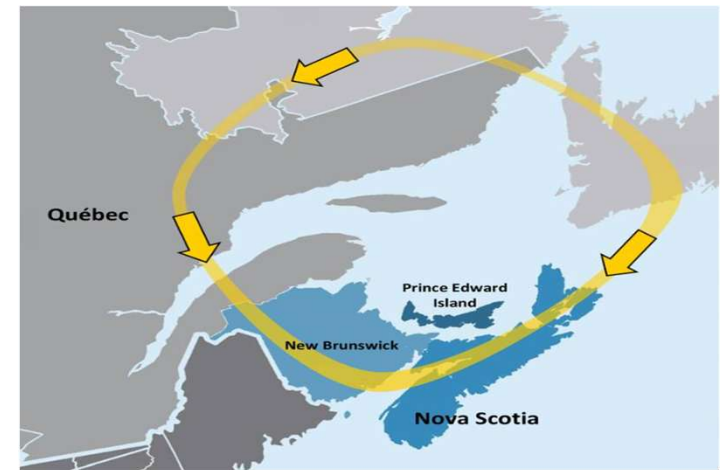


# Energy in New Brunswick “Setting the Stage”

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October 11, 2023



Energy impacts us in every way possible.

## What is Energy?

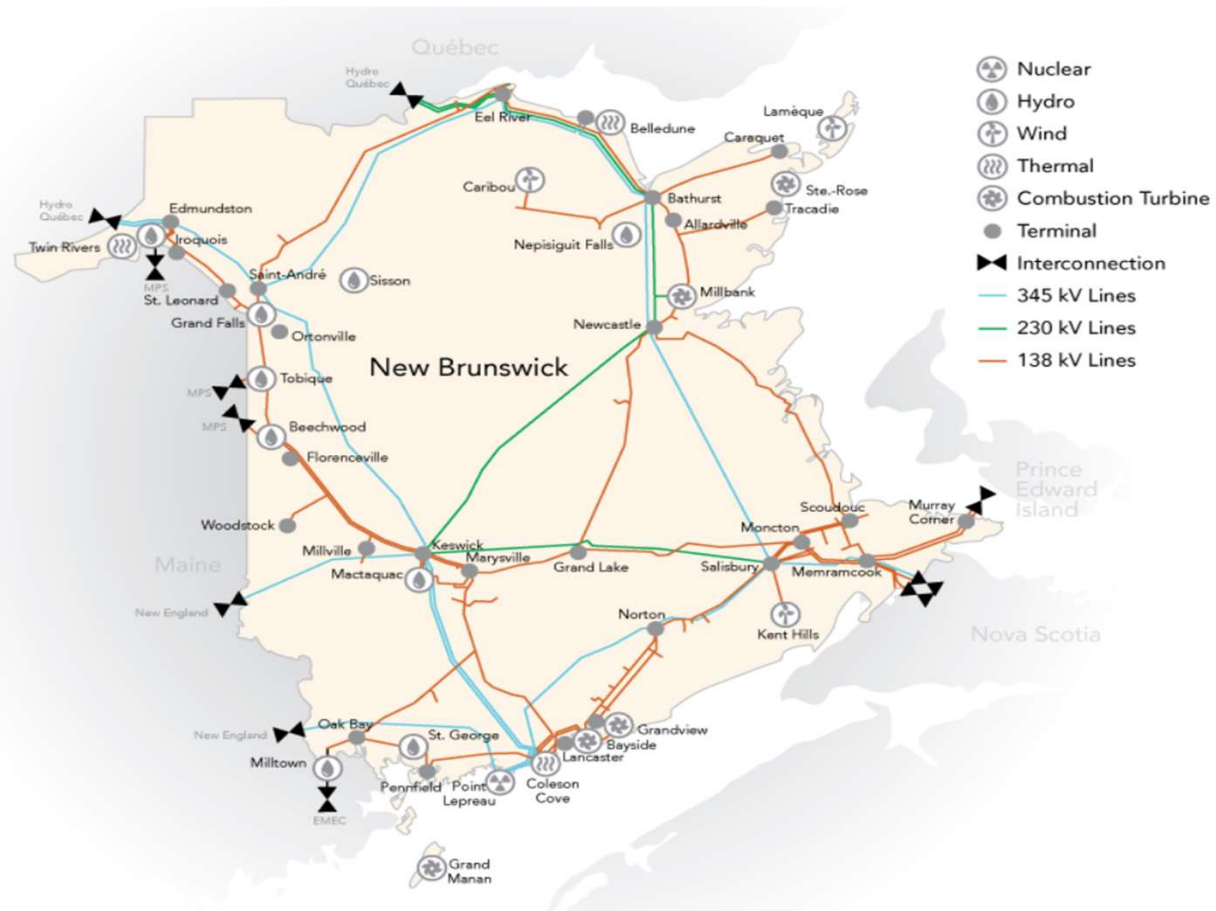
Energy makes change. Energy moves cars along the road and boats over the water. It bakes a cake in the oven and keeps ice frozen in the freezer. It plays our favorite songs on the radio and lights our homes. Energy makes our bodies grow and allows our minds to think. Scientists define energy as the ability to do work. People have learned how to change energy from one form to another so that we can do work more easily and live more comfortably.



$$z_1 g + \frac{1}{2} V_1^2 + u_1 + p_1 v_1 + w_{in} + q_{in} =$$
$$z_2 g + \frac{1}{2} V_2^2 + u_2 + p_2 v_2 + w_{out} + q_{out}$$

The energy equation is a statement of the 1<sup>st</sup> Law of thermodynamics conservation of energy;

***“Energy cannot be created or destroyed, it may only be transformed from one form into another”.***



- 1920 – Musquash Dam - **\$2M**
- 1920s/30s – Several private builds occur including Grand Falls
- 1931 – Grand Lake – using an average of 20,000 tons of coal per year
- 1940s – Build up of grid infrastructure – leads to problems!
- 1950s – Tobique is built – NB gets it's first international interconnection
- 1959 – Courtney Bay Unit 1 built – Unit 3 finished in 1966.
- 1966 – Mactaquac comes online - **\$130M**
- 1969 – Dalhousie Power is built
- 1977 – Coleson Cove starts using oil – by 1982 Oil has risen 1000% in cost.
- 1983 – Point Lepreau Nuclear Station – A worlds first CANDU, but not the only one!
- 1985 – More Quebec Interconnects
- 1993 – Belledune Generation Station + first sulphur scrubber in Canada - **\$1B**

Generating Capacity Thermal		
Coleson Cove	972	MW
Belledune	467	MW
Bayside	284	MW
<b>Total Thermal</b>	<b>1,723</b>	<b>MW</b>

Generating Capacity Hydro		
Mactaquac	668	MW
Beechwood	112	MW
Grand Falls	66	MW
Tobique	20	MW
Nepisiguit Falls	11	MW
Sisson	9	MW
Milltown	3	MW
<b>Total Hydro</b>	<b>889</b>	<b>MW</b>

Generating Capacity Nuclear		
Point Lepreau	663	MW

Generating Capacity Combustion Turbines		
Millbank	397	MW
Ste. Rose	99	MW
Grand Manan	29	MW
<b>Total Combustion Turbines</b>	<b>525</b>	<b>MW</b>

Total Generating Capacity		
Thermal	1,723	MW
Hydro	889	MW
Nuclear	663	MW
Combustion Turbines	525	MW
<b>Total Generating Capacity</b>	<b>3,800</b>	<b>MW</b>

Power Purchase Agreements (PPAs)	
Kent Hills (Wind)	167 MW
Caribou Mountain (Wind)	99 MW
Lamèque (Wind)	45 MW
Wisokolamson Energy (Wind)	18 MW
Wocawson Energy (Wind)	20 MW
Grandview (Natural Gas)	95 MW
Twin Rivers (Biomass)	39 MW
Irving Pulp & Paper (Biomass)	33 MW
AV Nackawic (Biomass)	26 MW
AV Cell (Biomass)	21 MW
Edmundston Hydro	9 MW
Other Renewable	22 MW
<b>Total Power Purchase Agreements</b>	<b>594 MW</b>

Number of Lines	
Distribution Lines	21,717 km
Transmission Lines	6,868 km

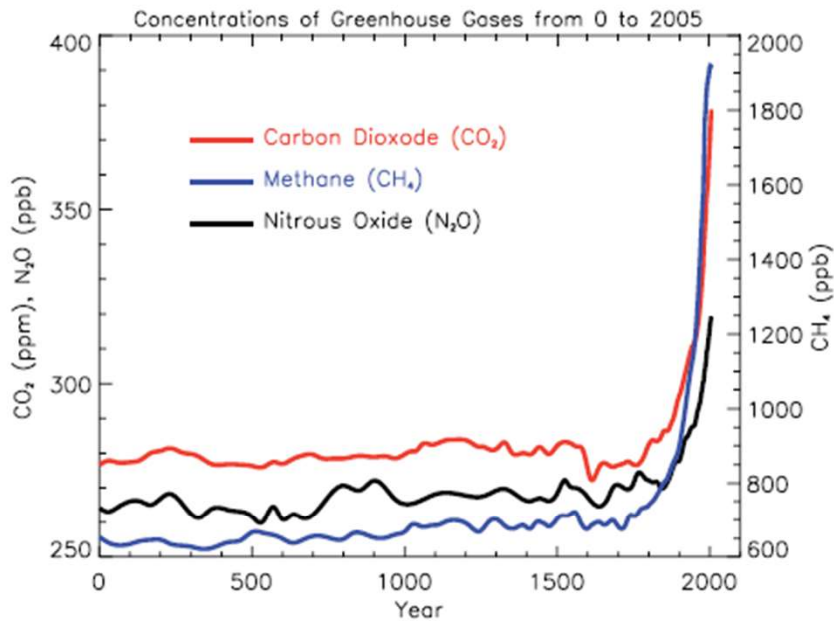
Exporting and Importing Capacity	
Export Capacity	2,538 MW
Import Capacity	2,448 MW

Number of Customers	
Direct Customers	379,148
Indirect Customers	46,365
<b>Total Customers</b>	<b>425,783</b>

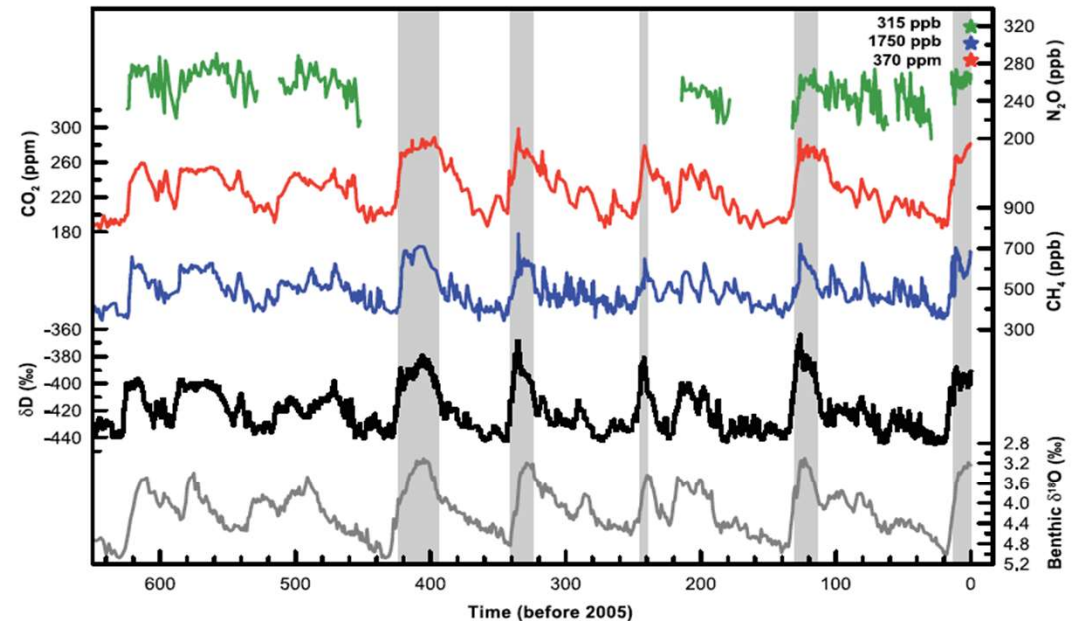




## Atmospheric Trends



## Ice Ages

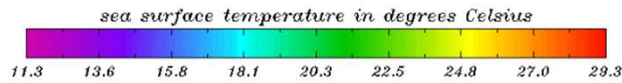
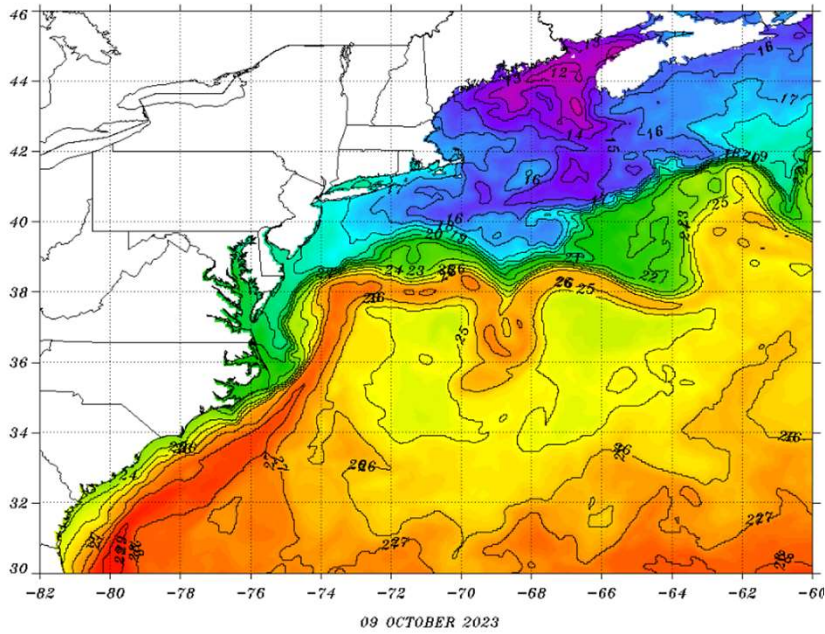


**FAQ 2.1, Figure 1.** Atmospheric concentrations of important long-lived greenhouse gases over the last 2,000 years. Increases since about 1750 are attributed to human activities in the industrial era. Concentration units are parts per million (ppm) or parts per billion (ppb), indicating the number of molecules of the greenhouse gas per million or billion air molecules, respectively, in an atmospheric sample. (Data combined and simplified from Chapters 6 and 2 of this report.)

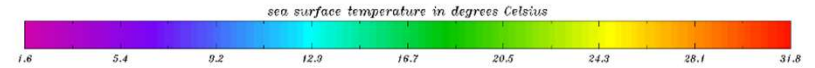
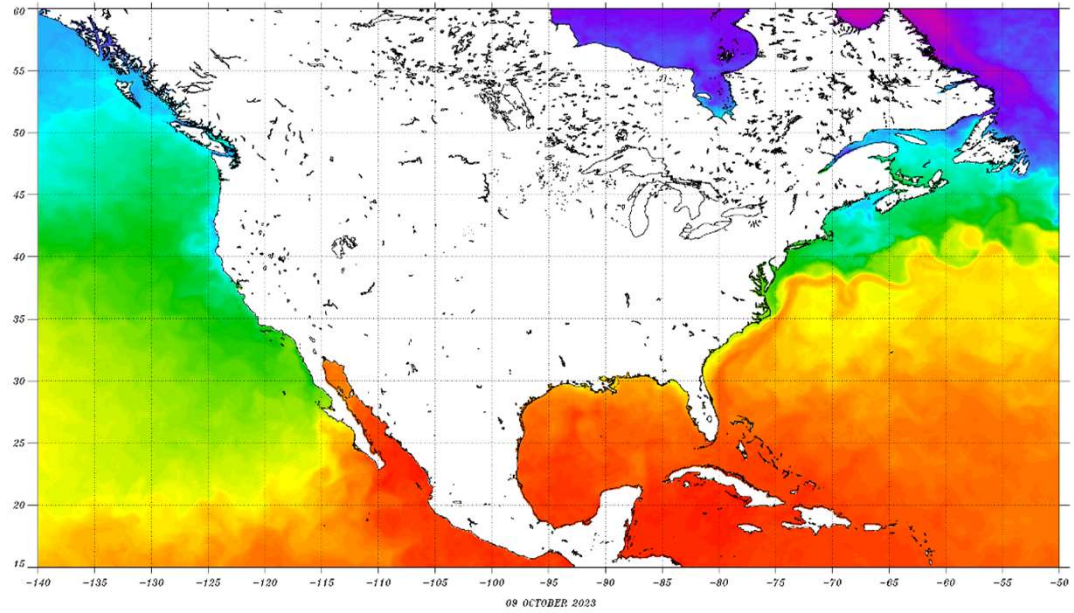
**Figure 6.3.** Variations of deuterium ( $\delta D$ ; black), a proxy for local temperature, and the atmospheric concentrations of the greenhouse gases  $CO_2$  (red),  $CH_4$  (blue), and nitrous oxide ( $N_2O$ ; green) derived from air trapped within ice cores from Antarctica and from recent atmospheric measurements (Petit et al., 1999; Indermühle et al., 2000; EPICA community members, 2004; Spahni et al., 2005; Siegenthaler et al., 2005a,b). The shading indicates the last interglacial warm periods. Interglacial periods also existed prior to 450 ka, but these were apparently colder than the typical interglacials of the latest Quaternary. The length of the current interglacial is not unusual in the context of the last 650 kyr. The stack of 57 globally distributed benthic  $\delta^{18}O$  marine records (dark grey), a proxy for global ice volume fluctuations (Lisiecki and Raymo, 2005), is displayed for comparison with the ice core data. Downward trends in the benthic  $\delta^{18}O$  curve reflect increasing ice volumes on land. Note that the shaded vertical bars are based on the ice core age model (EPICA community members, 2004), and that the marine record is plotted on its original time scale based on tuning to the orbital parameters (Lisiecki and Raymo, 2005). The stars and labels indicate atmospheric concentrations at year 2000.

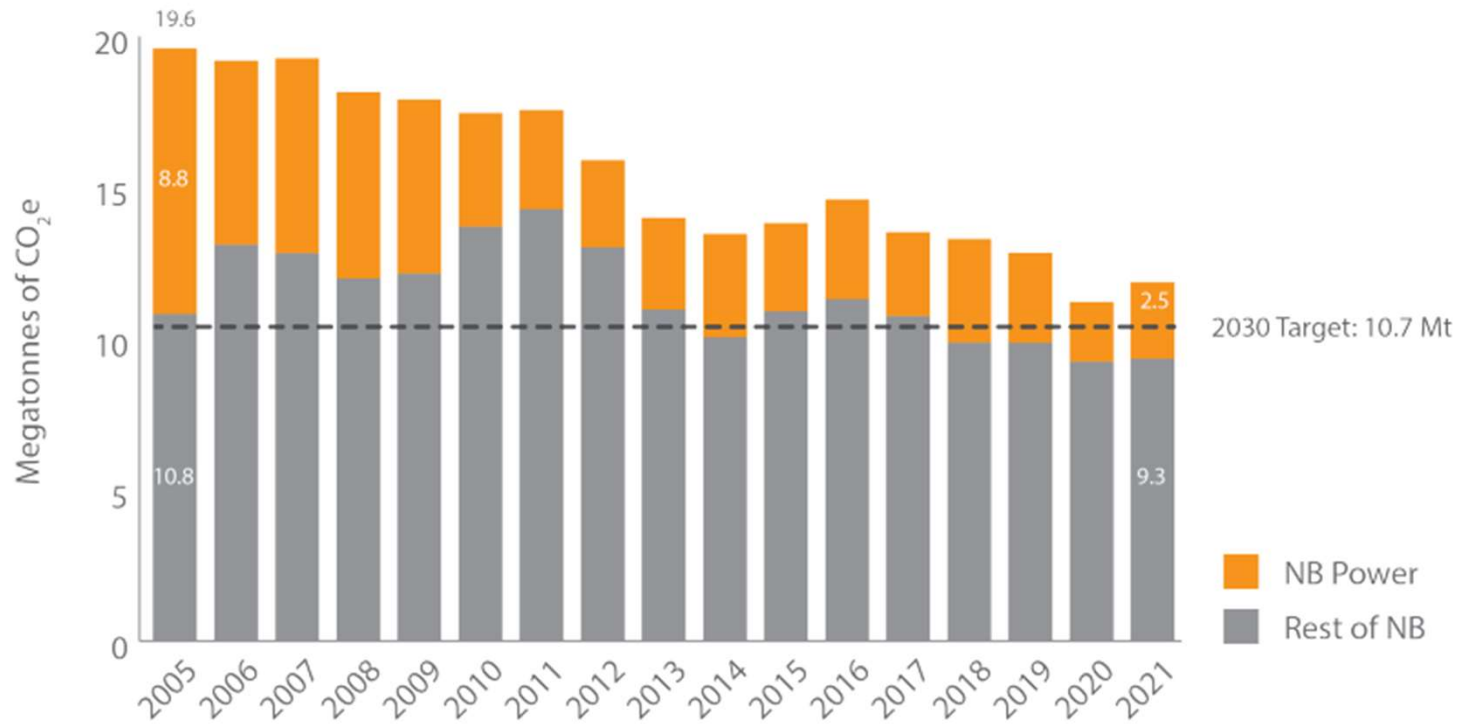


NOAA/NESDIS GEO-POLAR BLENDED 5 km SST ANALYSIS  
FOR THE NORTH ATLANTIC



NOAA/NESDIS GEO-POLAR BLENDED 5 km SST ANALYSIS  
FOR NORTH AMERICA



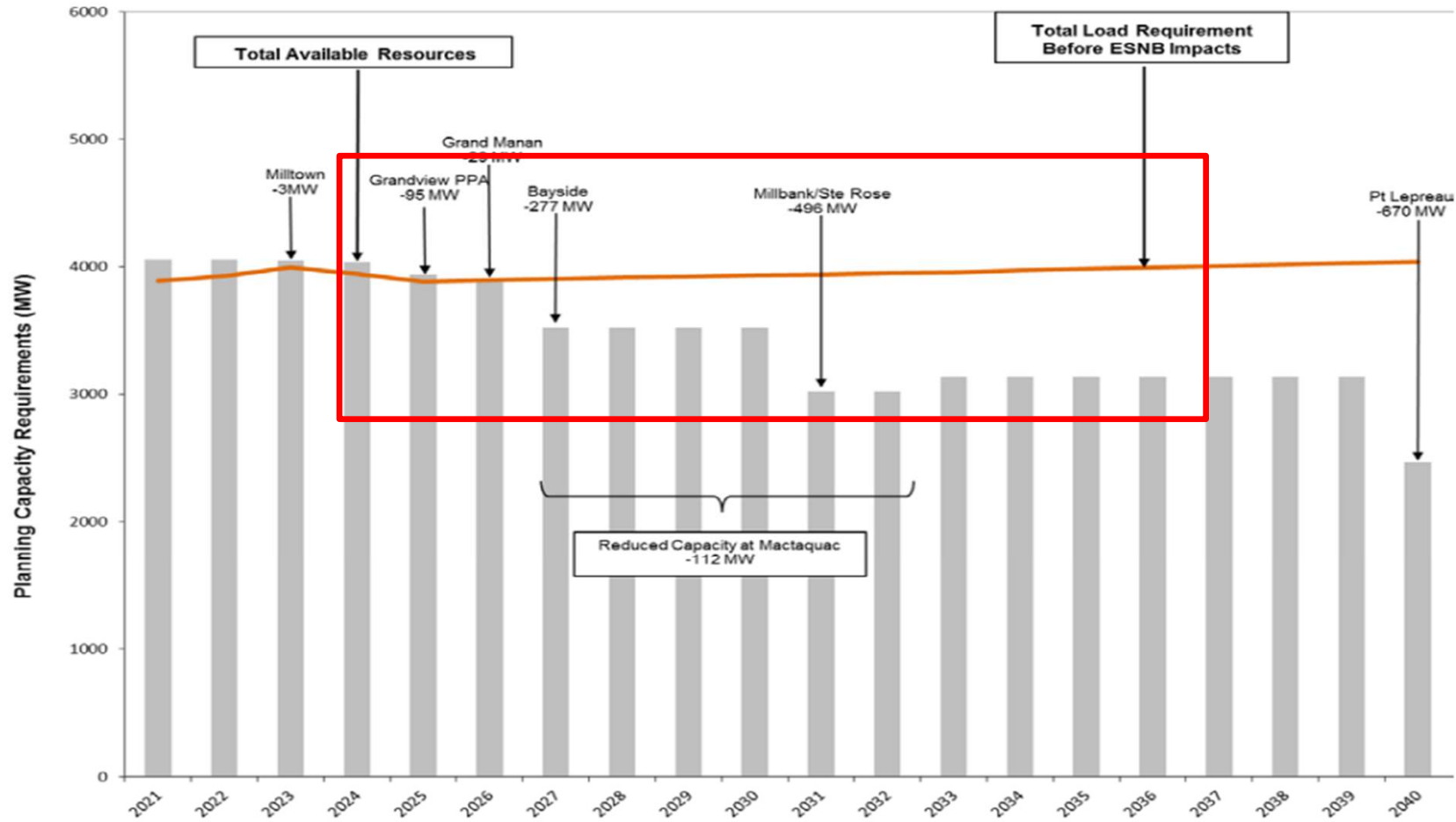


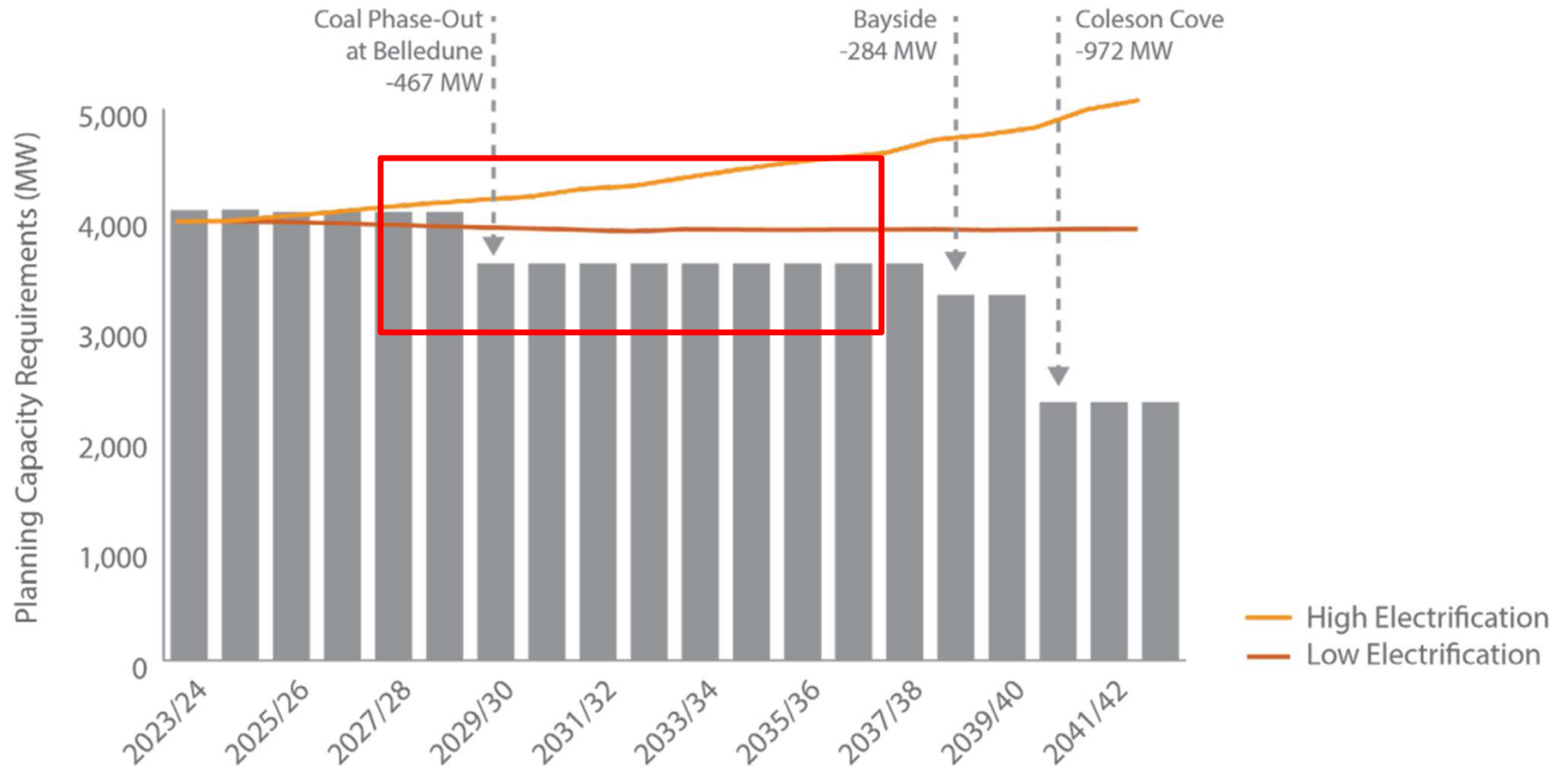
- Looming plant closures, refurbishments, & end of life
  - Mactaquac Life Achievement Project – 2028 through 2040 (**\$Billions?**)
  - Belledune 2030 (originally slated for 2043)
  - Point Lepreau 2041-2044 (after one refurbishment)
  - Coleson Cove 2040+ (mainly used for peaking so longer life?)
- Renewable Integration
  - Starting in the 1990s – around 400 MW of wind on the system today
  - Very minimal solar
  - No commercial geothermal
  - Tidal is experimental

- Public utility debt sits around \$5.4B
- Power rates in NB:
  - Residential - 12.27 ¢/kW
  - Large Industrial – 5.91 ¢/kW
- There are a number of factors:
  - Storms
  - Government decisions
  - Operations & maintenance
  - Unplanned events
  - Commodities markets & world events









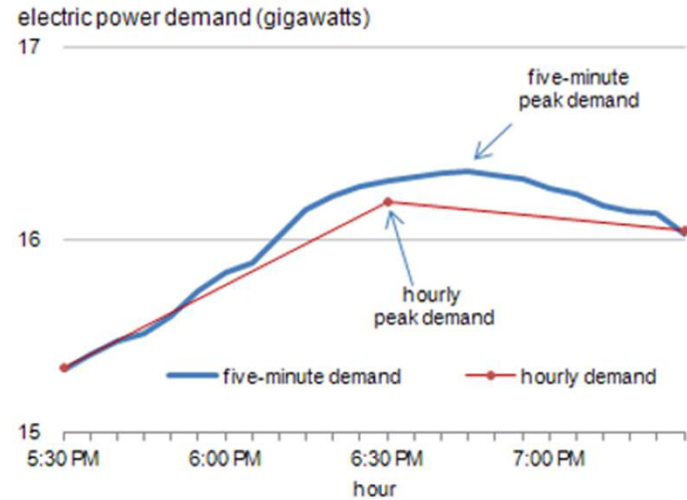
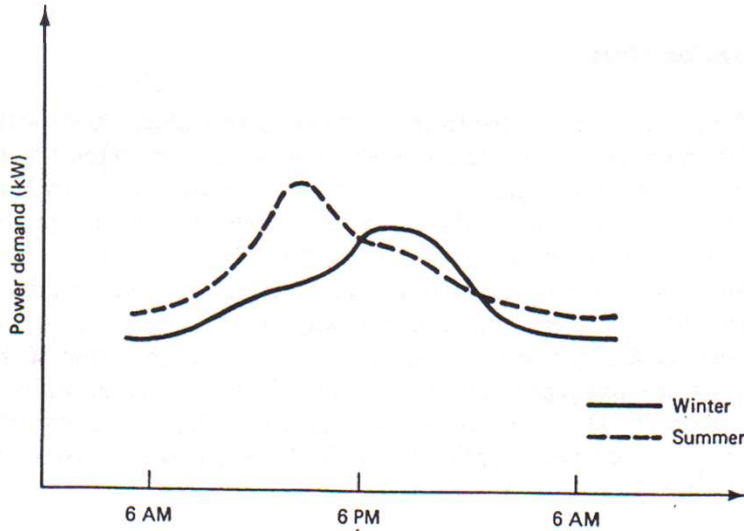
- Average North American growth is pegged at 3-4% a year.
- New Brunswick growth is traditionally less than 1% a year.
- There is a doubling time equation to product energy growth

$$t_{doubling} = \frac{0.693}{i}$$

- At New Brunswick's growth rate, the doubling time is 70 years.
- The EV challenge & Net Zero concept will complicate this as EV's are positioned to add 25% demand to the grid. Net zero challenges around conventional fuels will also present their own unique set of challenges.

- New Brunswick utilities are subject to the *Electricity Act*.
- NB Power must submit annually to the Energy & Utilities Board.
- Costly aging & new infrastructure projects fall under the purview of the NBEUB and must be discussed publicly such as:
  - Mactaquac life extension - \$2.7 - \$3.7B
  - Advanced Metering Infrastructure (AMI) - \$100+M
  - Coleson Cove / Bayside / Belledune work - ?
- Regulatory considerations such as carbon price (currently at \$65/ton).
- Political decisions.
- A power utility can set policy and direction as needed.





NB Load	NB Demand	Net Scheduled Interchange						Reserve Margins		
		ISO-NE	EMEC	MPS	QUEBEC	NOVA SCOTIA	PEI	10 Min Reserve Margin	10 Min Spinning Reserve Margin	30 Min Reserve Margin
3074	3216	-100	20	77	-1036	39	269	841	824	683

Note: For actual and scheduled columns, positive values are exports and negative values are imports.

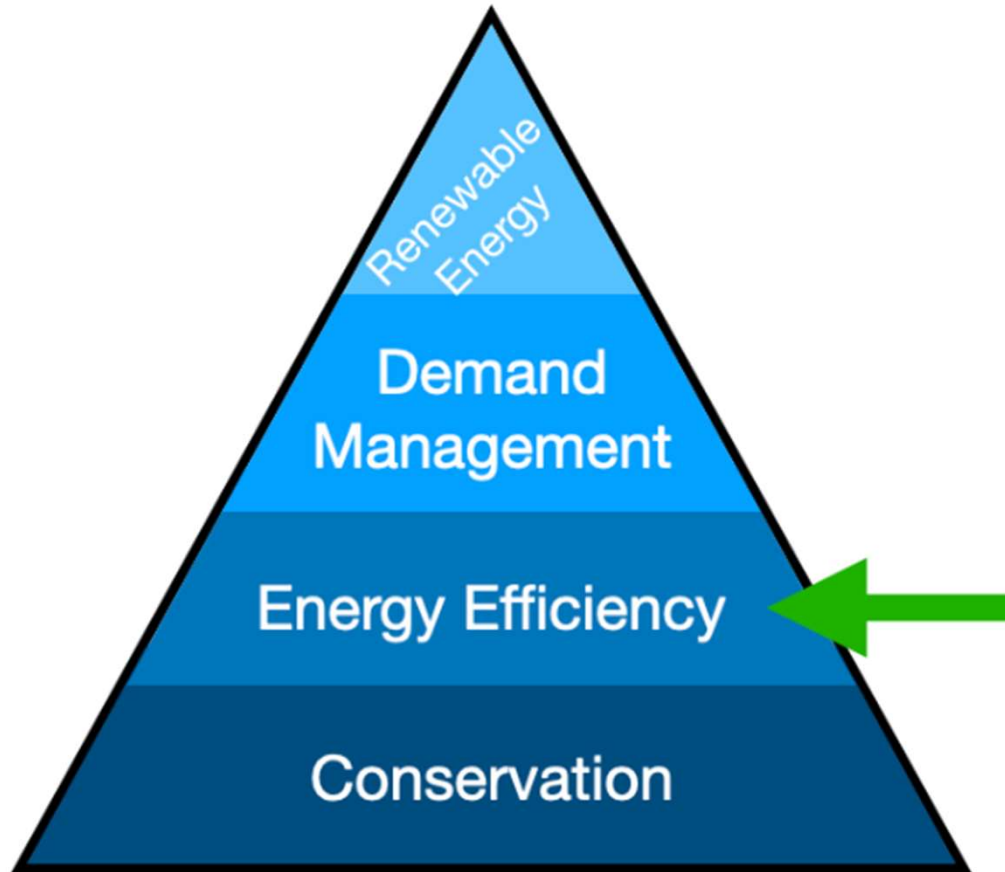
- Currently in New Brunswick you can participate in the net metering program if:
  - You generate electricity from a trusted renewable source
  - Do not produce more than 100 kW in nameplate capacity
  - Meet all certifications required to install the source
- The program is not designed to rebate you for additional energy you put on the grid, rather it appears as a credit on your bill.
- Any credits accrued as of March 31<sup>st</sup> of each calendar year will be lost when your net account is set back to zero.



- Smart Grid & Internet of Things (IOT)
- Electric Vehicles – NB target was 2500 vehicles by 2020.
  - 365 new Evs registered by mid 2023.
  - More charging stations needed.
- Energy Storage
  - Battery – Summerside Electric 500 – 1000 kW storage project
    - Government(s) of Canada & Ontario 250 MW battery storage facility for peak shaving
  - Molten Salts – Solar & SMRs
  - Thermal – Energy Dome's CO<sub>2</sub> battery project



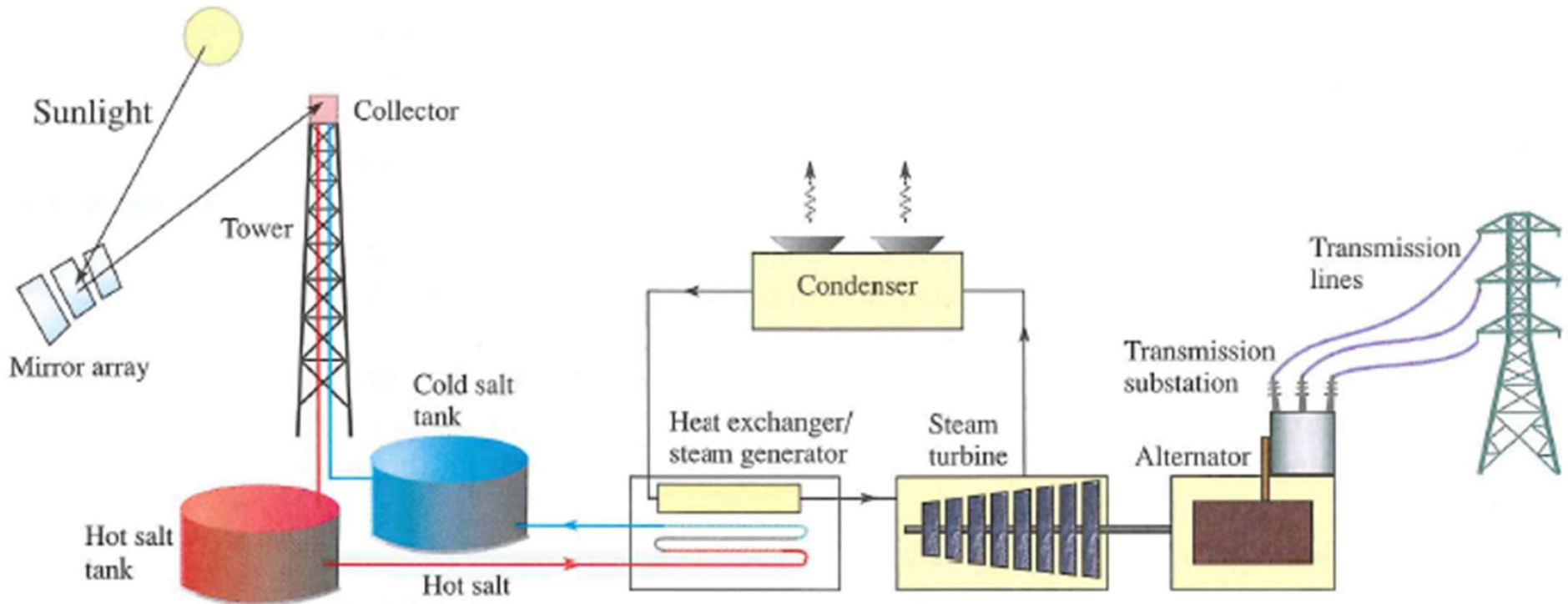
# The Energy Pyramid





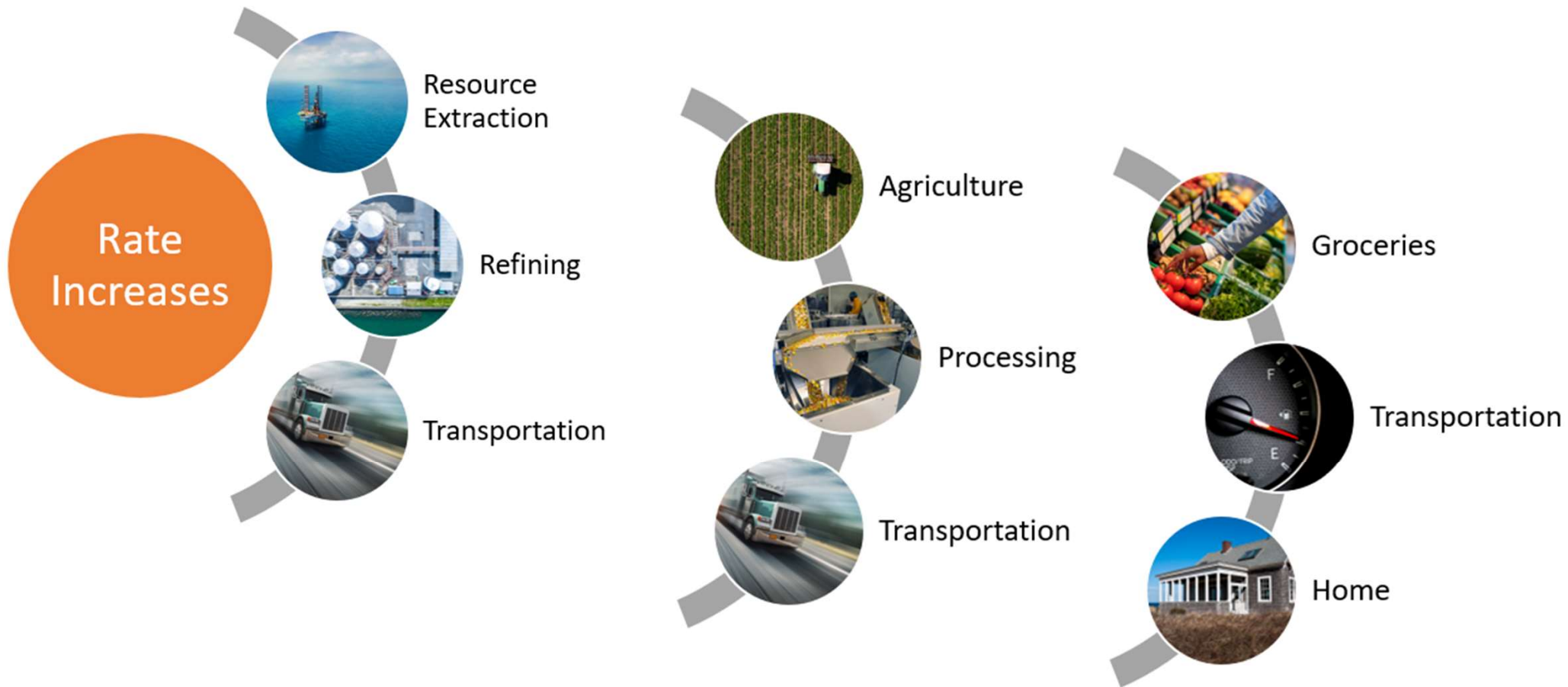
- Acknowledgements:
  - Dr. William Cook P. Eng. – Director at the Center for Nuclear Energy at UNB
  - NOAA - Sea Surface Temperature (SST) Contour Charts - Office of Satellite and Product Operations (noaa.gov)
  - NB Power www.nbpower.com
  - International Energy Agency www.iea.org
- Bradley J. McPherson – mcpherso@unb.ca  
Find me on LinkedIn





- 2030
  - Mactaquac refurbishment ~ \$3 Billion
  - Coal regulations take effect - \$0.5-1 Billion
  - First grid scale deployment of SMRs (2028-2033) - \$ ?
- 2040
  - Coleson Cove retires – 500-900 Mwe
  - Point Lepreau retires – 660 Mwe
  - Carbon price increase?
- 2050
  - Canada has joined over 120 countries in pledging net zero emissions.
  - 18 years until Mactaquac reaches end of life.

# The Trickle Down Effect



## SMR Skill Development and Nuclear Knowledge: Effective Preparation through Collaboration

