Wind/Hydro Integration for Manitoba Hydro's System

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by

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Power Supply

Outline

- Context for Wind in Manitoba Hydro’s System
- Modelling Wind Integration
- Results of Wind Integration Study

Wind and Hydro

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

Adding wind into a hydro system can create a product with high export value.

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

Wind and Hydro

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

Average Flow

- Increased export opportunities to the limit of installed generation or tie-line

High Flow

- Virtually no value once tie-lines saturated

Wind and Hydro

- Limited surplus interconnection capability
- Limited capability for firming & shaping wind.
- Three Issues:
  - How much wind can be enhanced ?
  - What is the market value of wind?
  - **What is the cost of wind integration?**

Value of Wind

Long-term firm contract value

+ Wind capacity credit

- Product enhancement *costs*

- Integration *costs*

- Other *costs*

= **Value of Wind Energy to Manitoba Hydro**

Wind Integration Cost Elements

1. Sub-optimal operations due to variability and uncertainty of wind generation

2. Lost opportunities from increased capacity reserve requirement for wind

Wind Forecast Uncertainty can result in Sub-Optimal Operations

- Significant **negative** deviations from the forecast could result in:
  - change in reservoir operation resulting in lower valued exports

- Significant **positive** deviations from the forecast could result in:
  - change in reservoir operation resulting in spill and/or lost export opportunities
  - for low flows – could over estimate import requirements

More Reserves for Wind Variability

Increased Regulation

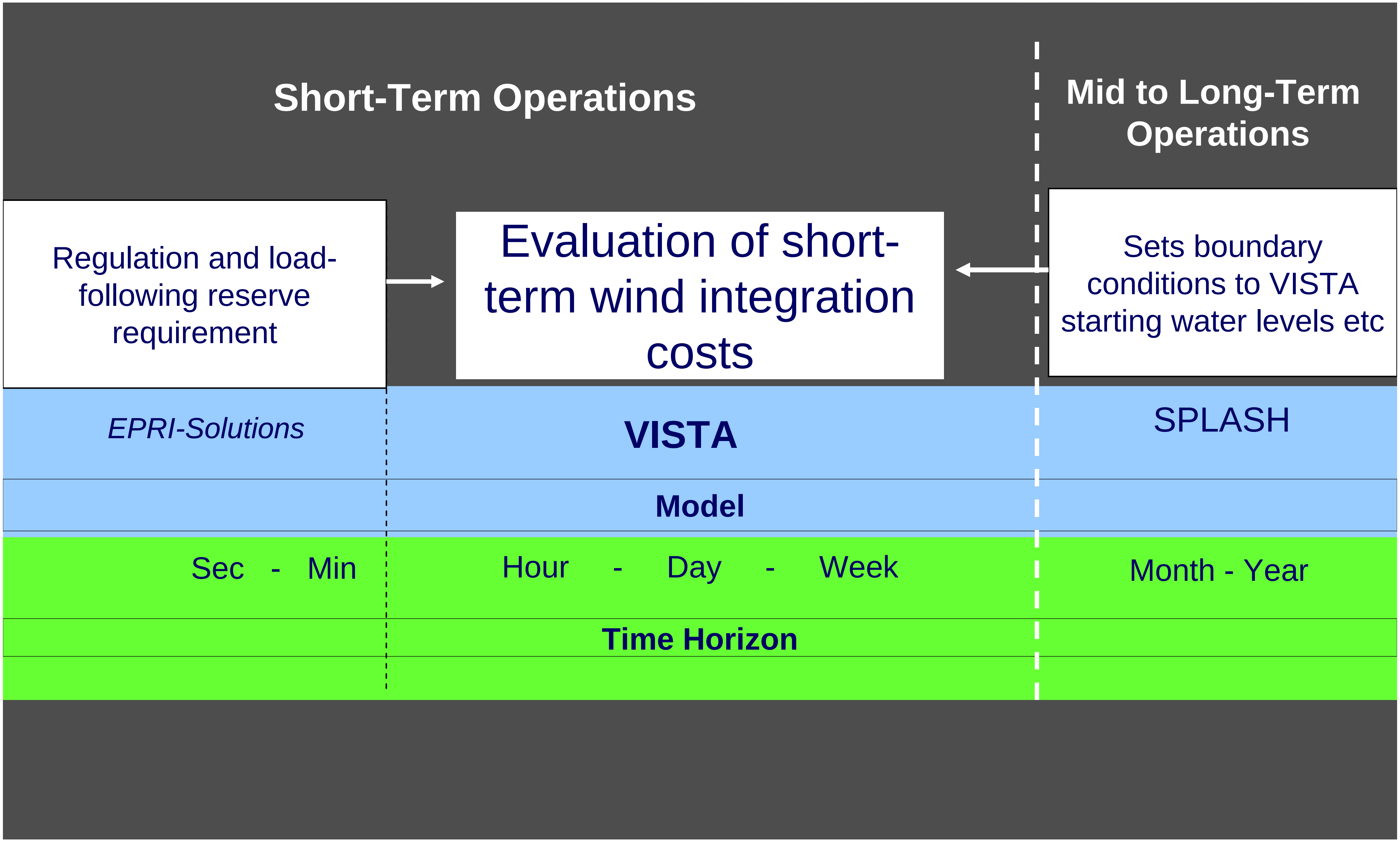
- Additional reserves required for sudden unexpected changes to wind generation in addition to load fluctuations

Increased Load Following

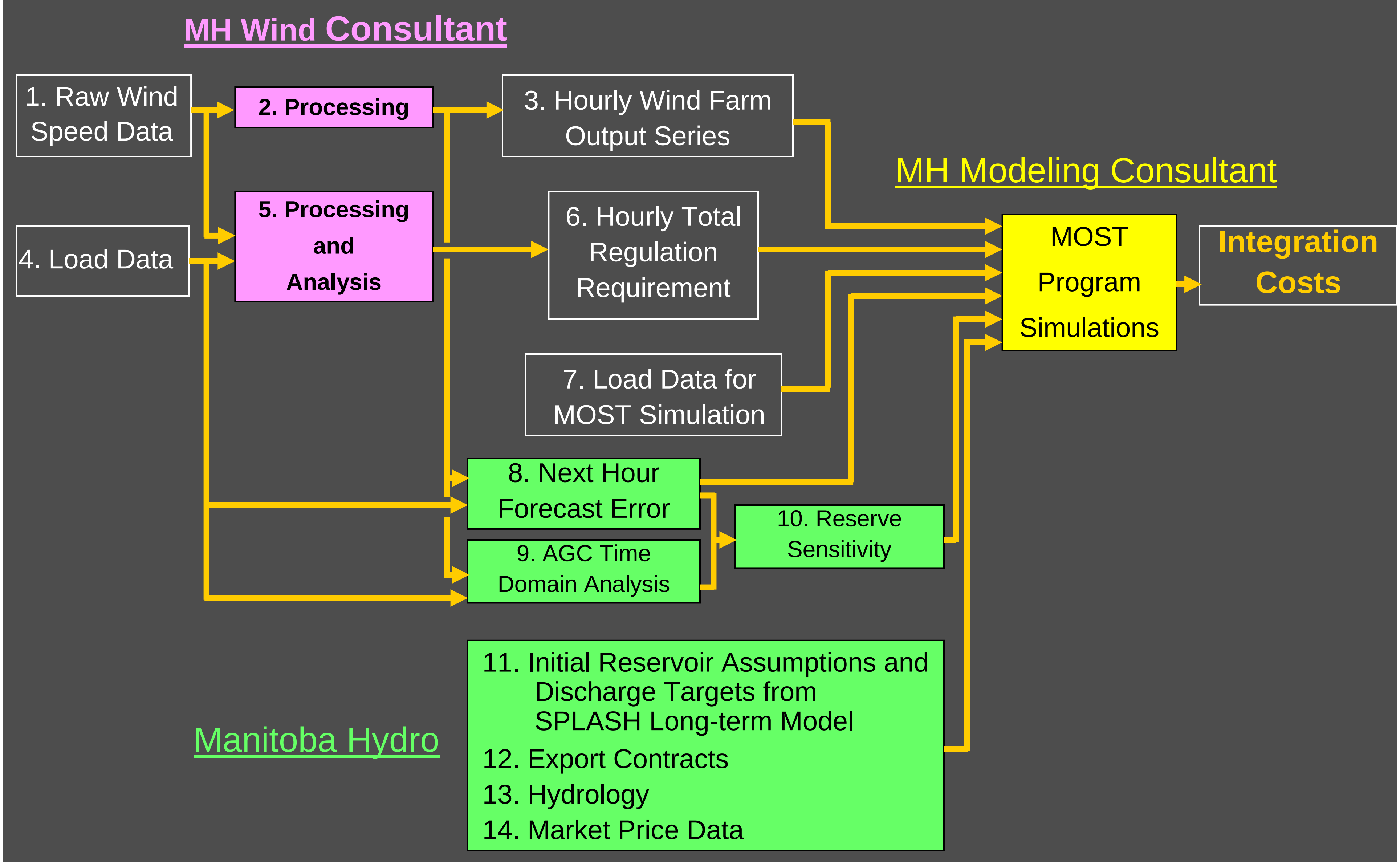
- Changes dispatch of existing generation
- Increased draw/pond operation of small reservoirs
- Increased frequency of inefficient operation

Modelling Wind Integration

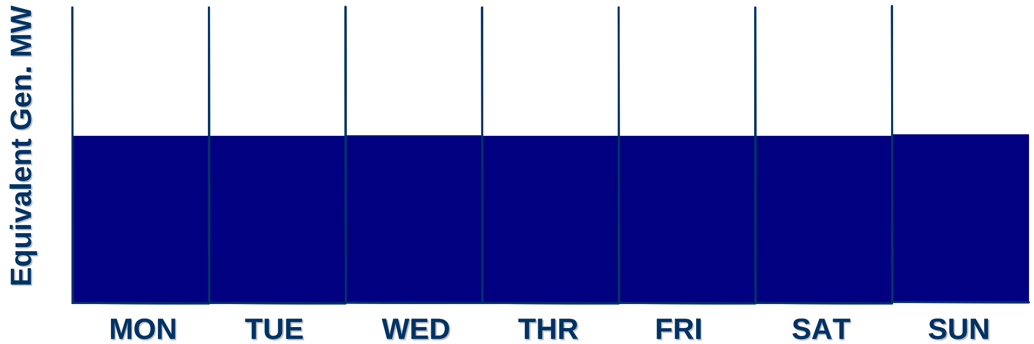
General Modeling Approach



Flow Chart For MH Integration Study

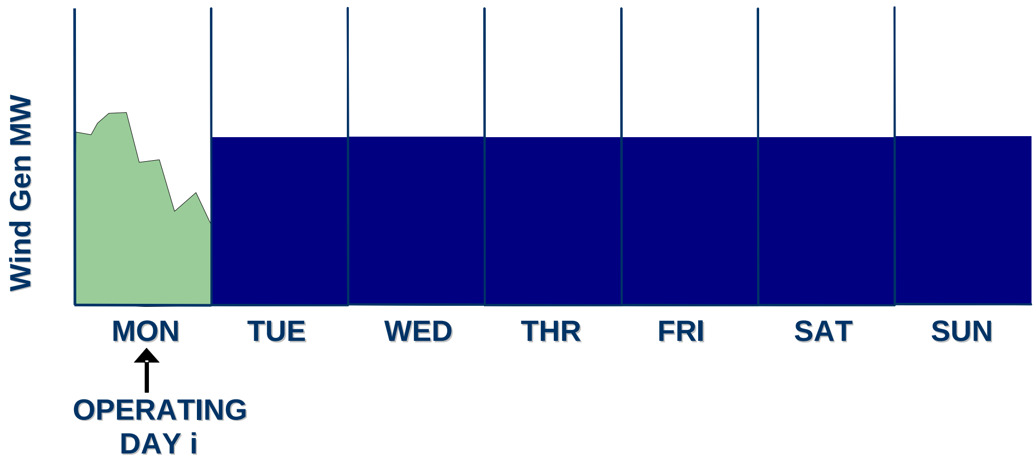


Wind vs. Equivalent Energy Base cases



EEB (baseload) case:

- Uniform generation
- No added reserves

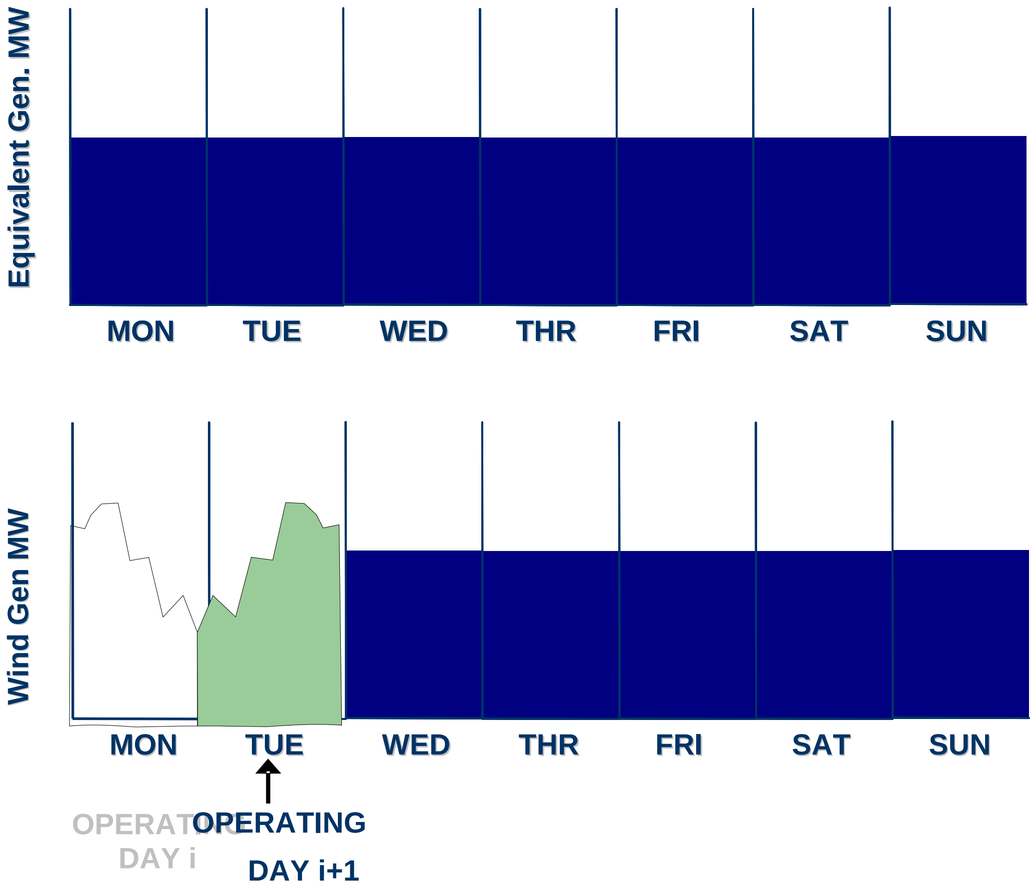


WIND Case:

- Actual hourly wind
- Higher reserves
- Inefficient Operation

WIND Revenue - EEB revenue = Integration Cost

Wind vs. Equivalent Energy Base cases



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WIND Case:

- Actual hourly wind
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- Inefficient Operation

WIND revenue- EEB revenue = Integration Cost

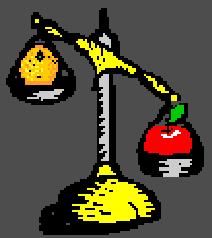
Results of Wind Integration Study

- Integration costs were influenced by geographic and spatial diversity
- Sub-optimal operations accounted for about half of integration costs
- Cost of carrying additional reserves accounted for balance of costs.
- Integration cost dependent upon flows

MH Wind Integration Costs

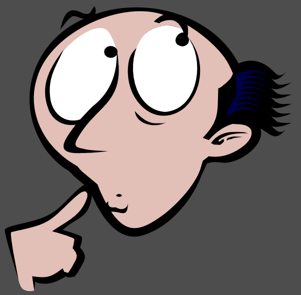
Levelized Cost in ¢/kWh (2006 Cdn$)

Wind Penetration Level	WIND Capacity MW	Integration Cost (¢/kWh)
6%	250	0.5 ¢/kWh
12%	500	0.55 ¢/kWh
17%	750	0.6 ¢/kWh
23%	1000	0.65 ¢/kWh



Conclusions

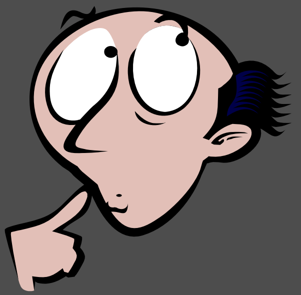
- Wind integration cost for MH system comparable to other wind/hydro integration costs



- Modelling approach appropriate to determine short term wind integration cost.

Conclusions cont'd.

- Hydraulic inefficiencies account for 50% cost, additional reserves 50%.
- Inefficient operations largely due to wind uncertainty.
  - *Better wind forecasting would be beneficial to weekly energy management.*
- Determination of reserve requirement very complex:
  - *Currently no industry standard*.



Next Steps in Wind Integration Analysis

- **Consider potential costs of:**
  - Inefficient sub-hourly operation
  - More maintenance
  - Enhanced controls for added AGC requirements with wind
- More analysis of impact of reserves

Thank You

Questions?