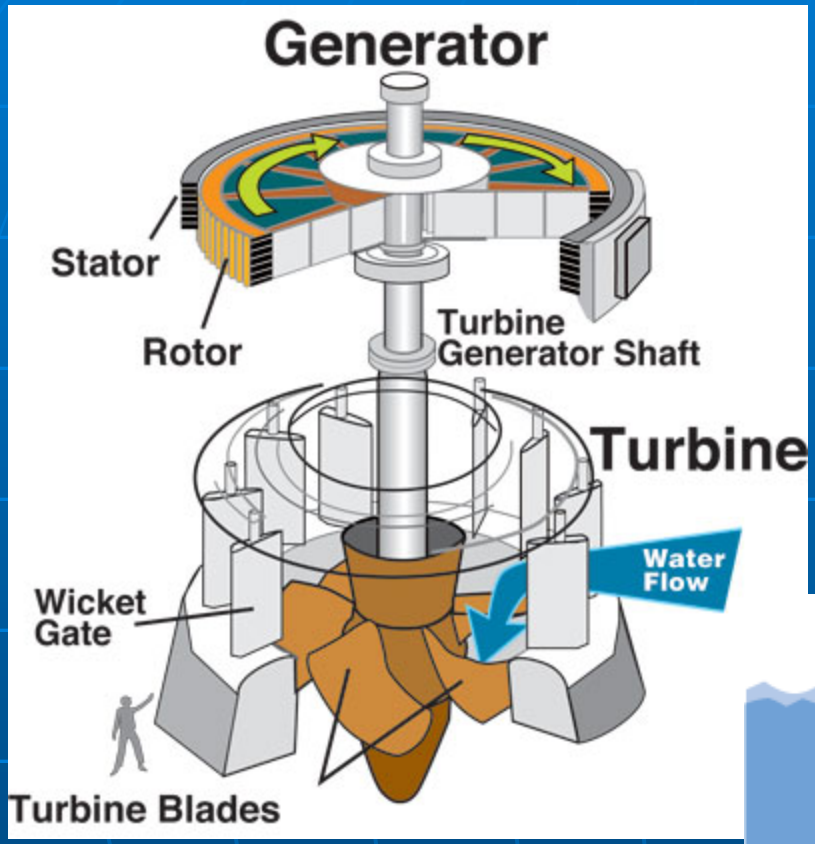
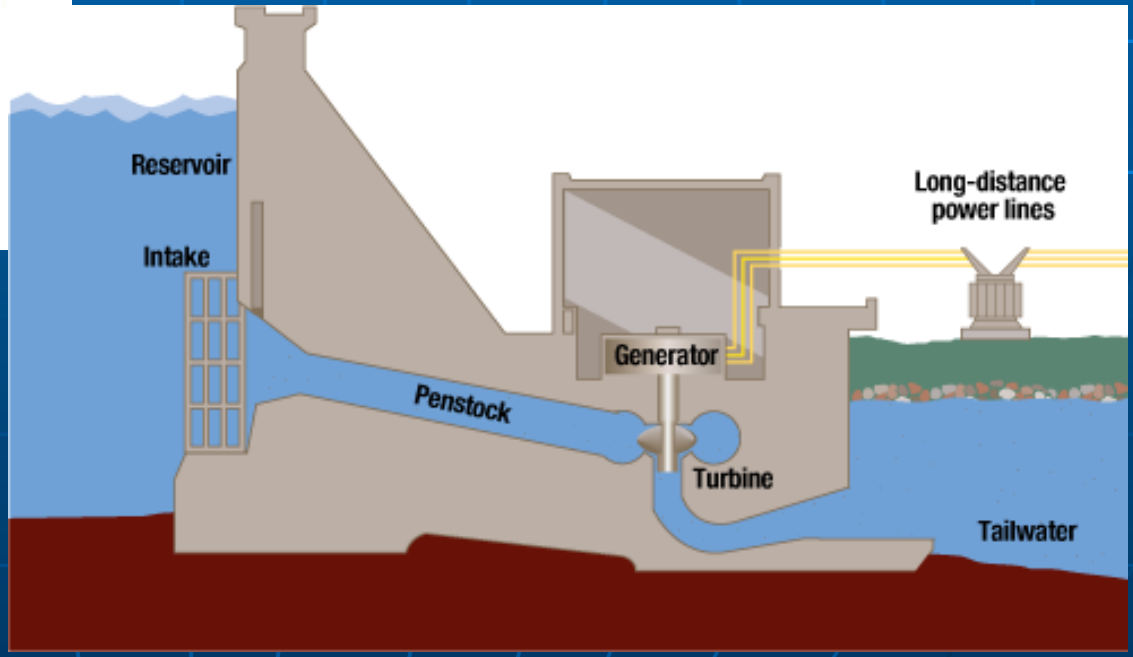
Hydro-Electric Development in Canada:

Past Recent Potential

Electricity production at a hydroelectric plant



Height x flow x density of water x acceleration (gravity) = electricity produced.



Kakabeka Falls

Hydroelectric power production:

P = ρhrgk where,

- **P is the electric power in watts**
- **ρ is the density of water (~1000 kg/ m^3)**
- **h is the height in metres**
- **r is the flow rate in cubic metres/ second**
- **g is the acceleration from gravity of 9.8 m/s^2**
- **k is the efficiency** (coefficient of efficiency from 0 to 1. Efficiency is often near 1 with larger, modern turbines.)

Example: Kakabeka Falls

P = ρhrgk

= (1000 kg/m^3 x 58 m x 31 m^3/s x 10 m/s^2 x 1) = 17,980,000 watts = 17.98 MW

Effects of Dams

Dams change the character of rivers

- Reservoir water temperature
- Bottom of reservoir is colder
- Barriers to migration
- Water can be uniform or erratic (habitat change)
- Generally low in dissolved oxygen
- Water flow and quantity variations harmful to downstream aquatic wildlife
- Sediment build-up in reservoir
- Removal of dams difficult (removing small dams in the US a new management technique).

Hydroelectricity And The James Bay Project

The "Quiet Revolution" Resulted in Four Major Events:

- Resurgence of ethnic nationalism (Quebecois)
- Quebec's joining the urban/industrial world of North America and expansion in the size of its industrial labour force and business class
- Removal of the old elite
- Aggressive role in the province's affairs

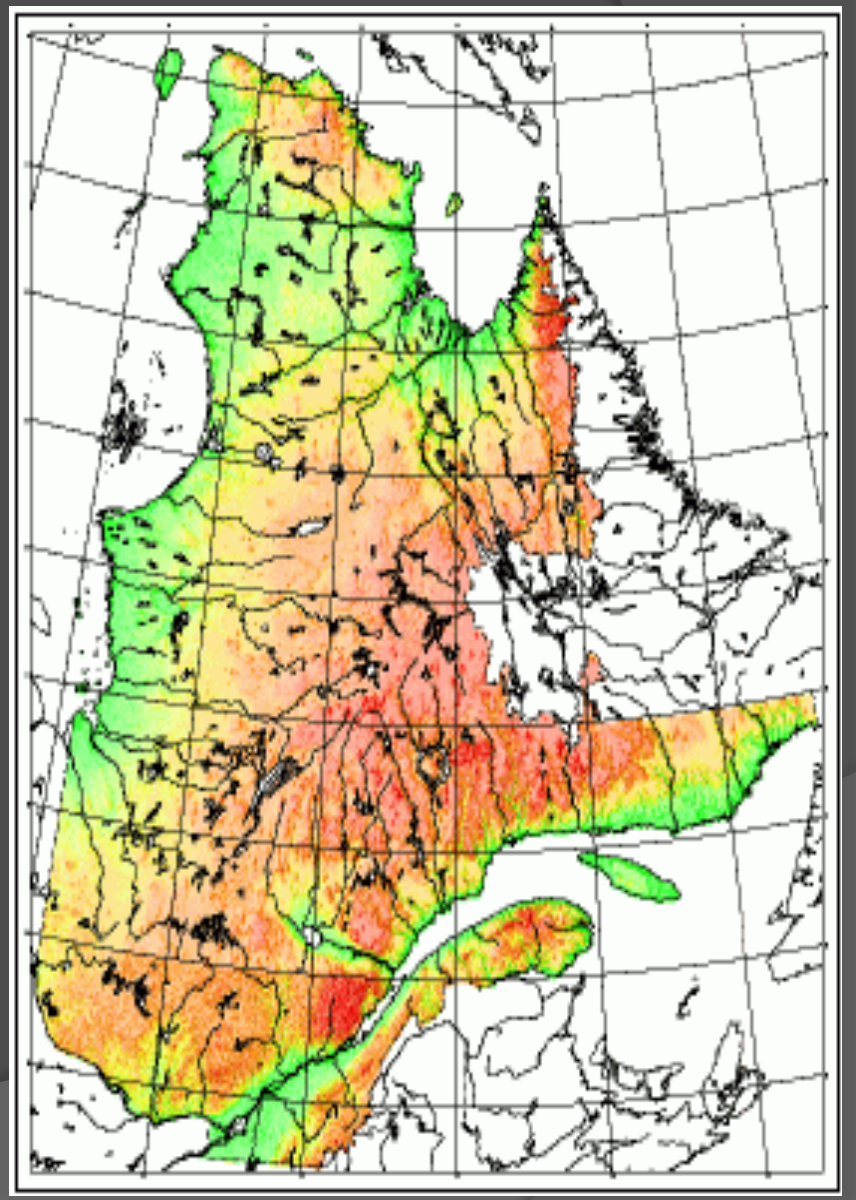
Hydroelectric Power in Quebec

Physical features

i. heavy annual precipitation

ii. high elevations of Can. Shield

- Massive hydroelectric plants
- Technology



Robert Bourassa Generating Station Spillway

Legal challenges

Cree vs Quebec

- 10,000-MW hydroelectric complex upstream from James Bay announced in 1970
- Opposition of 5,000 native Cree residents
- 1973 – The Cree get an injunction stopping construction
- The James Bay and Northern Quebec Agreement on signed on November 11, 1975. The agreement granted major financial compensation and management of health and education services to Cree communities in exchange for the continuation of the project.

Great Whale Project

Legal challenges (cont.)

Great Whale Project

- Total capacity of 3,160 MW
- Opposition of Cree, including lawsuits against Hydro-Québec, action in many U.S. states to prevent sales and appeals to the United Nations

Overhead crossing of Saint Lawrence River (1989)

- People in Grondines and Lotbinière opposed because of visual impact of the large towers
- A cable tunnel 4 km in length constructed: capacity 2250 MW

Disruptions of electrical supply

Geomagnetic storm: 1989

1998 ice storm: "triangle of darkness"

- Up to 80 hours of freezing rain and drizzle

Churchill Falls Generating Station

Construction began	1967
Opening date	1974
Construction cost	946 million
Hydraulic head	312.4 m (1,025 ft)
Turbines	11
Installed capacity	5,428 MW
Annual generation	35,000 GWh

Churchill Falls Generating Station

Second largest hydroelectric plant in North America

Legal challenges

Newfoundland and Labrador vs Quebec

- Quebec refused to allow power to be transferred - power was sold to Quebec
- Profits from the Upper Churchill contract: $1.7 billion per year for Quebec; Newfoundland and Labrador $63 million a year
- Two failed legal challenges
- Newfoundland and Labrador will be able to renegotiate in 2041.

Aboriginal rights?

Legal challenges (continued)

Aboriginal rights

- Development undertaken without agreement with the aboriginal Innu people of Labrador
- flooding of over 5,000 km^2 of traditional lands
- Offer of hunting rights plus $2 million compensation annually.

Legal challenges (continued)

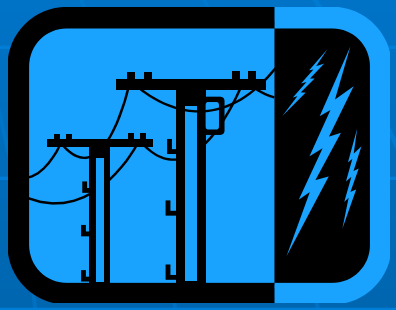
Lower Churchill Project

- Muskrat Falls - 824 MW. North dam 32 m high and 432 m long; the south dam 29 m high and 325 m long. The reservoir will be 59 km long with an area of 101 km^2
- Gull Island - 2,250 MW. Dam 99 m high and 1,315 m long with 213 km_2 reservoir (232 km long).

Labrador-Island Link

- Discussion

Ontario Electricity Supply in the Present



Future energy options for Ontario

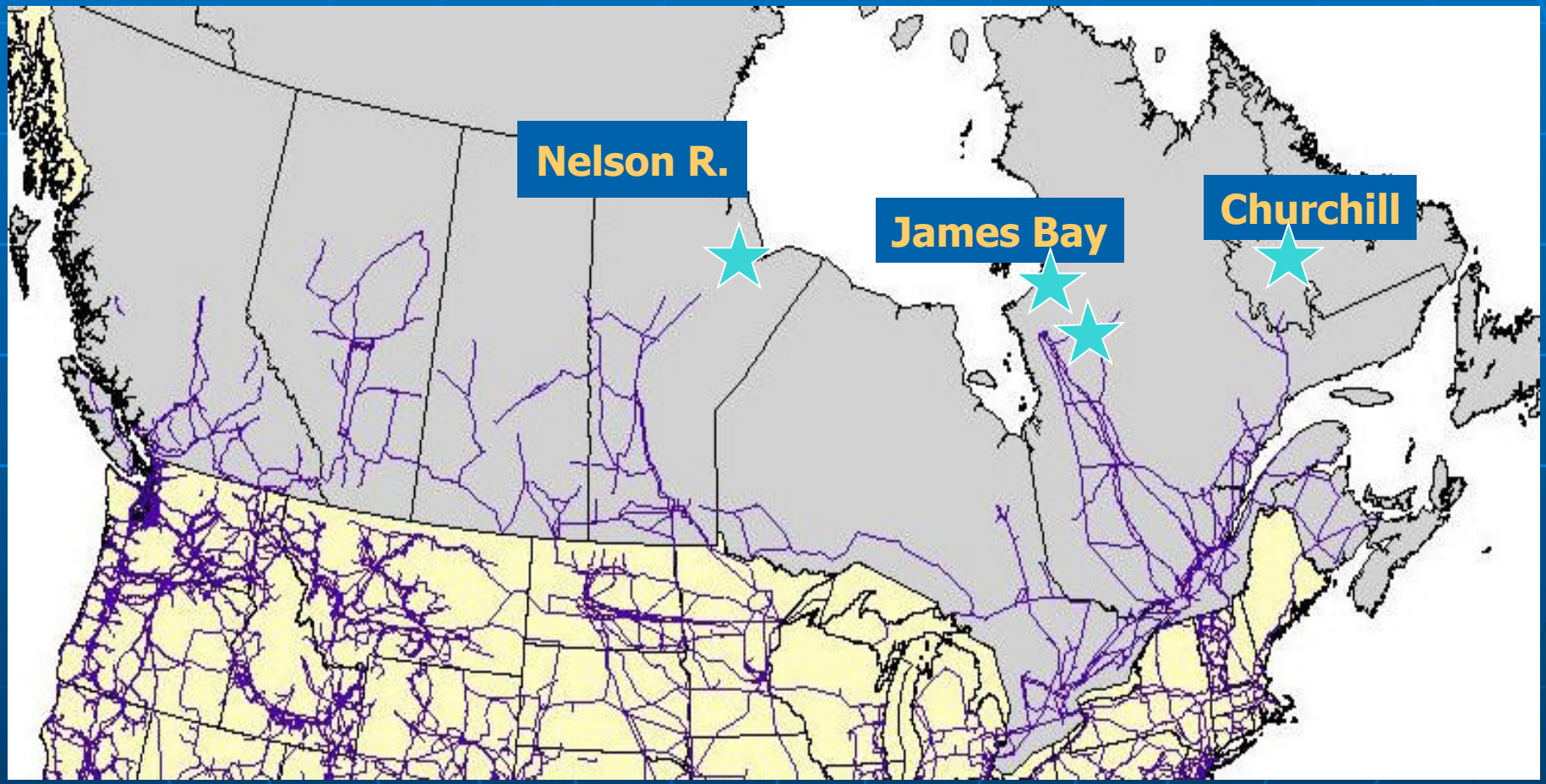
The Northwest Tie

Imports from

Quebec? Manitoba?

ONTARIO Installed Capacity MW	2003	2010	2030 (Projected)
Nuclear	10,061	11,446	12,000
Renewables – Hydroelectric	7,880	8,127	9,000
Renewables – Wind, Solar, Bioenergy	155	1,657	10,700
Gas	4,364	9,424	9,200
Coal	7,546	4,484	0
Conservation	0	1,837	7,100
Total	30,006	36,975	48,000

Canadian Hydro-Electric generation and transmission




Thunder Bay
Toronto
Ottawa
St.John's
Québec
Montréal
Boston, New York, Philadelphia, Washington
Houston
Miami
Puerto Rico
Mexico City
Havana

How do we assess large scale issues?

- Advantages
  - Costs – amount and for whom
  - Benefits – what and for whom
- Disadvantages
  - Dangers, Problems
- Externalities:
  - Economic
  - Social
  - Environmental
- Future supply

  (Especially critical with energy and resources)

Hydroelectric

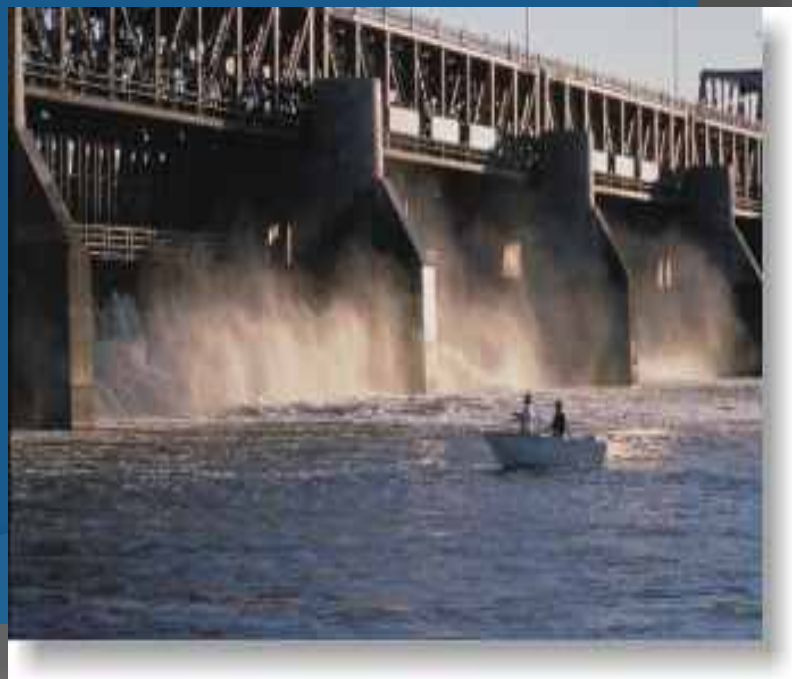
Advantages

Cost
(full cycle)

Disadvantages

Externalities

Lifetime



Coal - Natural gas

Advantages

Cost
(full cycle)

Disadvantages

Externalities

Lifetime

Nuclear

Advantages

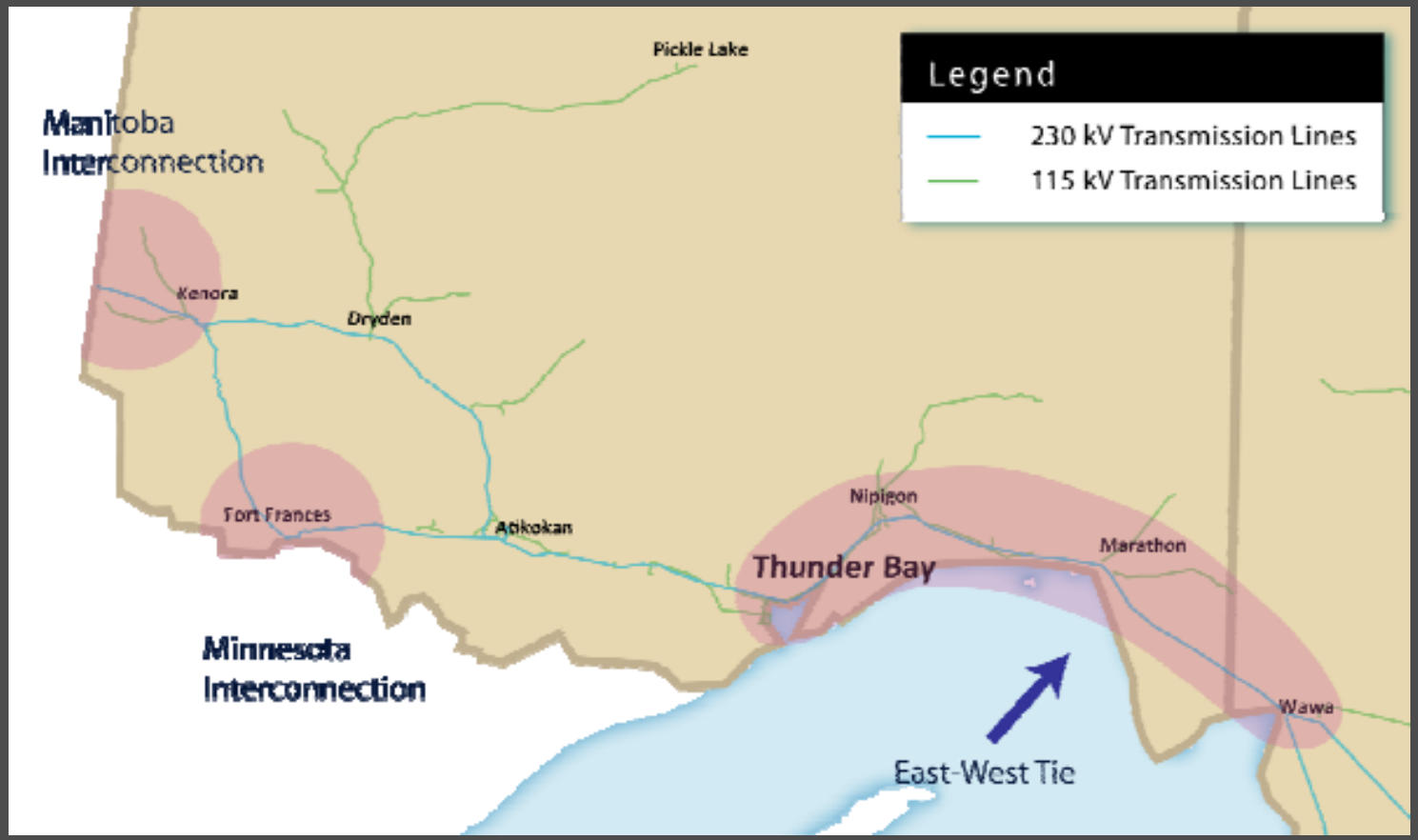
Cost
(full cycle)

Disadvantages

Externalities

Lifetime

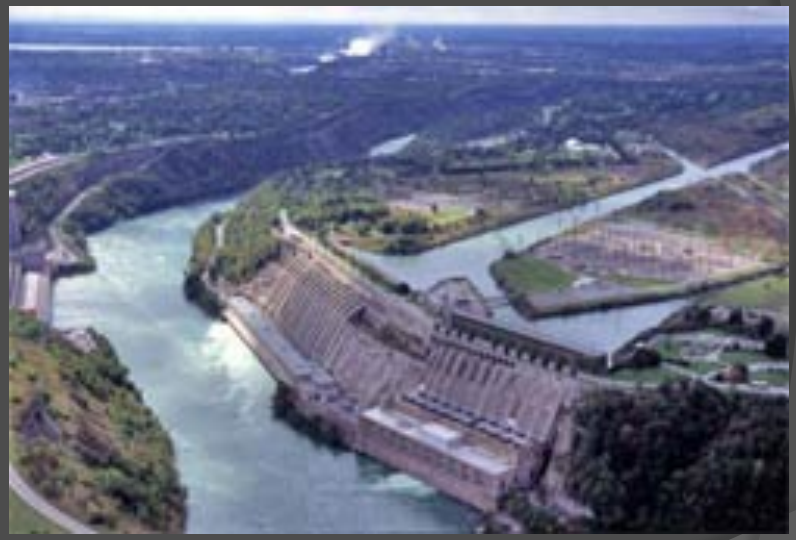
Figure 2 Transmission Lines in the West Grid
Import capacity to 570 MW, export to 490 MW



Discussion of proposed Tie Line

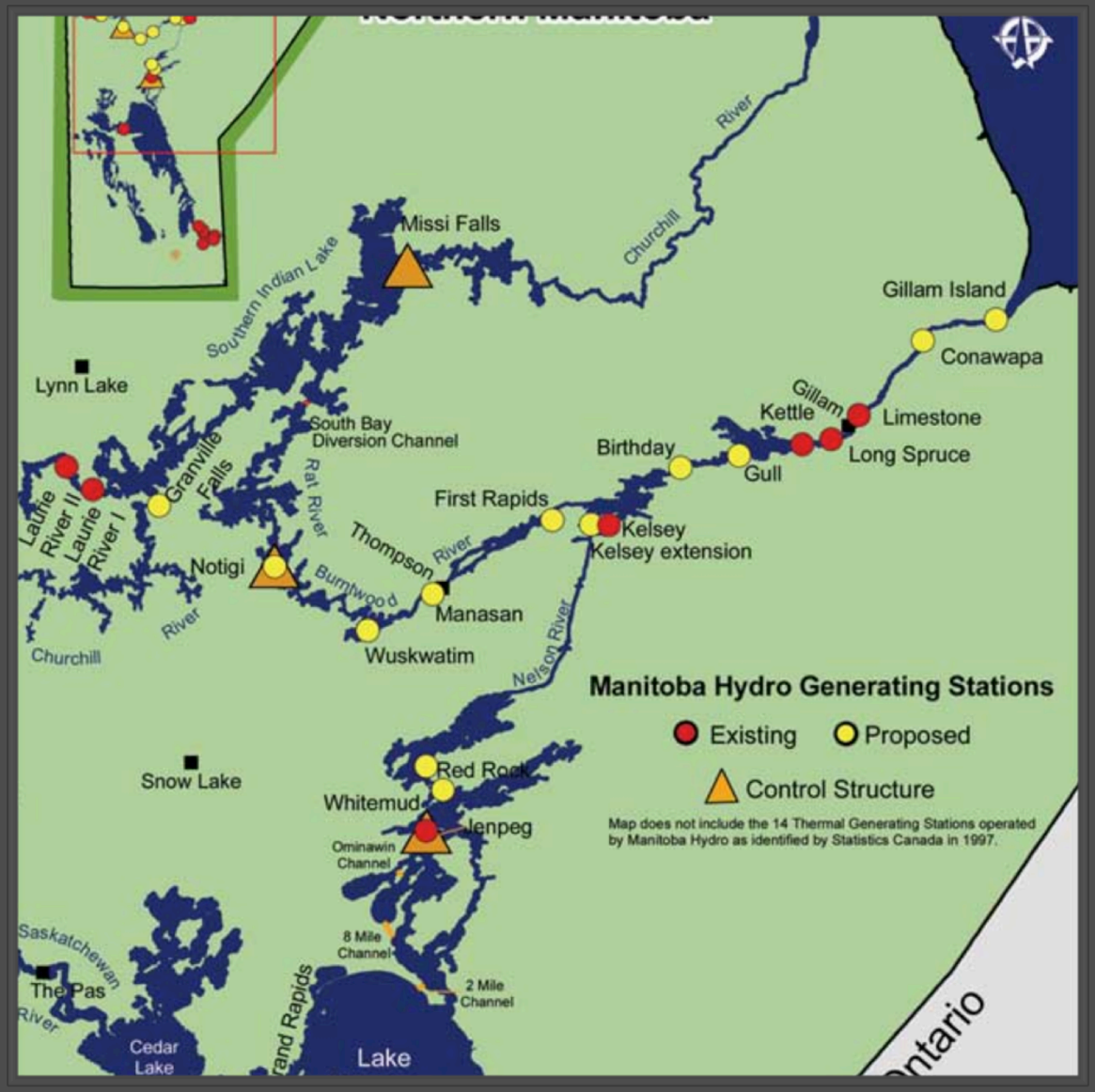
National East-West Power Grid

Manitoba, Quebec and Newfoundland have huge hydroelectric resources.



Ontario?

Northern Manitoba Hydro-electrical



Conawapa Generating Station

- Lower Nelson River, Manitoba
- 1250 mW
- no significant water storage upstream, i.e. limited flooding (about 5 sq. km, almost entirely within the natural banks of the Nelson River)
- Cost of $5 billion, 9 year construction period, approximately 2021.

Fox Lake Cree Nation Sign Agreement

Funding to Fox Lake to facilitate involvement in planning and consultation in project plans, "environmental and regulatory matters, training, employment and business opportunities, and the negotiation of adverse effects arrangements"

Elders in the community remain cautious and balance economic benefits, community concerns, and previous experience of the Fox Lake Cree Nation (and other First Nations) with Manitoba Hydro.

Clean Energy Transfer Initiative

Details and Routes

- Via Winnipeg and Thunder Bay
- Direct to Thunder Bay
- Direct to Timmins
- Hudson Bay to Timmins

Nelson River Transmission Lines