Hydro System Planning, Scheduling and Operation Fundamentals from a Manitoba Hydro Perspective

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Manitoba Hydro

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PRESENTATION OUTLINE

- Overview of Manitoba Hydro System
- Overview of Decision Support Systems
- Status of Wind Development in Manitoba
- How Wind Fits in our Hydro System
- Lessons Learned on Wind

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Manitoba Hydro Facts & Figures

- Hydro Dominated Generation Mix:
  - 5001 MW (hydro)
  - 468 MW (thermal)
  - 99 MW (purchased wind)

  Recent Hydro Energy Range
  - 19-37 TWh (yearly)
- Manitoba Demand – 22 TWh
  - Peak Load: 4200 MW (winter)
- Export 25% of energy in average flow year
- Canada's largest exporter to US in 2005

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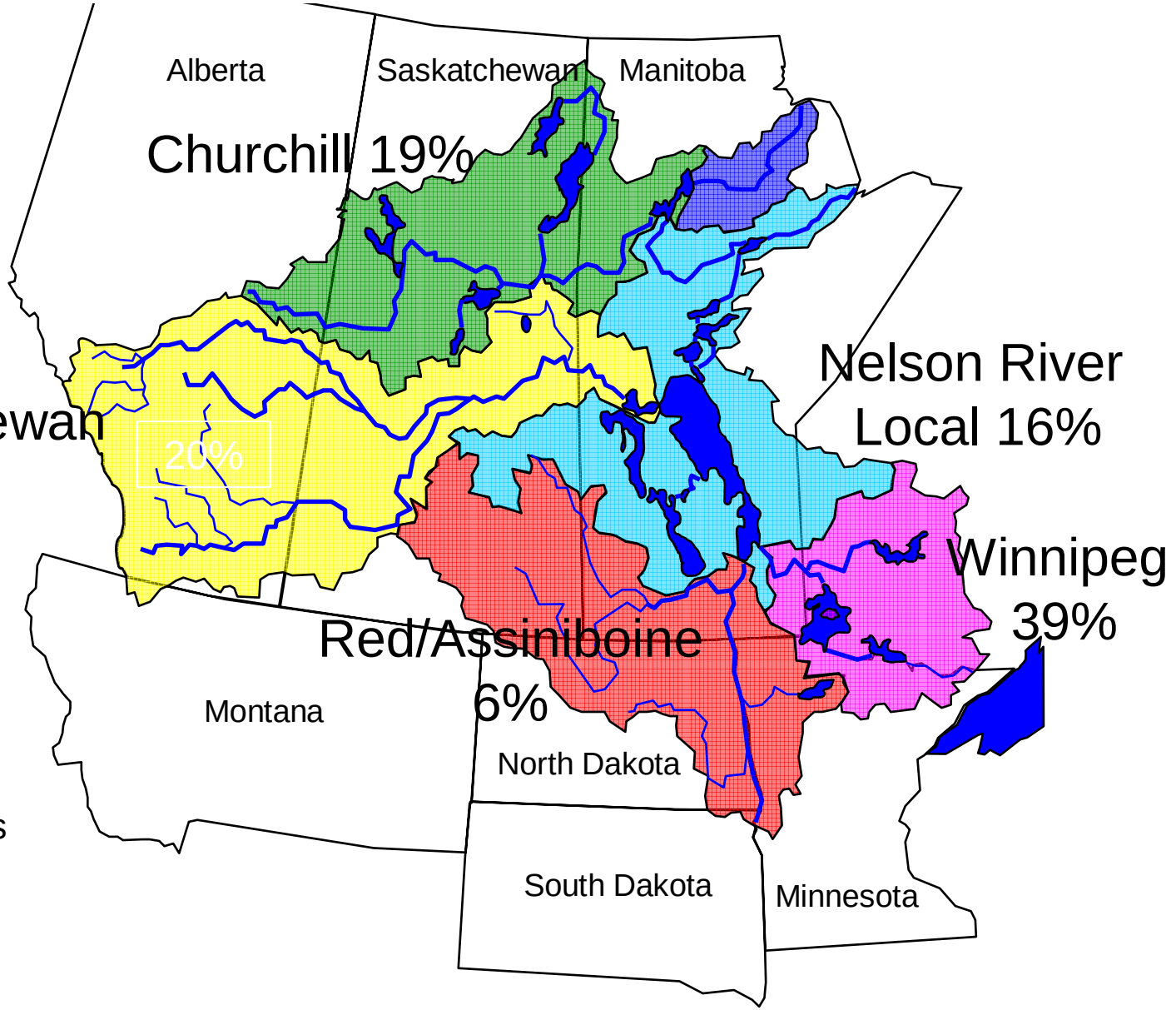
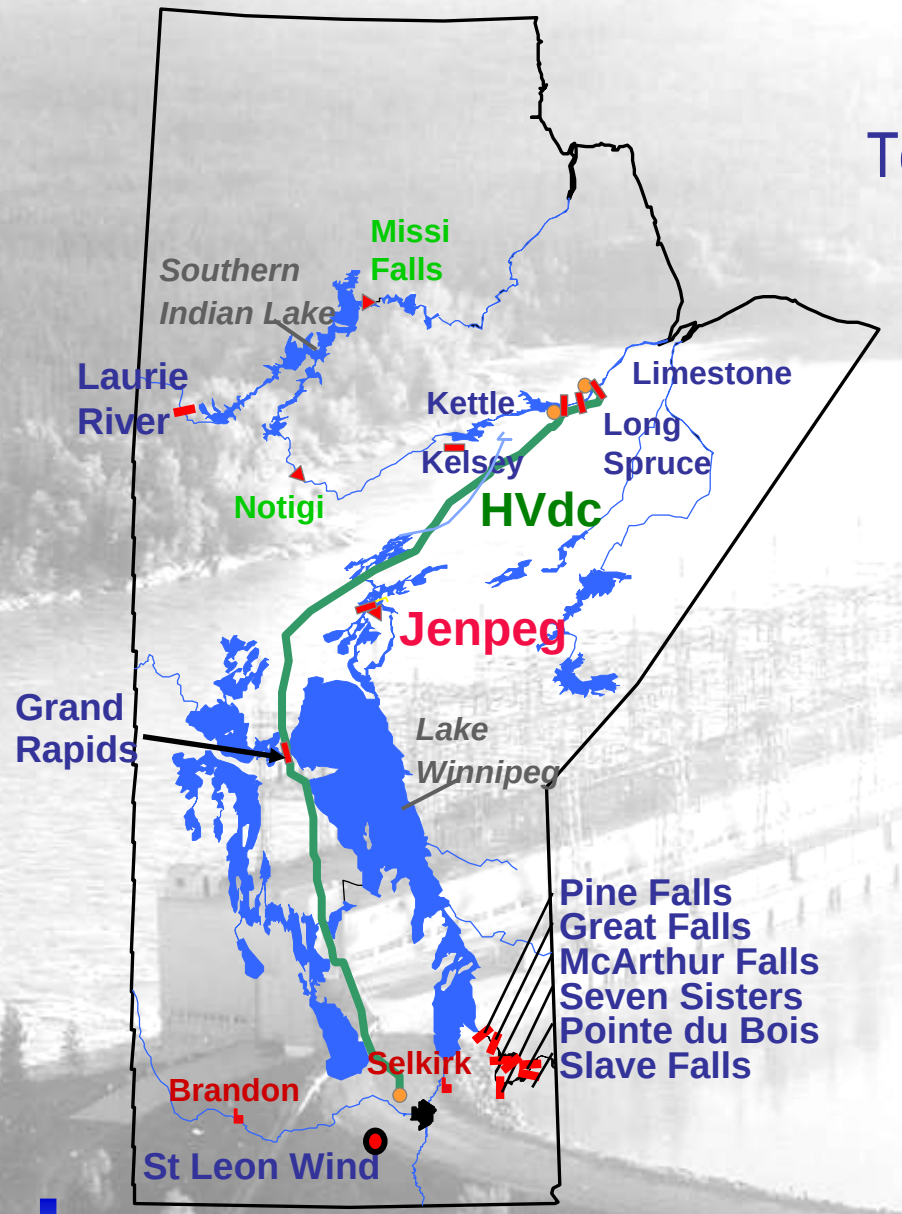
Nelson-Churchill Drainage Basin Energy Supply



Major Reservoirs:
- Lake Winnipeg
- Lake of the Woods
- Cedar Lake
- Southern Indian Lake

System Map



Total Installed Capacity 5478 MW

- Kettle (1220 MW)
- Long Spruce (1010 MW)
- Limestone (1340 MW)
- Jenpeg (133 MW)
- Kelsey (225 MW)
- Grand Rapids (479 MW)
- 6 Winnipeg River Stations (584 MW)
- 2 Laurie River Stations (10 MW)

- Wind – St. Leon (99 MW)
- 300 MW wind RFP pending

- Selkirk Gas (125 MW)
- Brandon Coal (96 MW)
- Brandon CT (247 MW)

- Control Structures (Missi, Notigi)

- Wuskwatim + 200 MW – new hydro in 2012

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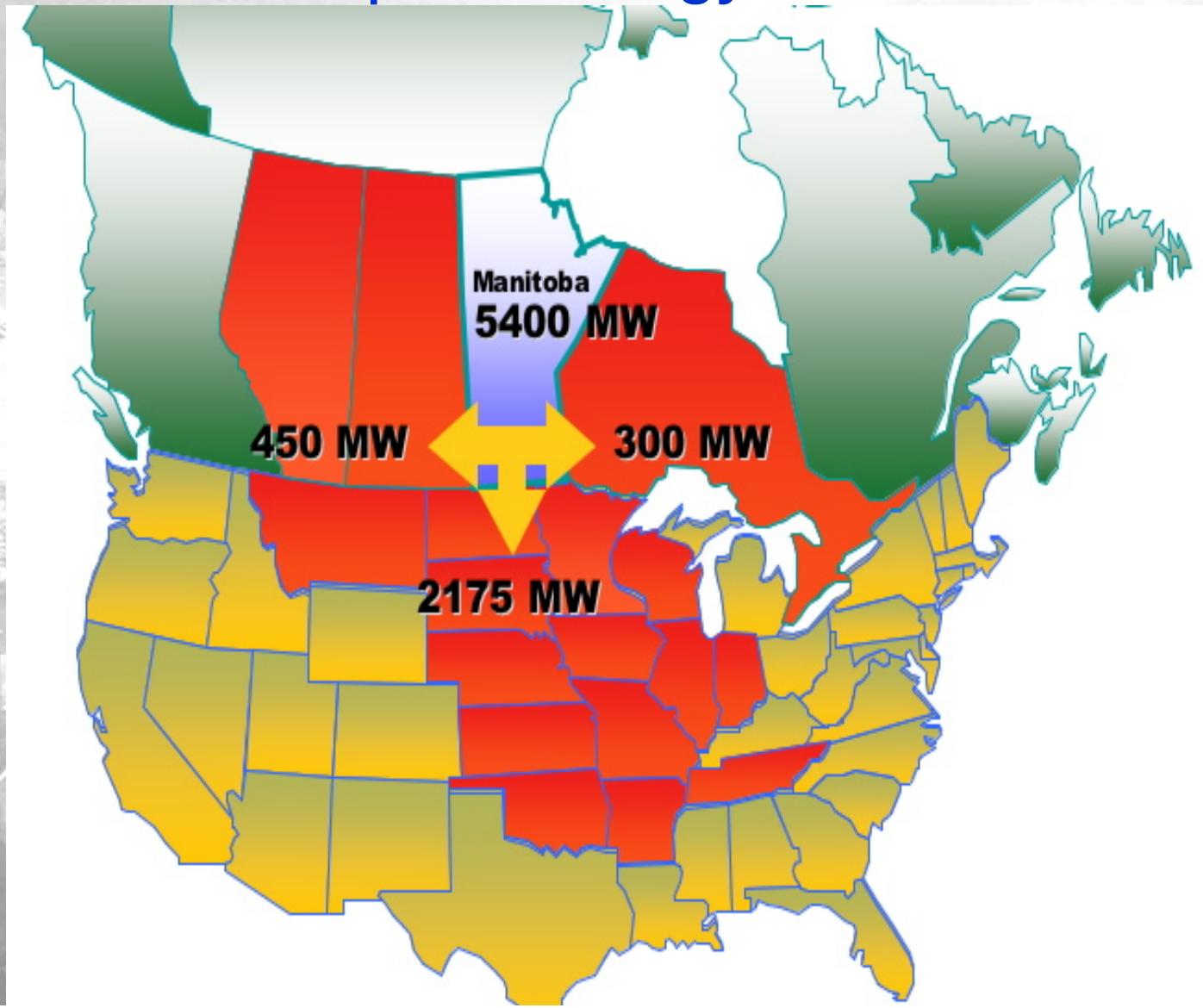
Interconnections are Key to Exporting Surplus Energy



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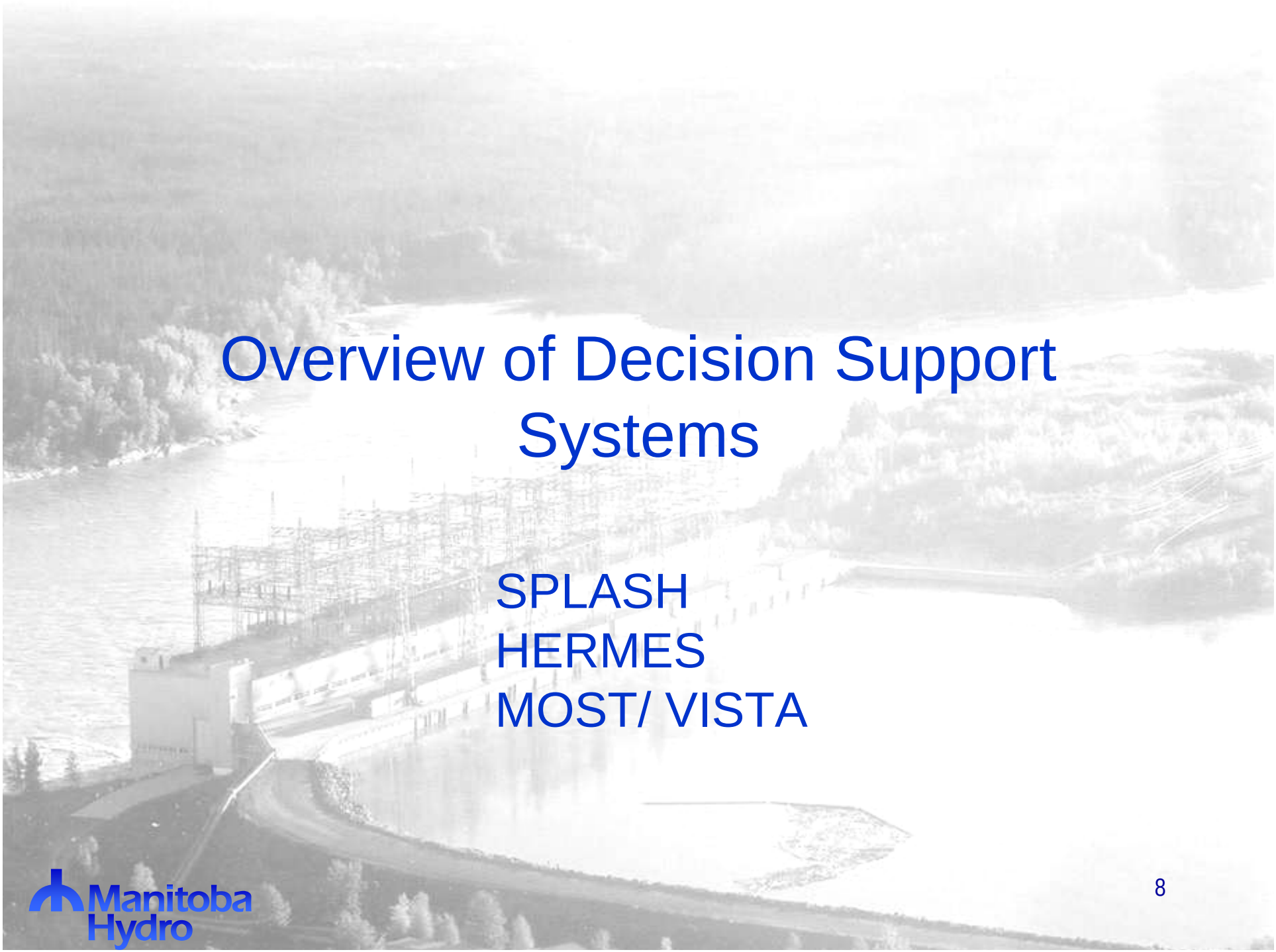
Manitoba Hydro is an External Participant in the MISO Market



Overview of Decision Support Systems

SPLASH
HERMES
MOST/ VISTA

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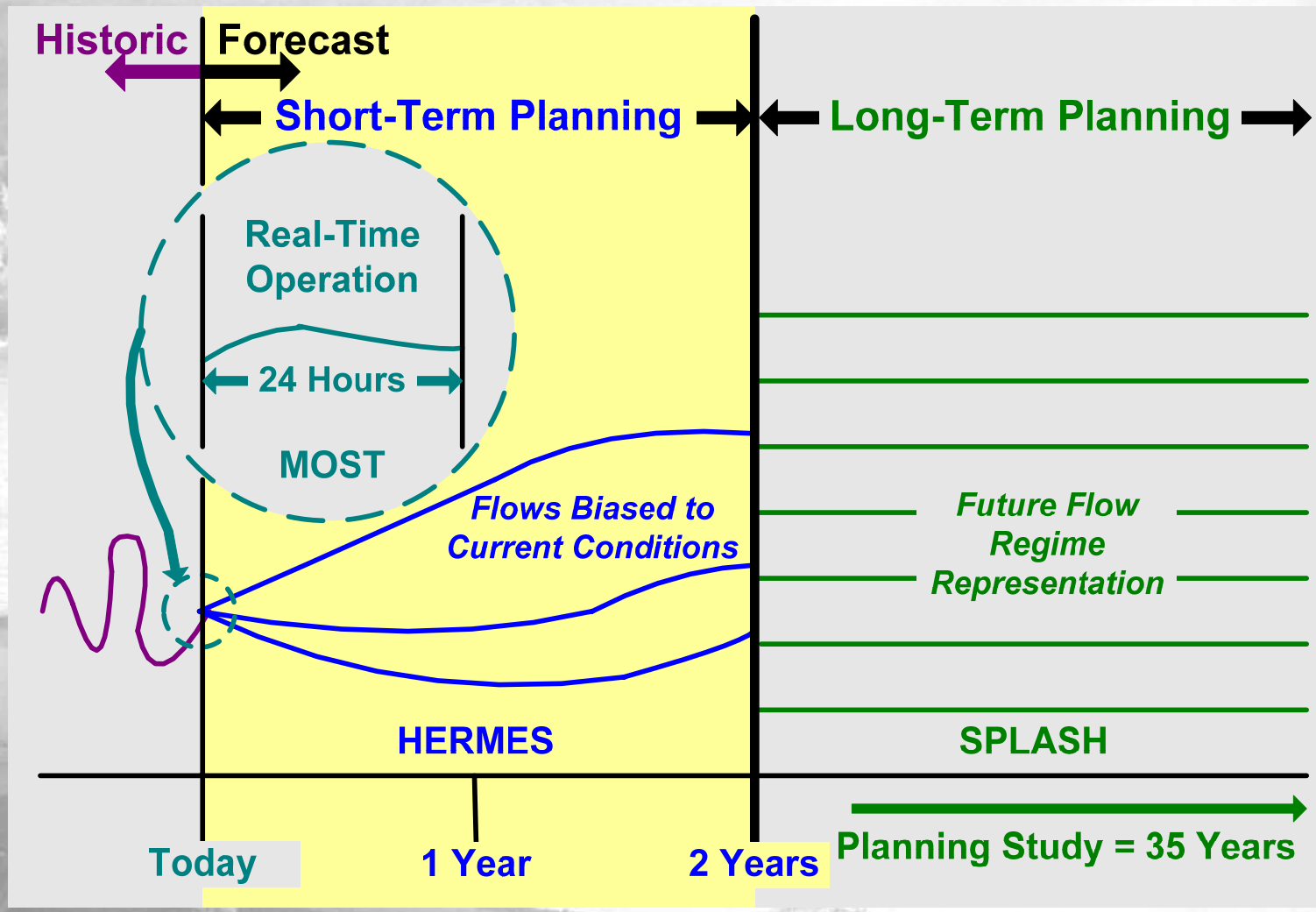
Planning Horizons & Inflow Forecasts



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Power Resource Management

- inflows, storage, coal, gas
- imports
- plant capability

- domestic load
- exports
- outages
- losses

Resource Management Decisions

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Long Term Planning Horizon: SPLASH Model

- **S**imulation **P**rogram for **L**ong Term **A**nalysis of **S**ystem **H**ydraulics
  - Monthly resolution energy model, on peak and off peak
  - Physical multi reservoir model of Manitoba Hydro system (including load, generation, hydraulic constraints), plus a model of external power markets
  - Transmission interconnections also a constraint
  - Uses linear programming to maximize the objective function: i.e. maximize net flow related revenue, considering the entire hydraulic flow record of 93 years

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Planning Horizon Uses of SPLASH

- Need for and timing of new generation
- Can evaluate the economic value of new generation to the Manitoba Hydro system
- All energy sources treated the same
  - Analysis indifferent to the source of the energy
  - Are resources are fixed energy sources
- Used to determine the value of wind energy to Manitoba Hydro
- Too coarse to model wind intermittency

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HERMES Operations Planning Tool

- **H**ydro-**E**lectric **R**eservoir **M**anagement **E**valuation **S**ystem
- Similar to SPLASH (same objective function), but designed for operations time frame
- In comparison to SPLASH,
  - Finer resolution (weekly, vs. monthly)
  - More detailed hydrology, such as for Nelson River
- Resolution still not fine enough for wind integration studies

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VISTA Decision Support System

- In the process of implementing the VISTA DSS from Synexus Global
- Similar to SPLASH and HERMES in that they both use linear programming program to maximize the same objective function
- Finest resolution – down to one hour time steps
- Capable of modeling operating reserves
- Used for wind integration studies

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Status of Wind Development in Manitoba

99 MW purchase from St. Leon Wind Farm

RPF for 300 MW of wind power is imminent

Province of Manitoba anticipates potential "allocations of 200 megawatts each are currently targeted for 2013-14, 2015-16, and 2017-18, based on economic viability."

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How Wind Fits in our Hydro System

- Have sufficient resources to serve domestic load until around 2020
- Until wind or other energy is needed for domestic load, wind energy will increase supply for export, under most water conditions
- During the lowest water conditions, wind can offset purchases (imports) or thermal generation.
- Shorter lead time compared to hydraulic options.
- Less potential annual variation in wind plant output than hydro output

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Lessons Learned on Wind … 1

1. Each hydro system is unique. Value of wind energy and the integration costs will vary by system
2. A flexible hydro resource is technically capable of integrating wind. However, there is an opportunity cost
3. Wind value and integration costs are both dependent upon water conditions
4. The load you integrate into may be different from where the energy is ultimately delivered. We integrated to the Manitoba load – but the energy is typically delivered in hourly schedules to external markets

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Lessons Learned on Wind … 2

5. Transmission is very important. Having wind and hydro behind a transmission constraint is expensive. Make sure your transmission (and future generation and wind diversity) assumptions are valid.

6. Need for multi-day aggregate wind energy forecast

7. There is a real O&M cost to carrying operating reserves

8. On peak – off peak pricing is a driver of integration costs (courtesy of Idaho Power)

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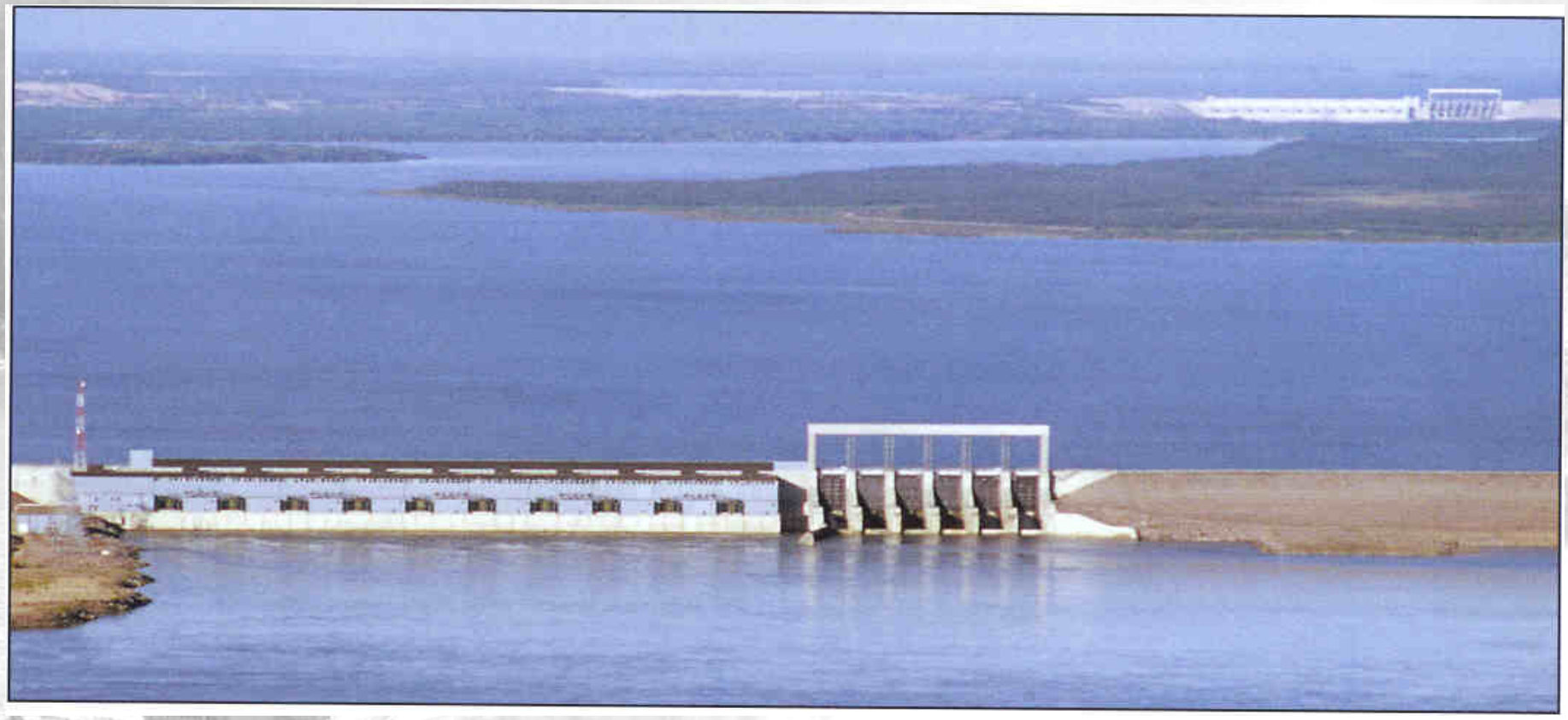
Questions?



Long Spruce G.S. (1010 MW)

Kettle G.S. (1220MW) in background