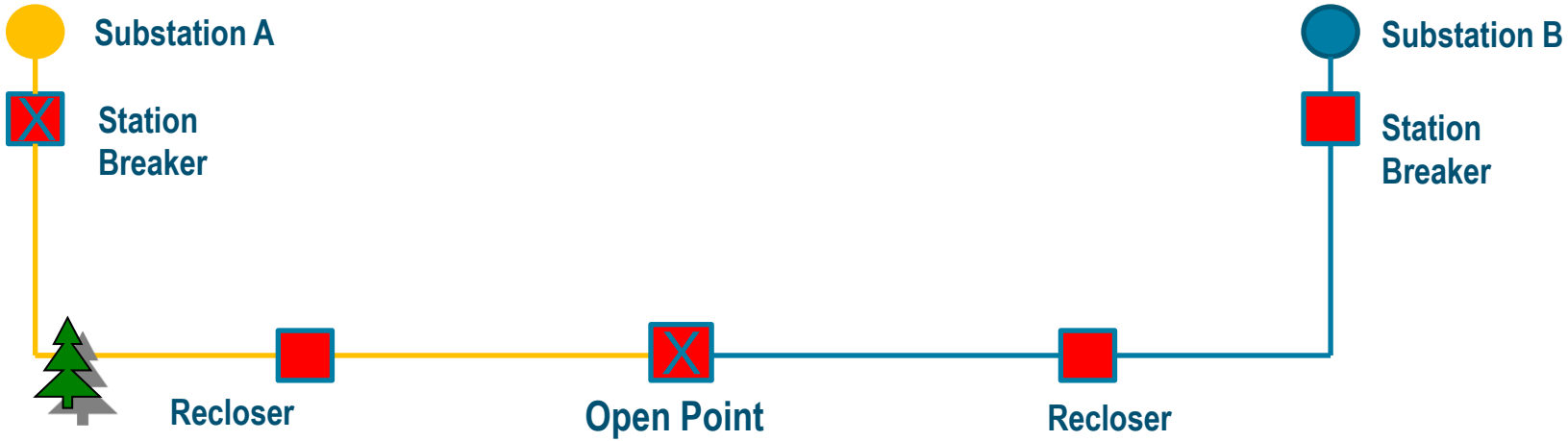

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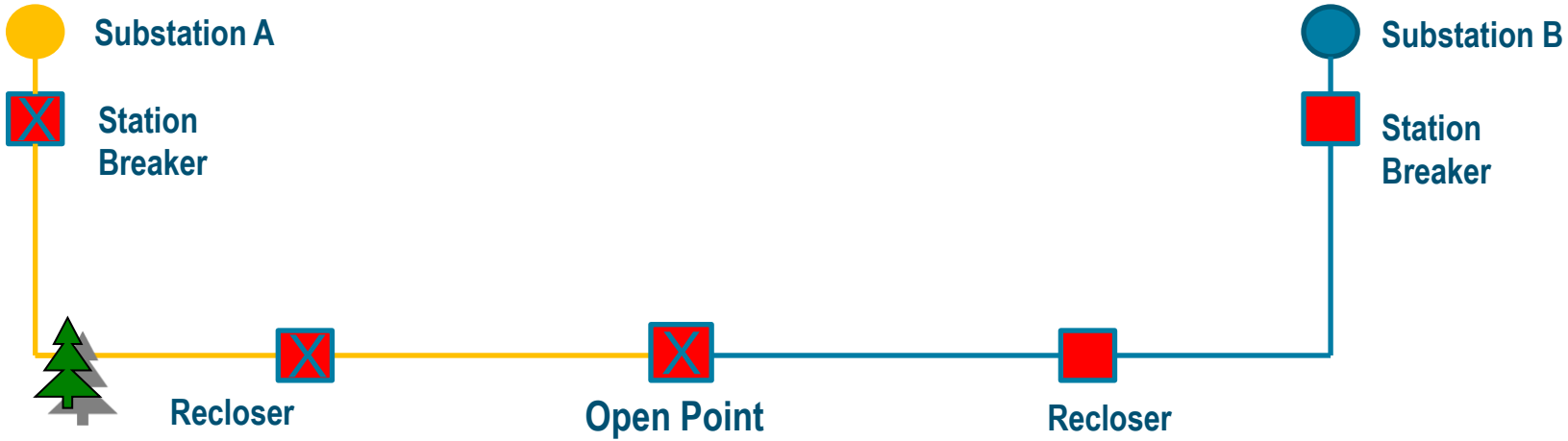

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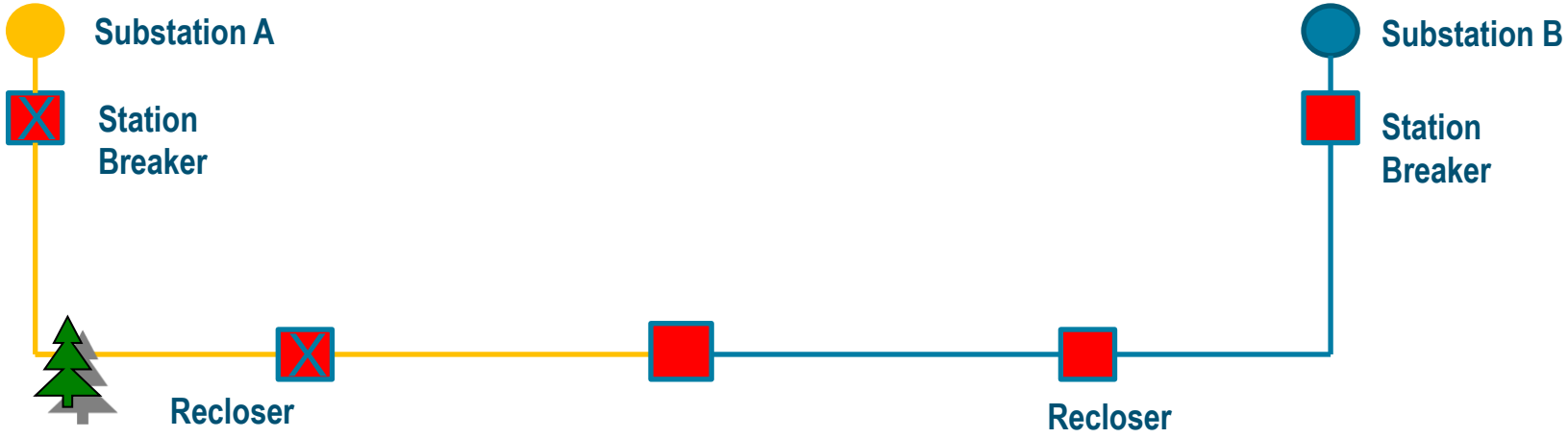

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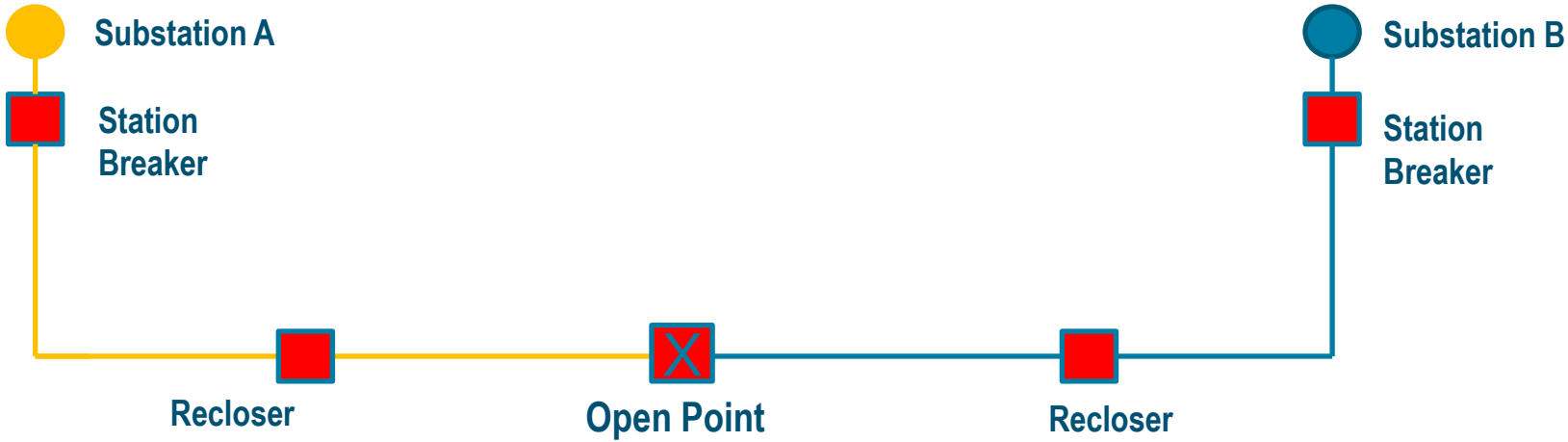

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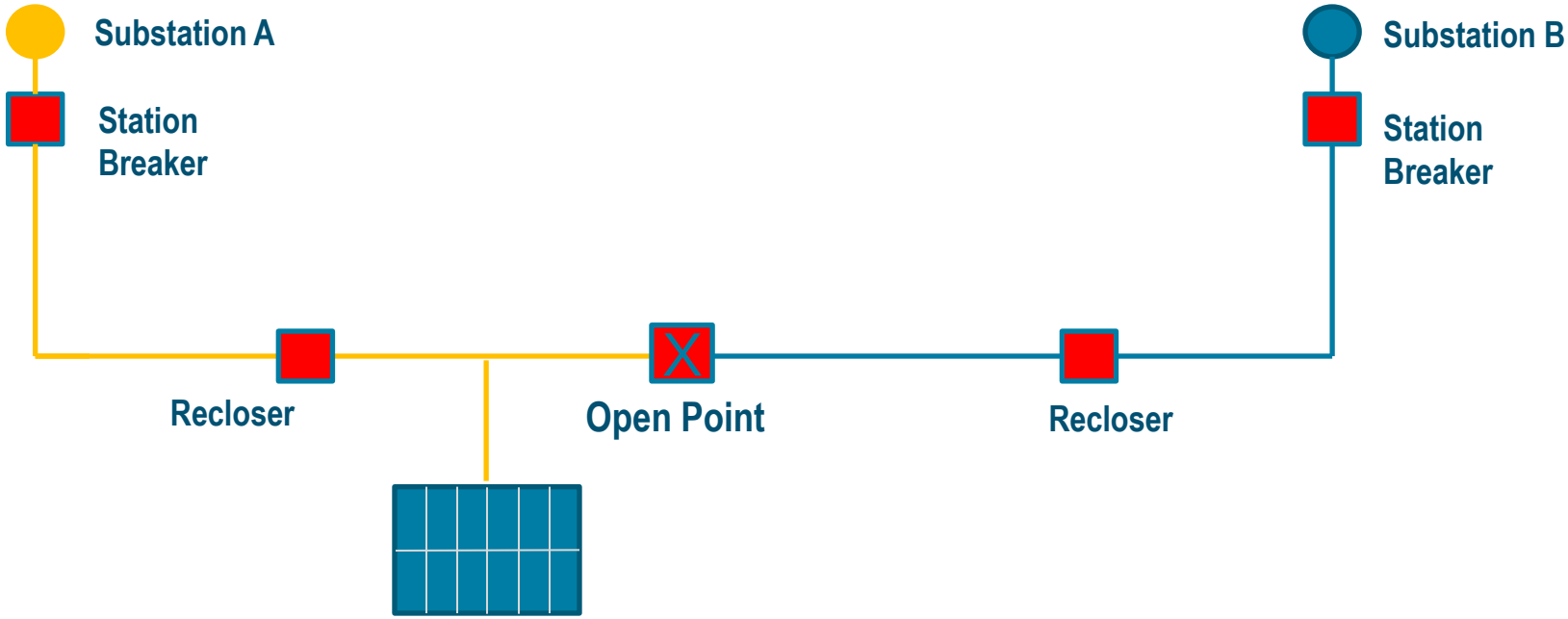

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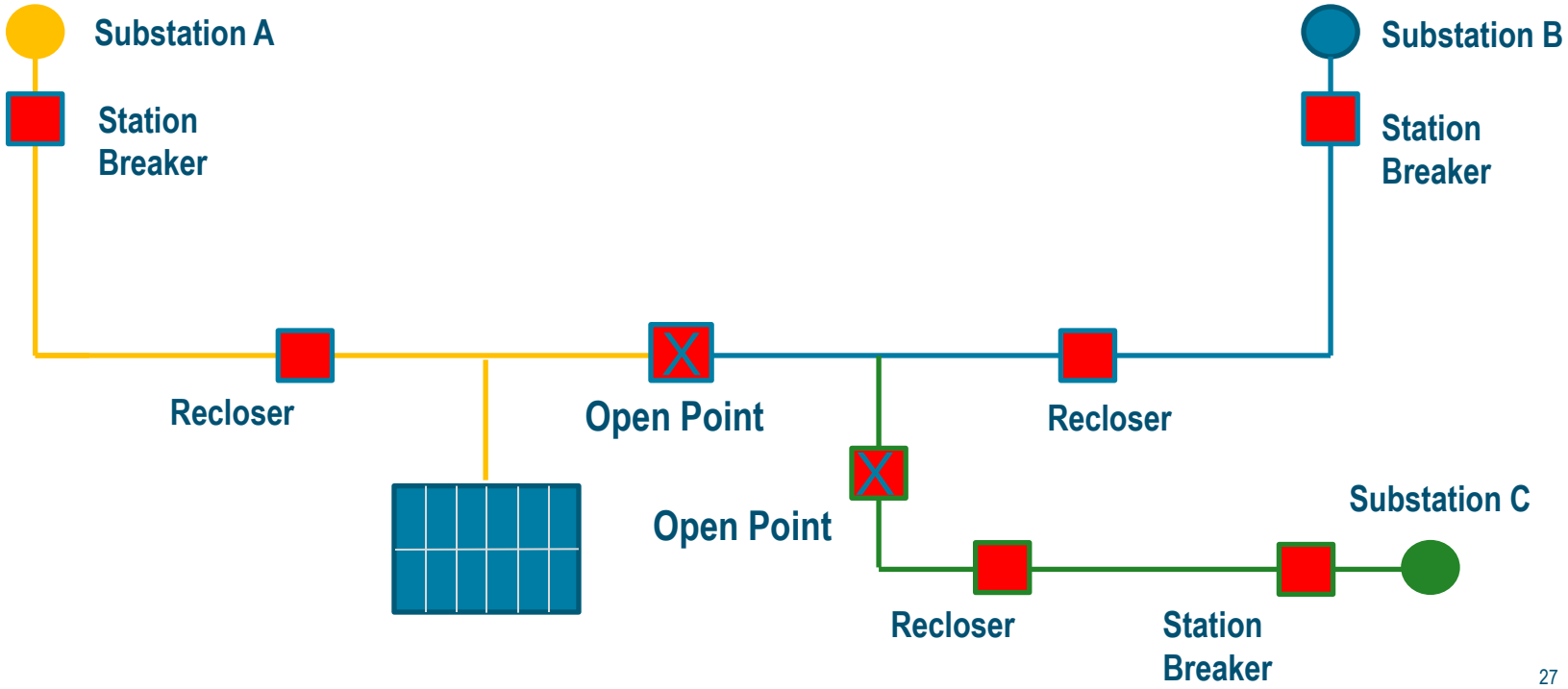
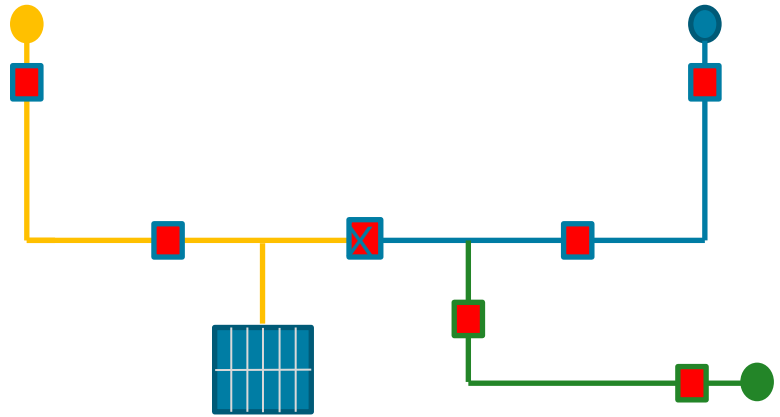
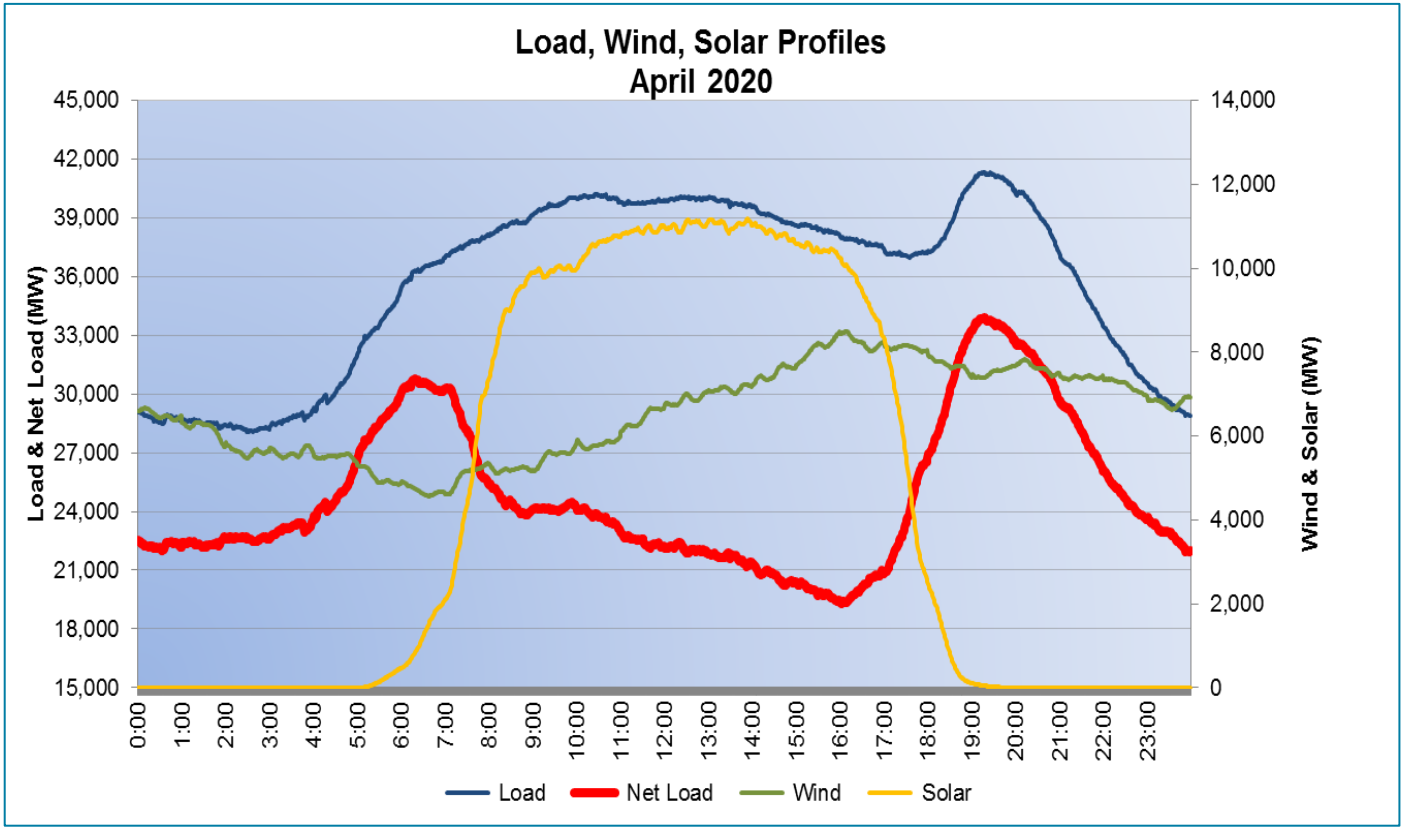


- Circuit Upgrades
  - Reconductor
  - Dedicated DER Feeders
- Integration of Battery Storage
  - Co-located with Solar
  - Distributed around Circuits
- Smart Regulator Controls



Duck Curve


Load, Wind, Solar Profiles
April 2020
Load & Net Load (MW)
Wind & Solar (MW)
45,000
42,000
39,000
36,000
33,000
30,000
27,000
24,000
21,000
18,000
15,000
14,000
12,000
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Load
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Wind
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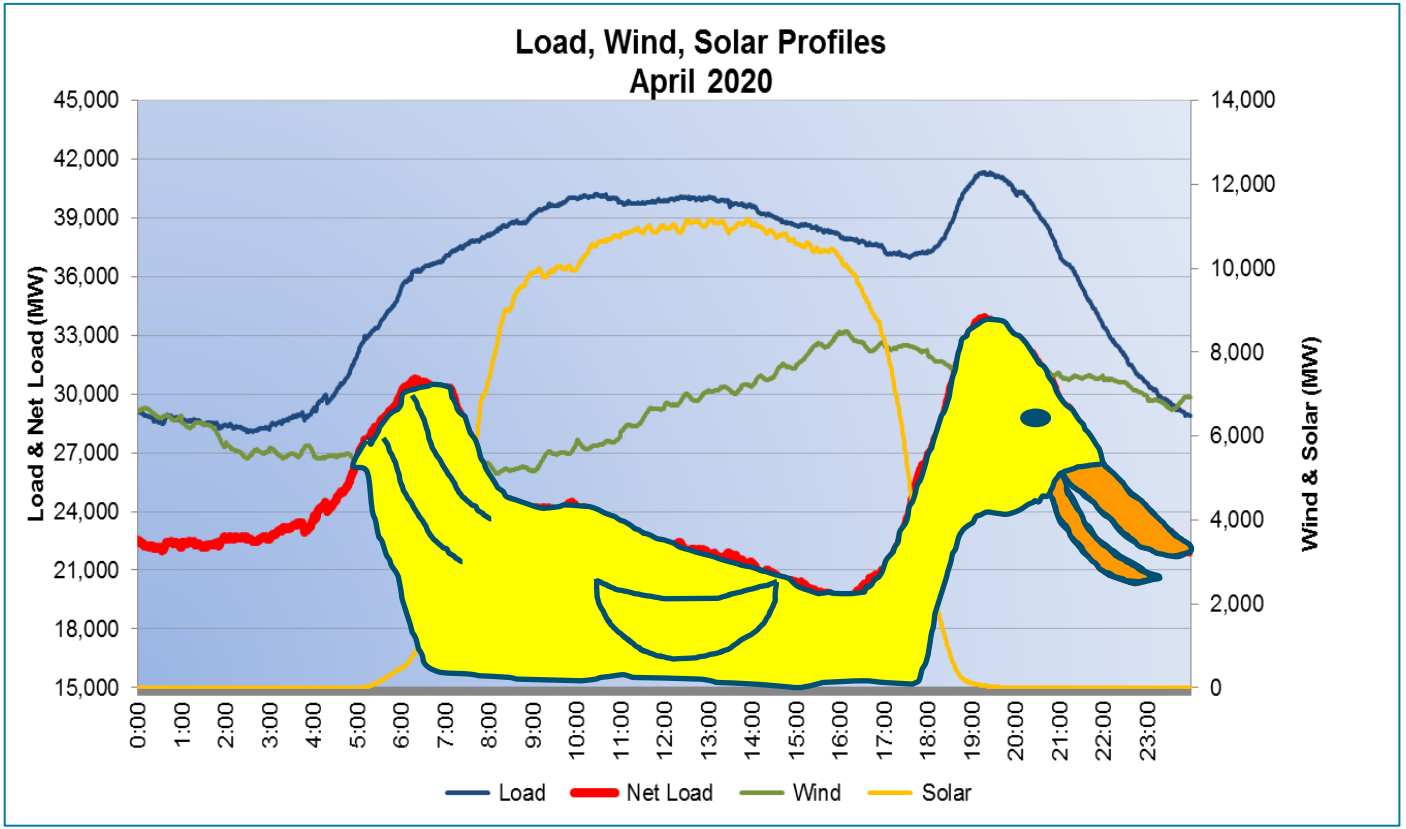
Duck Curve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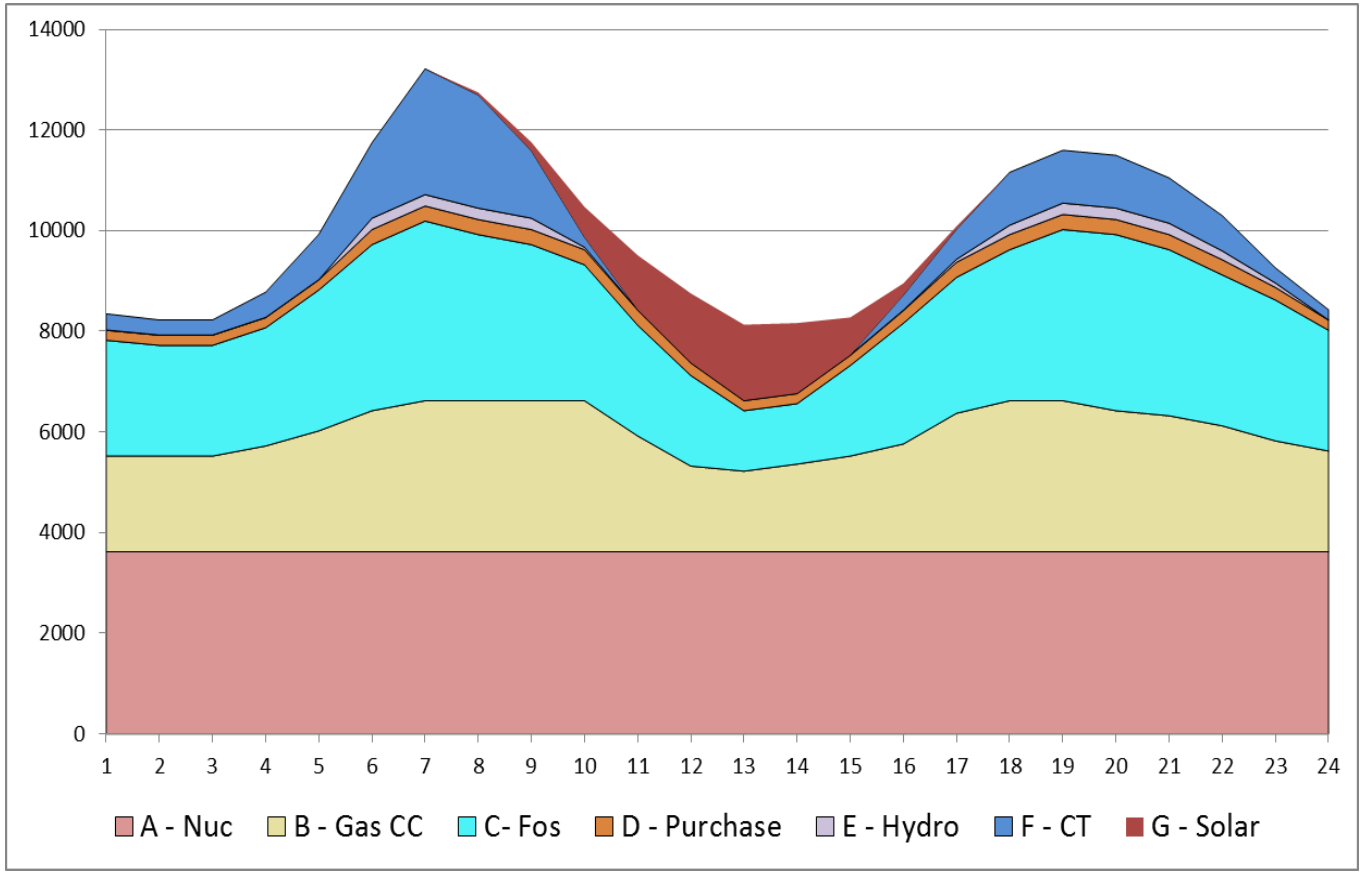
DEP Winter Load Shape w/1700 MW of Solar



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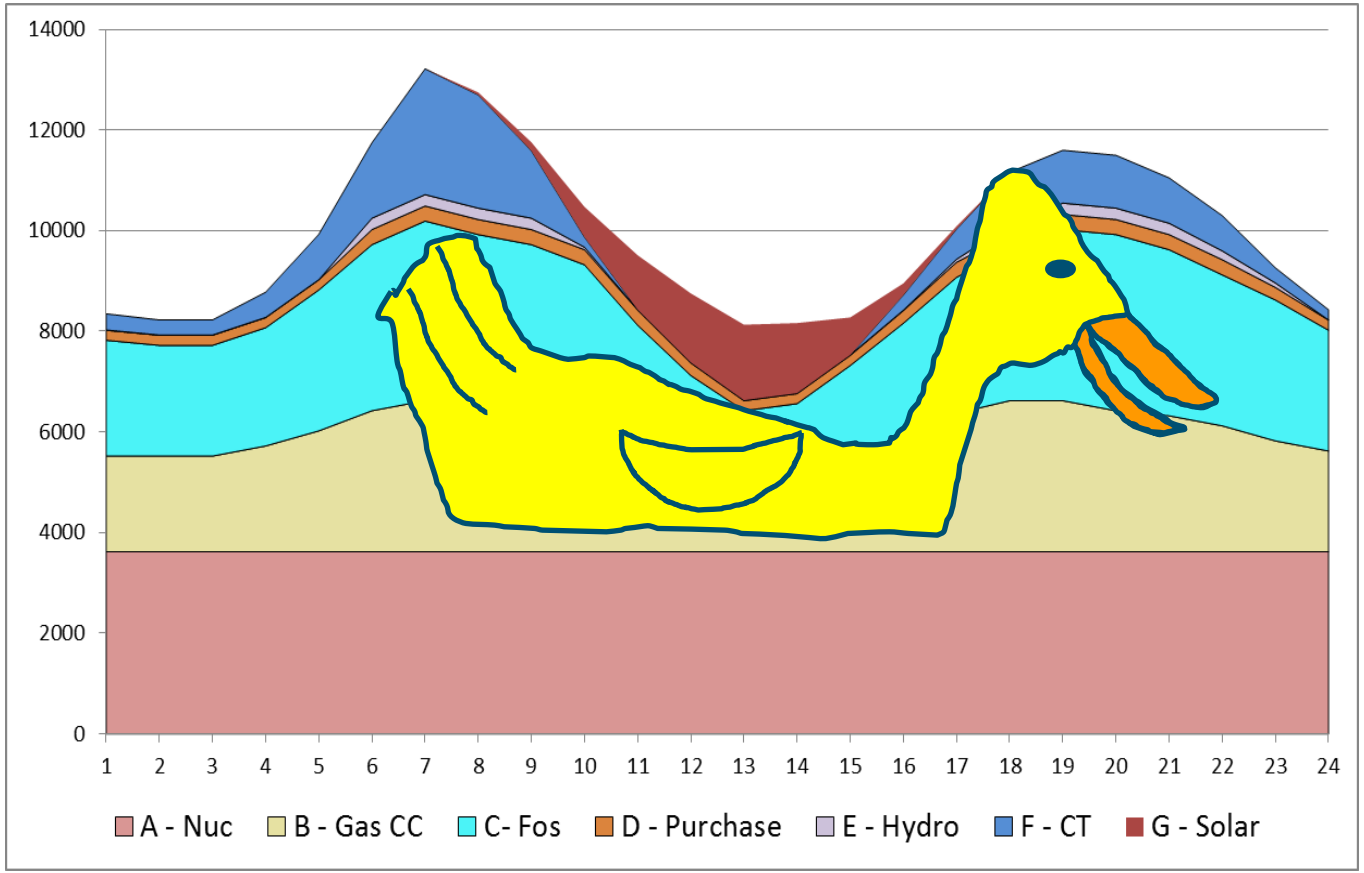
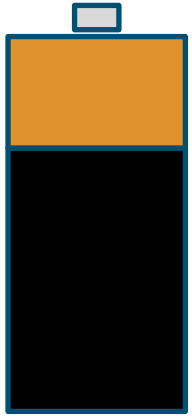


Bad Creek Pumped Storage

Batteries



- Operational Impacts of Customer Switching
  - Large Customer-Owned Transformers
  - Long Rural Circuits
  - Customer repeatedly energizing and de-energizing transformer during troubleshooting
  - Magnetizing inrush creating significant voltage drop
  - Nearby customers' equipment mis-operates or shuts down

Other Work in Progress

- Continue DMS development
- Continue standardization efforts across geographic regions
- Work with NREL
  - Effects on regulators and capacitors, control strategies
  - Effects of smart inverter control
- Additional Studies and Simulations with Higher Solar Penetration in Future Years
- Integrating Energy Storage

Questions???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