The CESAR Pathways Project: *An Overview*

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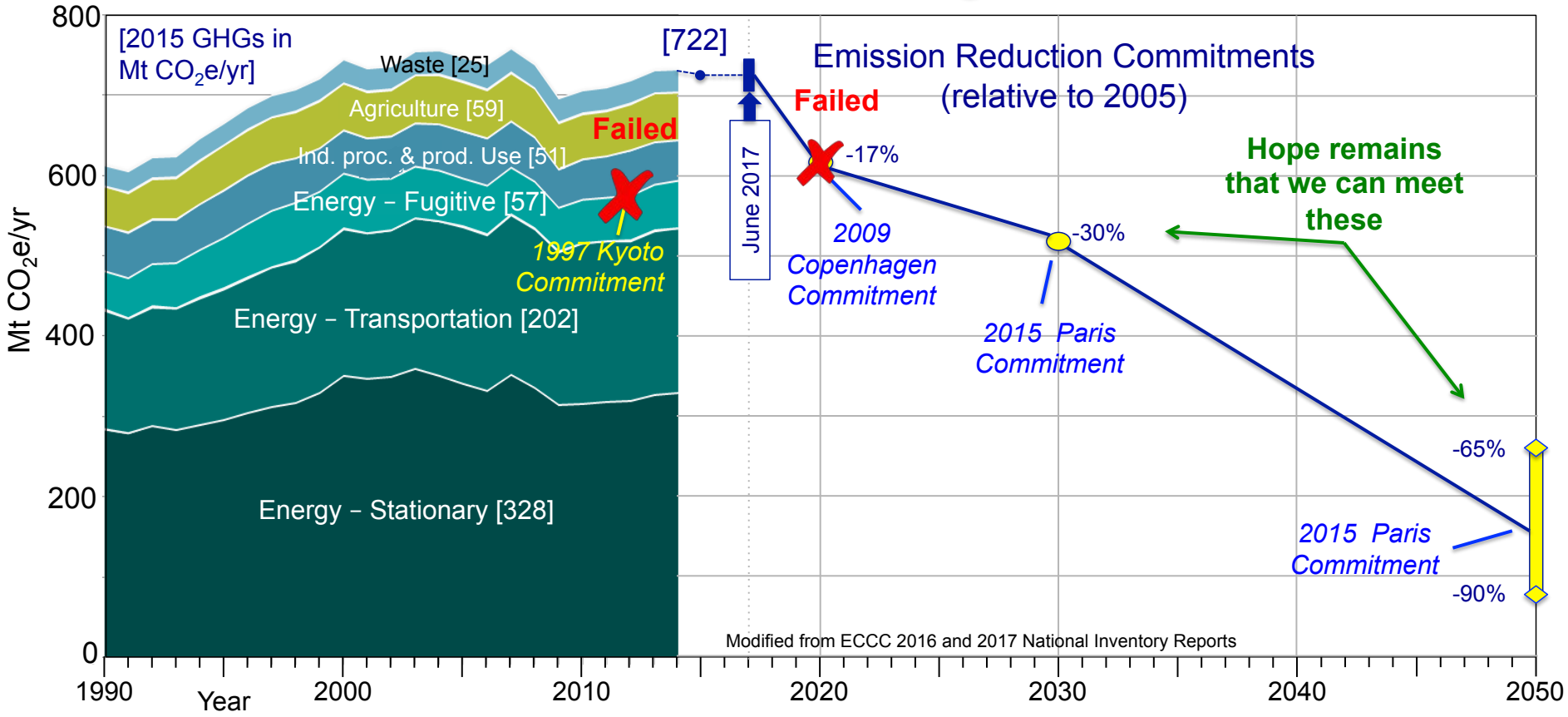
Canada's Greenhouse Gas (GHG) Emissions & Targets

CESAR CANADIAN ENERGY SYSTEMS ANALYSIS RESEARCH



Why did we Fail?

- Targets were set in the absence of a **Vision** and/or a **Strategy** for how to reach the objectives;
- The **Strategy** needs to include quantitative, evidence-supported details of the **Pathway(s)** envisaged to achieve the objectives. *This includes the nature and timing of technological, infrastructure and behavioural changes.*
- Lack of political will and public support
- …

Why Pathways?

- *To create tools for public engagement;*
- *To define the necessary timing and conditions for deployment;*
- *To identify potential winners and losers, and/or decision milestones;*
- *To provide metrics by which to measure progress towards the goal.*

What about the Paris Commitments?

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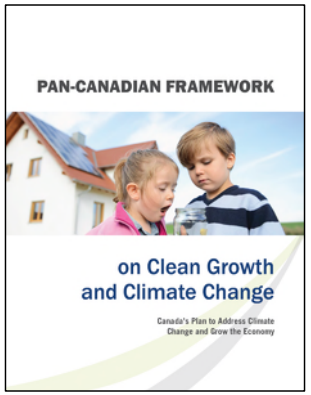
Pan-Canadian Framework



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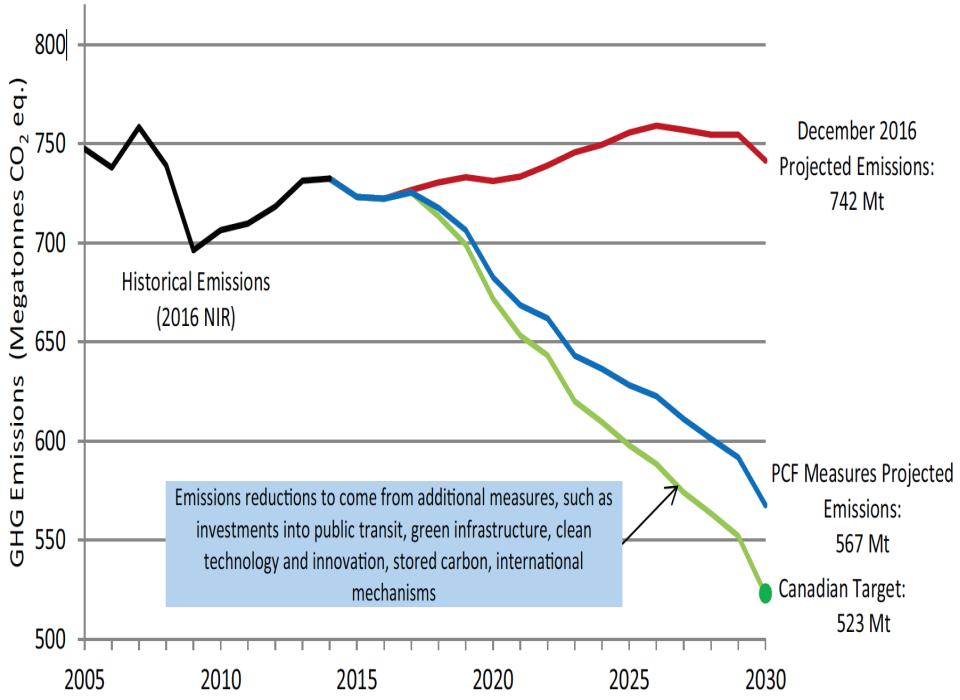
2–25 Pathway to Canada's 2030 target



From ECCC 2017, Nat'l Inventory Report

Four Scenarios are envisaged for the CESAR Pathways Project:

A. **'NEB' Reference**
B. **'CESAR' Reference**
C. **Transition Lite** (gentle movement of the 'levers' impacting GHGs)
D. **Deep Decarbonization** (adjust 'levers' sufficient to meet targets)

The CESAR Pathways Project

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1. Understand existing anthropogenic energy and carbon systems:
✓ Strengths & Weaknesses/unintended consequences (incl., but not limited to GHGs)

3. Identify alternative technologies or business models
✓ Esp. those that could address the unintended consequences

4. Create **Narratives** to describe a **compelling Vision** for a improved energy future

Five Narratives:

A. Personal Mobility
B. Supply Chain
C. Industry
D. Smart Grids & Efficient Space
E. Biological Solutions

2. Build a comprehensive, technology-rich model of Canada's energy systems.

CanESS

by whatIf? Technologies Inc, Ottawa, ON (CESAR partner)

Iteration

5. Identify 'levers' in the model that would need to be moved (how far and when) to realize the alternative energy future

6. Analyze modelled pathway(s)
✓ assess costs, benefits & tradeoffs; readjust as needed

7. Identify / recommend policy options

"We cannot predict the future, but we can invent it."
Dennis Gabor, Nobel Prize in Physics (1971)

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A: Personal Mobility

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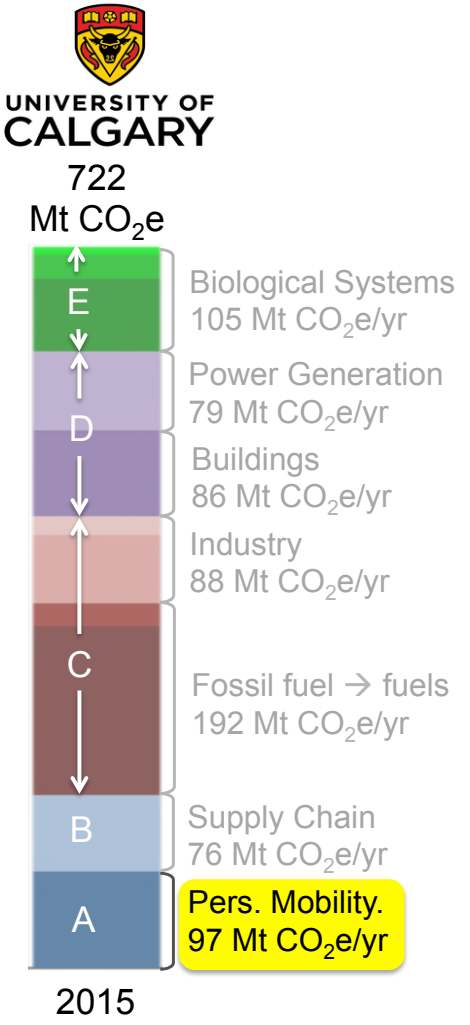

Problems:

- ✓ Car Accidents (~5% GDP)
- ✓ Congestion (productivity)
- ✓ Value for $ (cars unused 96%)
- ✓ Land use (esp. parking)
- ✓ Air pollution
- ✓ GHG emissions

Disruptive Forces (+/-):

- ➢ Autonomous Vehicles
- ➢ Shared Vehicles
- ➢ Electric Vehicles
- ➢ Generational changes

Key Energy Transition Opportunities:

- ➢ Convergence of **Autonomous, Shared & Electric Vehicles**:
  - With autonomous: Improved safety & productivity, reduced congestion only if integrated with public transit;
  - … + shared: lower costs, more convenient, right-sizing, electrification, reduced air pollution and GHG emissions;
  - Fewer registered vehicles on road, but more VKT/yr and PKT/yr;
  - New tax system to replace gas tax, discourage sprawl;
  - Densification of Urban design: reduced parking, more walkable communities;
  - Reduction in oil demand, price, production, emissions.

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B: Supply Chain

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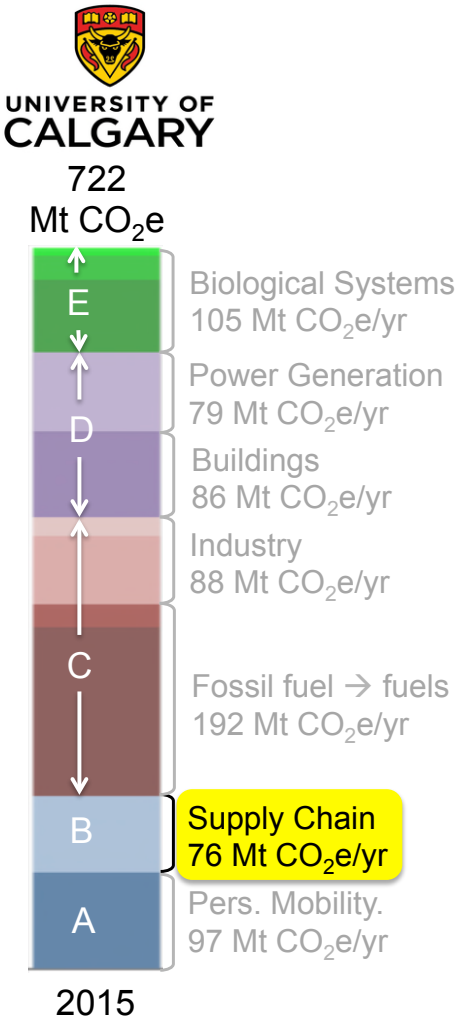

Problems:

- ✓ Air pollution (esp. PM)
- ✓ GHG emissions
- ✓ Rapid growth in demand
- ✓ Empty km travelled
- ✓ Mode shift: trains→trucks

Disruptive Forces (+/-):

- ➢ Retail → internet shopping
- ➢ Autonomous Trucks
- ➢ Electric Vehicles (esp. for 'last mile')
- ➢ Big data and robotics
- ➢ New biofuels / synfuels

Key Energy Transition Opportunities:

- ➢ Possible mode shift back to rail for LD freight (500 km+); may need changes in track vs. train ownership;
- ➢ Fuel / engine changes:
  - Electrification where possible
  - Alternative → Biofuels: Poss. CNG vehicles then RNG and SNG (Power to Gas)
- ➢ Improved vehicle use efficiency

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C: Industry

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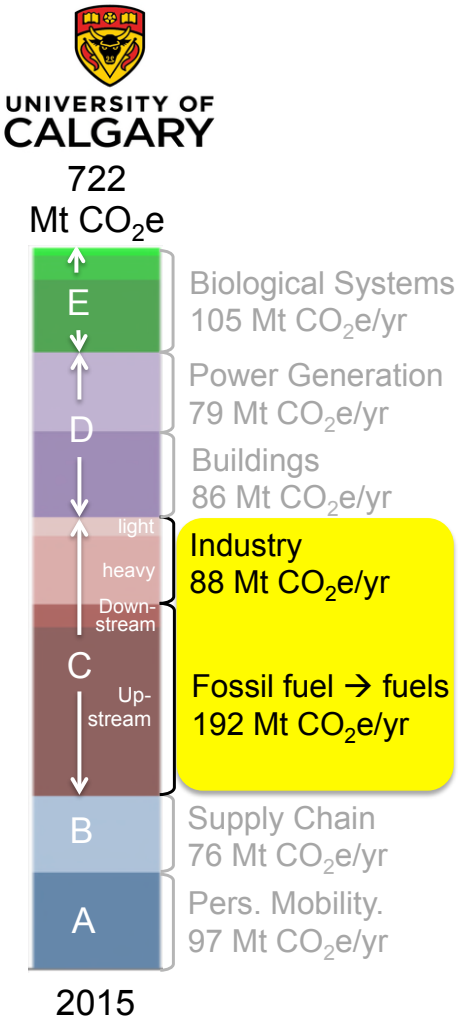


Problems:

- ✓ GHG emissions
- ✓ Air, water, land impacts

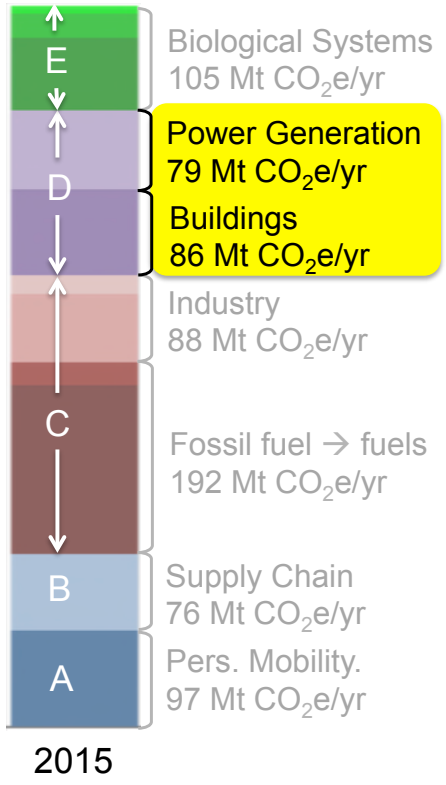
(Disruptive) Forces (+/-):

- ➢ Reduction or Increases in Demand (varies with sector)
- ➢ Cogeneration w/ fuel cells or nuclear
- ➢ Electrification
- ➢ Carbon capture and storage

Key Energy Transition Opportunities:

- ➢ Demand reduction (e,g. oil) or increase (mining);
- ➢ Cogeneration (heat and power), esp. in prov. with thermal FF power;
- ➢ Technology changes to reduce energy use or emissions (electrification in mining; new cement technologies; more steel recycling);
- ➢ Carbon Capture and Storage where possible (poss. coupled to MCFC and SOFC)

D. Smart Grids & Efficient Spaces



Problems:

- GHG Emissions (Grid and space/water heating);
- Legacy grid (one way only);
- Low efficiency builds;
- Car, not people centric communities

Disruptive forces (+/-)

- Lower cost solar, wind & energy storage;
- Prosumers etc. undermining utility model;
- Internet of Things, big, open data & artificial intelligence;
- Smart communities (cities, buildings, connected devices)

Key Energy Transition Opportunities:

- New building standards (more efficient, comfortable and fit-for-purpose);
- Reduce waste by repurposing heat, cold & biomass;
- Electrify space conditioning with integrated designs & heat pumps;
- Integrate energy efficiency (demand side management), demand response (load flexibility) & clean, distributed energy generation;
- Combine renewables with storage and sufficient East-West grid connectivity

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E. Biological Solutions

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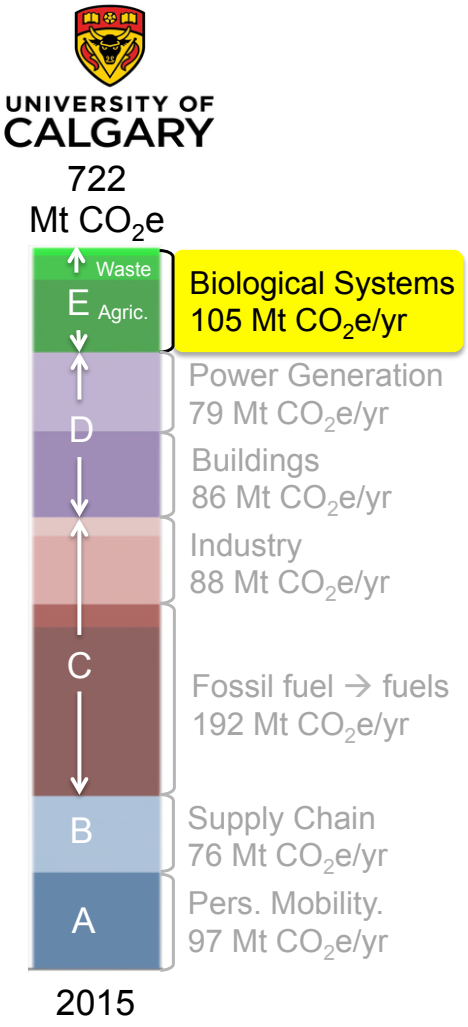

Problems:

- Land and water impacts;
- GHG Emissions (esp agric.);
- Inefficient use of bio-base energy and C stocks.

Disruptive forces (+/-)

- Climate change itself;
- Canada's role in feeding 9.5B by 2050?;
- Biotechnology (esp. Crispr);
- Biofuel technologies;
- Carbon management strategies.

Key Energy Transition Opportunities:

- Increase in agricultural inputs & production;
- Enhanced use of wood/straw/MSW for biofuels and/or biocarbon storage;
- Precision agriculture and biotechnologies to reduce CH_4 and N_2O emissions;
- Possible dietary changes to reduce demand for high footprint pathways;
- Afforestation, reforestation, silviculture to build and protect C stocks

Discussion

1. *Comments / questions / concerns / suggestions regarding the CESAR Pathway Project?*
2. *What existing government policies and programs should be included in our models? What outcomes do you expect or hope to see by 2030?*
3. *Are there other policy, technology, infrastructure or behavioural changes that you would like to see being explored in some of our scenarios?*
4. *Would it be useful to organize a Webinar in Fall 2017 to engage a broader group of your provincial government policy makers to review the state of our modeling efforts at that time and provide insights and suggestions?*

Thank you for your input!