Overview of ISO New England Big Data Analytics

US Department of Energy
Electricity Advisory Committee

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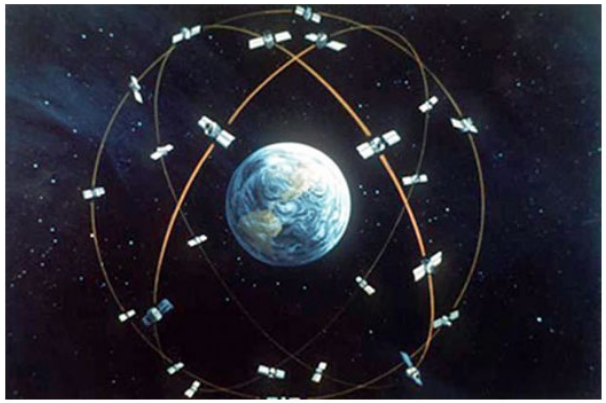
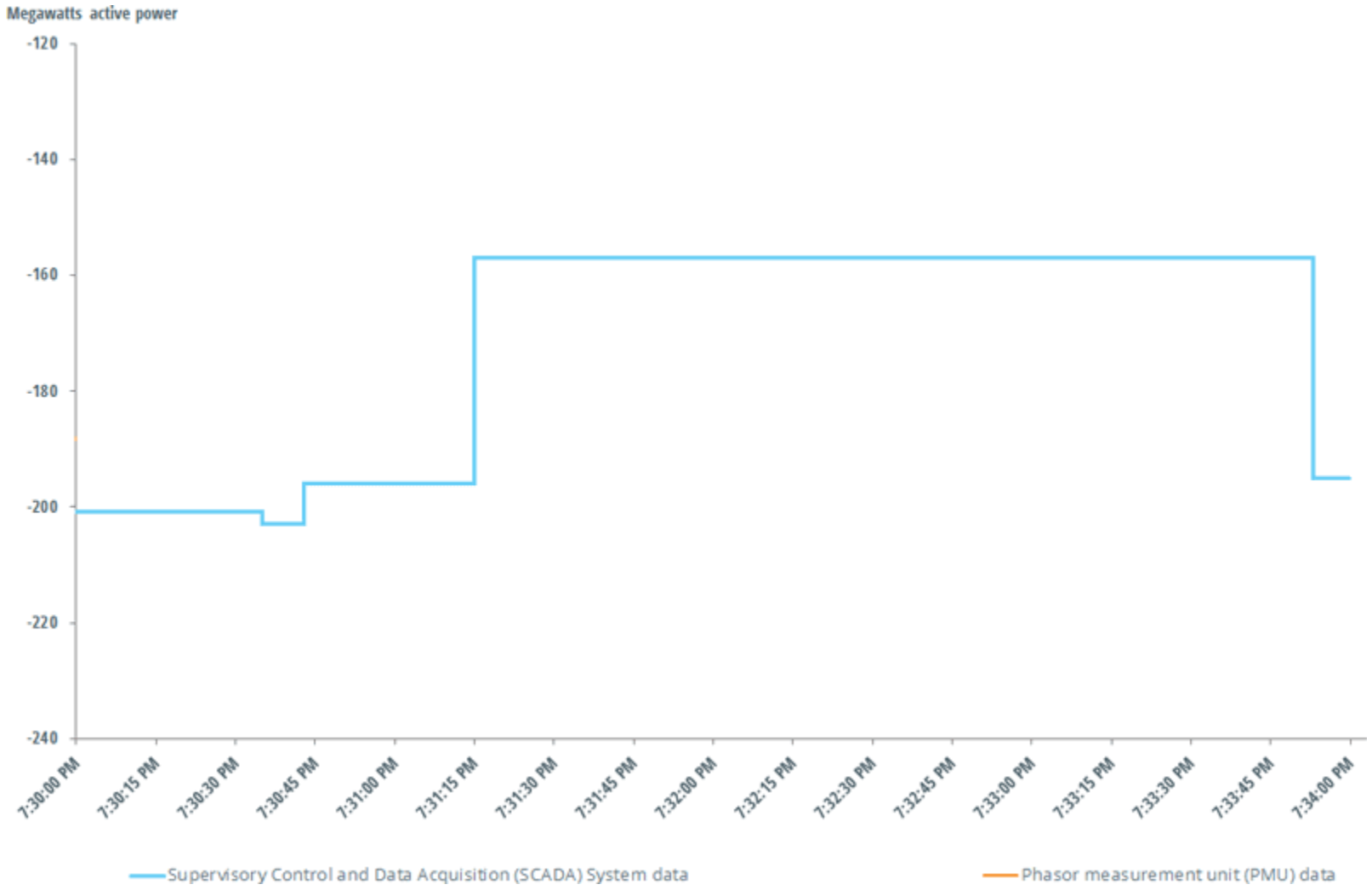
INFORMATION TECHNOLOGY

Purpose and Benefits of Synchrophasor Technology



- Phasor provides measurement of:
  - Voltage magnitude and phase angle
  - Current magnitude and phase angle
- Synchrophasor:
  - Precisely GPS time-synchronized phasor
  - High sampling rates (30 to 120 measurements/second
- PMU Measurements include:
  - Synchrophasor: V and I (A, B, C phases and/or positive sequence)
  - Synchro-scalars: Frequency and Rate Of Change Of Frequency (ROCOF)
  - Synchro-digits: Discrete values (e.g. breaker statuses)

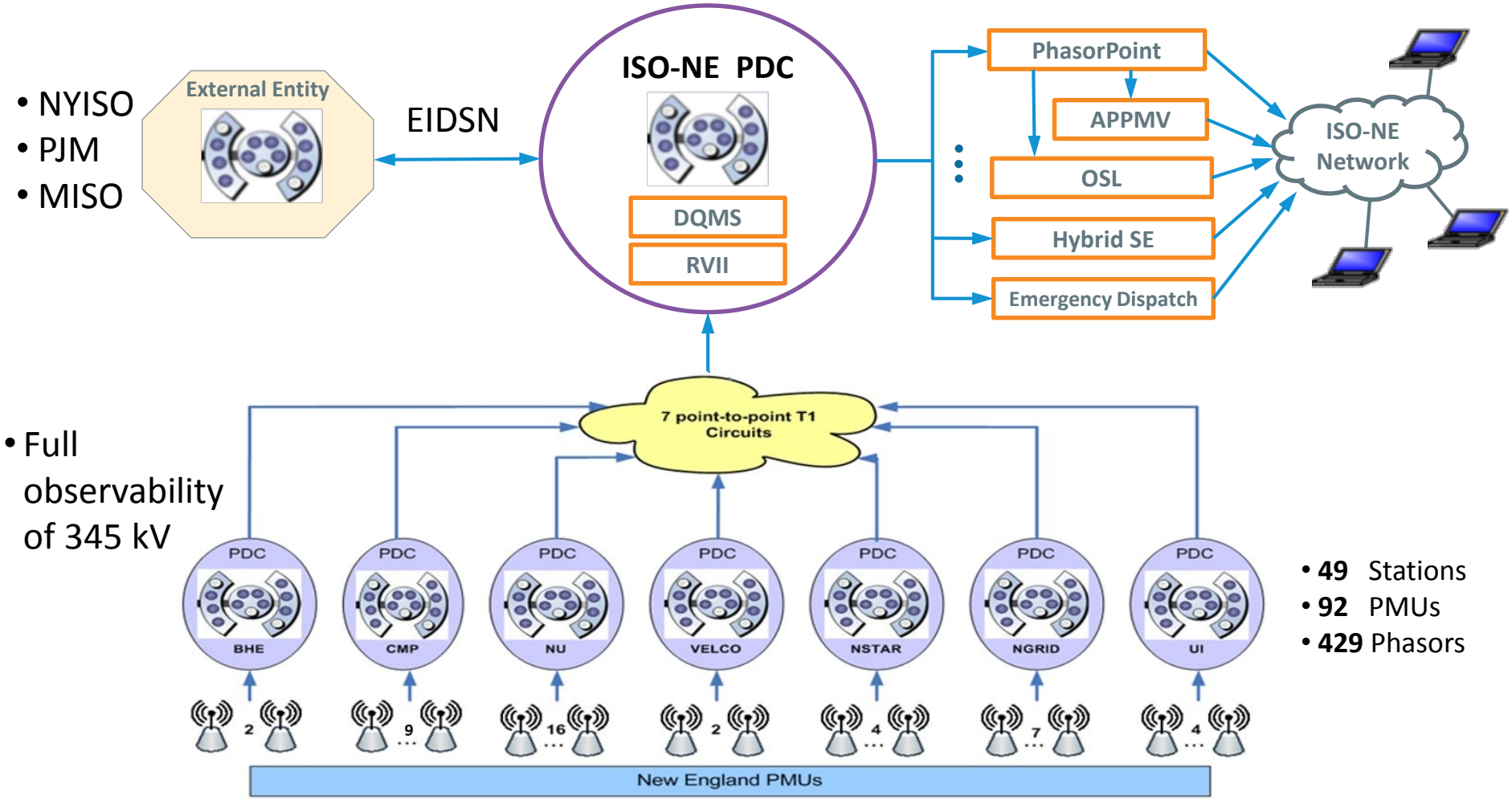
Synchrohasor = Phasor + GPS + high sampling rate


Megawatts active power
-120
-140
-160
-180
-200
-220
-240
7:30:00 PM
7:30:15 PM
7:30:30 PM
7:30:45 PM
7:31:00 PM
7:31:15 PM
7:31:30 PM
7:31:45 PM
7:32:00 PM
7:32:15 PM
7:32:30 PM
7:32:45 PM
7:33:00 PM
7:33:15 PM
7:33:30 PM
7:33:45 PM
7:34:00 PM
Supervisory Control and Data Acquisition (SCADA) System data
Phasor measurement unit (PMU) data

Synchrophasor Infrastructure and Data Utilization (SIDU)

- Purpose: Develop Synchrophasor infrastructure and the technology platform upon which advanced analysis and visualization tools can be developed and deployed to enhance situational awareness
- US Department of Energy Recovery Act *Smart Grid Investment Grant* (SGIG)
  - Implementation period: 7/1/2010- 6/30/2013
  - Observation period: 7/1/2013 – 6/30/2015
- Approved Operating Procedure 22 (OP #22) changes (effective Dec. 2017) to require new PMU installations by Transmission Owner (TO)
- OP #22 changes will *double the number* of PMUs in the next five years

Existing PMU Infrastructure in New England



- Full observability of 345 kV

- **49** Stations
- **92** PMUs
- **429** Phasors

PMU-Based Applications at ISO New England

- OpenPDC
- PhasorPoint
- Data Quality Monitoring System (DQMS)
- Oscillation Source Location (OSL) and integrated PmuEmailAlarm notification
- Automated Power Plant Model Verification (APPMV)
- PMU-based ACE calculation in MLCC-21
- Control Room PMU-based situational awareness displays
- Phasor Analytics (off-line)
  - PMU, SCADA, DFR, Simulation

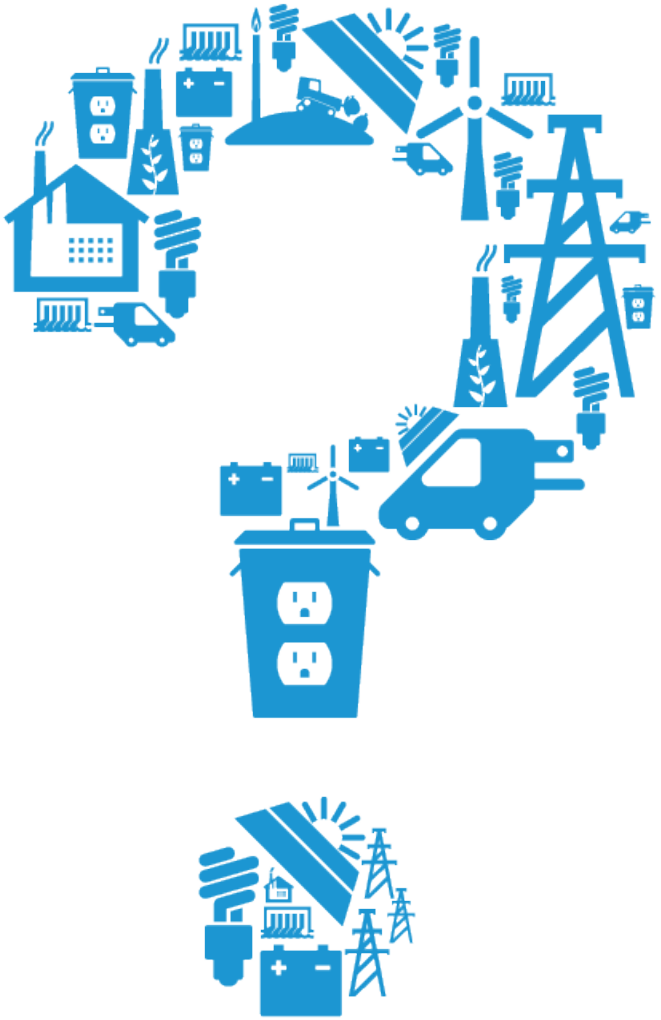
Future Applications of PMUs (Not Currently in Production)

- PI repository for PMU data that can scale
- Situational Awareness (SA), Oscillation Source Location (OSL) and Master Local Control Center 21 (MLCC-21) to use PMU data
- Hybrid State Estimation – SCADA and PMU
  - Accuracy and robustness
- PMU only State Estimation
- Measurement based voltage instability indicator
- PMU-based emergency generation dispatch
- PMU-based line parameter estimation and verification

Ongoing Research into PMU Technologies

- Evaluation of new PMU data storage technologies (with GE)
- PMU and SCADA cyber-attack detection
- Eastern Interconnection-wide oscillation detection and source location
- Cloud-hosted PMU streaming, processing, archiving and data analytics

Questions



APPENDIX

Comparison of Synchrophasor vs. SCADA

Attribute	SCADA	Synchrophasor
Resolution	One sample every 2 to 4 seconds	30 to 120 sample per second
Measured Quantity	Magnitude	Magnitude and phase angle
Time synchronization	NO	YES
Focus	Control area (local) monitoring and control	Wide area (interconnection) monitoring and control
Observability	Steady state only	Steady state and system dynamics
Monitoring angles, damping, frequency response, etc	NO	YES
Oscillation Detection	NO	YES

Synchrophasor technology is NOT a replacement for SCADA; rather it complements existing SCADA system

Future Projects in Real-Time Operations

Phase 1

- Develop a real time synchrophasor-based backup system for grid monitoring
  - Automate the MLCC-21 spreadsheet with PMU data source to populate:
    - PMU measured tie line flows and frequency
    - PMU-monitored generators outputs (100 MW and above)
    - Calculate PMU-based ACE
    - Display system diagram with periodically refreshed PMU measurement on generator outputs, substation voltages, transmission line flows, etc.
- Production deployment of hybrid state estimation
- EMS Alarm Summary display is updated with oscillation alarm notifications

Future Projects in Real-Time Operations *(cont'd)*

Phase 2

- Develop a real time synchrophasor-based backup system for grid and control
  - Implement emergency dispatch of PMU-monitored generators for load following and system balance
  - Linear State Estimation (LSE) to extend the PMU observability and grid monitoring
- EMS Alarms display is updated to include alarms from voltage angle difference for system stress and line reclosing, system islanding, voltage instability indicator, etc.