Maintaining Canada’s Economic Prosperity while Achieving Net-Zero by 2050; Net Zero Webinar #1

Presentation by;
Oskar Sigvaldason FCAE
An example of Canadian expertise and capability for deriving optimal pathways, strategies and policies for integrated, comprehensive, fact based planning for economic growth, GHG mitigation and transformation of energy systems
Trottier Energy Futures Project (TEFP)
Goal & Report

Goal; To assess options and pathways for reducing greenhouse gas emissions (GHG’s) in Canada by 80% by 2050, relative to 1990

Report; Canada’s Challenge & Opportunity;
Transformations for Major Reductions in GHG Emissions
(publically accessible from CAE website)
1. Funded by Trottier Family Foundation (TFF)
2. Co-sponsored by Canadian Academy of Engineering (CAE) and David Suzuki Foundation (DSF)
Trottier Energy Futures Project (TEFP) Approach and Methodology

1. Assembly of strong multi-disciplinary team from across Canada
2. Complementing use of two calibrated mathematical models; optimization model and simulation model
3. Data for models peer reviewed; expert review panel; electricity by CEA; petrochemicals by CAPP
4. Eleven scenarios
5. Objective was maximize present worth economic value for 2011 to 2050 period, to meet increasing demands and GHG mitigation targets, for all of Canada, and 13 jurisdictions
1. Growing demands with increasing population, GDP/capita, and industrial output; “real” growth in demand more than 100%
2. “No constraints” premise
3. Long term planning us a three phase process;
   - long term “pathways”
   - strategies
   - policies
4. Considerations, such as dispatch constraints and dependable capacity with intermittent renewables, differential costs of transmission grids, grid storage, changing costs over time, etc.
GHG Emissions in Canada (1990): 589 MT

- Fossil fuel production: 57 Mt (10%)
- Industrial processes: 56 Mt (10%)
- Non-combustion sources: 164.1 Mt (28%)
- Agriculture processes: 47 Mt (8%)
- Waste: 19 Mt (3%)
- Electricity: 92 Mt (16%)
- Transport: 146 Mt (25%)
- Residential: 43 Mt (7%)
- Commercial: 26 Mt (4%)
- Agricultural: 2.4 Mt (0%)

Trottier Energy Futures Project (TEFP)
Total and Non-combustion Emissions in 1990
Representation of Canada

<table>
<thead>
<tr>
<th>Code</th>
<th>Province/Territory</th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>AB</td>
<td>Alberta</td>
<td>West</td>
</tr>
<tr>
<td>BC</td>
<td>British Colombia</td>
<td>West</td>
</tr>
<tr>
<td>MB</td>
<td>Manitoba</td>
<td>West</td>
</tr>
<tr>
<td>NB</td>
<td>New Brunswick</td>
<td>East</td>
</tr>
<tr>
<td>NL</td>
<td>Newfoundland</td>
<td>East</td>
</tr>
<tr>
<td>NS</td>
<td>Nova Scotia</td>
<td>East</td>
</tr>
<tr>
<td>NT</td>
<td>Northwest territories</td>
<td>North</td>
</tr>
<tr>
<td>NU</td>
<td>Nunavut</td>
<td>North</td>
</tr>
<tr>
<td>ON</td>
<td>Ontario</td>
<td>Central</td>
</tr>
<tr>
<td>PE</td>
<td>Prince Edward Island</td>
<td>East</td>
</tr>
<tr>
<td>QC</td>
<td>Quebec</td>
<td>Central</td>
</tr>
<tr>
<td>SK</td>
<td>Saskatchewan</td>
<td>West</td>
</tr>
<tr>
<td>YT</td>
<td>Yukon</td>
<td>North</td>
</tr>
</tbody>
</table>
## Trottier Energy Futures Project (TEFP)

### Scenarios

<table>
<thead>
<tr>
<th>Premises Included</th>
<th>High Fossil Fuel Production</th>
<th>Low Fossil Fuel Production</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>No Reduction in GHG Emissions</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Reduction in GHG Emissions</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>No Additional High Voltage Inter-connections</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Additional High Voltage Inter-connections</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Change in &quot;Urban Form&quot;</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Addition of Second Generation Biofuels</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Addition of Carbon Capture and Storage (CCS)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Additional Electricity Export to U.S.</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Addition of Nuclear Generation</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>No Additional Nuclear Generation</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Addition of Biojet Fuel</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Addition of Bioenergy with CCS (BECCS)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Addition of Conventional Large Scale Hydro in B.C.</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
GHG Emissions in Canada (2050): 1109 MT
(Comparison to 1990: 589 MT)
Scenario 3: 60% GHG Reductions
## Final Energy in Canada -

### Scenario S1, S3, S3a, S8, S8a

<table>
<thead>
<tr>
<th>Year</th>
<th>S1</th>
<th>S3R60</th>
<th>S3aR60</th>
<th>S8R60</th>
<th>S8aR60</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>2,000</td>
<td>4,000</td>
<td>6,000</td>
<td>8,000</td>
<td>10,000</td>
</tr>
<tr>
<td>2030</td>
<td>22%</td>
<td>33% - 40%</td>
<td>56% - 60%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Electricity component**

- **Others**: Green
- **Hydrogen**: Blue
- **Biomass**: Light green
- **Electricity**: Dark green
- **Fossil fuels**: Brown

*Note: The percentage values are estimated and may vary depending on the actual data.*
Marginal Costs for Mitigating Combustion Emissions

2011$ per tonne of CO2-eq

- S3R60
- S3aR60
- S8R60
- S8aR60
1. Dominant source of combustion emissions is end uses (85%)
2. First priority is energy conservation and energy efficiency
3. Dramatic changes for meeting energy based end uses: fossil fuels decreasing from 74% to less than 25%; electricity increasing from 22% to more than 60%; biomass/biofuels increasing from 4% to more than 15%
4. Generating capacity increasing in Canada from 135,000 Mw to more that 500,000 Mw.
5. Decarbonizing electricity supply and transportation is early priority
6. Major increase in high voltage interconnections
7. CCS, carbon retention in forests and agriculture, and other carbon sinks and uses early priority for GHG mitigation
Engineering, Management and Technologies for Net Zero: Challenges and Strategies

The next five power points are a few selected examples of challenges and strategies that combine major engineering, management and technology developments, for achieving net zero, while simultaneously contributing optimally to Canada’s economic growth, and transformation of its energy systems.
Challenges and Opportunities
Grid Scale Electricity Supply

Challenges:
1. Three fold increase; 130,000 Mw to 500,000 Mw plus
2. Decarbonizing existing supply
3. Replacing and upgrading existing capacity
4. Interconnections
5. Grid scale storage

Strategies:
1. Bulk generation supply dominated by hydro, nuclear, thermal
2. Thermal supply increasingly dominated by natural gas; however, will require carbon capture – recent studies show this as very promising, especially in Western Sedimentary Basin
3. Hydro, including incremental capacity at existing sites, best complement for wind and solar intermittency
4. Interconnections, with large scale export from hydro dominated jurisdictions to thermal dominated jurisdictions
5. Large scale grid storage, for regional integration
Challenges and Opportunities
Low Cost Wind and Solar

Attraction:
1. Low cost
2. Quick and easy to install
3. Good public support

Challenges:
1. Virtually no contribution to dependable capacity
2. Highly variable output, requiring fast response compensating supply; hydro, pumped storage, batteries, grid expansion

Strategies:
1. Wind and solar should be maximized, up to system integration limits – limits which may be 20% or less, depending on composition of supply system
2. Planning for fast response compensating supply critically important; refer to CAETS Report: Solutions for High-Level Penetration of Intermittent Renewable Electricity
Challenges and Opportunities
Engineering and Project Delivery for Large scale Power Projects

Challenges:
1. Canada has lowest cost electricity supply in G7; derived from past investments in major projects – hydro, nuclear and thermal
2. Currently, major cost overruns and project completion delays with large projects; hydro, nuclear
3. Lack of public confidence in managing delivery of large projects
4. This was not the case 50 years ago; what has changed??
5. Expertise for engineering and delivery of large scale projects, in many organizations, has retired, and not been replaced; decision processes more politicized

Strategies:
1. Need to acknowledge politically and institutionally that this is a serious problem
2. Need to rebuild Canadian capacity for engineering and managing delivery of large infrastructure developments
3. Need to maintain this capacity by ensuring an ongoing sustained infrastructure development program – engineering, construction and installation
Challenges and Opportunities
Expanded Role for Forest Sector

Challenges:
1. Forest sector is major resources sector for long life harvested wood products (lumber), pulp & paper, biomass/ biofuels and specialty bio-products
2. Major potential as carbon sink;
   - Afforestation and reforestation
   - Lumber for buildings (long life carbon retention) and for export
   - Displacement of emissions intensive building materials (concrete, steel)
   - Bioenergy
   - Bioenergy with CCS (BECCS)
   - Improved harvesting

Strategies:
1. Expanded and optimized role of forest sector for economic growth (including export), and large scale carbon retention – integrated systems approach combined with bioscience
Challenges and Opportunities
CCUS

Opportunities:
1. Natural gas likely to assume major increased role for electricity supply in Canada and globally – will require CC. Current technologies include CO2 emissions down by 96% compared to conventional coal without CCS
2. Western sedimentary basin is one of best land based storage sites in the world for permanent deep CO2 sequestration
3. CO2 is feedstock for urea based fertilizer and methanol production, and other products; also, used for enhanced oil recovery.
4. Opportunities for capture, transport and disposal of CO2 important for industrial sectors, such as cement production

Strategies:
1. Acceptance that CCUS is absolutely essential for achieving net zero
2. Continued engineering and research for alternative capture technologies and improving existing approaches for efficiency, reduced thermal energy, and reduced parasitic losses
3. Comprehensive systems approach for optimally integrating capture, transport, use as feedstock, and disposal of CO2 in a multi-jurisdictional context
Integrating Engineering Developments with Comprehensive, Integrated Fact-based Planning for Achieving Net Zero

1. Challenge is to systematically define “optimal pathways” to achieve economic growth, reduce emissions and transform Canada’s energy systems

2. Recognition that the challenge is very complex, and that interplays between various sectors of the economy are very substantial

3. Costs for GHG mitigation are in trillions of dollars, but can be contained at a modest percentage of GDP, with systematic selection and implementation of “best decisions”

4. Planning needs to be fully integrated with progressive engineered improvements in technologies and innovations

5. Long term planning is three phase process;
   - long term “pathways”
   - strategies
   - policies

6. Output from planning and consensus building should serve as basis for continually updating engineering and research priorities
Maintaining Canada’s Economic Prosperity while Achieving Net-Zero by 2050; Net Zero Webinar #1

Thank you

Q & A

The Canadian Academy of Engineering
L’Académie canadienne du génie