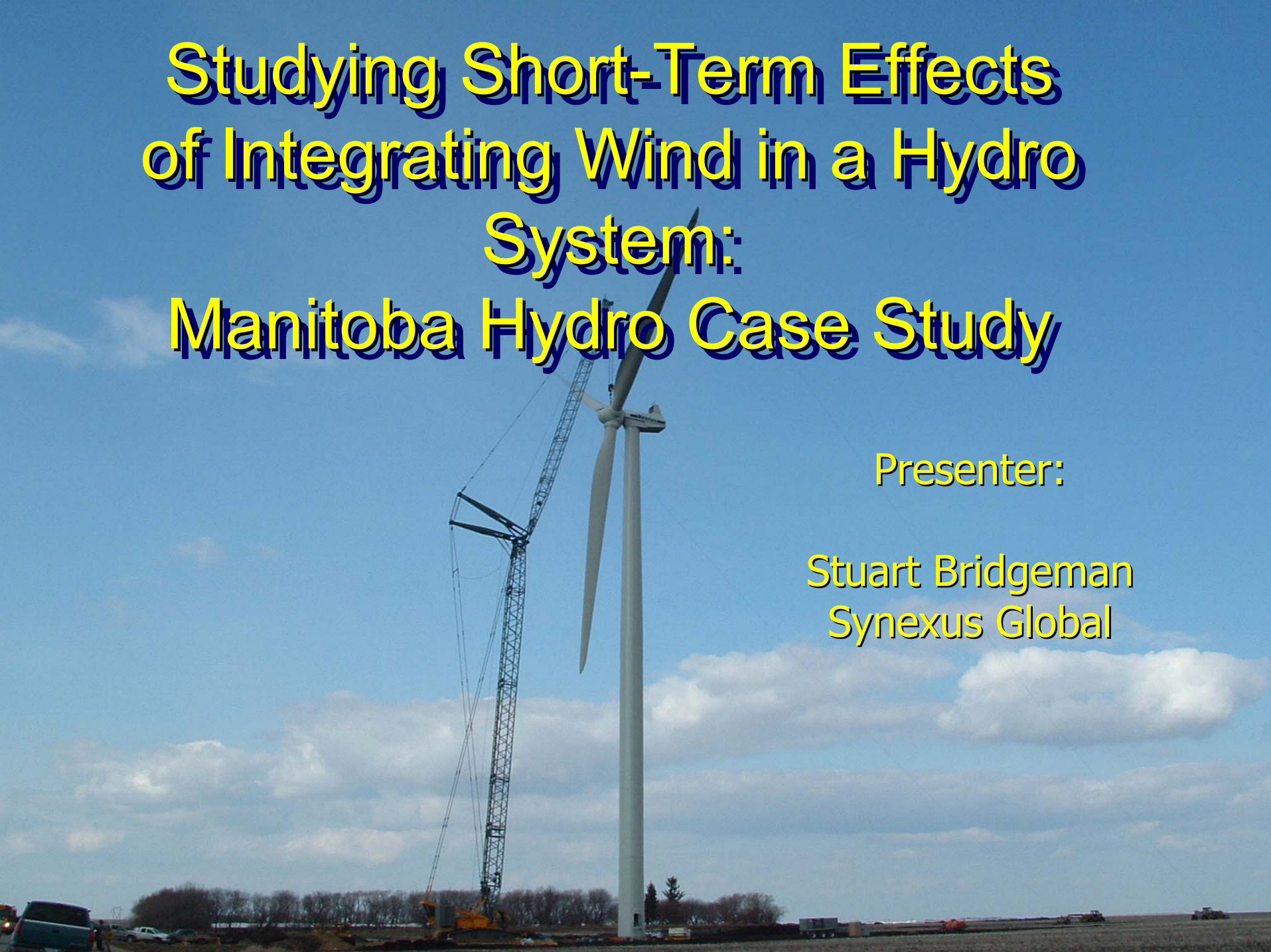
Studying Short-Term Effects of Integrating Wind in a Hydro System: Manitoba Hydro Case Study



Presenter:

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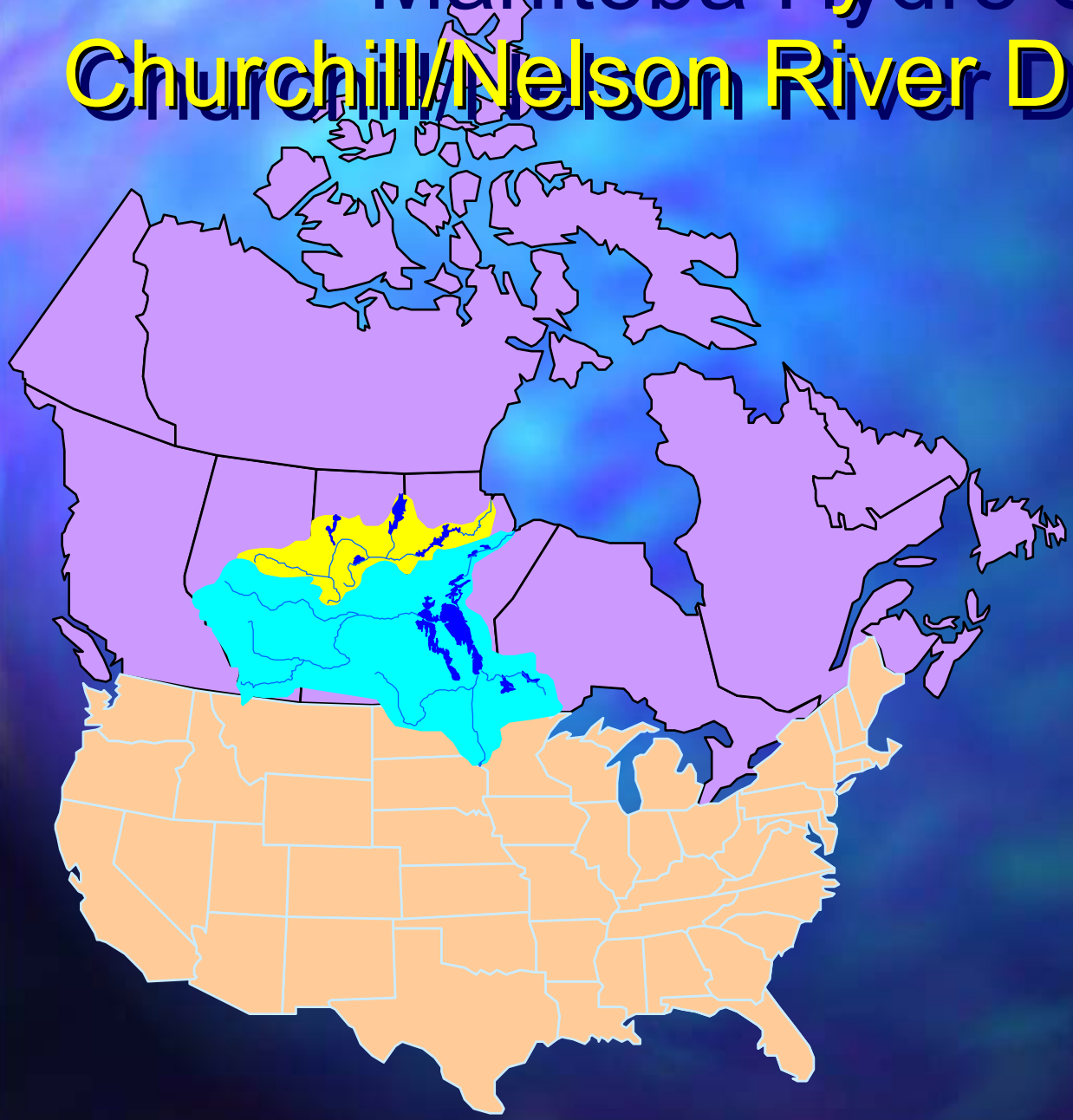
Synexus Global

Presentation Outline

Manitoba Hydro

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

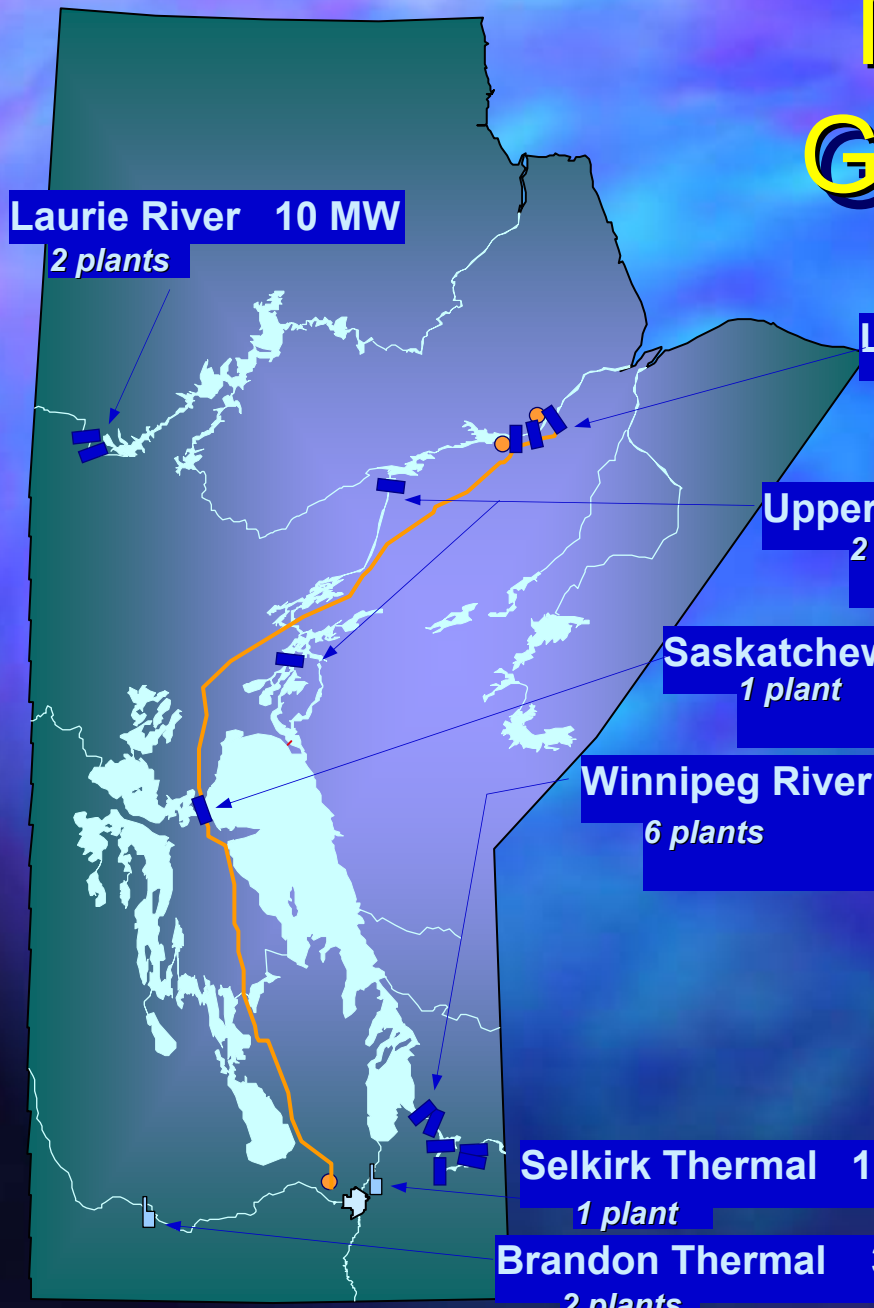
Manitoba Hydro System
Churchill/Nelson River Drainage Basin



97% Hydro - similar to Hydro-Quebec

Water Supply comes from: four Provinces three US States

Manitoba Hydro's Generating Stations



Laurie River 10 MW
2 plants

Lower Nelson River 3580 MW
3 plants

Upper Nelson River 310 MW
2 plants

Saskatchewan River 470 MW
1 plant

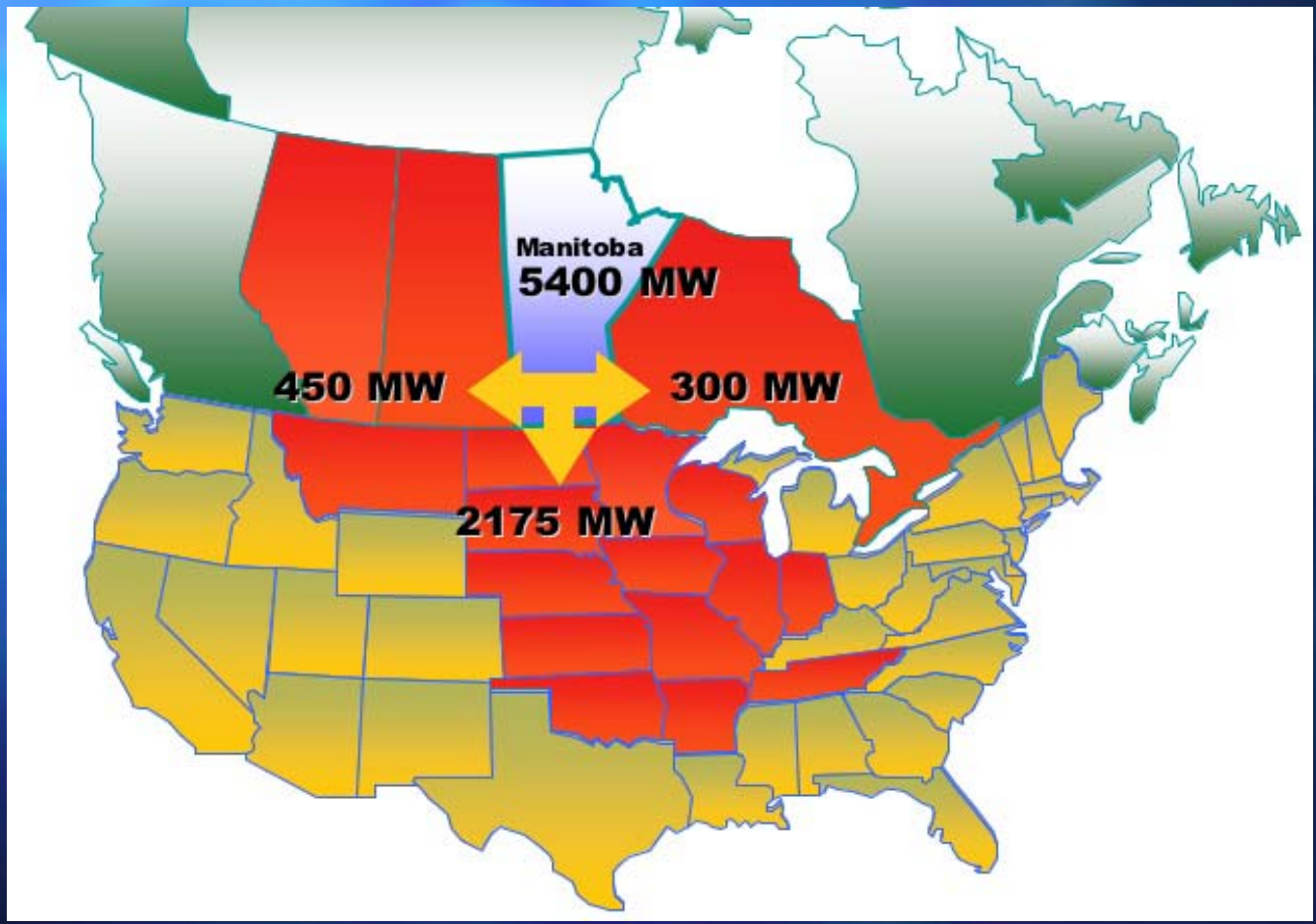
Winnipeg River 570 MW
6 plants

Selkirk Thermal 135 MW
1 plant

Brandon Thermal 365 MW
2 plants

Total Hydro:	4930 MW
Total Thermal:	500 MW
Total :	5430 MW

Interconnections – 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.

Integrating Wind and Hydro

- Manitoba Hydro is 95% hydropower with large reservoirs capable of storing wind energy and shifting it to more valuable periods.

- Integrating wind with hydro operations can create a product with high value on export market.

- Need to know value of wind power to Manitoba Hydro's system in order to determine purchase price from independent wind developers.

Integrating Wind and Hydro

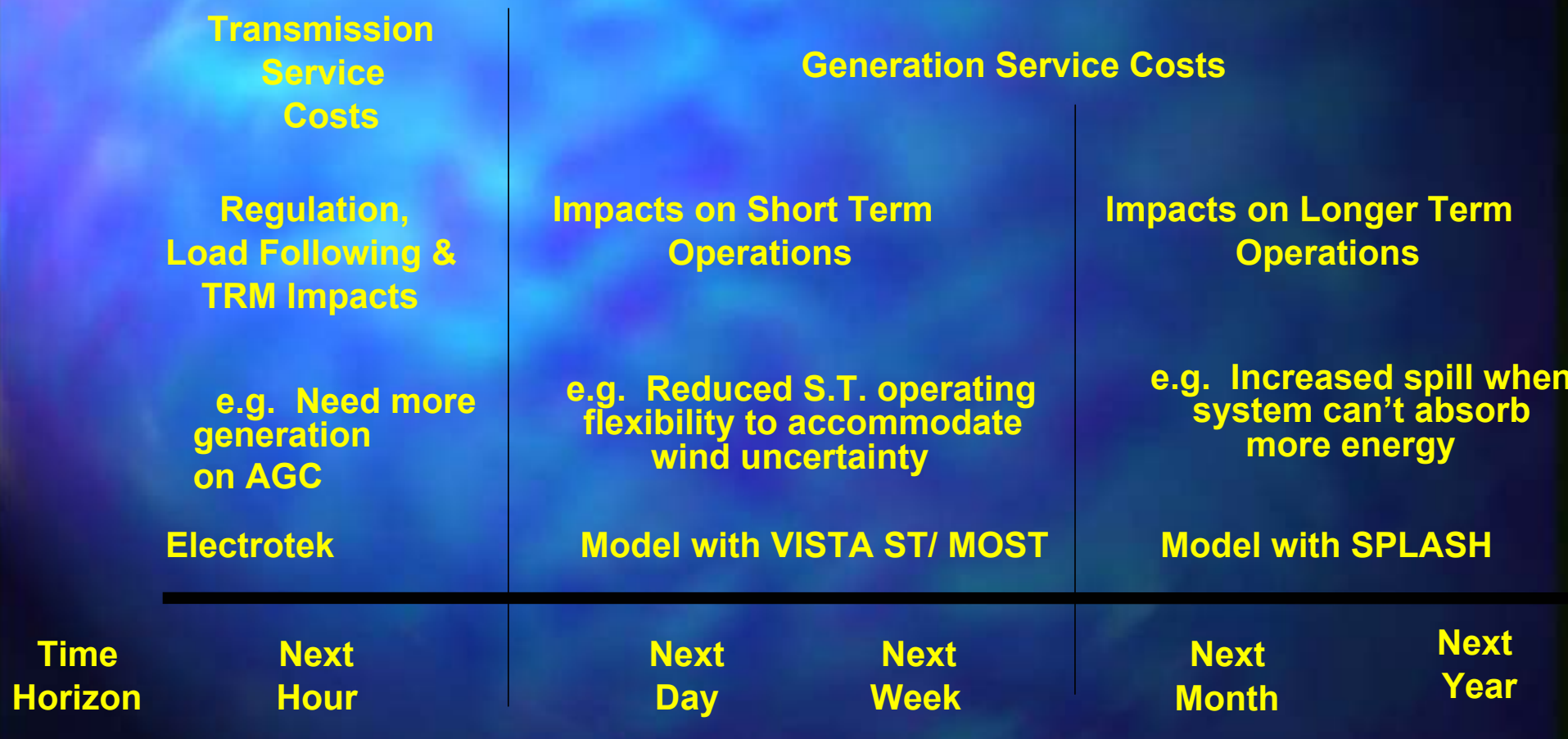
- The value of wind power is set by the cost of operating on the margin of the market
- The ability to get wind power to the market is dependent on flow conditions:
  - Low Flow
    - Reduced import (on-peak & off-peak)
    - Reduced operation of thermal
    - Increased firm export opportunities
  - Moderate Flow
    - Increased export opportunities to the limit of installed generation or tie-line
  - High Flow
    - Virtually no value

Wind Power Integration Issues

- Wind Power is intermittent
  - Wind is inherently variable, it can neither be dispatched or scheduled accurately
- Requires regulation and load following backup capacity in the short-term (seconds to hours)
- Requires shaping and firming capacity in the long-term (hours/days/seasons)

Modeling Framework

Types of Wind Integration Costs in Different Time Horizons



Short-Term Operational Impacts

- Sub-optimal hydro operations due to short-term variability and uncertainty of wind generation
- Increased capacity reserves are a lost opportunity cost
- Increased reserves for wind
  - Regulation reserve for uncorrelated minute to minute variations in net load (on AGC control)
  - Load following reserve for sub-hourly ramp in net load and next hour forecast error (idle capacity reservation)

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

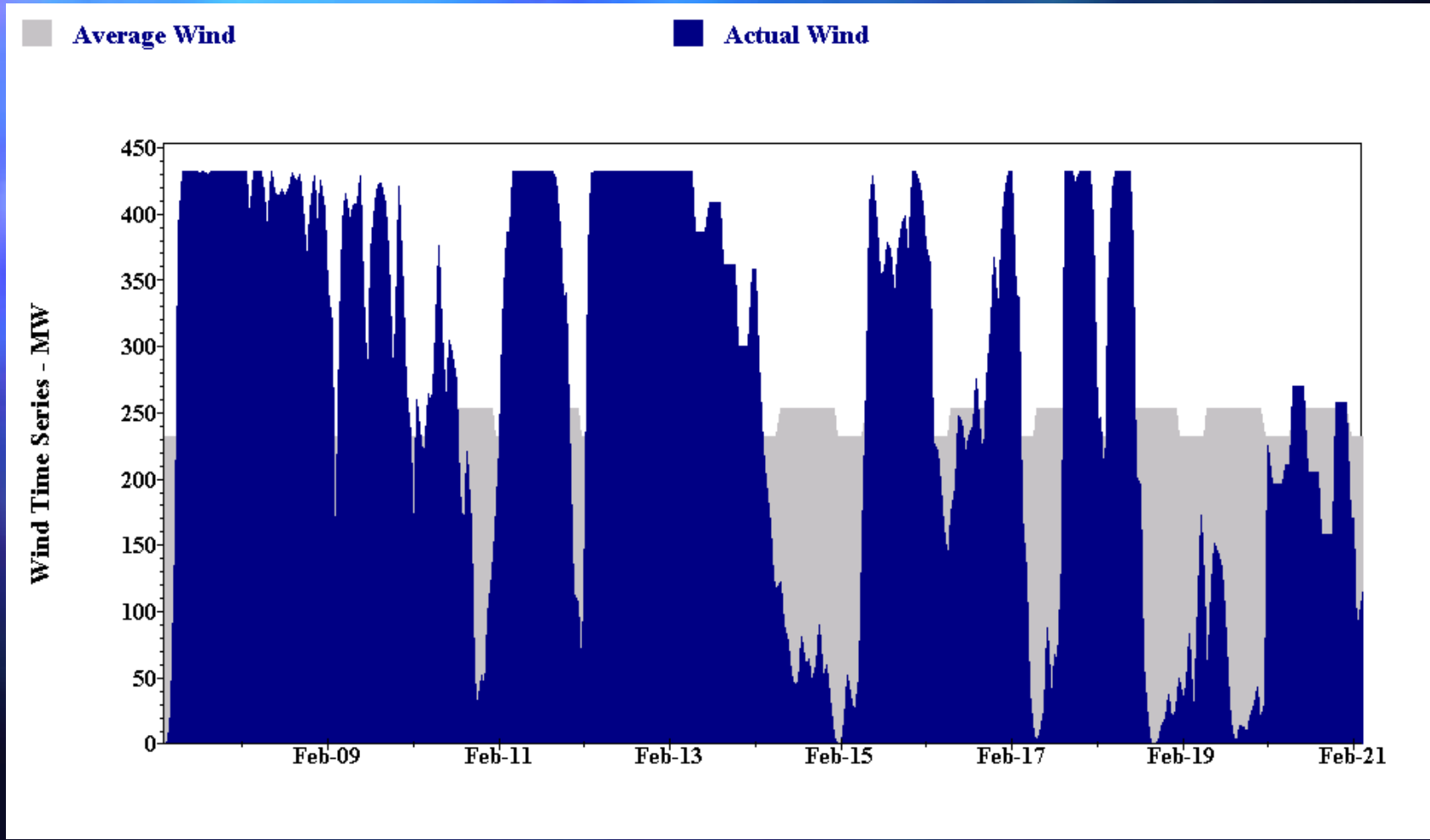
- System Related (Manitoba Hydro)
  - Uncontrolled Lakes and channels
  - Long river reaches and lag times
  - Ice conditions in winter
- Wind Related
  - Uncertainty in wind forecasts
  - Variability in wind energy delivery

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

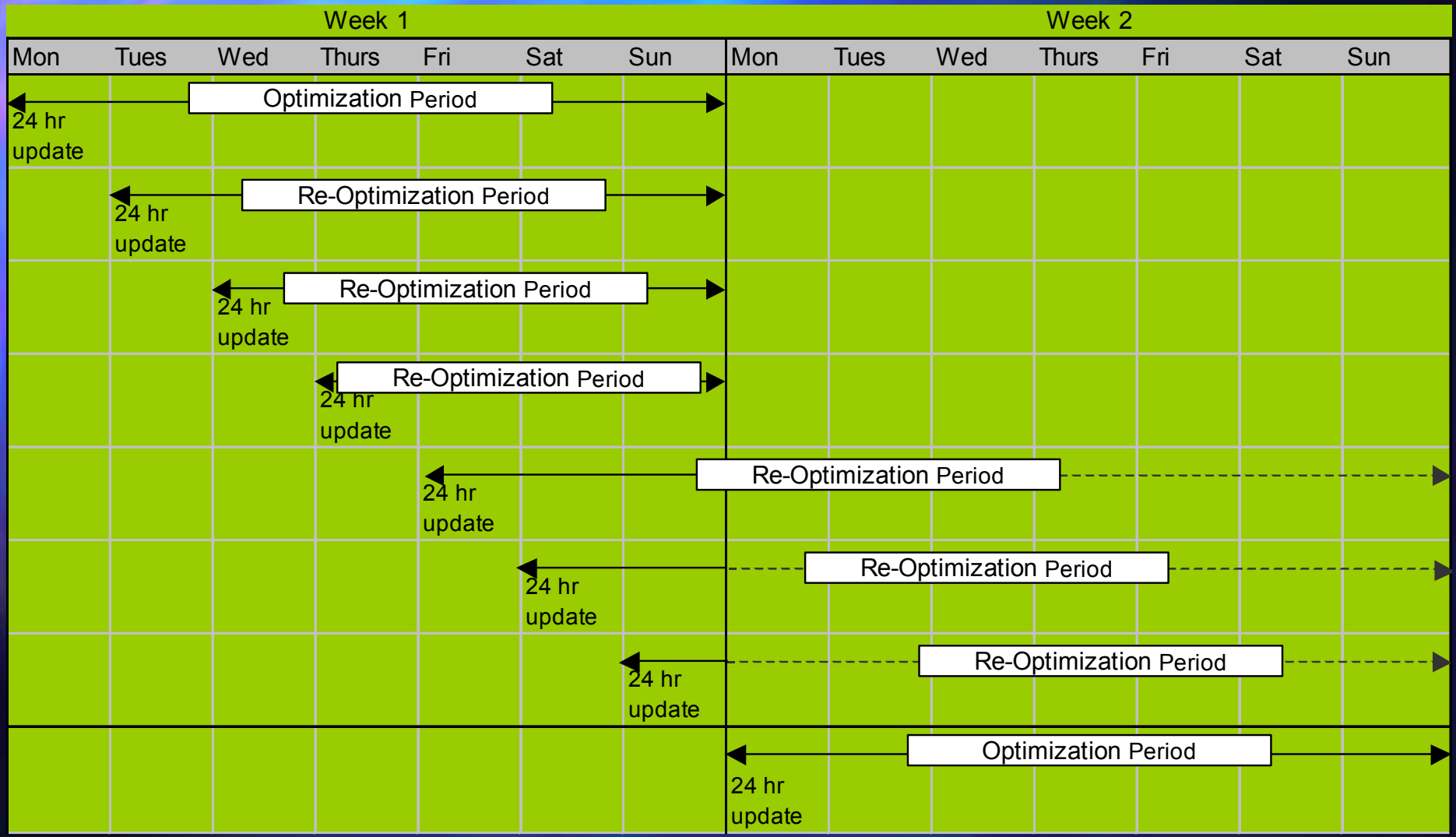
- Accurate for the first 24 hrs
- High variability from hour to hour



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



System Transactions

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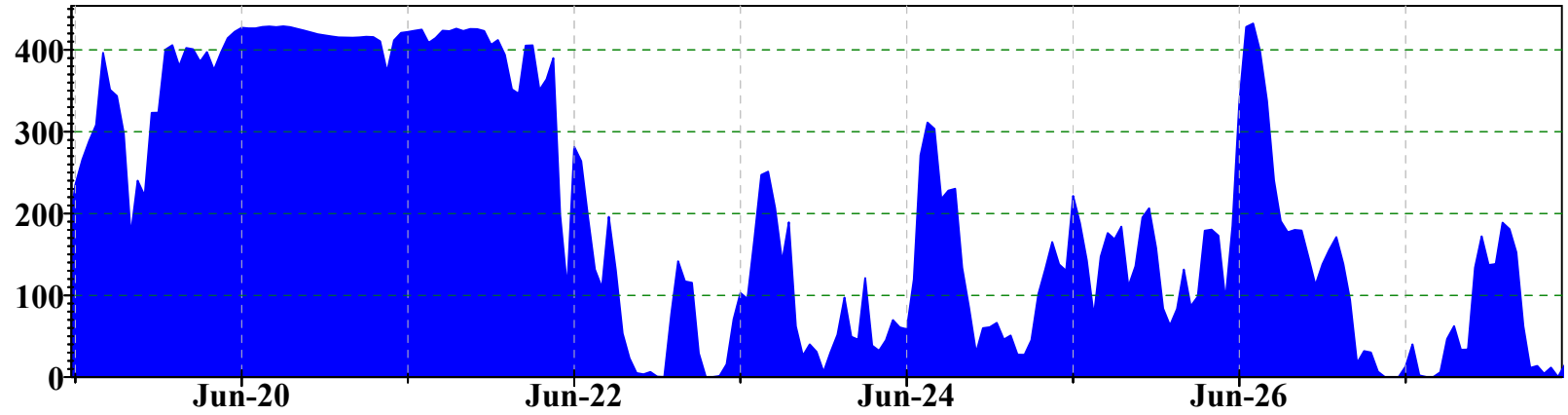
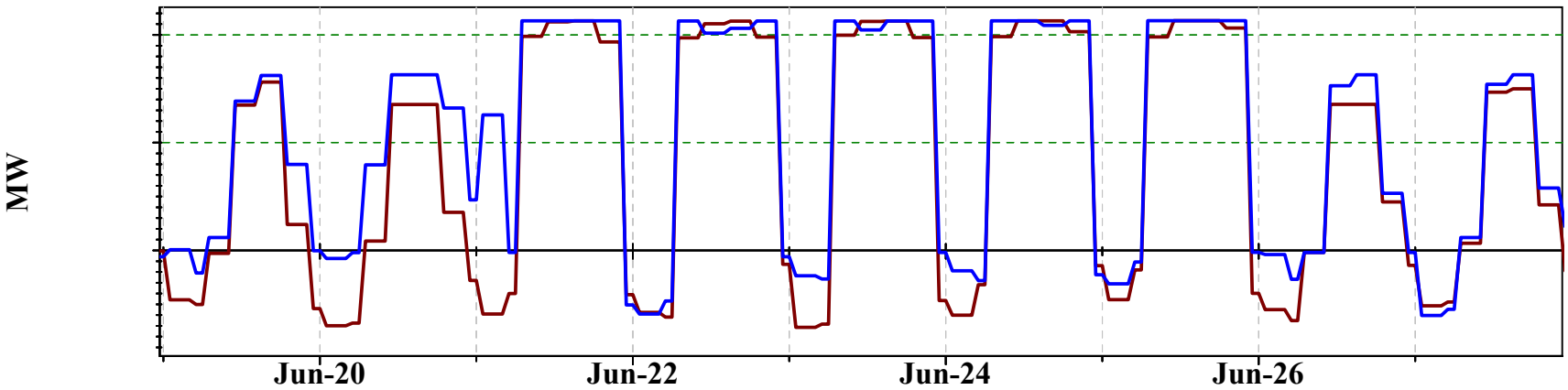
Wind Time Series



Base No Wind

500 MW Wind Capacity



Tie Line

Central To USA

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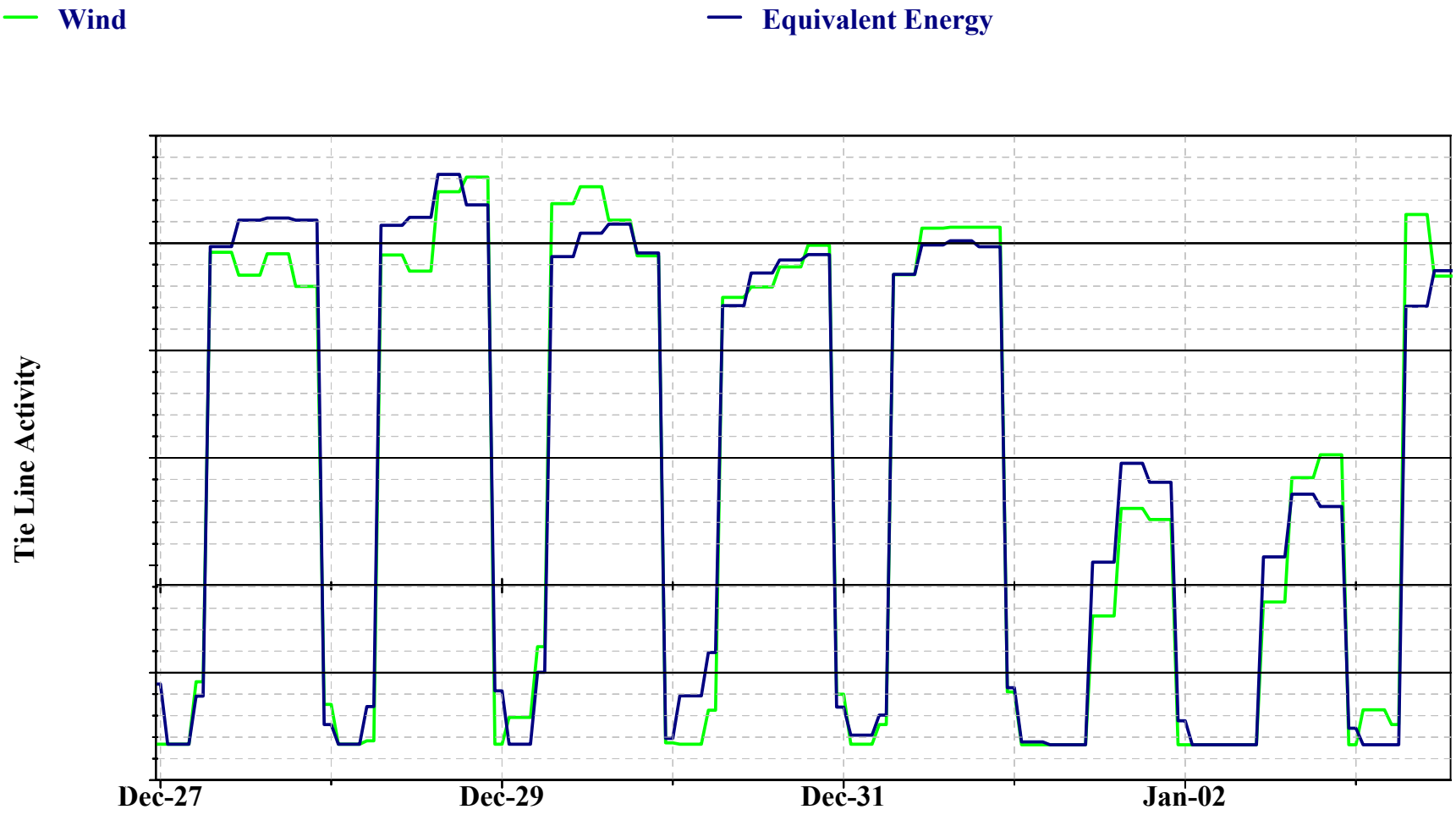
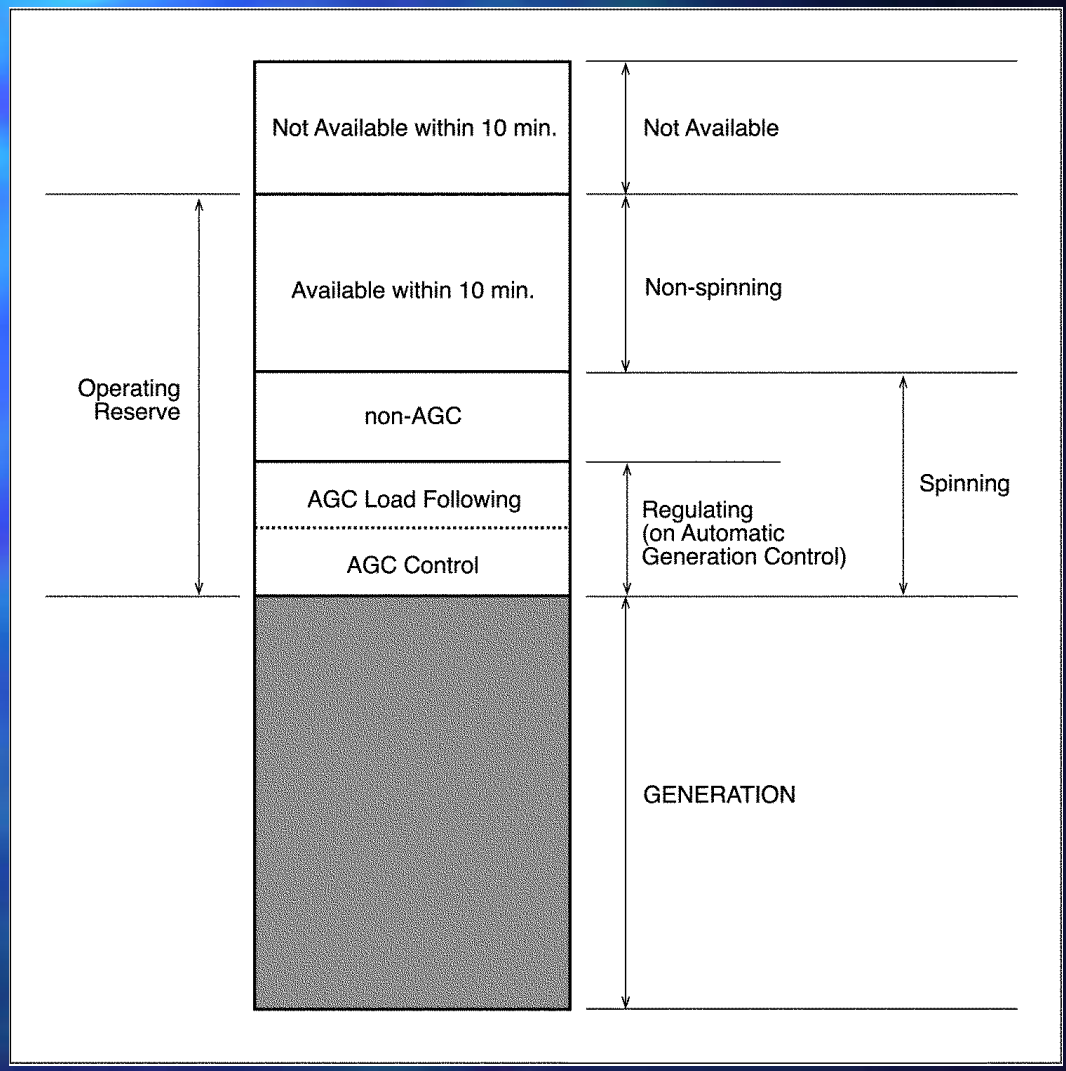


Incremental Cost of Reserves

- Can model both the variability and uncertainty of wind and the associated reshaping of operations
- Estimate the incremental cost of reserves



Plant Reserve low Hydrology

AGC

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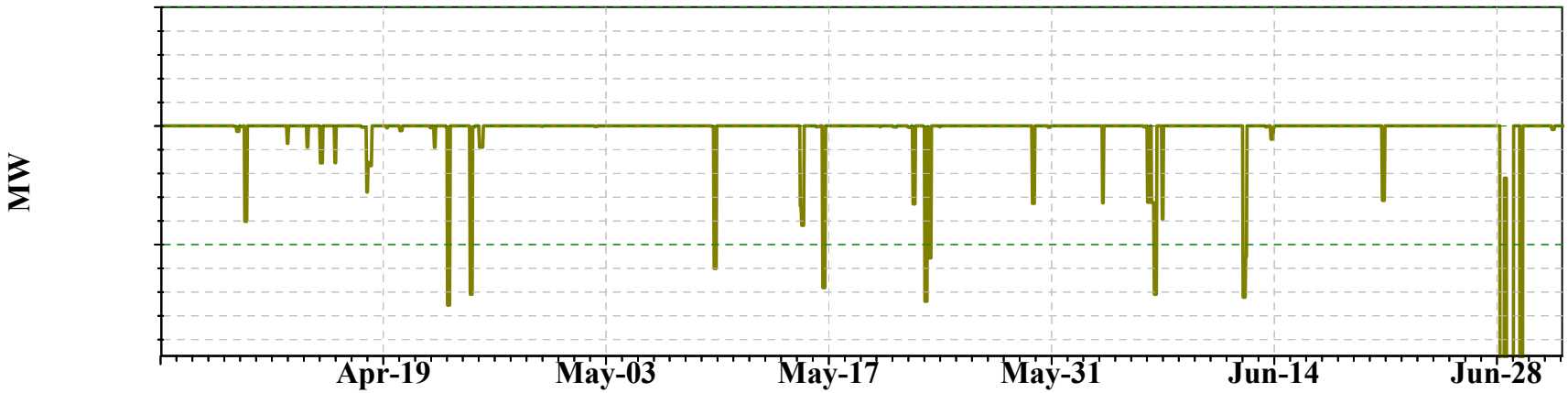
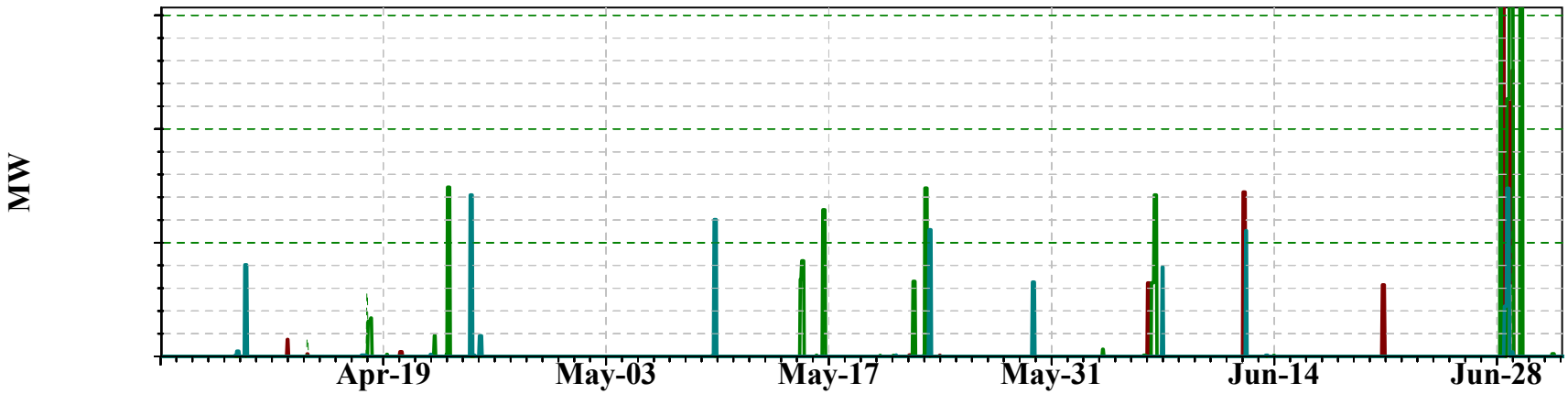
Swing Plant



Plant 1 - LNR

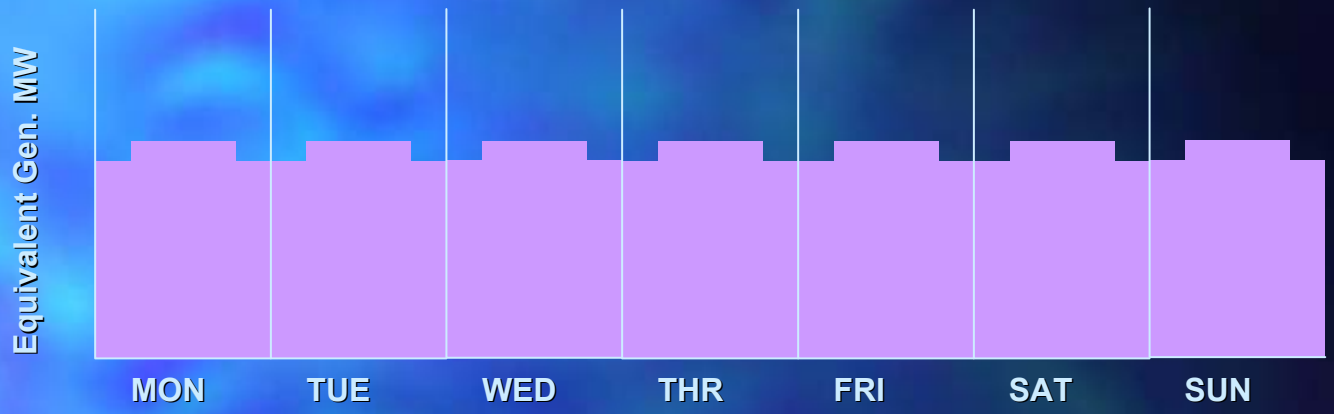
Plant 2 - LNR

Plant 3 - LNR

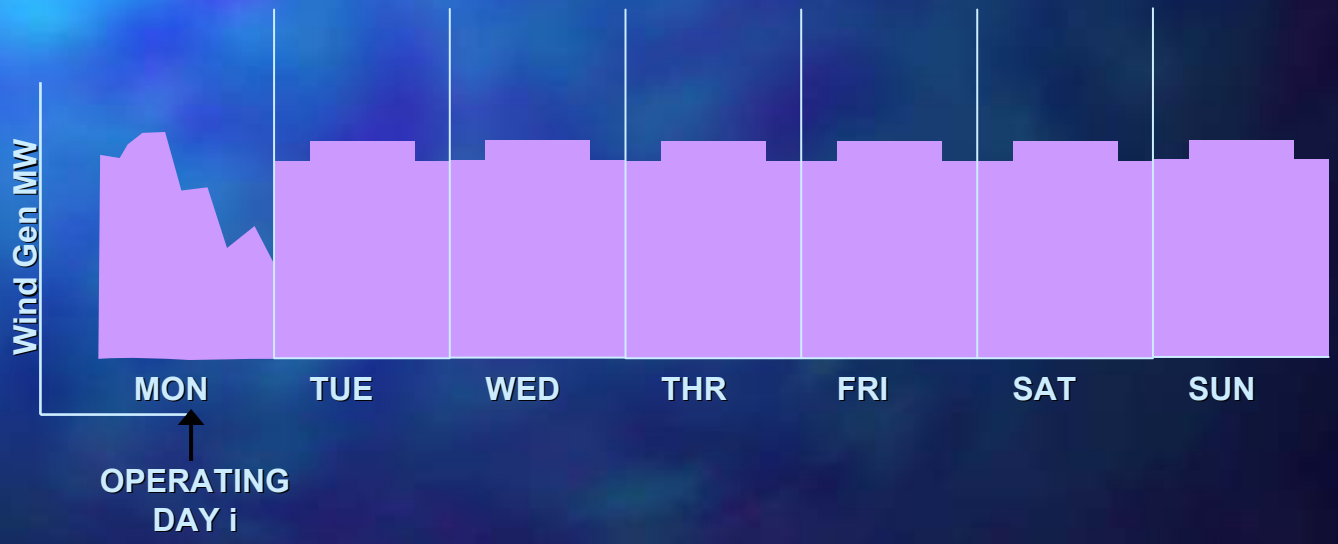


Modeling Short Term Wind Uncertainty/Variability

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



Median Wind Time Series

Median Hydrology

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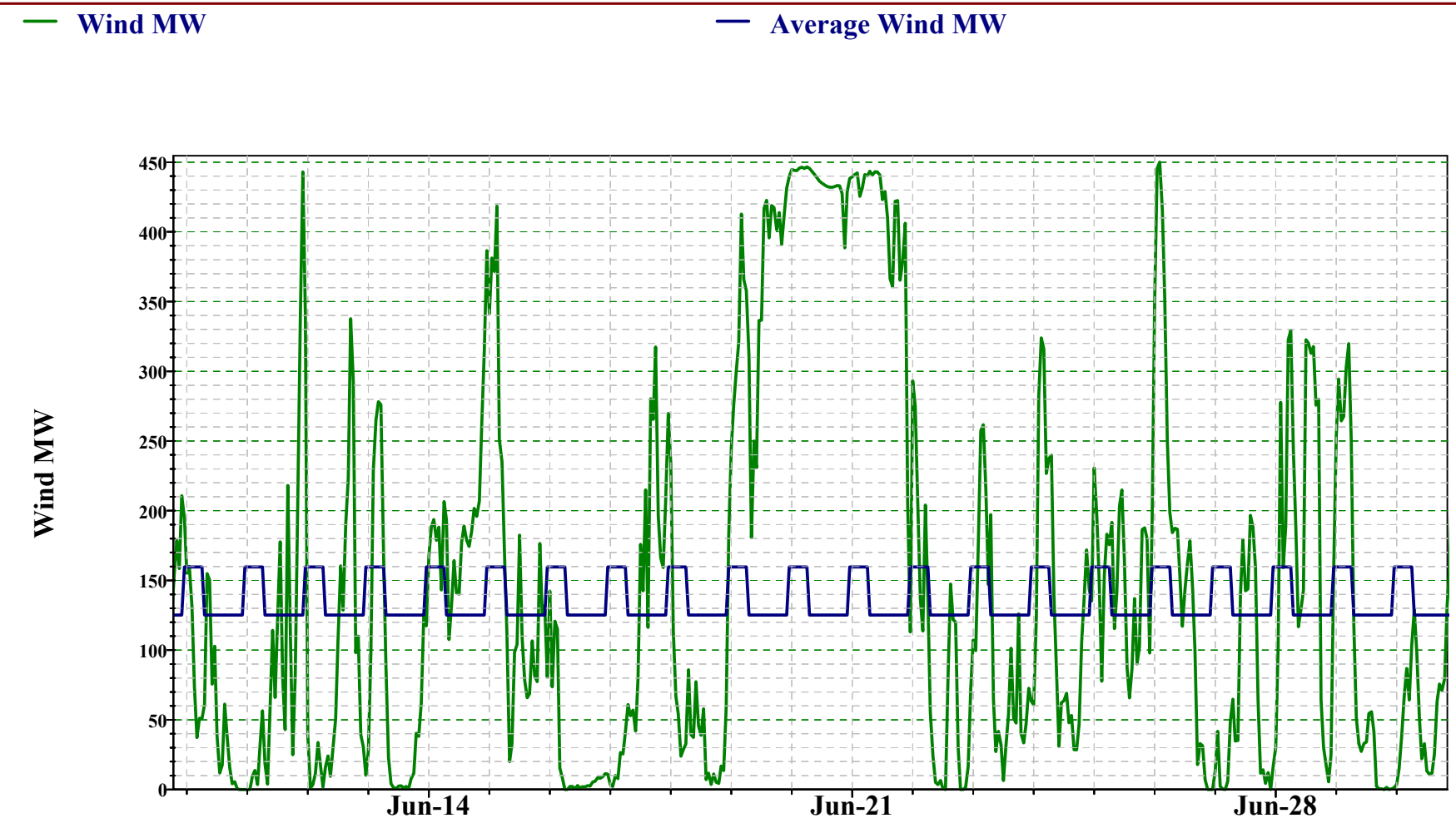

Transactions

wind

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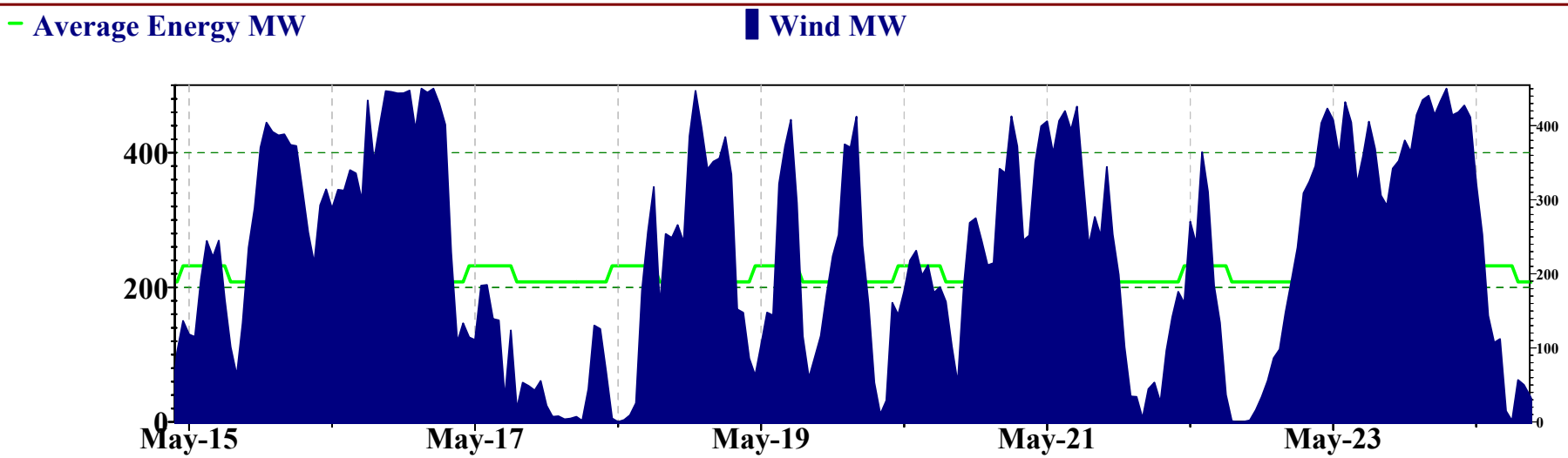

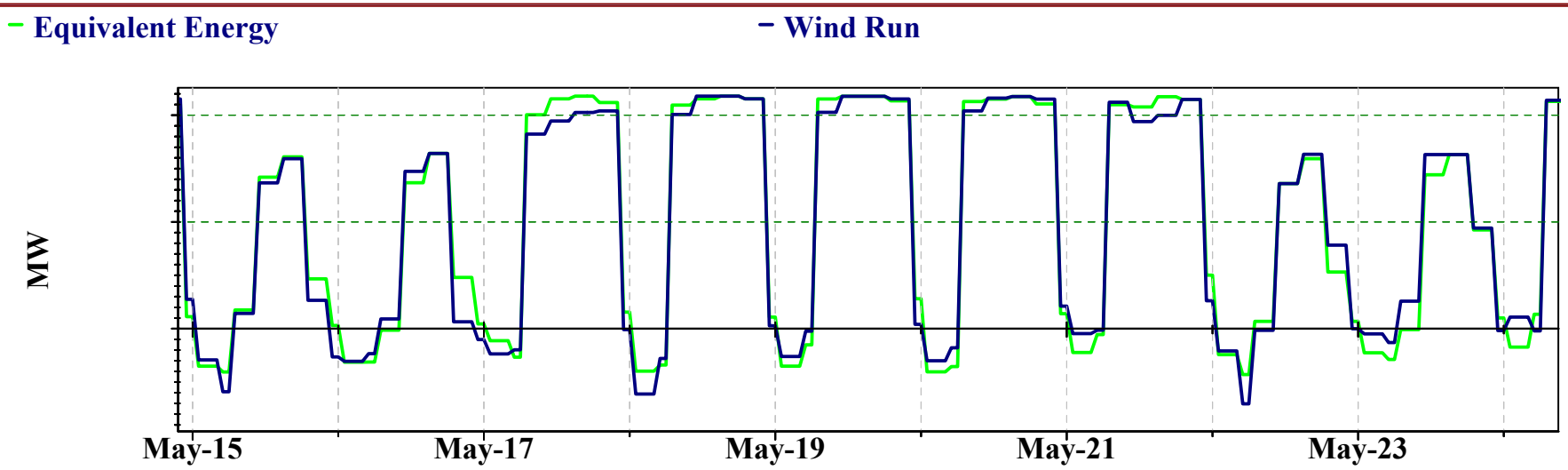

Final Points

- 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.