Wide Area Monitoring and Control Technologies

Optimal Grid Operation using Phasor Measurement Units

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New Challenges Facing Grid Operators

- **Growth of The Grid**
  - ***1882 – Edison's Pearl Station***
    - 59 customers / 600kW of generation / 10.5 miles of main lines
  - ***2012 – New York Control Area***
    - 7M customers / 43GW of GTDR / 11,000+ circuit miles of HV transmission
- **Wind Power**
  - ***2005 – 48 MW of wind power capacity in New York State***
  - ***2006 – NYISO exempts wind from under-generation penalties***
  - ***2008 – NYISO establishes centralized wind forecasting system***
  - ***2009 – NYISO integrates wind into economic dispatch system (First in Nation)***
  - ***2013 – 1,634 MW of wind power capacity in NYS (Another 2,000+ MW proposed)***
- **Energy Storage**
  - ***2009 – NYISO implements first market rules in US enabling storage systems to participate in the markets as frequency regulation providers***
  - ***2011 – first commercial grid-scale battery-based storage system to operate as a generator in the US (AES Energy Storage)***
  - ***2011 – first full-scale flywheel energy storage facility to provide frequency regulation service in the US (Beacon Power)***

New Challenges Facing Grid Operators (Cont.)

- **Solar Power**
  - ***2011 – The largest photovoltaic array in the eastern US completed (32 MW Long Island Solar Farm)***
  - ***2012 – NYISO exempts solar power from under-generation penalties to compensate solar fully for all energy production***
- **Demand Response**
  - ***2013 – DR reduced demand by 1,000+ MW when new, record peak load of 33,956 MW set in NY during July heat wave***
- **Deregulation of electricity market - unique mix of engineering and economics**
  - ***Day-ahead-market – hourly schedules / one-day ahead***
  - ***Real-time-market – 5-minute schedules / once an hour***
- **Dynamic Pricing**
  - ***2009 NYISO/Brattle Group Study***
    - Dynamic Pricing can encourage shift to off-peak usage
    - Potential 10-14% reduction in system peak

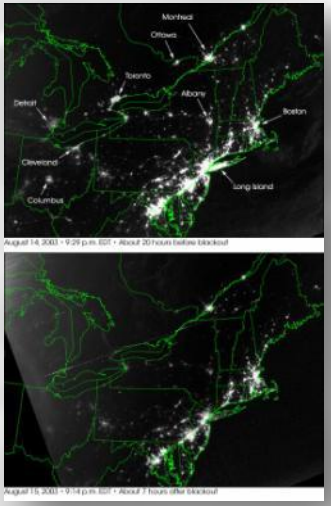
How to Leverage Immense Potential of PMUs ?

Paradigm Change in Power System

Traditional	Future
Adjust supply to meet changing demand	*Adjust demand to meet changing supply*
Generation & demand connected via transmission lines	*Generation & demand are aggregated (i.e., distributed generation)*

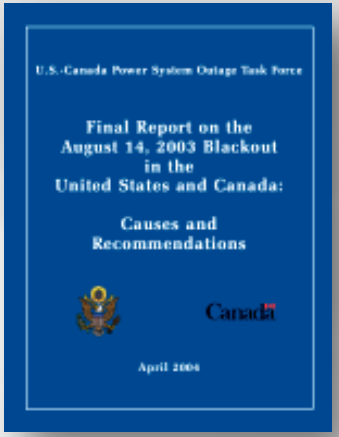
Improve Visibility!

2003 Blackout & Situational Awareness



The US–Canada Power System Outage Task Force – formed to research the 2003 Northeast Blackout – issued a final report in 2004, which concluded that *"a lack of situational awareness"* was one of the principal causes of the event – and recommended…

"Development of practical real-time applications for wide-area system monitoring using phasor measurements and other synchronized measuring devices, including post-disturbance applications…"



PMU Potential Benefits

Facilitating Optimal Grid Operation

- **Self-healing from power disturbance events**
  - *Faster (scan rate) state estimation, wide-area observability, multi-level monitoring capability, SPS*
- **Enabling active participation by consumers in demand response**
  - *Monitoring at lower voltage levels (Demand response, price-sensitive load)*
- **Operating resiliently against physical and cyber attack**
  - *Redundancy and strategic placement of measuring devices/sensors*
  - *Detection, identification and elimination of errors in data and models*
- **Providing quality power to meet the needs of the 21st century**
  - *Accommodating all generation and storage options*
  - *Enabling new products, services, and markets*
  - *Wide-area monitoring to facilitate the feedback to address congestion, avoid spilling renewable energy, active market participation, Micro grid*
- **Optimizing assets and operating efficiently and investment signal**
  - *Monitoring dynamic line loading, equipment operating limits, dynamic reserves requirement, monitoring voltage collapse, dynamic contingency list*

***Note:* Phasor technology is NOT (today) a replacement for SCADA, rather it complements existing SCADA systems**

DOE Smart Grid Investment Grant (SGIG)

On-Line Applications:

EMS-based (RTU/PMU-driven)

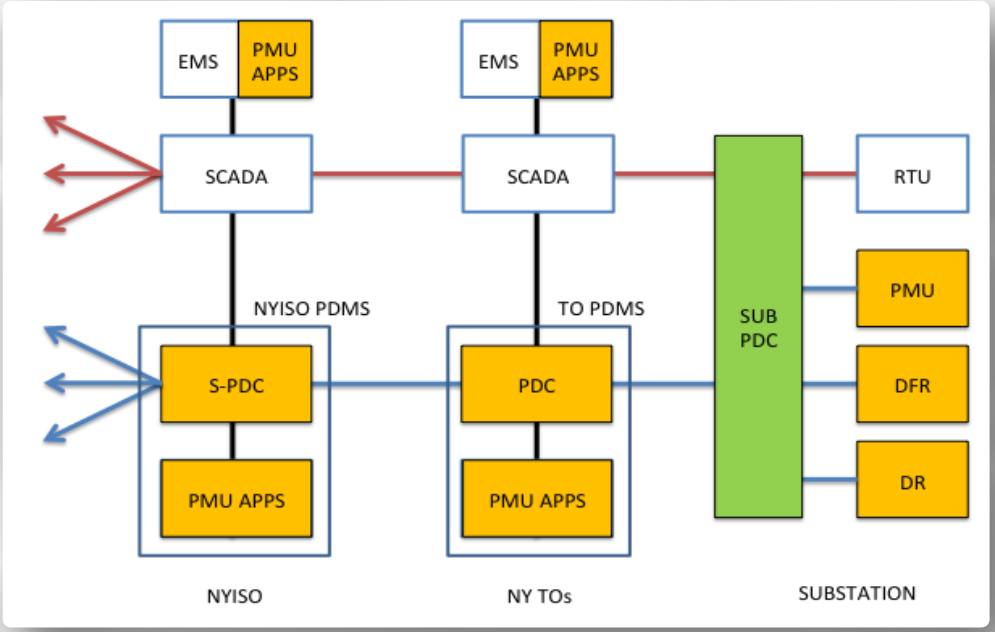
- *Enhanced state estimator*
- *Voltage stability monitor*

PMU-driven

- *Stress monitor*
- *Oscillations monitor*
- *Mode meter*
- *Frequency and voltage monitoring*
- *MW and MVAR monitoring*

System Deployment in NY

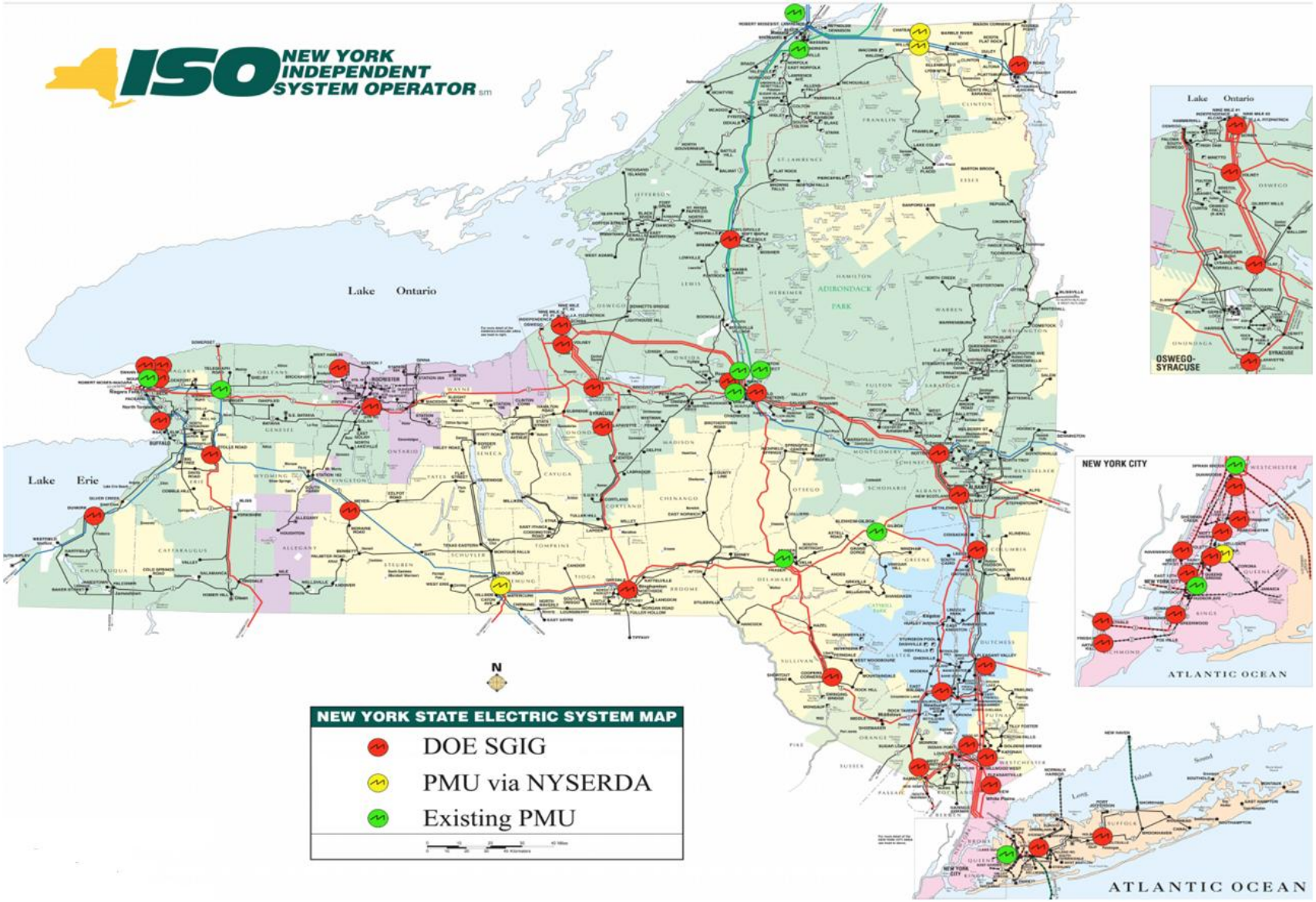
- *PMU/PDC Placement Study*
- *PMU/PDC/PDMS Specifications*
- *52 PMUs (NY TOs)*
- *10 PDCs (NYISO and TOs)*
- *Communications*



Off-Line Applications:

- Dynamic System Validation and Calibration
- Controlled System Separation

Installation of Capacitors - 938 MVAr

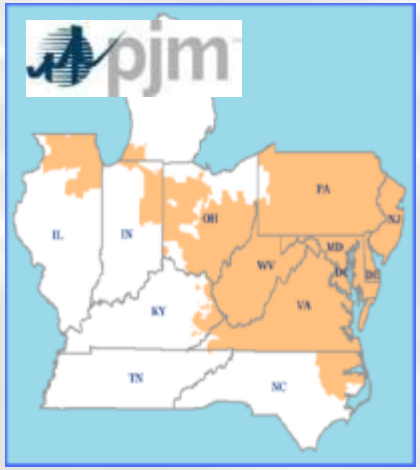


Markets & System Operations 2017 - Broader

Broader Regional Markets, Gas-Electric Coordination, Smart Grid – system visualization & security

Gas Distribution Companies

Electric System Status



Coordinate Operations & Practices

Operational Flow Orders

Gas Pipelines

NYISO Control Center

PMU Data

Markets & System Operations 2017 - Deeper

DR, PV, PEV aggregation and Wind/Solar integration

Aggregator

Demand Response

Dispatch Instructions & Prices

NYISO

Control Center

Evolutionary Market Design

Wind/Solar Generators

The New York Independent System Operator (NYISO) is a not-for-profit corporation responsible for operating the state's bulk electricity grid, administering New York's competitive wholesale electricity markets, conducting comprehensive long-term planning for the state's electric power system, and advancing the technological infrastructure of the electric system serving the Empire State.

www.nyiso.com