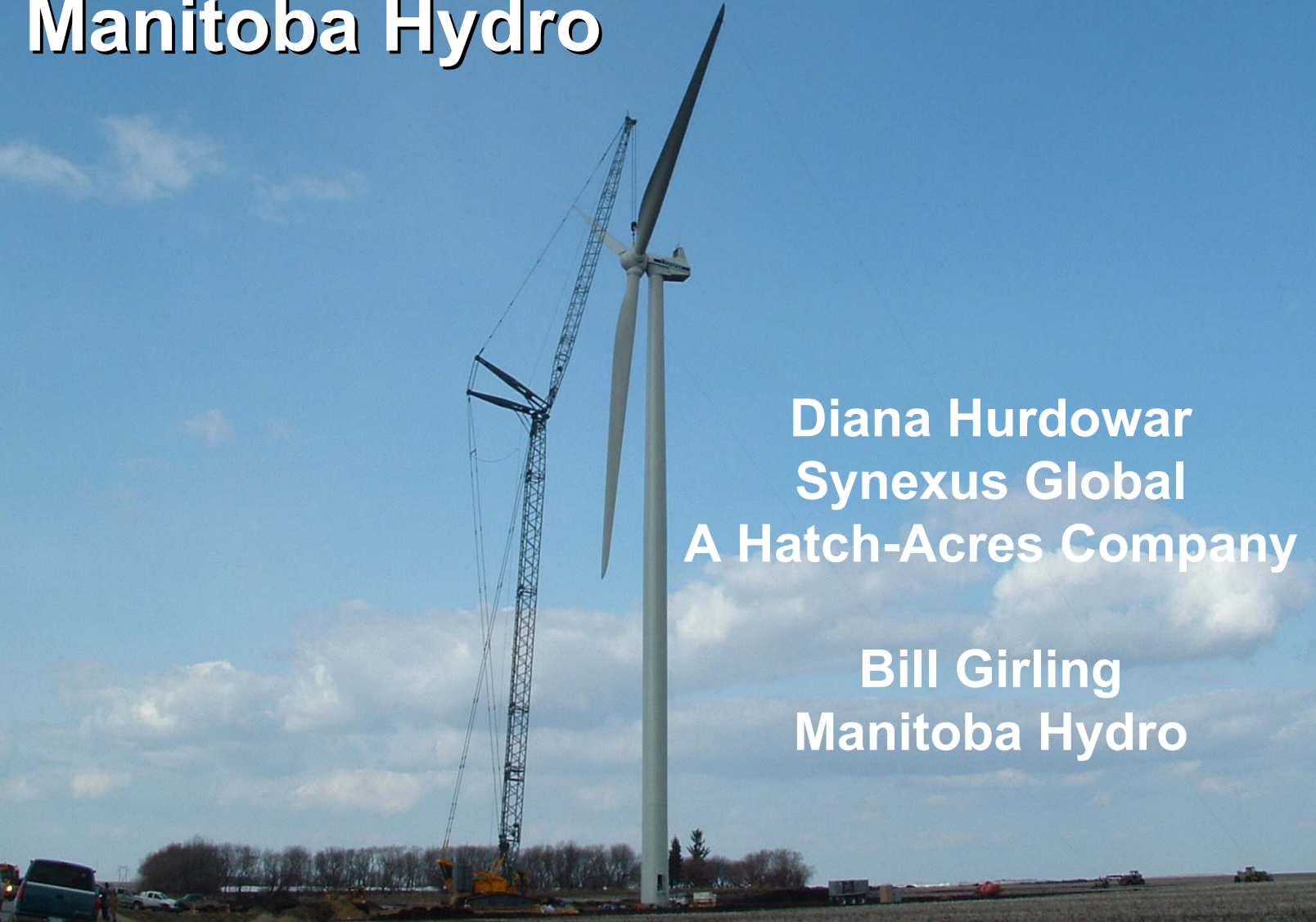




Coordination of Hydroelectric and Wind Generation for Manitoba Hydro



Diana Hurdowar
Synexus Global
A Hatch-Acres Company

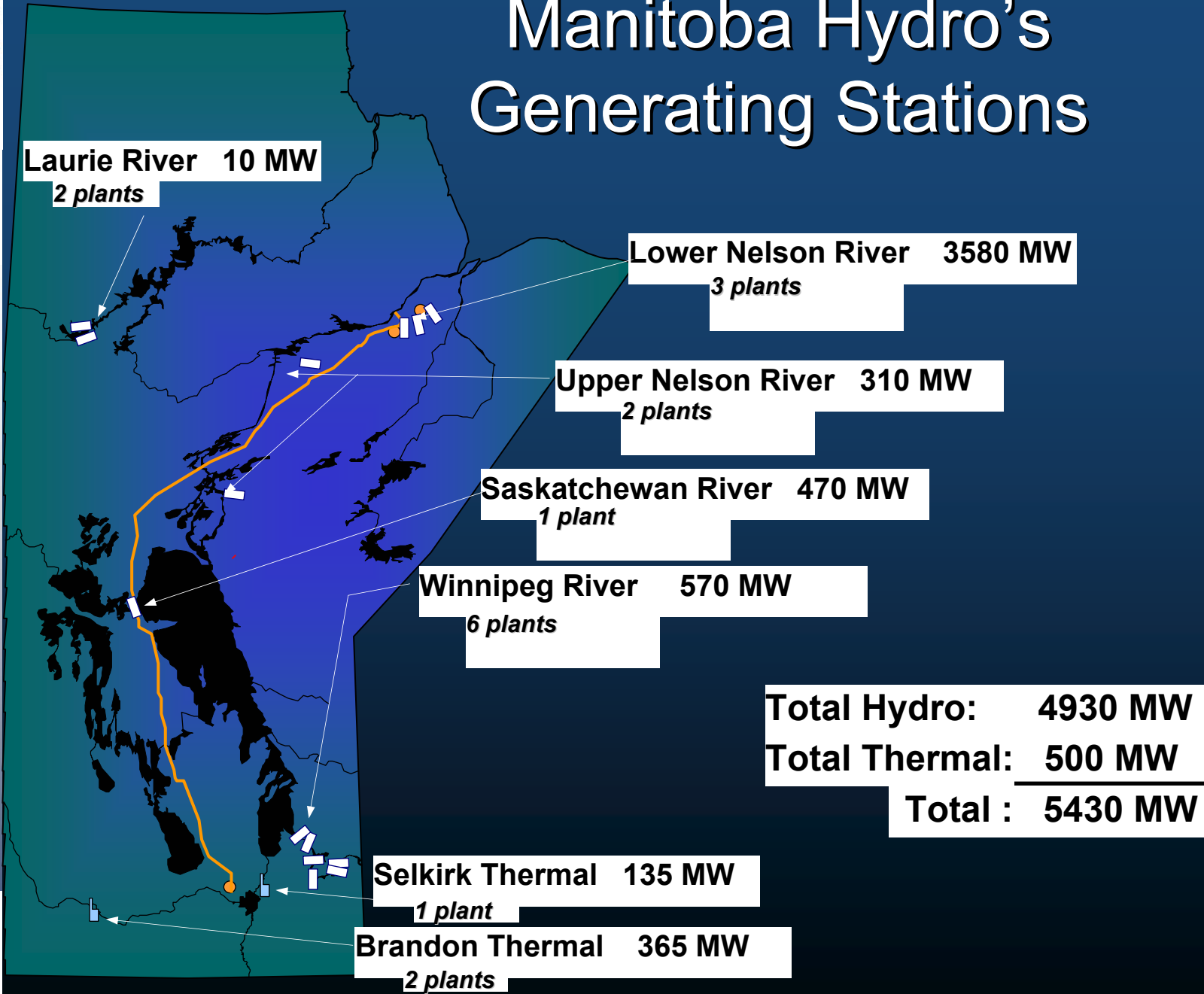
Bill Girling
Manitoba Hydro



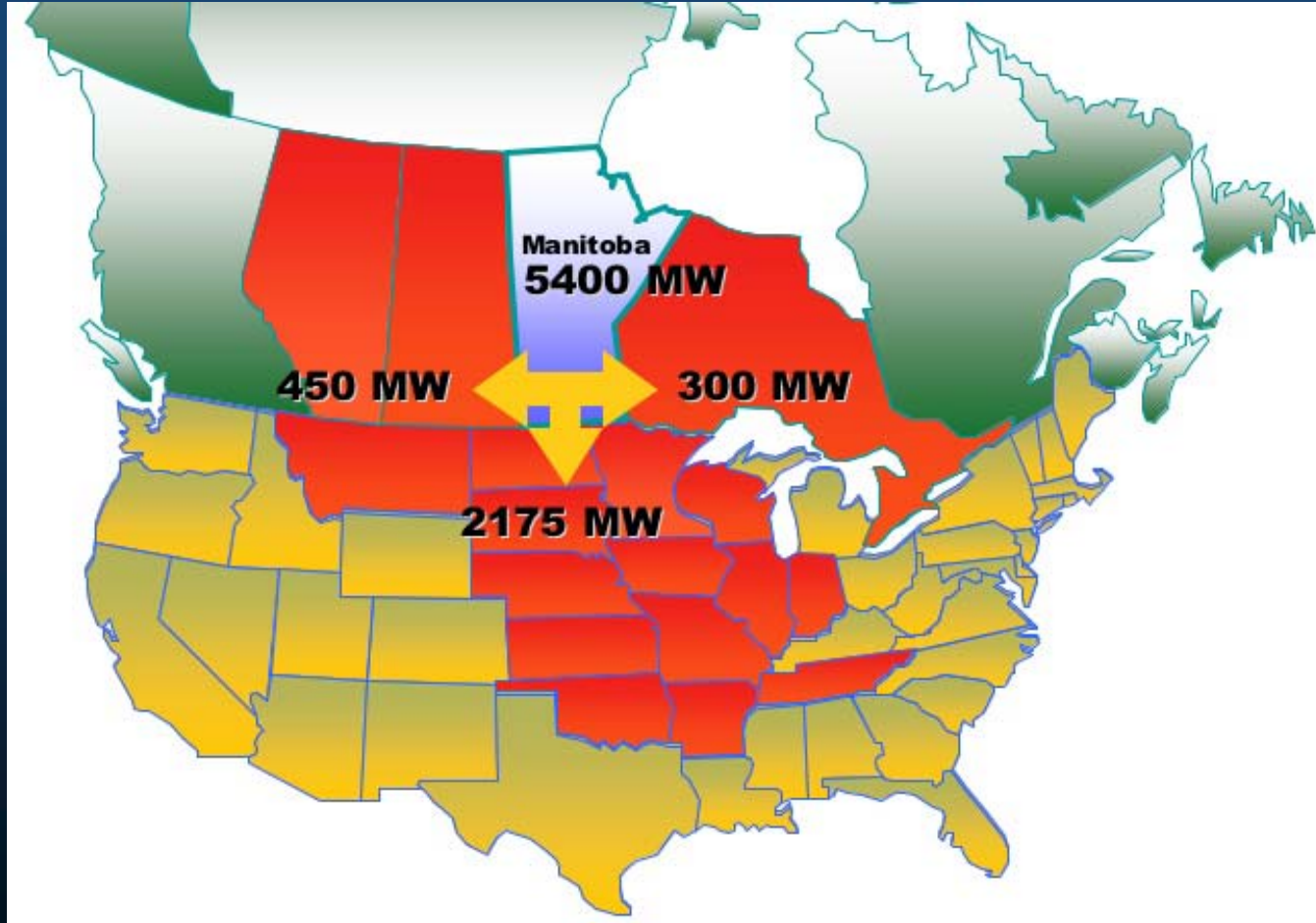
Presentation Outline

- **Manitoba Hydro System**
- **Wind Power in Manitoba**
- **Wind Integration issues**
- **Short-Term Model**
- **The '*Vista*' Tool**
- **Short-Term Wind Uncertainty and Variability**
- **Final Points**

Manitoba Hydro's Generating Stations



Interconnections Provide Market Access



Why is Manitoba Hydro studying Wind Power?

Manitoba does not require new generation for domestic load until around 2020 but wind power can be exported.

Alternative source of power during drought periods when expensive thermal is needed.

Can be put into service in 1 to 2 years.

Wind Power Integration Issues

- Wind Power is intermittent
 - Wind is inherently variable, it can neither be dispatched nor scheduled accurately
- Sub-optimal hydro operations due to short-term variability and uncertainty of wind generation
- Increased reserves for wind

Short-Term Model

- ⇒ Need to model wind using a short term model to capture the effects of the day-to-day and week-to-week wind variability and uncertainty on reservoir operations.
- ⇒ Reshaping - Integration of wind energy into a hydro system is complex.
- ⇒ Reservoirs can redistribute wind energy to peak hours and/or offset off peak imports or both.
- ⇒ Complications arise when you look at multiple reservoirs with hydraulic considerations

The Manitoba Hydro System

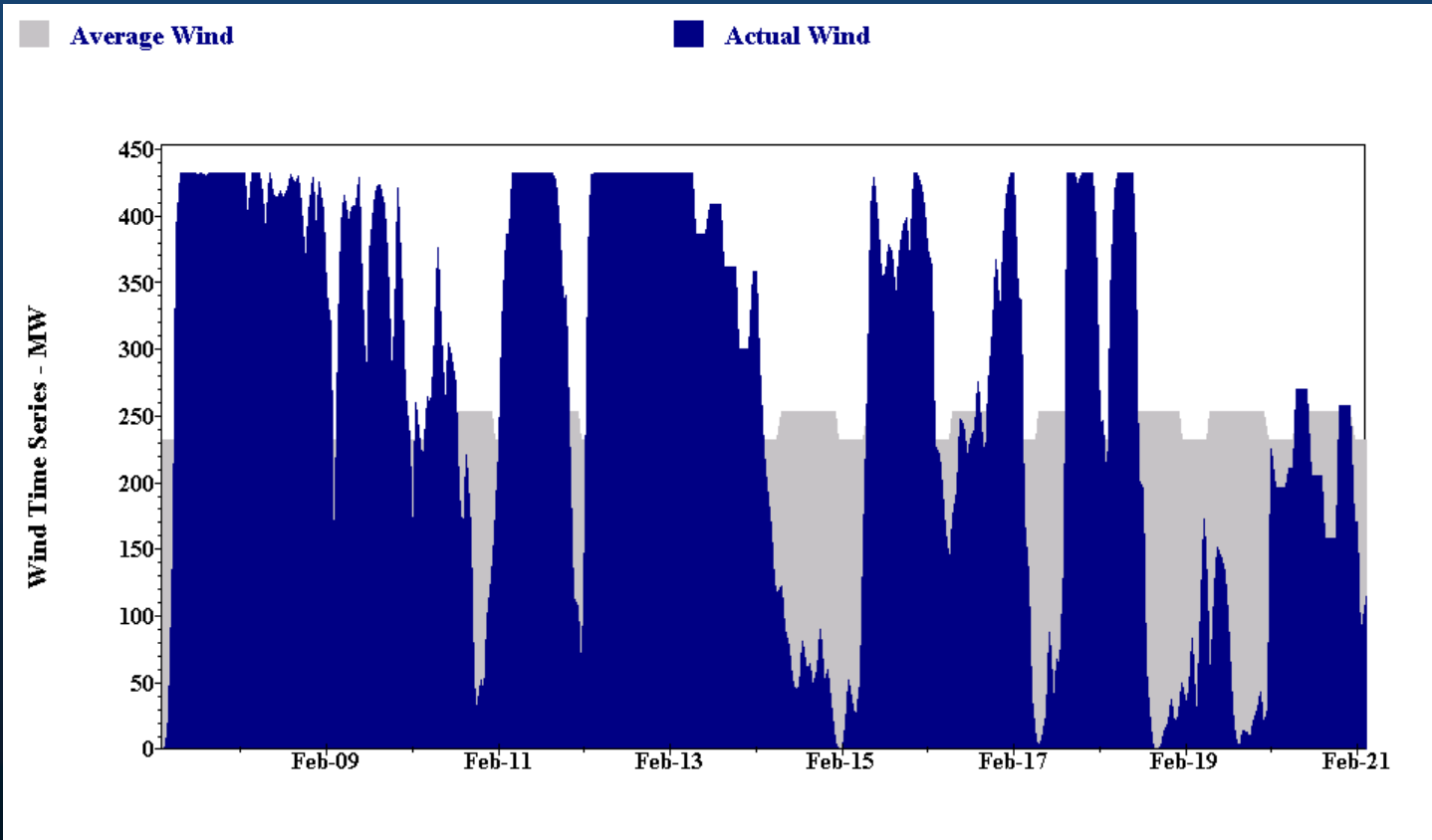
- System Related (Manitoba Hydro)
 - Uncontrolled Lakes and channels
 - Long river reaches and lag times
 - Ice conditions in winter
- Wind Related
 - Uncertainty in wind forecasts
 - Variability in wind energy delivery

The Analysis Tool - "Vista"

- Suite of programs developed under the Acres umbrella within Synexus Global.
- An operations model used by dispatchers to schedule generation in a manner that maximizes revenue.
- ST (hour to week) -- LT (week to year) – Auto (Planning)
- Model workings
 - Physical/hydraulic/transmission characteristics and constraints
 - Market Price forecasts
 - Firm Contracts
 - Historical/forecast Inflow sequences
 - Load demands
 - Within-plant dispatch (Unit Operations)
 - Transaction opportunities
- *Auto Vista*
 - Performs analysis over 1 year

Wind – Uncertainty & Variability

- Accurate for the first 24 hrs – High variability from hour to hour

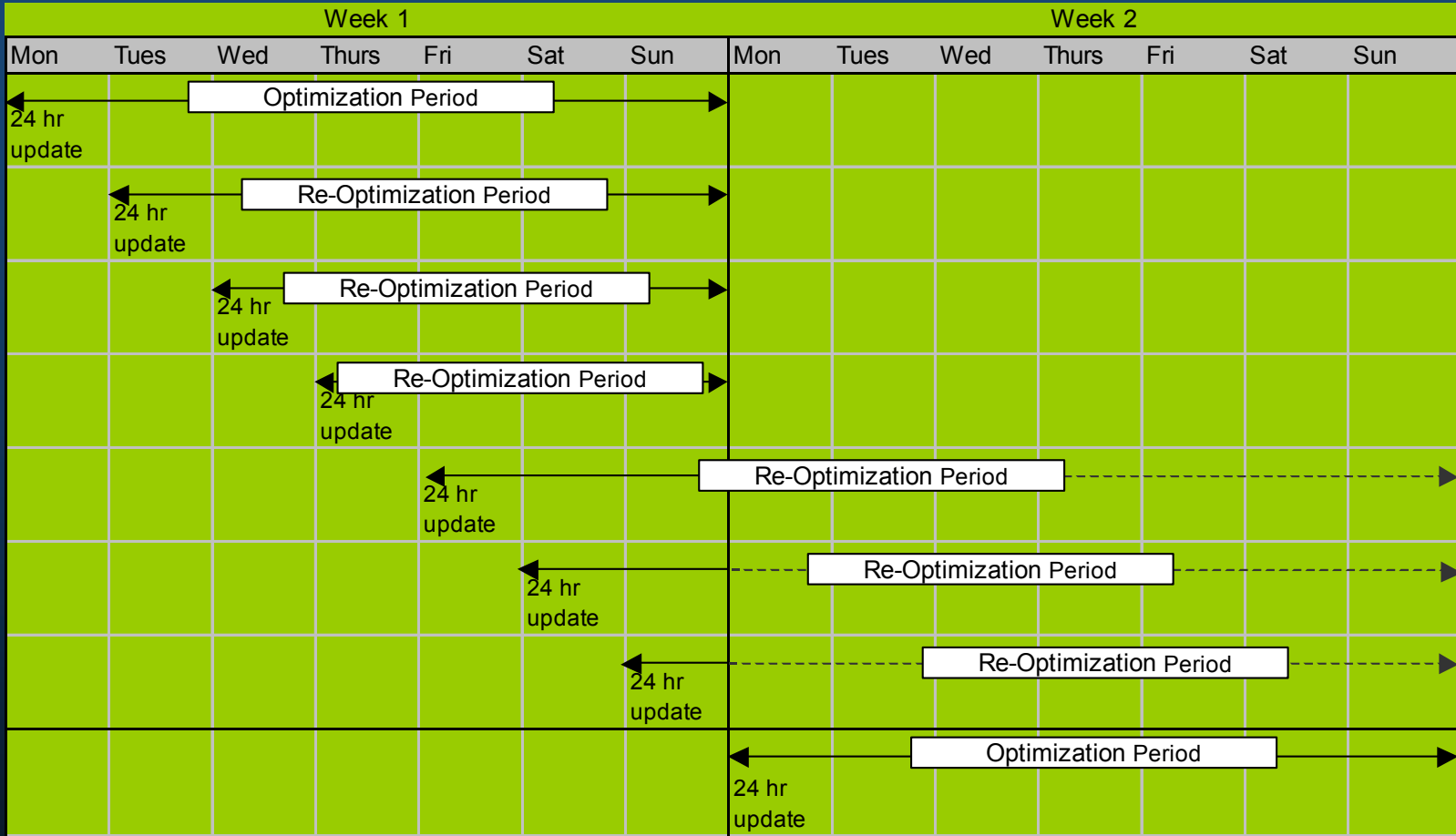


Modeling Wind

- Could assume perfect foreknowledge of wind much like we do for hydrology – does not capture the uncertainty
- Could assume an average energy for the week, derived from the wind time series – does not capture wind variability
- Adopt perfect foreknowledge for the first 24 hours and average for the remainder of the week.
- *AUTO Vista* has been enhanced to re-optimize periodically (e.g. daily); each time with a new wind forecast for the current day

Wind Updating

HATCH ACRES



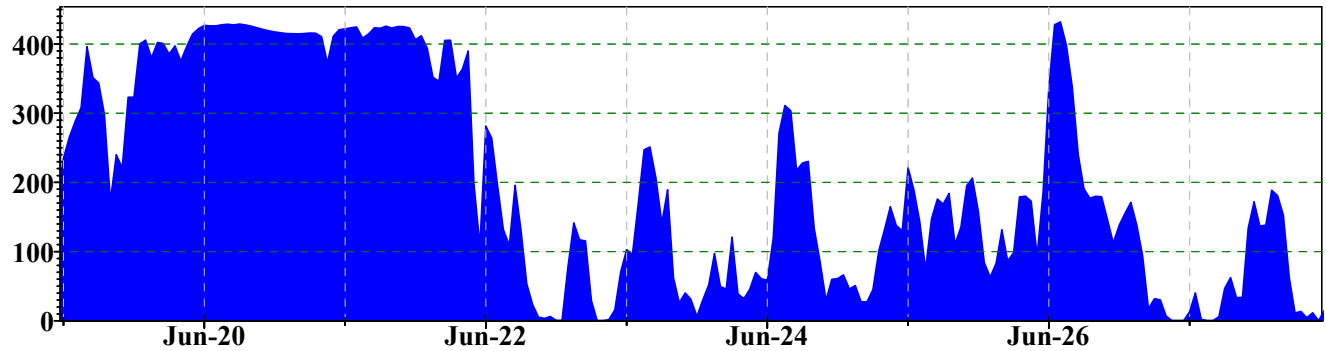
System Transactions

System Transactions

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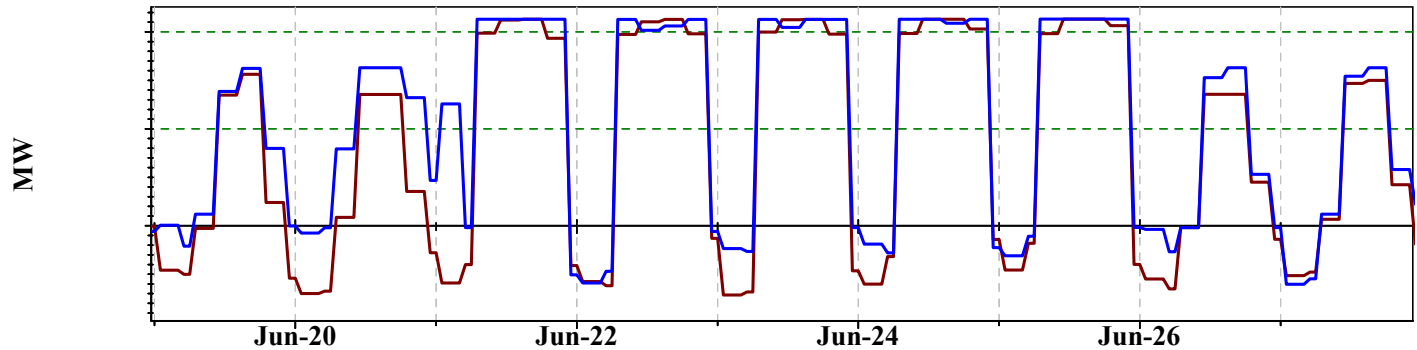
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Wind Time Series



- Base No Wind

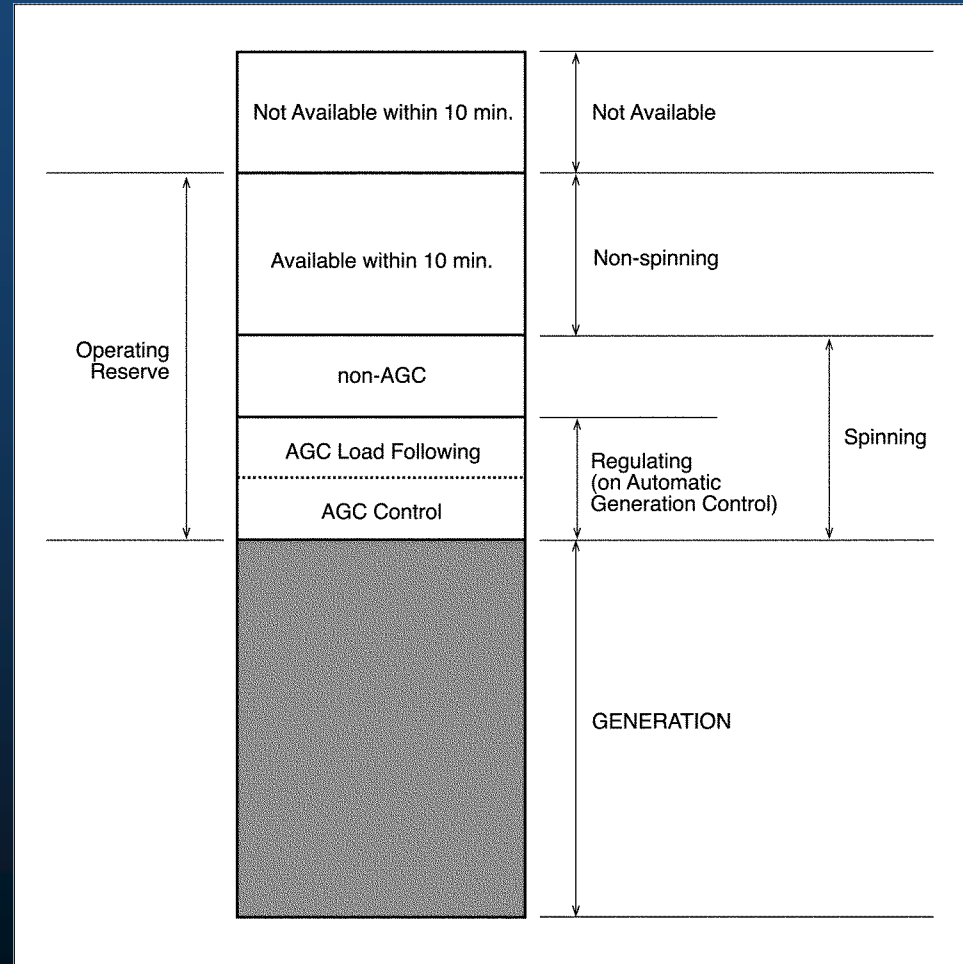
- 500 MW Wind Capacity



Incremental Cost of Reserves

Can model both the variability and uncertainty of wind and the associated reshaping of operations.

Estimate the incremental cost of reserves



Reserve Requirements

Plant Reserve low Hydrology

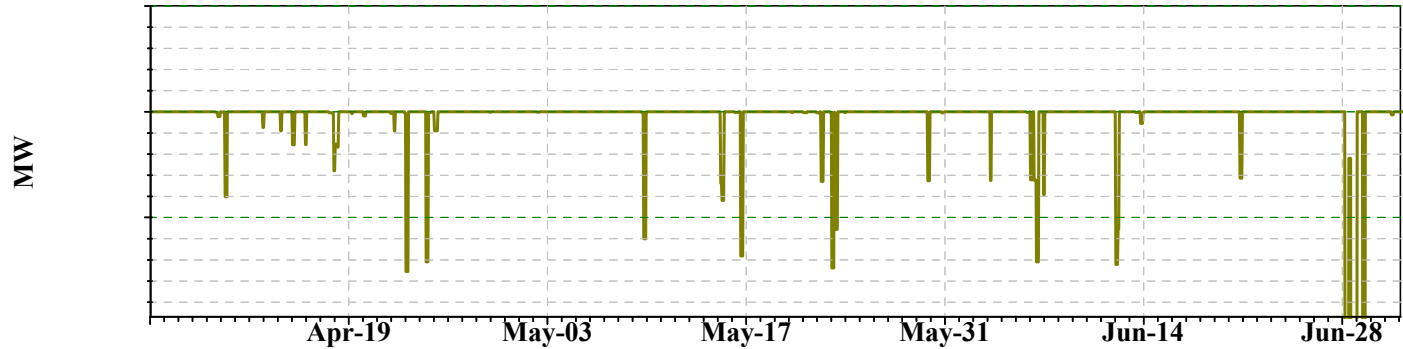
AGC

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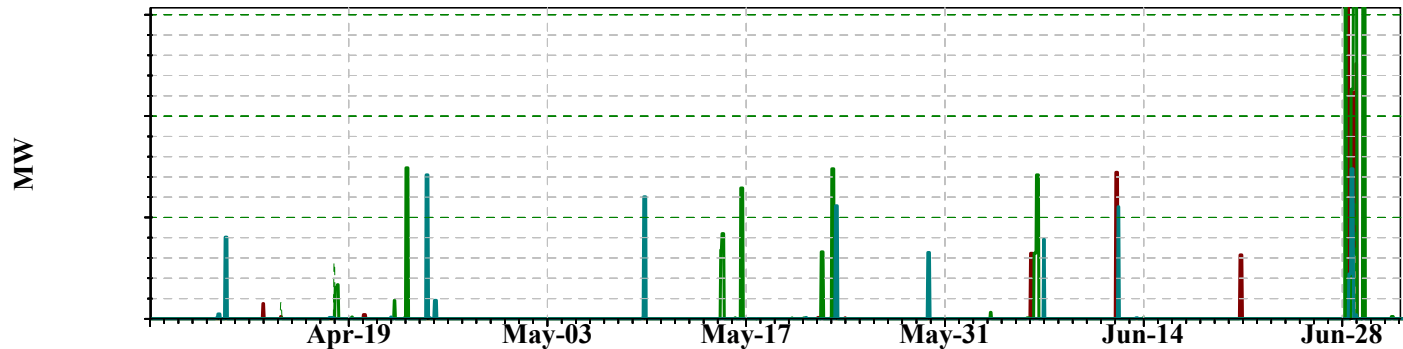
- Swing Plant



- Plant 1 - LNR

- Plant 2 - LNR

- Plant 3 - LNR

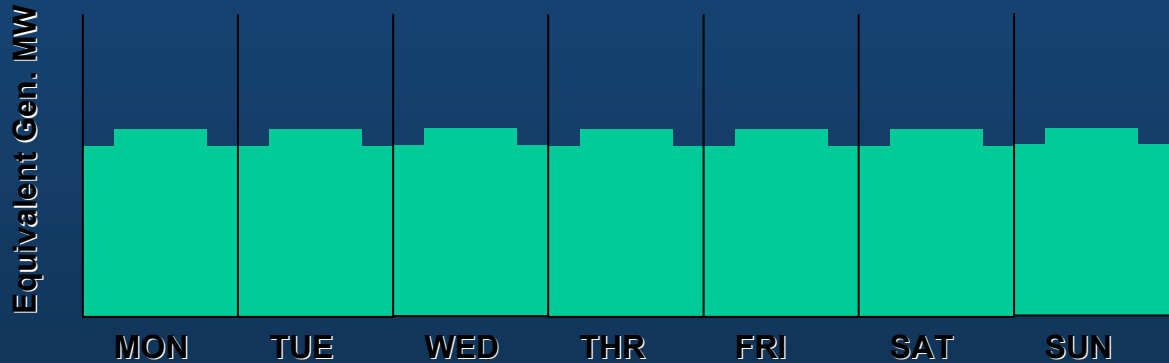


Modeling Short Term Wind Uncertainty/Variability

HATCH ACRES

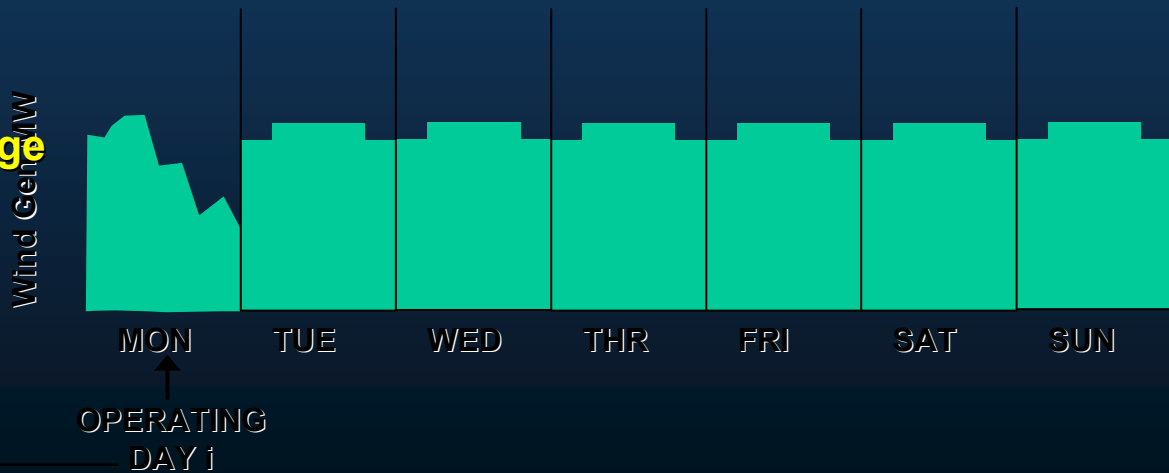
CASE 1

- Monthly average energy
- No added reserves



CASE 2

- Perfect foreknowledge on operating day
- Assume monthly average for subsequent days
- Advance daily
- Added reserves



Wind Time Series

Median Wind Time Series

Median Hydrology

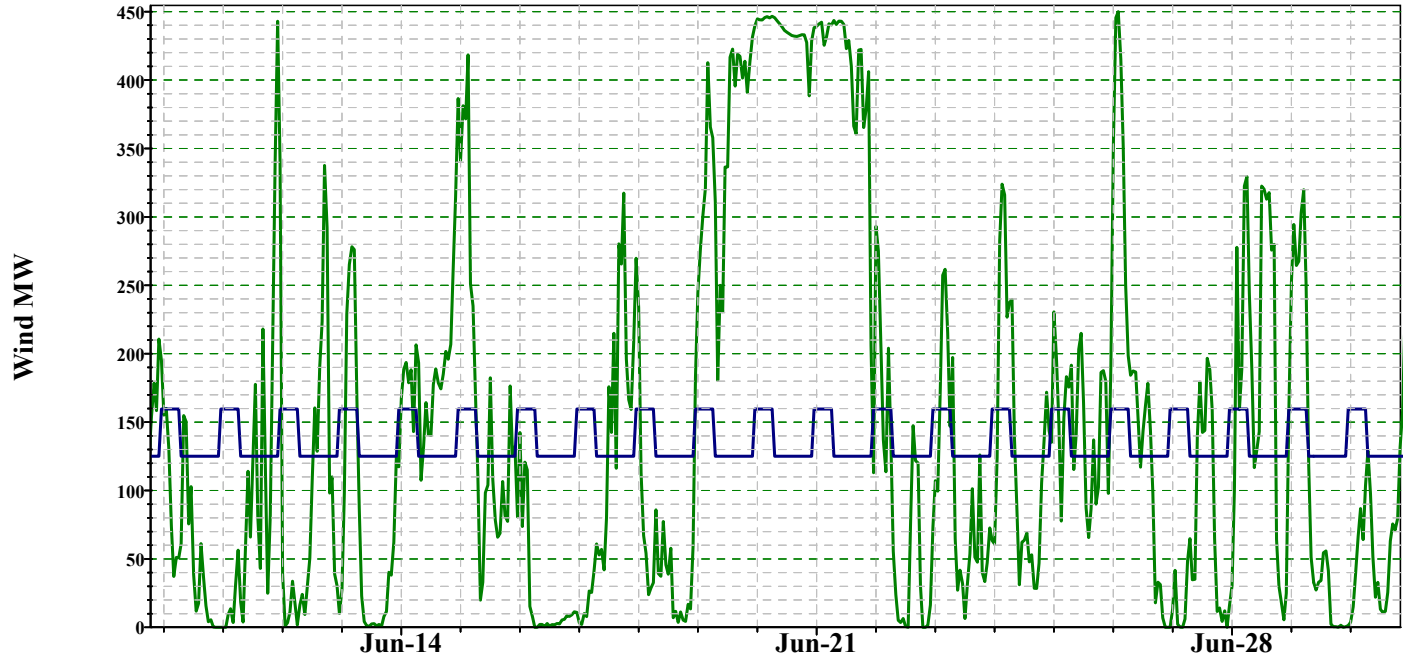
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— Wind MW

— Average Wind MW



Incremental Transactions

HATCH ACRES

Transactions

wind

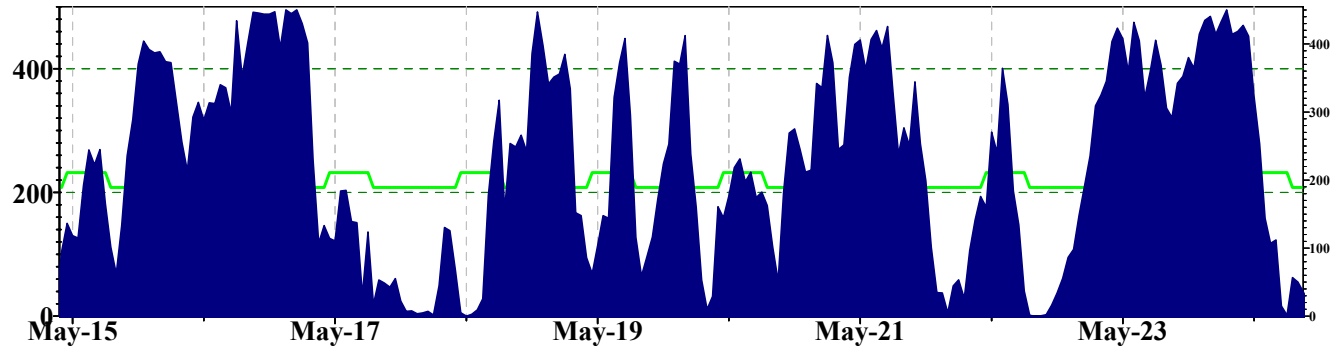
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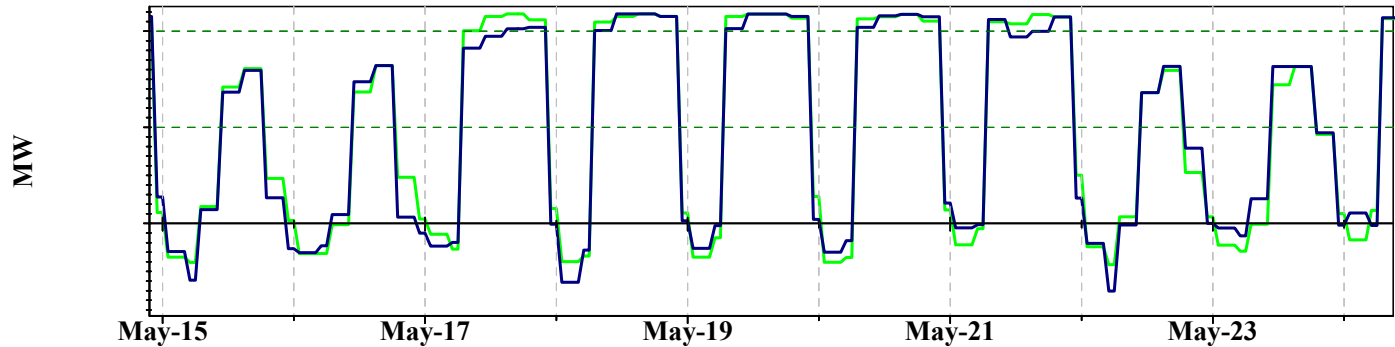
- Average Energy MW

■ Wind MW



- Equivalent Energy

- Wind Run



Final Points

- Using MOST (*ST Vista*)
 - Able to determine the incremental cost of reserves associated with a wind supply source
 - View the change in Hydro operations to accommodate wind
- Further we can
 - Assess different levels of wind capacity
 - Assess the impacts to the transmission system
 - Determine a point of saturation, at what point will the system be saturated and spill is just directly traded off with wind energy.