The Manitoba Hydro System and its Operation

Harold Surminski

Power Supply
December 15, 2010

Broad Overview of...

- Key components
  - Generation
  - Transmission
  - Water Control
- System Operation
  - Water Supply
  - Manitoba Load
  - Export markets
  - LWR and CRD
MH Generating Stations and Control Structures

- **Hydro (4,900 MW)**
  - Winnipeg River
  - Grand Rapids
  - Jenpeg
  - Kelsey
  - Laurie River
  - Lower Nelson

- **Lake Winnipeg Regulation**
  - Jenpeg Control

- **Churchill River Diversion**
  - Notigi Control
  - Missi Control

- **Thermal (500 MW)**
  - Selkirk Gas
  - Brandon Coal and GT

Wind Power

- **St. Leon Wind Energy LP**
  - 63 turbines
  - 99 MW
  - Privately owned
  - P.P.A with MH
Imports

Firm
- Seasonal Diversity
  - Capacity swap
  - 350 MW NSP
  - 150 MW GRE
  - 20% winter season capacity factor

Non Firm
- 750 MW – 1800 MW
- Market purchases
  - MISO
  - Ontario
  - Bid curve

MH Generation Costs
(Fuel and O&M)

<table>
<thead>
<tr>
<th>Source</th>
<th>Cost</th>
<th>% of Time ITM (since 01/04/2005)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro</td>
<td>$3/MWh</td>
<td>99.7%</td>
</tr>
<tr>
<td>Coal</td>
<td>$25/MWh</td>
<td>65%</td>
</tr>
<tr>
<td>Wind</td>
<td>$60/MWh</td>
<td>41%</td>
</tr>
<tr>
<td>Gas</td>
<td>$40 - $100+/MWh</td>
<td>8%</td>
</tr>
<tr>
<td>Market Purchases</td>
<td></td>
<td></td>
</tr>
<tr>
<td>On Peak</td>
<td>$30 - $80+/MWh</td>
<td></td>
</tr>
<tr>
<td>Off Peak</td>
<td>$15 - $30+/MWh</td>
<td></td>
</tr>
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Water Supply


%’s indicate portion of total hydraulic generation from basin waters.

Winnipeg River

Winnipeg River at Slave Falls GS Total Discharge 05PF063

Flow [cfs]

1996 - 2006
2006
2007
Average 1996 - 2006

Spillage
Red River

Lake Winnipeg Inflow vs. Outflow
Averages for Period 1991-2010
Lake Winnipeg

50% of Storage in Nelson Churchill basin

Nelson River Water Supply
(Inflows)
Manitoba Electricity Demand
Varies Hourly, Daily and Seasonally

Manitoba is Strongly Interconnected
Interconnections Provide

- Reliability
  - Emergency response
  - During Maintenance Outages
  - Drought support

- Economy
  - Use of Capital
    - Generation Expansion
    - Load Diversity
  - System Operations (Sales and Purchases)
  - Reserve Sharing (Reserve Sharing Pools)

- Efficiency
  - Competitive markets

Energy Sales/Purchases Depend Upon Water Supply
What is MISO?

- Midwest Independent System Operator
  - Regional Transmission Organization
  - Operates transmission grid on behalf of transmission owners
- Independent, non discriminatory
  - Ensure all generators have equal access to grid
- Energy Market Operator
  - MH full market participant
    - External generator
How is Energy Sold?

• Buyers / Sellers enter into negotiated fixed price contracts
  – Multi-year, seasonal, monthly
  – Over 90% of electricity
  – Provides price and supply certainty
• Balance of energy is sold
  – Day Ahead (based upon a forecast)
  – Real Time (based upon actual demand)

How do the MISO Balancing Markets Work?

• Electronic Commodity Market
• Day Ahead Market
  – Generators offer in,
  – Energy price is determined by most expensive generator used to serve load
  – Market clears and is settled
• Real Time Market
  – MISO dispatches generation
  – 5 minute prices set by most expensive generator
**MH Day Ahead Offers to MISO for April 4th 7-8 am**

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<tr>
<th>Source</th>
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<th>US$/MWh</th>
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<tr>
<td>Nelson 1</td>
<td>100</td>
<td>10</td>
</tr>
<tr>
<td>Nelson 2</td>
<td>100</td>
<td>11</td>
</tr>
<tr>
<td>Nelson 3</td>
<td>100</td>
<td>14</td>
</tr>
<tr>
<td>Nelson 4</td>
<td>250</td>
<td>15</td>
</tr>
<tr>
<td>Nelson 5</td>
<td>250</td>
<td>15</td>
</tr>
<tr>
<td>Nelson 6</td>
<td>100</td>
<td>15</td>
</tr>
<tr>
<td>Nelson 7</td>
<td>100</td>
<td>19</td>
</tr>
<tr>
<td>Nelson 8</td>
<td>100</td>
<td>23</td>
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At 5 pm April 3rd MISO Accepted These Offers from MH @ US$55.00/MWh
Lower Nelson Provides 90% of Hourly and Daily Matching of Supply to Demand

Lower Nelson Operations

Stephen’s Lake
- 10 ft Operating Range
- 250,000 MWh
- provides daily storage
  - Kettle
  - Long Spruce
  - Limestone

Long Spruce/Limestone
- near constant level
- hourly storage
- time delays
Export Prices Vary Seasonally

Lake Winnipeg Is Used to Shift Surplus Energy To Higher Value Months if Possible

Lake Winnipeg Regulation

- Seasonal balancing reservoir
- 50% increase outflow capability
- 4 ft storage for power
- 3,000,000 MWh per foot
- Shape water supply to power demand
- Jenpeg controls 85% of the outflow
- East Channel is uncontrolled
Ominawin Bypass Channel

Lake Winnipeg Regulation

Modes of Operation

- **Flood Conditions**: Regulate for flood control
  - Water level: 715 feet

- **Normal Conditions**: Regulate for power system economics
  - Water level: 711 feet
  - 4 feet for power purposes

- **Conservation**: Outflows are set to ensure energy supply security
  - Water level: 711 feet

- **Extreme Drought**: Outflows set by Minister of Water Stewardship
Lake Winnipeg Monthly Average Levels 1913 - 2006

Average Levels
- Pre-Regulation = 713.4
- Post-Regulation = 713.5
- Overall = 713.4

Lake Winnipeg Regulation

Jenpeg Operations

LWR Primary Objective:
Meet the Downstream Power Demand

LWR Secondary Objective:
Efficient Powerhouse Operations at Jenpeg

Lower Nelson (3600 MW)

Jenpeg (120 MW)
Ice Restrictions Still Limit Lake Winnipeg Outflow Capability

Churchill River Diversion Water Is Most Useful in Winter

Churchill River Diversion

- 25% of Nelson River flow
Southern Indian Lake
Water Levels

Maximum Licence Level 847.5
Minimum Licence Level 843.0

Maximize Winter Drawdown

2000 2001 2002 2003

CRD Operation Follows Predictable Seasonal Patterns

REGULATORY CONSTRAINTS

• Water Power Act licences include 25 constraints under which Manitoba Hydro must operate

• Constraints apply to:
  – Generating Stations
  – Control Structures
  – Reservoirs (Lakes)
  – Rivers

• Nature of constraints:
  – Minimum and Maximum Elevations
  – Minimum and Maximum Outflows
  – Maximum Outflow Rates of Change
QUESTIONS?
The Manitoba Hydro System and its Operation (Summary)

Harold Surminski
Power Supply
February 3, 2011

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Varies Hourly, Daily and Seasonally

Hourly Variation in Generation

[Graph showing daily and seasonal matching with forebays and storage]

[Graph showing hourly variation in generation with different labels for export, real time, day ahead, contracts, and Manitoba]
Lower Nelson Operations

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- 10 ft Operating Range
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Long Spruce/Limestone
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Lake Winnipeg Ice Limits Winter Outflows

Ice
Water
River Bottom

Elevation

660
665
670
675
680
685
690
695
700
705
710
Lake Winnipeg Inflow vs. Outflow
Averages for Period 1991-2010

Flow (1000 cfs)

Smoothed Average Inflow
Daily Average Avg Outflow

Lake Winnipeg Regulation

Modes of Operation

Flood Conditions
- Regulate for flood control
715 feet

Normal Conditions
- Regulate for power system economics
4 feet for power purposes

Conservation
- Outflows are set to ensure energy supply security
711 feet

Extreme Drought
- Outflows set by Minister of Water Stewardship
**Lake Winnipeg**

**Nelson River Water Supply**

**Fiscal Year Ending**

- **Churchill River**
- **Whole System**

**PUBLIC INVOLVEMENT SUPPORTING VOLUME**

**APPENDIX 4B: CLFN (PCN) ARTICLE 9 CONSULTATION PRESENTATIONS**

4B-157
QUESTIONS?