QUANTA TECHNOLOGY
A QUANTA SERVICES COMPANY

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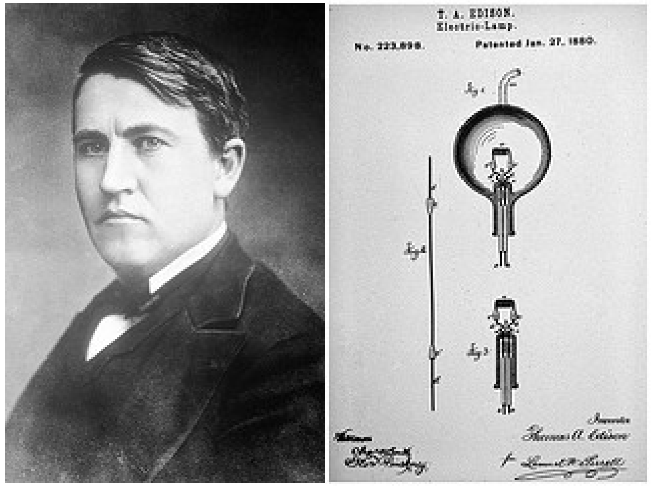
Building the “New Grid” is a Marathon not a Sprint

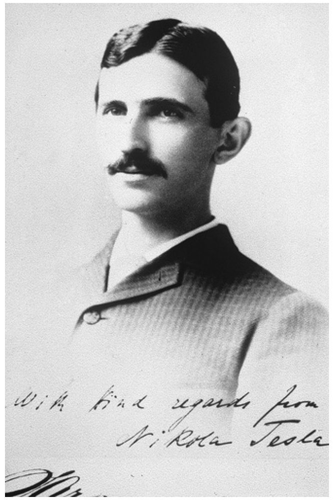
Jonathan Sykes, VP Advanced Applications PAC

Where the "Old" Grid Started



Thomas Edison and his incandescent light patent

Edison's first commercial plant, Pearl St., NY 1882



Nikola Tesla, inventor of the induction motor and a comprehensive system for polyphase AC power

Samuel Insull built the reliable "power pool", reducing production costs, rates, and increased efficiency

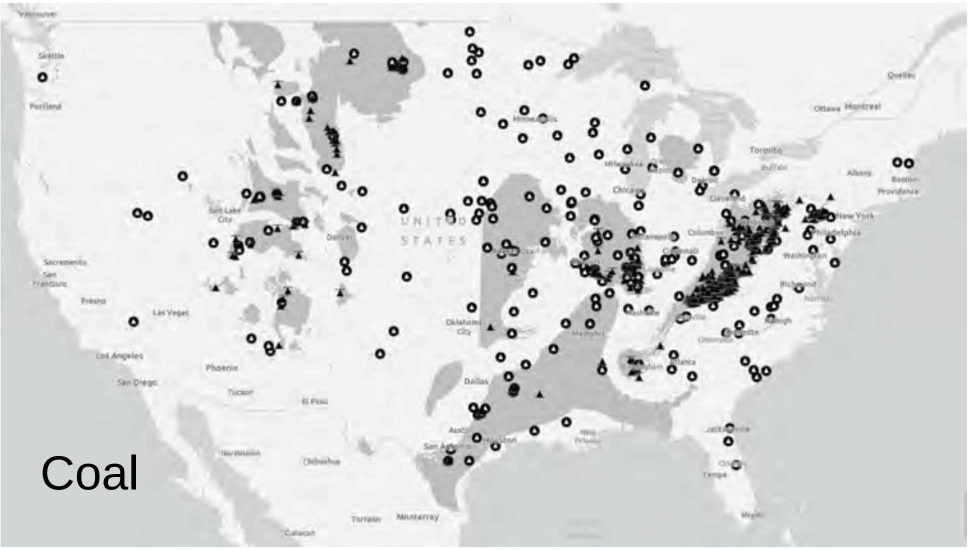
- Edison opened his first electric power plant in New York in 1882
  Was it the first micro-grid?
- Within a decade, electric power had spread to every corner of the globe, with many new applications!
- Why was grid interconnected throughout the years?

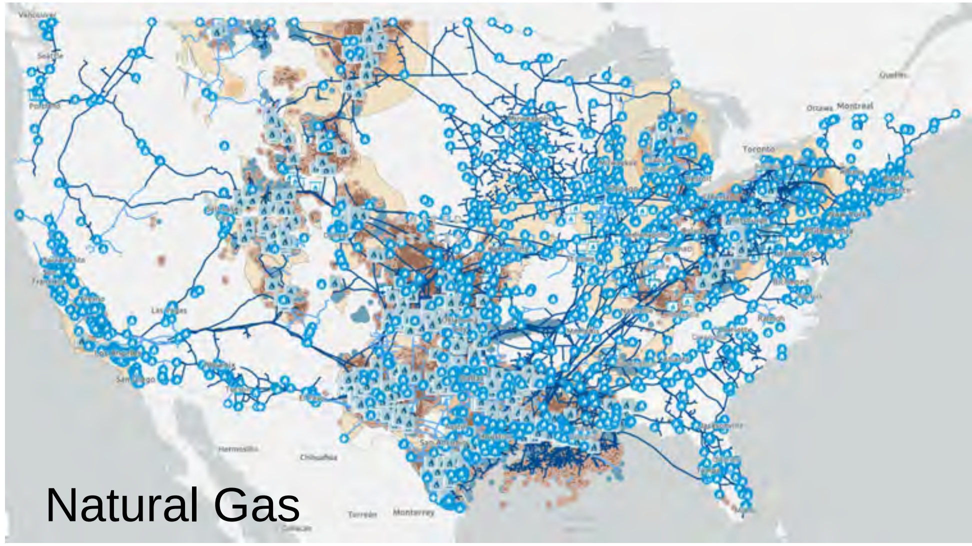
Cost-effectiveness

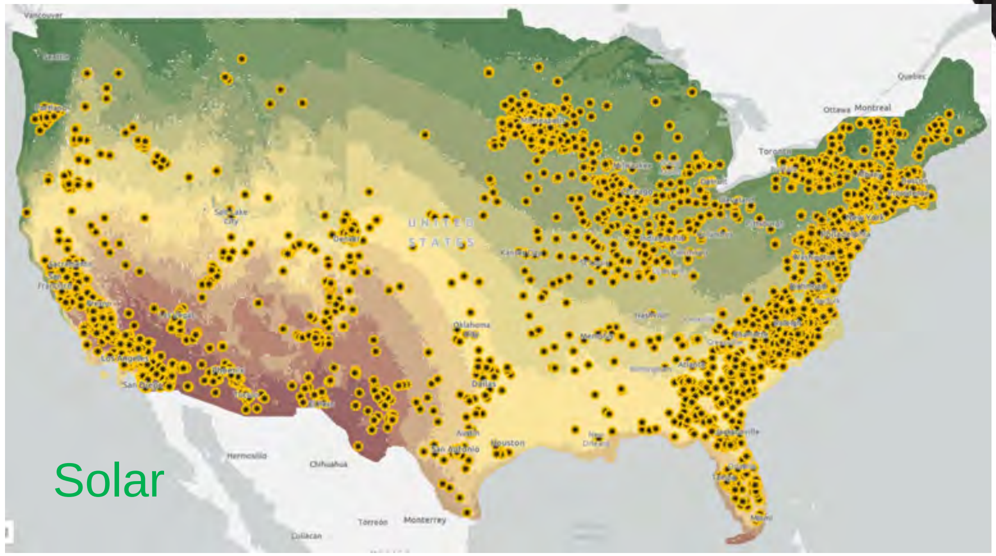
Reliability

Safety

Re-Inventing the “New” Grid



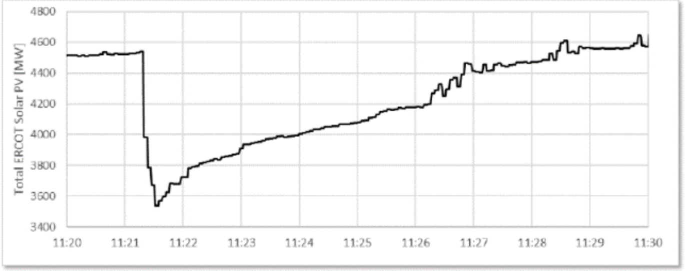




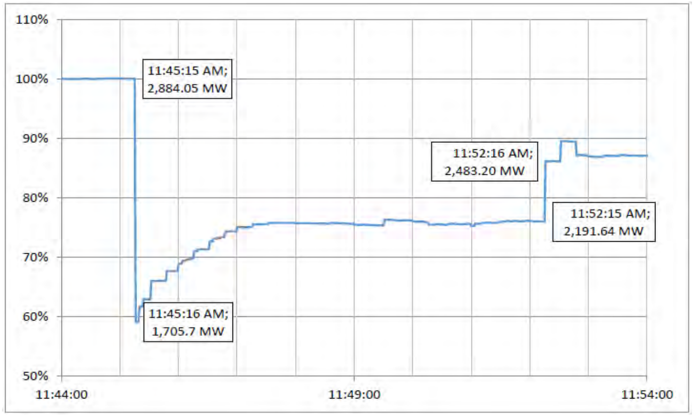
Addressing Systems with Inverter-based Resources (IBR)

Transformation from a few hundred large-scale, dispatchable generation resources to a system involving a large number of DERs located on the traditional "supply" and "demand" sides of the system, not fully visible to the operator.

ERCOT
Solar resource loss
May 9, 2021



Southern California
Solar resource loss
August 2016



Loads and DER will have to participate in coordinated control by providing network regulation and flexibility services.

Fundamental changes in T&D planning, operation, protection, control, and monitoring.

- **Need for Integrated Resource and T&D Planning**
- **Exponential growth of interconnection requests:**
  - Dynamic analysis requires accurate models
  - Hosting capacity maps are becoming a requirement
  - Need for creating a headroom for future renewable requests
- **Distribution networks no longer passive loads:**
  - Drastically changed daily load curve, including effects of EV charging infrastructure
  - Weather conditions have major impact on both consumption and generation
  - Circuits with very different dynamic characteristics
  - Increased significance of near real-time communications

IBR Impacts on System Protection

IBR related challenges:

- Low fault-current magnitude
- Little or no negative sequence fault current injection
- Angle change impact.

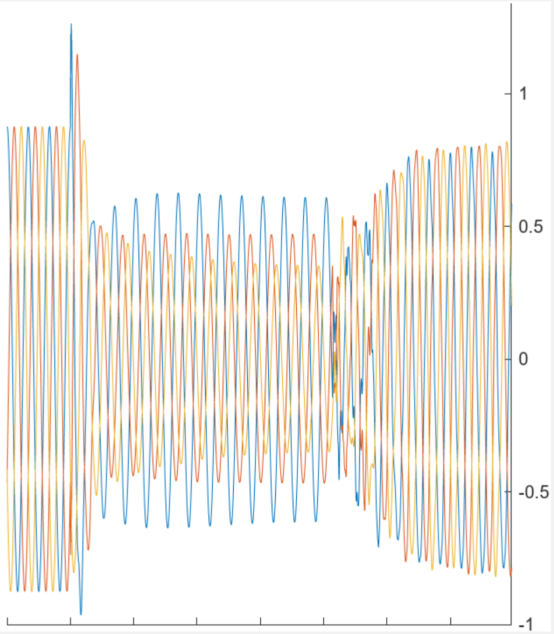
Impacted protection schemes:

- Directional
- Distance
- Overcurrent.

No impact on differential protection

Insufficient fault current

IBR fault current is typically limited to 1.3 pu. Some IBRs may even have less than 1 pu fault current.



Angle change impact

Typically, I2 leads V2 by 90 degrees for a forward fault. But this is no longer true for system with high IBR penetration.

<V2-V12 Angle (Degrees)

Fault type	No IBR	IBR Penetration Increase		
AG	-97	-143	-164	-198
AB	-97	-143	-166	-199
ABG	-97	-143	-163	-199

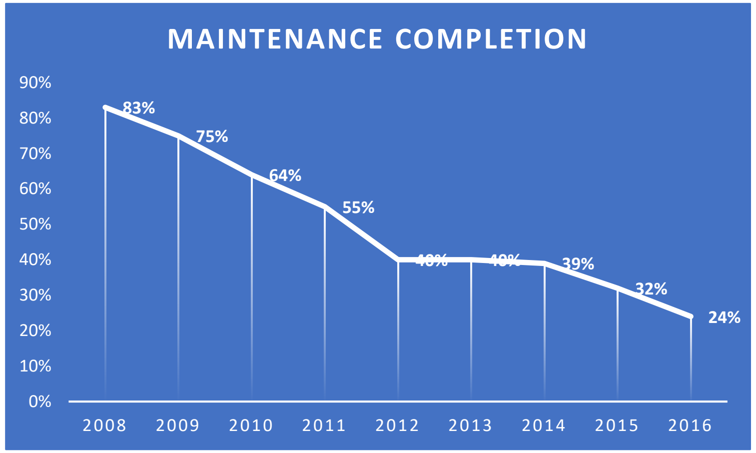
Luma (PR) State of the system – Drivers for change

EM RELAYS

WIRING

FULL CONDUITS

AGING EQUIPMENT

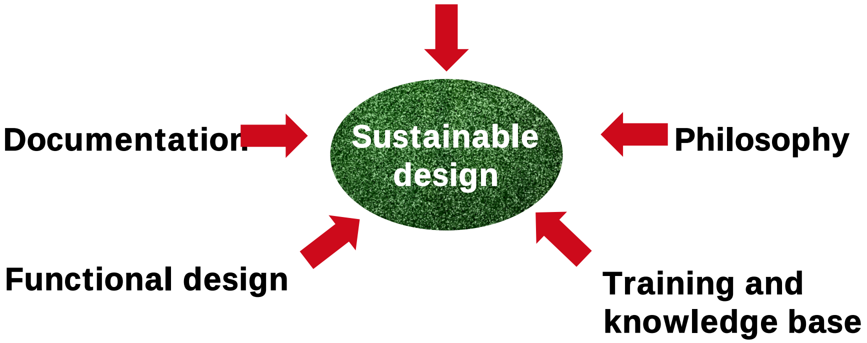


- AGING EQUIPMENT
- OOS LINES
- OOS BREAKERS
- OOS UNDERGROUND
- OOS FEEDERS
- UNSTABLE GENERATORS
- OVERLOADED TRANSFORMERS
- SUPPLY CHAIN
- RESOURCES

Digital Substations: Sustainable Design

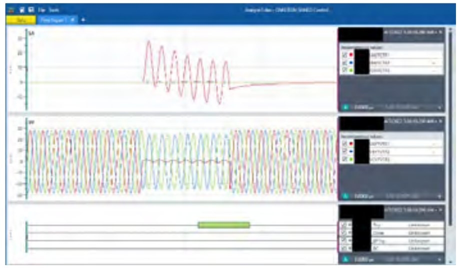
Sustainable, standardized functional design:

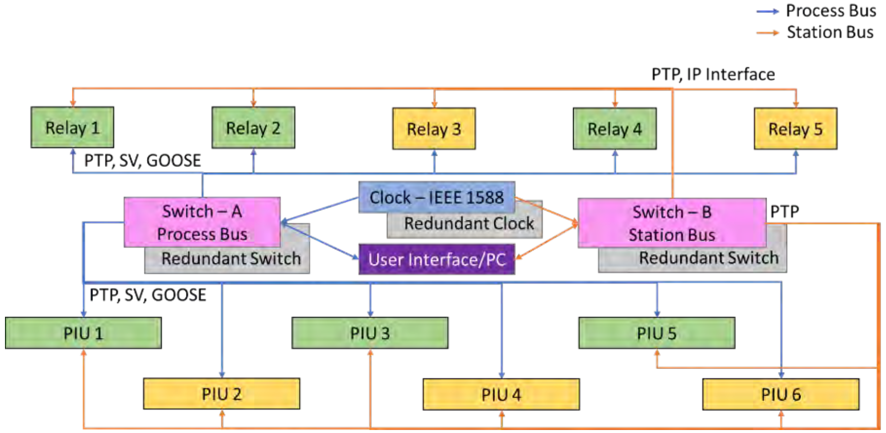
- Prepares substations and utilities for adjusting to renewable generation, storage, and electrification
- A digital substation uses IEC 61850 to replace analog interfaces with digital data
- Unlocks the value of operational and non-operational data for asset performance management, condition-based maintenance, improving power system operations
- Streamlines functional testing and commissioning



Deployment process:

- Cost-benefit analysis
- Digital substation system design
- IEC 61850 training
- RTDS verification of system designs with hands-on training

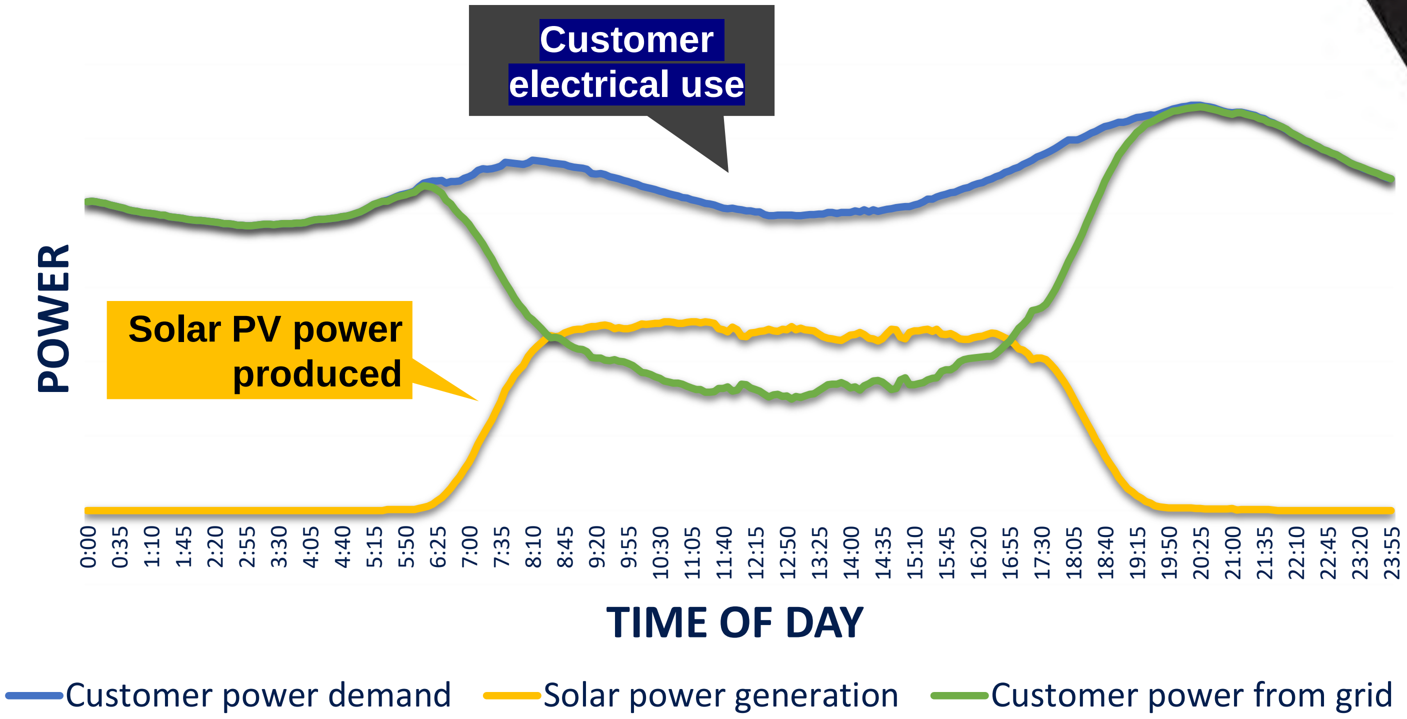




Continuing Challenges of an Island Grid

Puerto Rico's path to 100% renewables must include a smooth transition to provide affordable, reliable, and resilient energy.

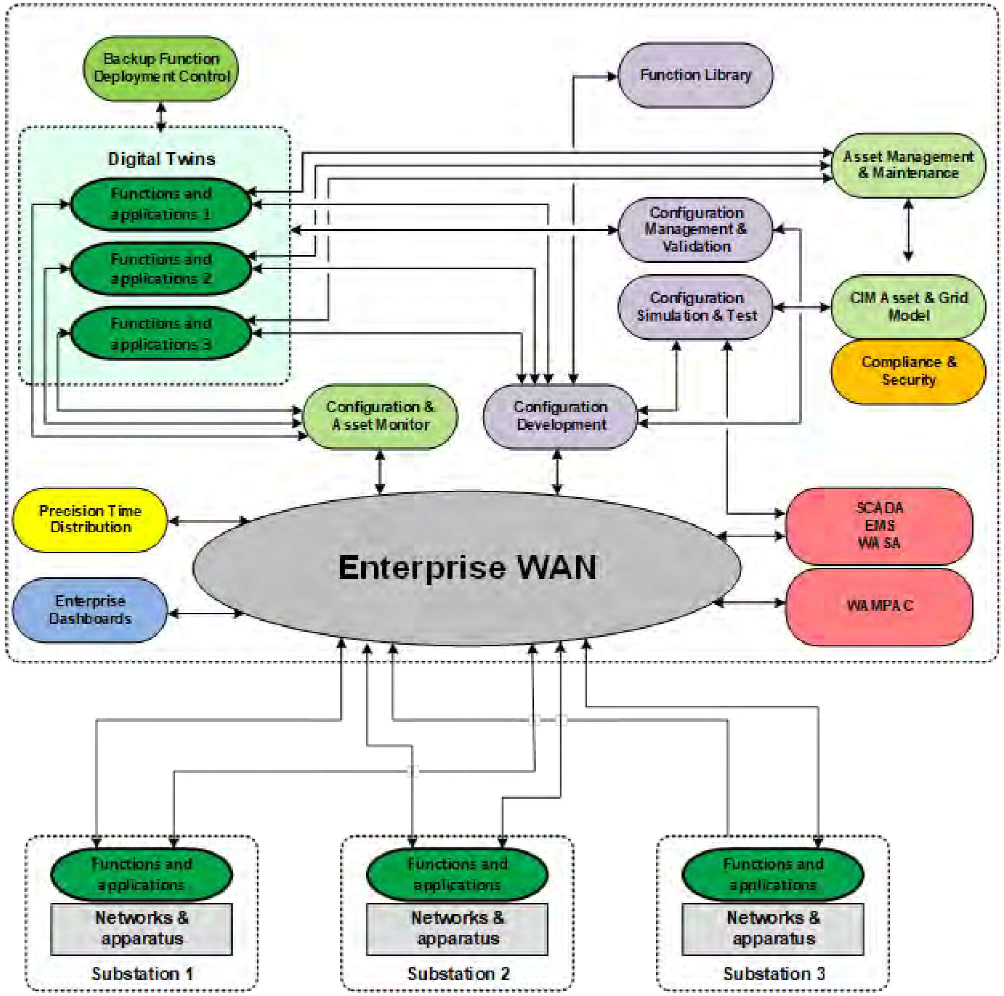
- **No external interconnections to import electricity.**
- **Three hurricanes in the last six years, two black starts in the last 9 months**
- **Decades of under-maintenance**



Efforts to restore customer following Hurricane Fiona were constrained by the amount of available generation and the need to balance supply and demand in real time.

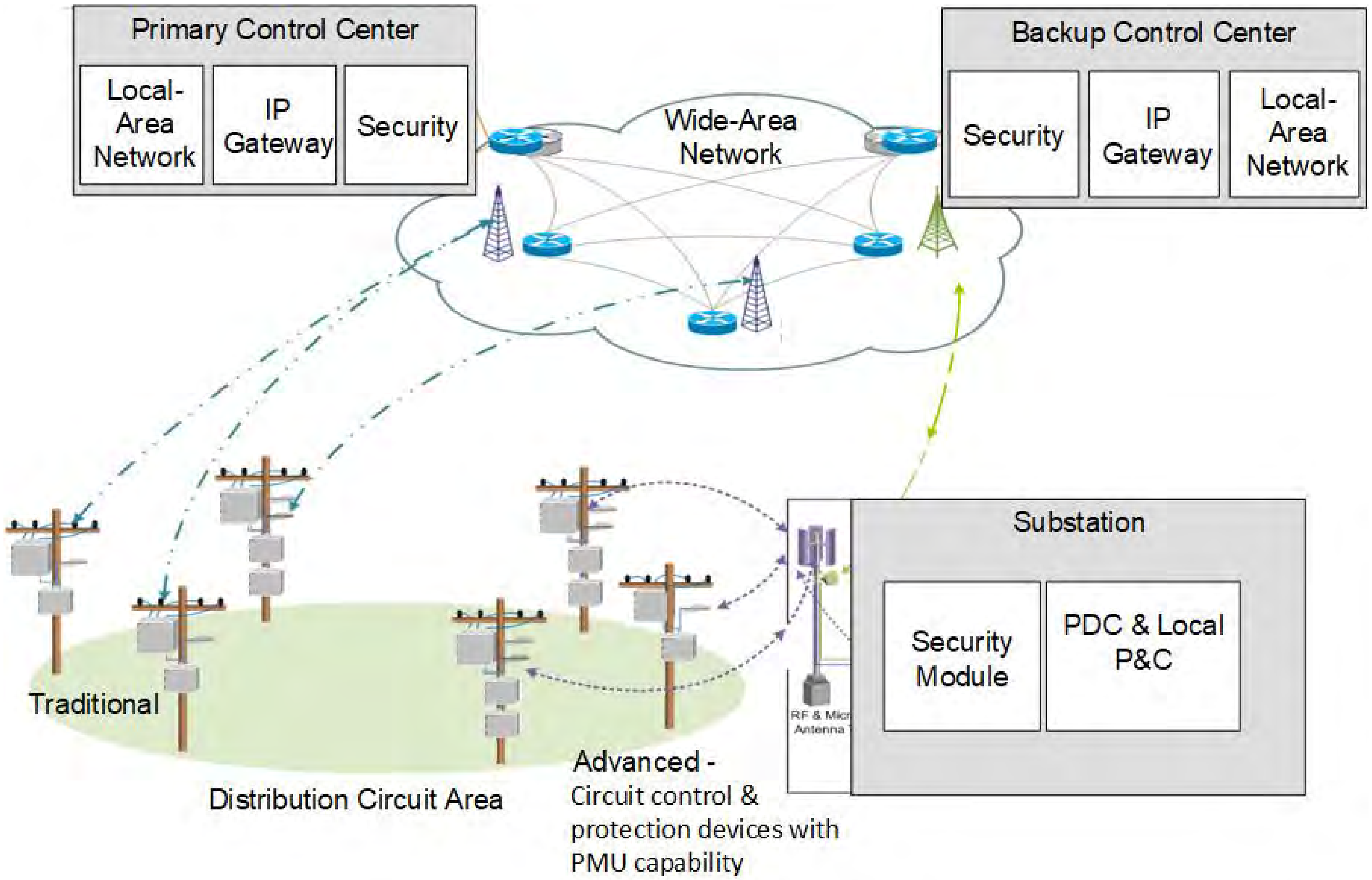
Wide-Area System Monitoring (PMU/Synchrophasor)

- Wide-area synchrophasor measurement concepts were first presented in 1983.
- Phasor measurement unit (PMU)
- Synchrophasor - precision time source (~ 1 µs)
- Phasors from multiple PMUs are streamed to a Phasor Data Concentrator (PDC)
- Wider deployment in *transmission* triggered when major blackouts demonstrated need for situational awareness and modeling.
- Recent deployment in *distribution* triggered by high penetration of distributed energy resources (DER) on circuits with little monitoring.



Distribution Synchrophasor Measurement Deployment – System Platform

Low-cost PMU devices and wideband communications combine with legacy D-SCADA to support a long list of new high-speed and high-accuracy applications.



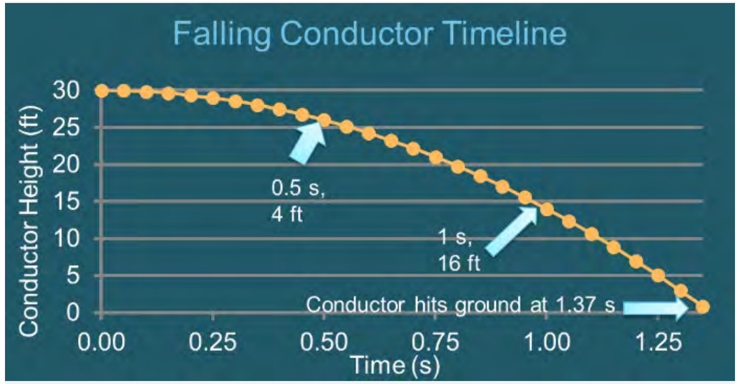
Technology Example: Distribution Synchronized Measurements

Five top-priority application groups use synchronized measurements at medium cost with high benefit:

- Advanced microgrid applications and operation
- High-accuracy fault detection and location
- Advanced monitoring of distribution grid
- Improved load-shedding schemes
- Wide-area visualization

Mid-tier application groups with high benefits needing more development effort:

- Advanced distribution protection and control
- Real-time distribution system operation
- DER integration and control

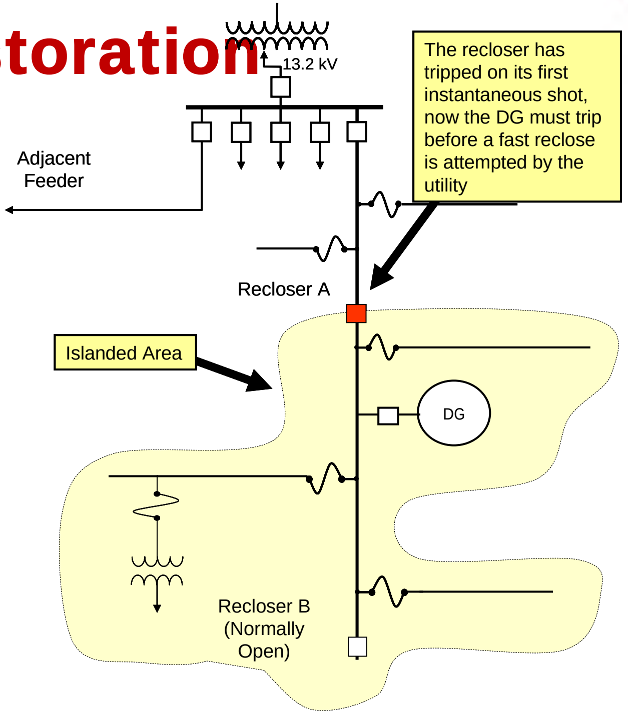


Deenergize the conductor *before* it hits the ground:

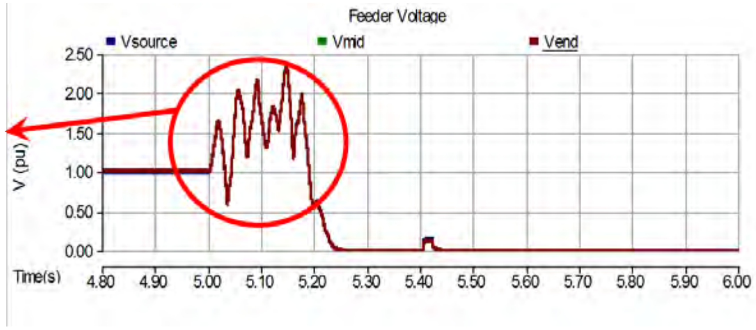
- Break isolated in 200–500 ms
- Avoids high-impedance fault arcing and fire risk
- In service since 2016
- SDG&E planning 70 circuits by 2023 and 135 by 2028 and deploying next-generation wideband Ethernet radio system using private cells

Technology Example:
DG and Microgrid Islanding Detection and Restoration

- Promptly detect islanding conditions.
- Avoid issues like Temporary Overvoltage (TOV), reclosing out of synchronism, and damage to DG equipment.
- Utilize PMU circuit devices and control platform to sustain islanding operation:
  - Power balancing among DERs
  - Automatic load switching and sectionalizing
  - Voltage and reactive power management
  - Large PV facility control & power curtailment
- Utilize PMUs and communications during restoration and synchronization with the grid:
  - Checks voltages, pre-fault loads to support, closing angles and conditions as customers are restored.



TOV caused by opening feeder circuit breaker at t = 5 seconds

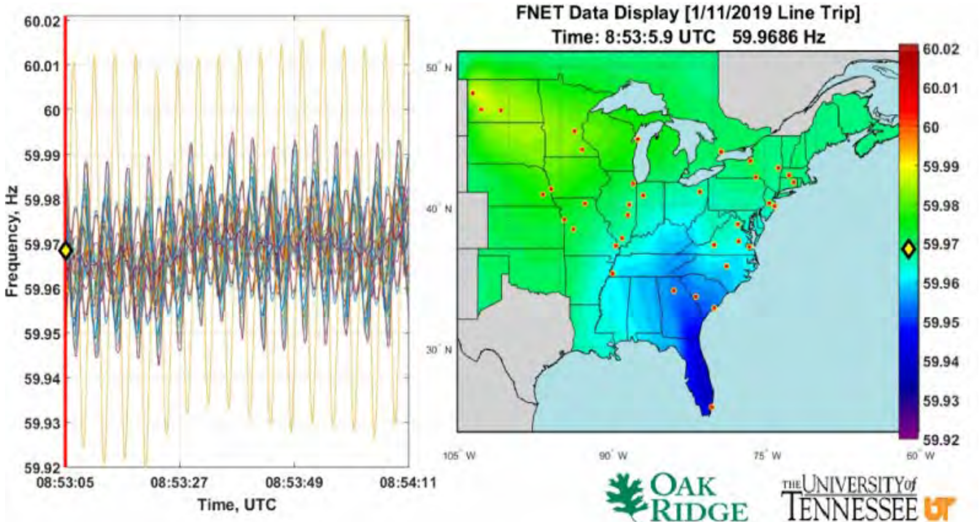


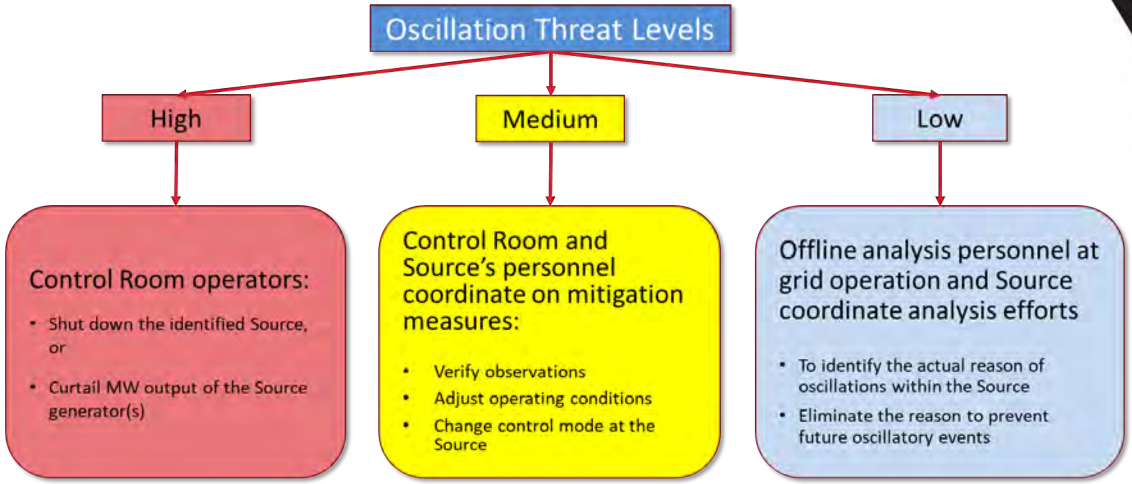
Source: *Slava Maslennikov, ISO NE*

Technology Example:
Situational Awareness - Detection and Mitigation of Oscillations

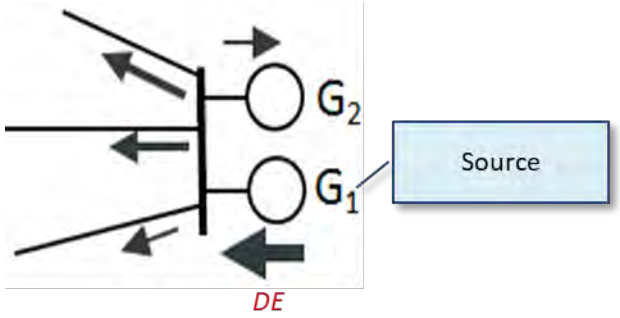
- Variety of oscillation detection methods
  - Ringdown methods
  - Mode meter methods
  - Non-linear analysis methods

Source: IEEE PES-TR15 *Identification of Electromechanical Modes in Power Systems*





- Oscillation source location using Dissipating Energy (DE) flow method

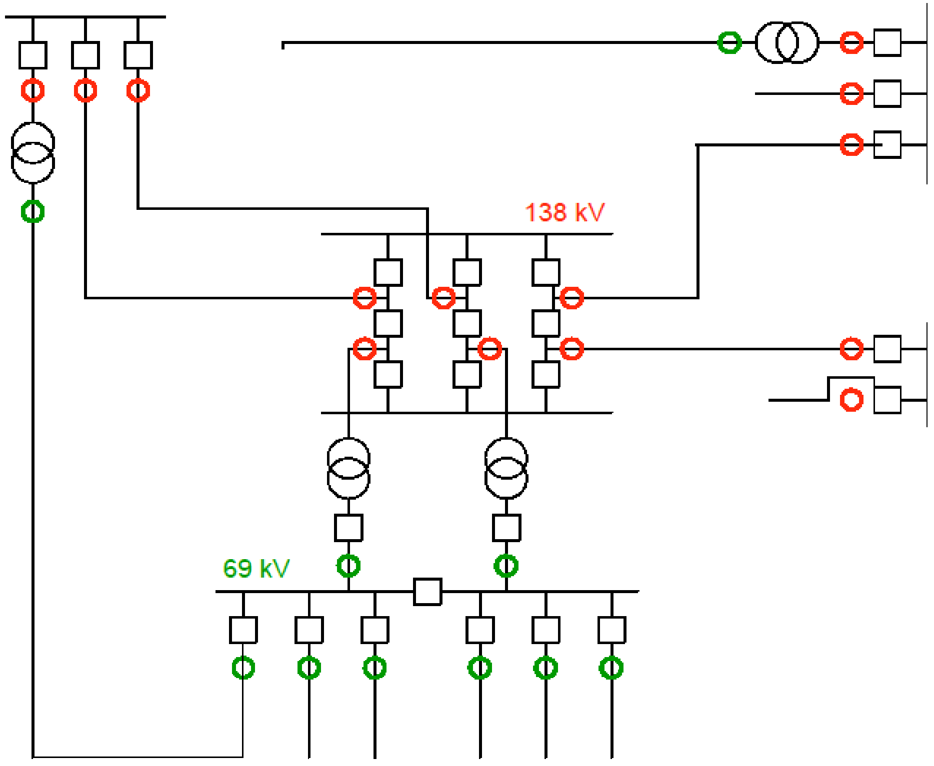


Source: *Slava Maslennikov, ISO NE*

Technology Example:
WASA and WAMPAC Functions

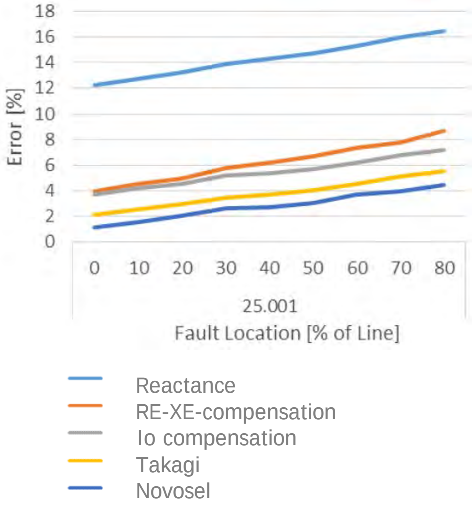
Wide-area fault and swing protection

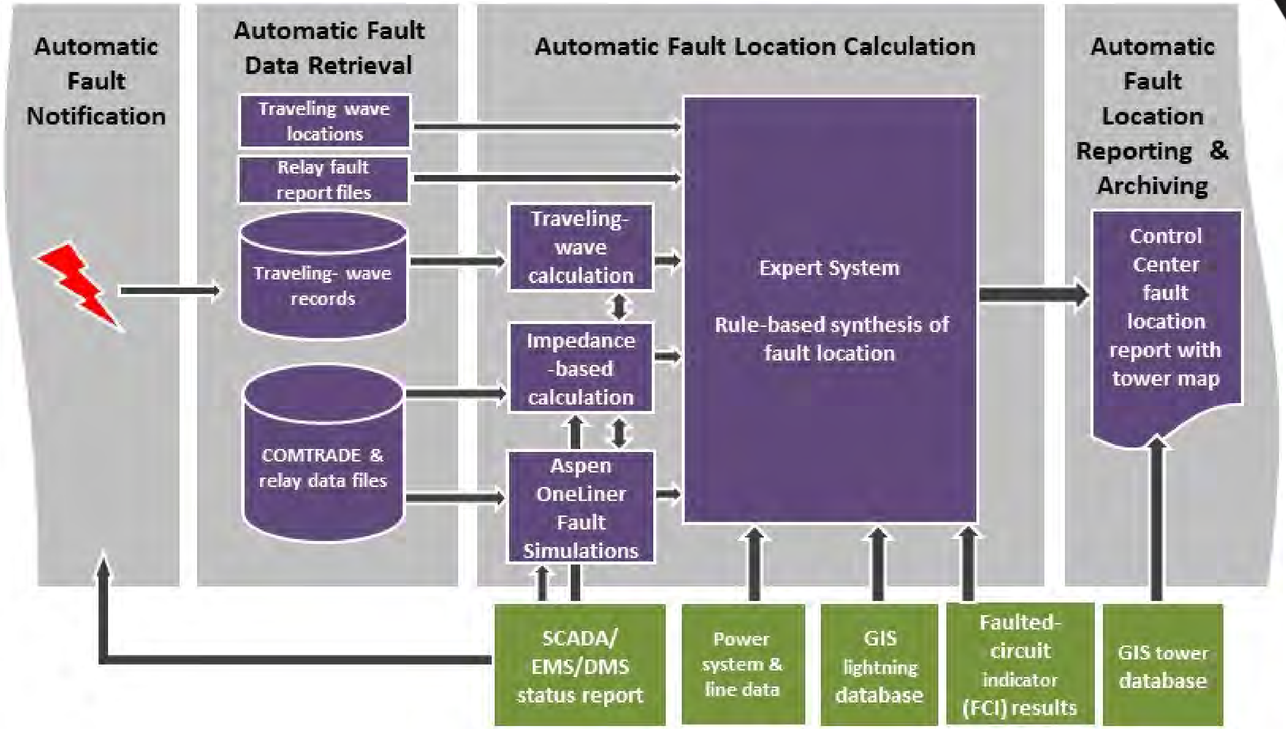
- Holistic current differential protection on high-density PMU deployment.
- A couple of cycles behind local high-speed protection.
- Surgically removes faulted zones and failed breakers before Zone 2 and Zone 3 remote backup can react.
- Immune to swings, low fault currents, and inverter-based generation.
- Separate swing protection/islanding with voltage phasors.
- See CIGRÉ Session 2014 B5-112.



WASA - wide-area situation awareness ***WAMPAC*** - wide-area protection, automation, and control

Technology Example:
Automated Fault-Location System





- Quick and automatic
- With map location identifying the most probable tower and error estimates
- With best accuracy

Electrification: Challenges and Opportunities

Why the interest in heavy-duty fleets?
Chargers can be 150 times the size of light-duty vehicle chargers and diesel engines account for most harmful emissions impacting society.

EV transportation, whether heavy or light-duty vehicles, requires unique solutions and approach:

- **Determine how to achieve collaboration** among fleet owners, charging developers, utilities, regulators, city officials, vehicle manufacturers
- **Locate where, when, and how big loads will be (roadmaps)**
- **Determine how to disaggregate load data** to specific feeders and substations
- **Determine what the best are solutions to mitigate this new load**

Comprehensive approach to address challenges and opportunities:

- **Electrification forecasting** based on regulatory and industry trends and advanced driving pattern analysis to assist with short- to long-term planning
- **Assessment** of charging technologies, vehicle adoption, and locations
- **EV load-impact analysis** of residential and commercial fleets on electricity grids
- **Deployment and implementation** of mitigation technologies, including grid upgrades and reconfiguration, charging and demand-side management, photovoltaic, and storage

Thank You for Your Time Today! Accelerate Successful Outcomes for Your Projects.

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