Integration of Renewables Forecasts into the EMS and MMS

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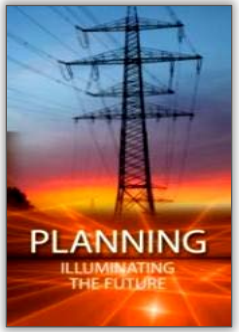
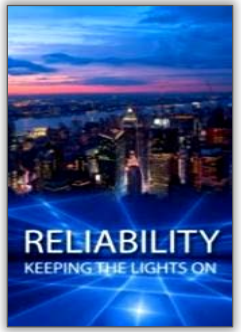
NEW YORK INDEPENDENT SYSTEM OPERATOR

Roles of the NYISO

- **Reliable operation of the bulk electricity grid**
  - Managing the flow of power on 11,000 circuit-miles of transmission lines from hundreds of generating units
- **Administration of open and competitive wholesale electricity markets**
  - Bringing together buyers and sellers of energy and related products and services
- **Planning for New York's energy future**
  - Assessing needs over a 10-year horizon and evaluating projects proposed to meet those needs
- **Advancing the technological infrastructure of the electric system**
  - Developing and deploying information technology and tools to make the grid smarter





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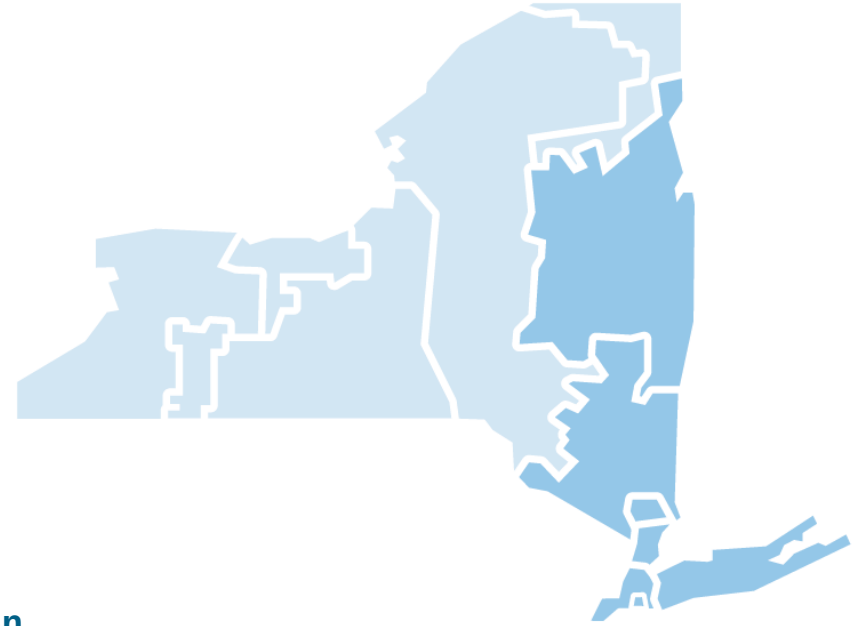
NYISO by the numbers

- New York population: 19.75 million
- 2017 Energy Demand: 156,370 GWh
- 2018 Required Installed Capacity: 42,839 MW
- 2017 Peak: 29,699 MW
- Record peak: 33,956 MW (July 19, 2013)
- Transmission: 11,173 circuit miles
- Power Generation: 700+ units
- Wholesale Market Participants: 434
- Average Annual Market Transactions: $5.3 billion



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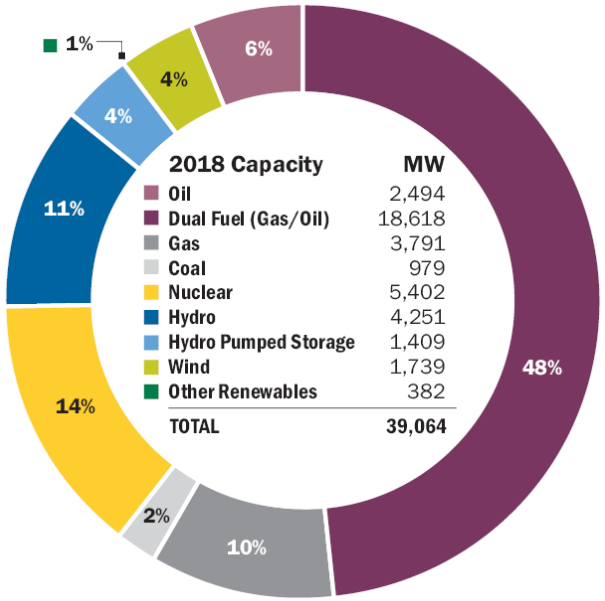
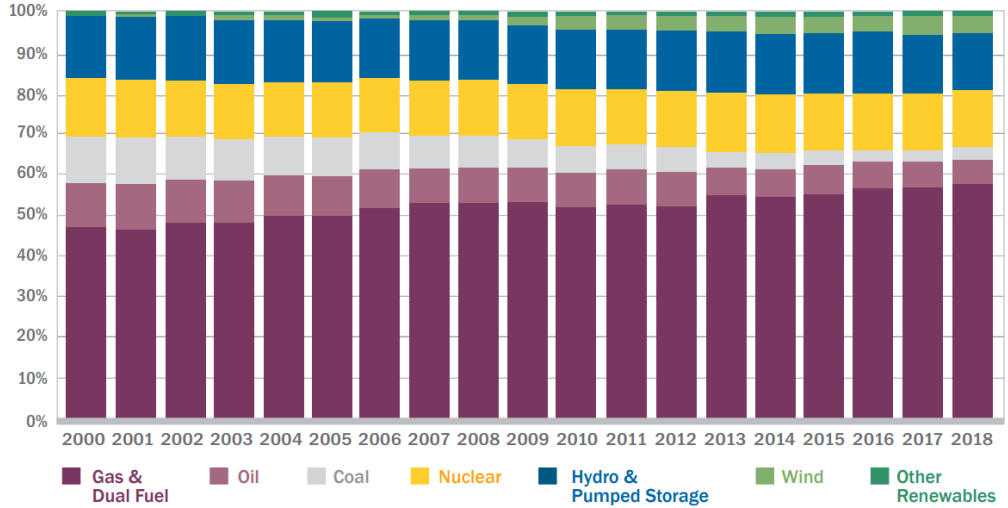
Fuel Mix

New York Statewide Generating Capacity by Fuel Source: 2018



New York State Fuel Mix Trends: 2000-2018



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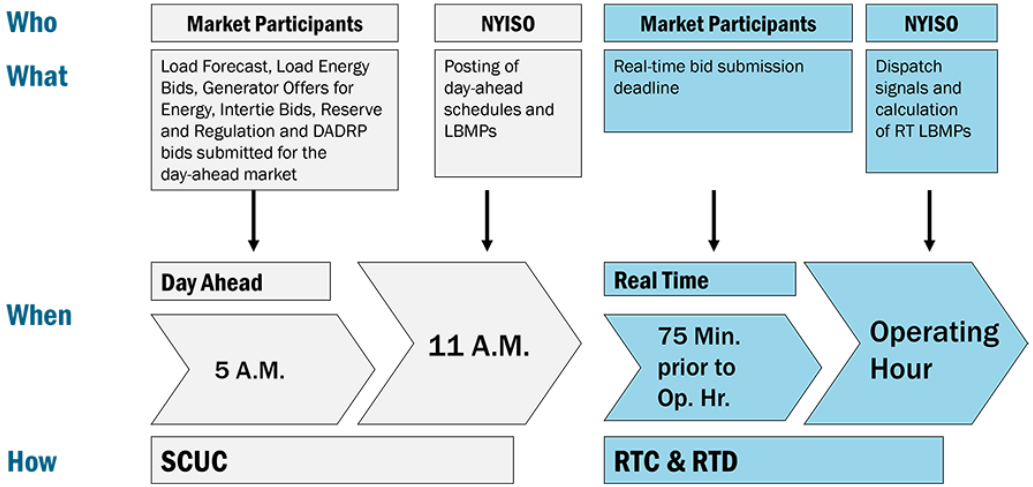
Energy Market Overview

- Full two-settlement market for energy, reserves, and regulation
- Bid based Security-Constrained Economic Dispatch (SCED) and Commitment (SCUC)
- Simultaneous co-optimization of energy, interchange, operating reserves and regulation to minimize total production cost
- Shortage pricing for operating reserves and regulation
- Demand side resource participation



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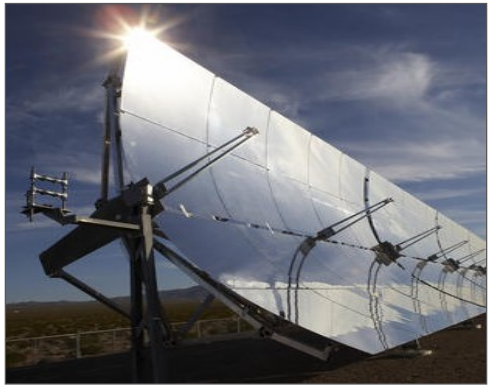
Energy Market Overview (Cont.)

- **Day-Ahead Market**
  - Binding forward contracts issued to Suppliers and Load
  - Hourly Locational Based Marginal Prices (LBMP)
  - Bilateral Transaction scheduling
  - Virtual resource (zonal) scheduling



- **Real-Time Commitment (RTC)**
  - Runs every 15 minutes - optimizes over next 2 ½ hour period
  - Issues binding commitments for units to start
    - Provides for commitment of “quick start” resources including 10-minute and 30-minute gas turbines
  - Issues binding schedules for transactions

- **Real-Time Dispatch (RTD)**
  - Runs approximately every 5 minutes, optimizing over next 60 minute period
  - Produces 5-minute Locational Based Marginal Prices (LBMP)
  - Multi-period security constrained dispatch
  - Issues binding dispatch instructions for units to operate

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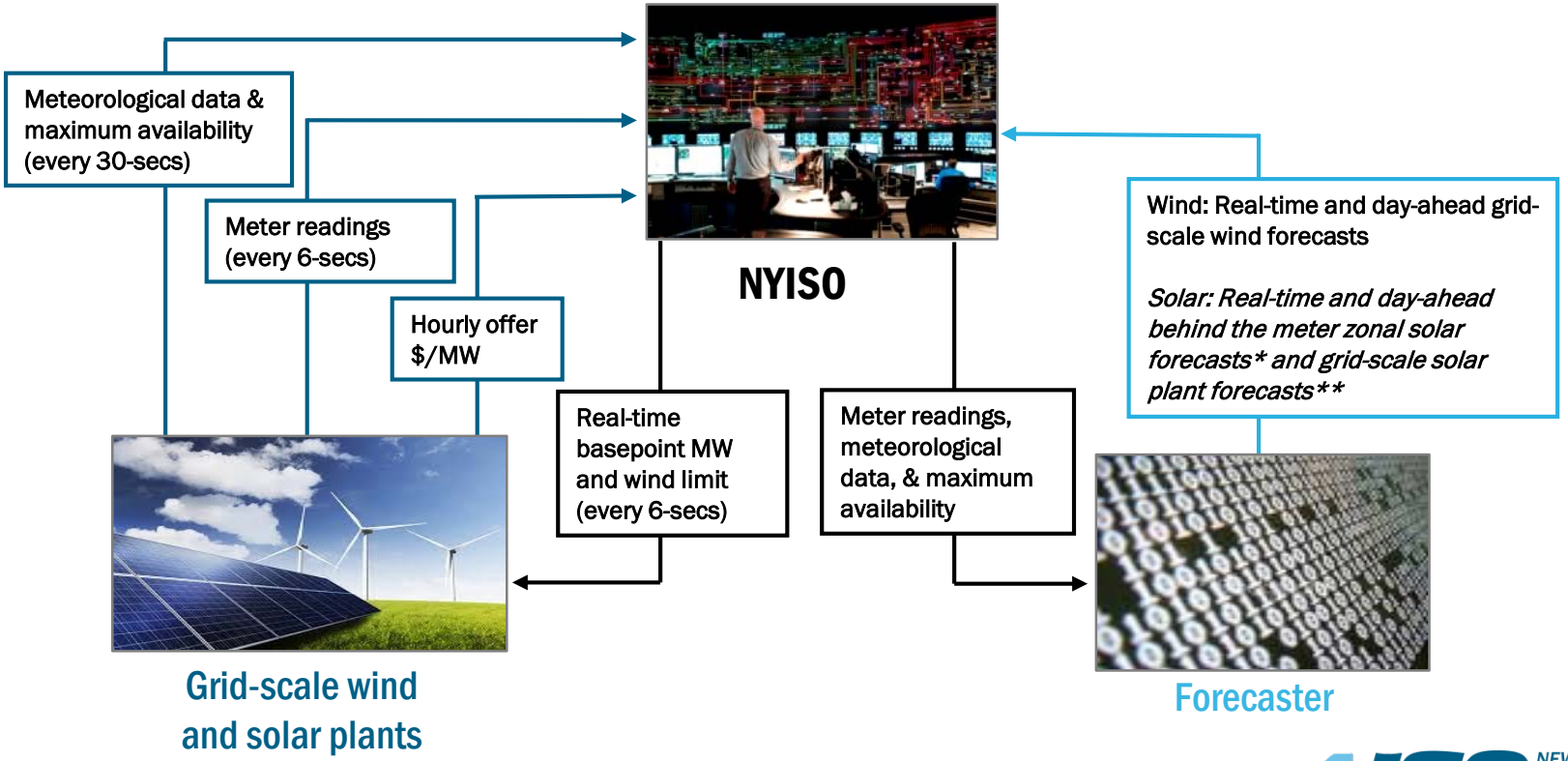
Forecasting Details



* Behind the meter zonal solar forecasts are integrated into the NYISO's load forecasting tools

** Grid-scale solar plant forecasts are only integrated into NYISO's EMS at this time, not its MMS

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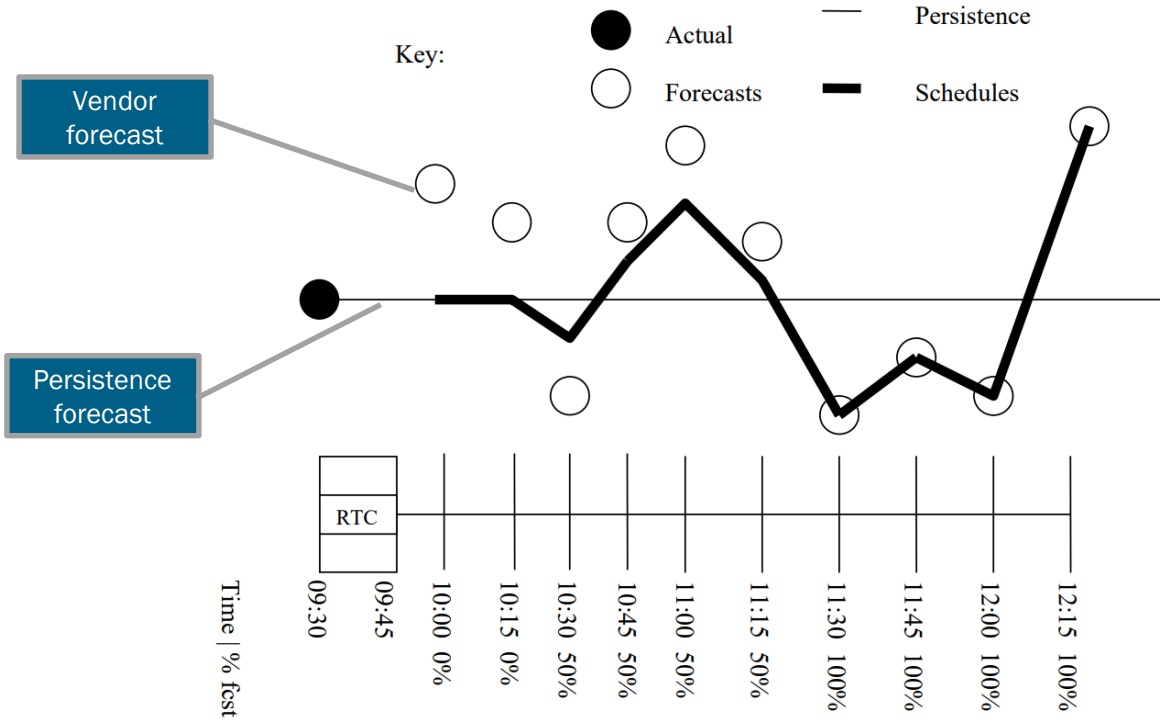
Market Management System Integration

- ## Day-Ahead Market
  - Wind power forecasts are received just prior to 5AM initialization of Day-Ahead Market execution, covering the next market day
  - Wind power forecasts are input into the Day-Ahead Market passes that solve for forecasted load, regardless of whether the wind generator provided an offer
    - **Bid passes:** Only wind generators that provide financial offers will be considered. Binding financial schedules may be established for wind generators out of these passes.
    - **Forecast (reliability) passes:** Wind generator offers (if any) will be dropped and wind generation forecasts are used. No binding financial schedules for wind generators are established out of these passes.

Market Management System Integration (Cont.)

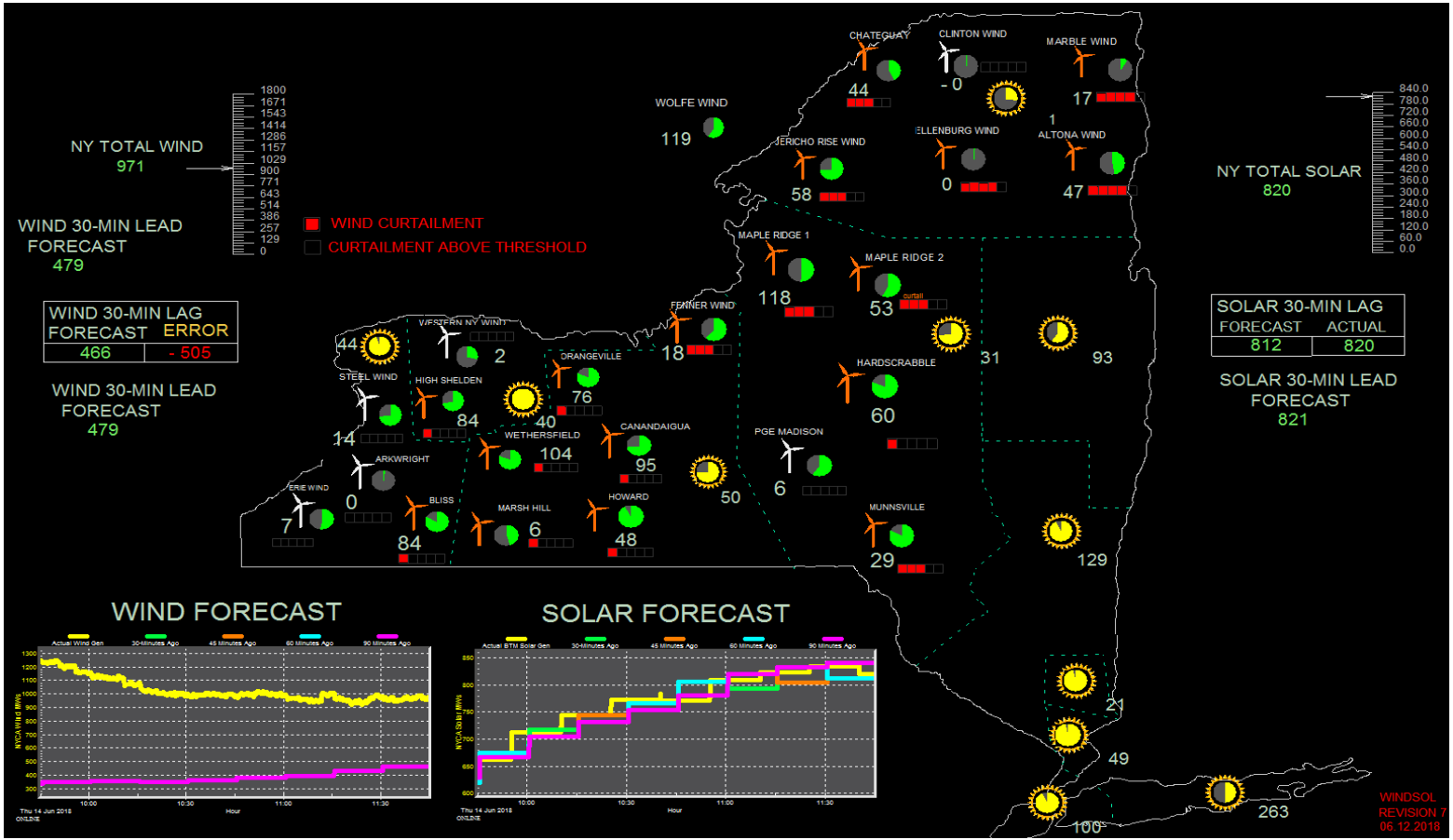
- **Real-Time Market**
  - Wind power forecasts are received every 15-minutes covering the next several hours
  - Wind generators are expected to offer as flexible resources into the Real-Time Market, with an economic upper limit reflecting their full nameplate capability
  - The economic upper limit for each wind generator's offer is then adjusted by the NYISO's forecast for that generator for each time step
    - The NYISO's forecasted output is persistence-based for the most near-term time-steps, and gradually blends higher percentages of our external vendor's forecast with persistence over the forward-looking market horizon (see next slide for example).
  - The Real-Time Market dispatches wind generators between zero MW and their economic upper limit

Example: blending persistence wind forecast with vendor wind forecast

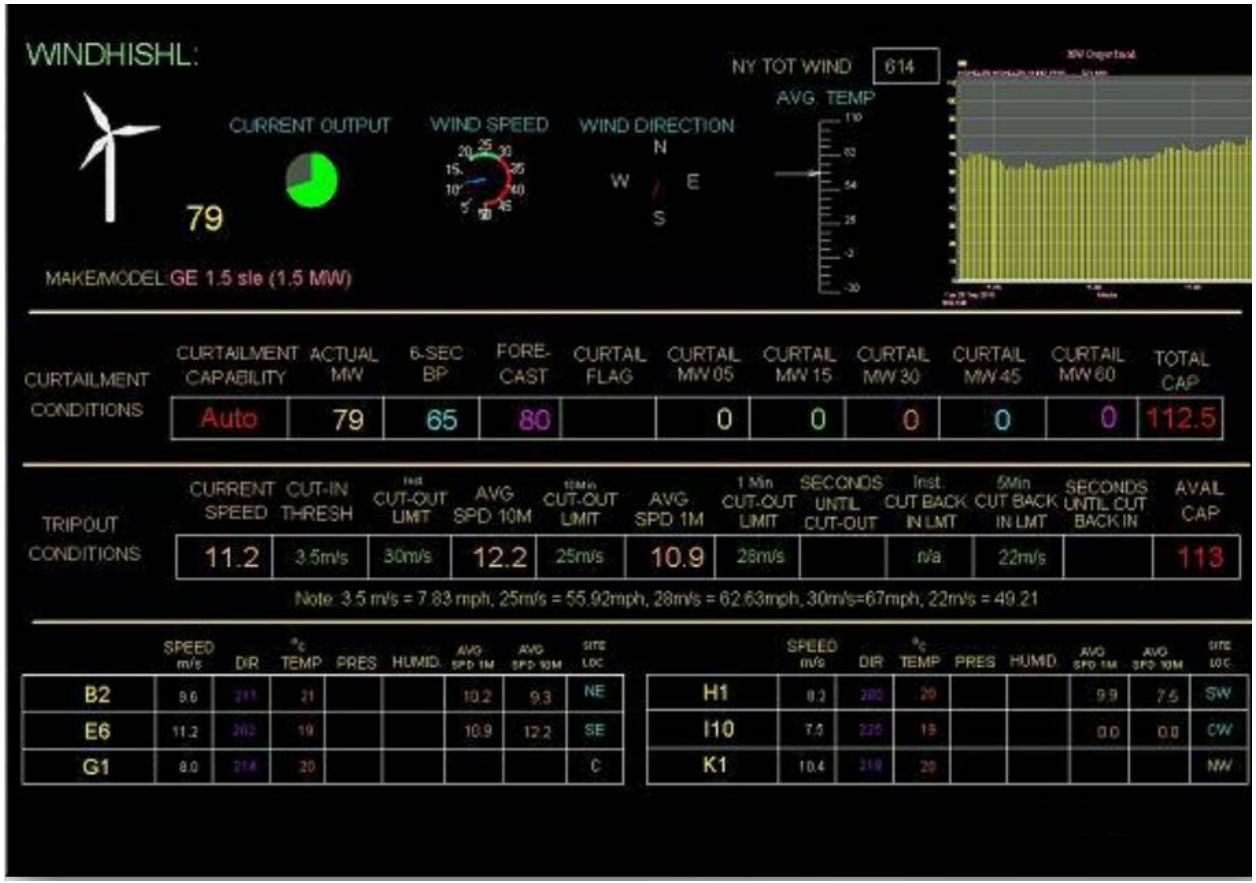


Note: Schedules above assume wind plant is fully economic

EMS Integration: Monitoring



EMS Integration: Monitoring (Cont.)



Individual Wind Plant data, including cut-in and cut-out speeds, current meteorological conditions, and production levels.

EMS Integration: Monitoring (Cont.)

Behind-the-meter zonal solar output and forecasts

Grid-scale solar output and forecasts

The Mission of the New York Independent System Operator, in collaboration with its stakeholders, is to serve the public interest and provide benefits to consumers by:

- Maintaining and enhancing regional reliability
- Operating open, fair and competitive wholesale electricity markets
- Planning the power system for the future
- Providing factual information to policymakers, stakeholders and investors in the power system

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Questions?

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