

The CESAR Pathways Project:

Towards Climate Change Solutions



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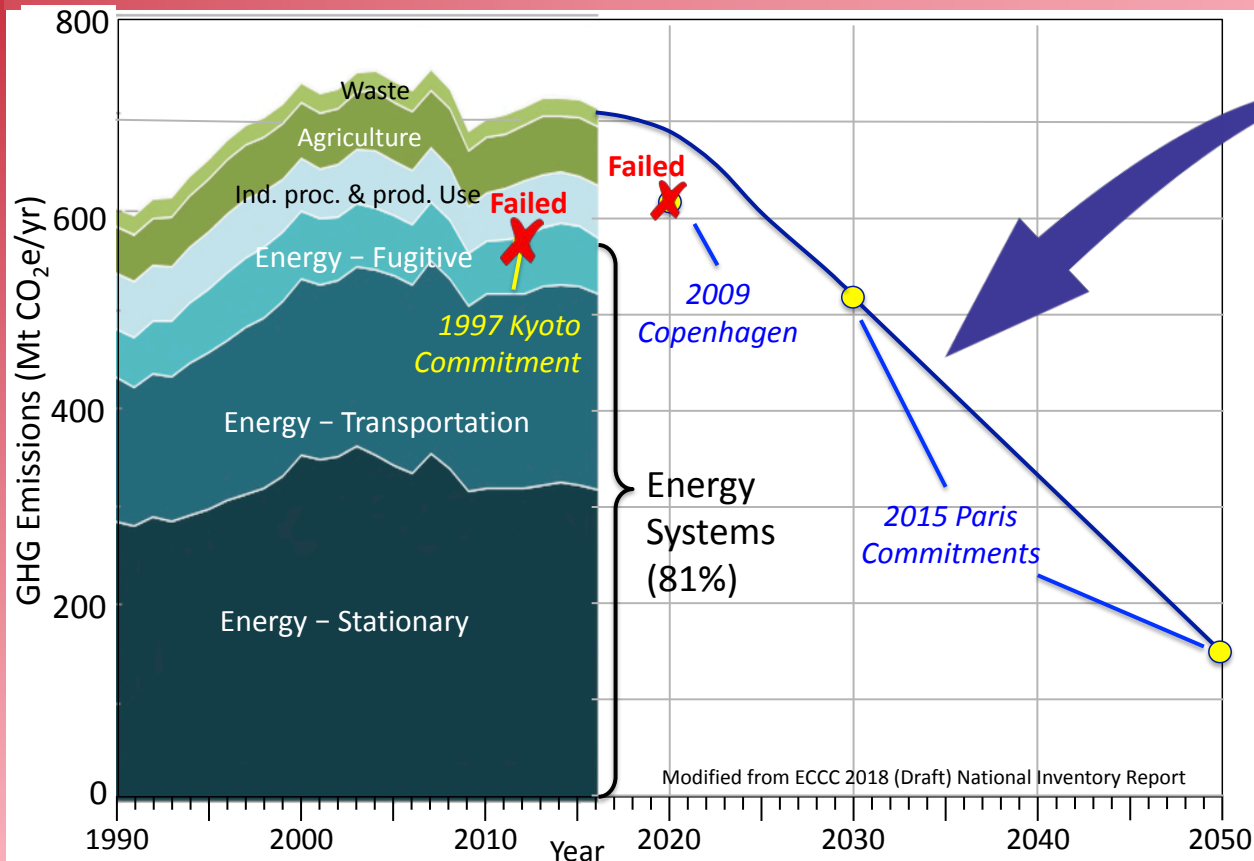
CESAR
CANADIAN
ENERGY SYSTEMS
ANALYSIS RESEARCH



With special
thanks:



Canada's Climate Change Challenge



This requires
TRANSFORMATIVE
- EVEN *DISRUPTIVE* -
SYSTEMS CHANGE

Canadians want to achieve this while:

- ✓ *Enhancing economic prosperity;*
- ✓ *Growing the Cdn population.*

Current Climate Policy Tools

CURRENT TOOLS:

- Carbon Pricing
- Regulations
- Incentives

- Useful tools but they not capable of achieving the 2015 Paris targets;
- Transformative, systems-level changes are required to achieve -14 to -18 Mt CO₂e/yr.

But we live in a time of rapid change driven by other forces:



Consider...

- Media
- Retail
- Music
- Movies
- Books
- Photography
- Telecommunications

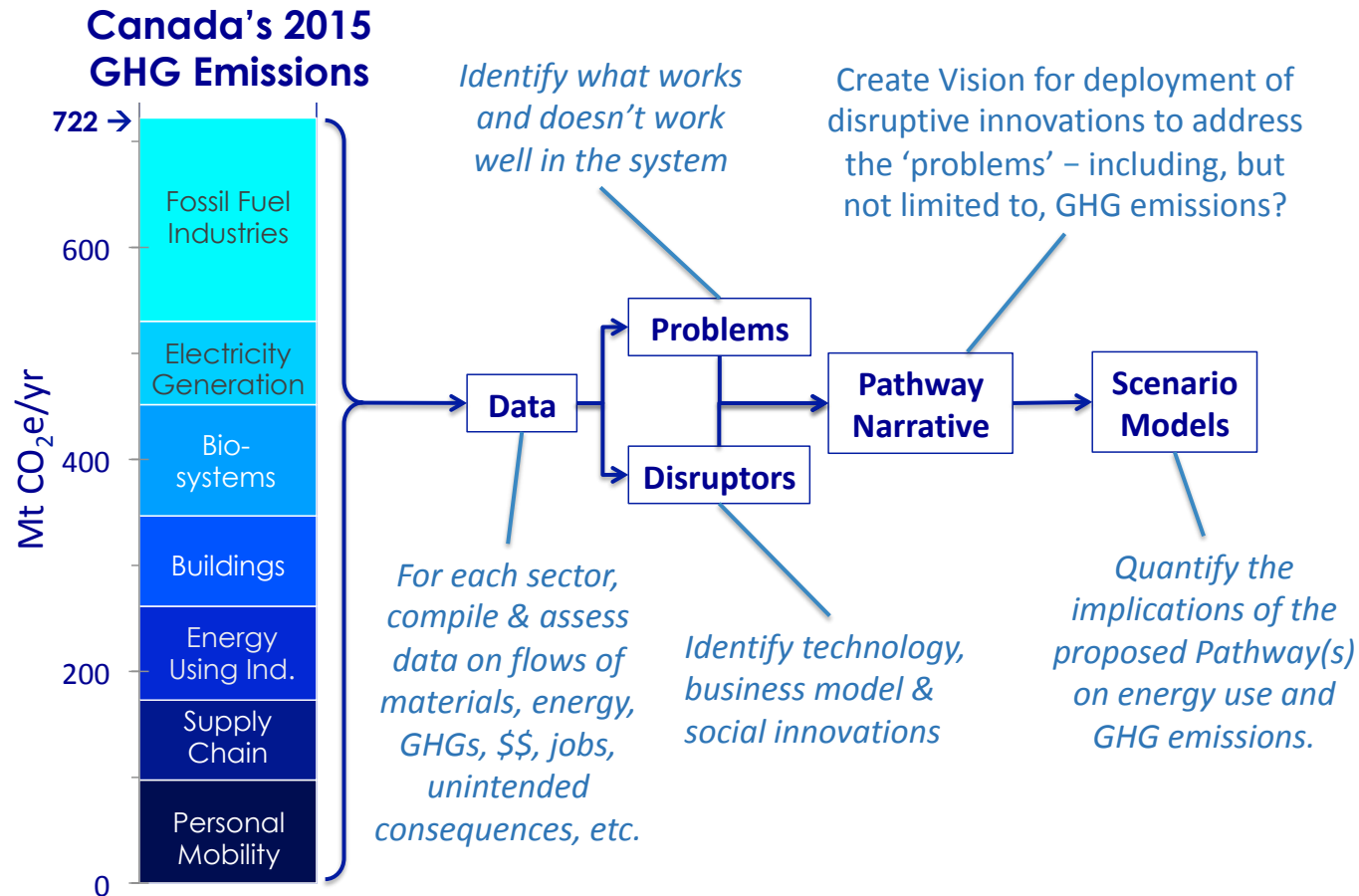
PROPOSAL TO MEET GHG

TARGETS: *Develop policy tools to 'direct' disruptive innovations that are occurring for other reasons so societal objectives are met.*

Outline

- 1. *Directing Disruption: A new evidence-based approach to climate policy making***
 - aka “CESAR Pathways Project”
- 2. Transportation as an example**
 - A. Personal Mobility**
 - B. Supply Chain**
- 3. Conclusions**

The CESAR Pathway Project



Defining Pathways



PATHWAYS must be:

1. CREDIBLE

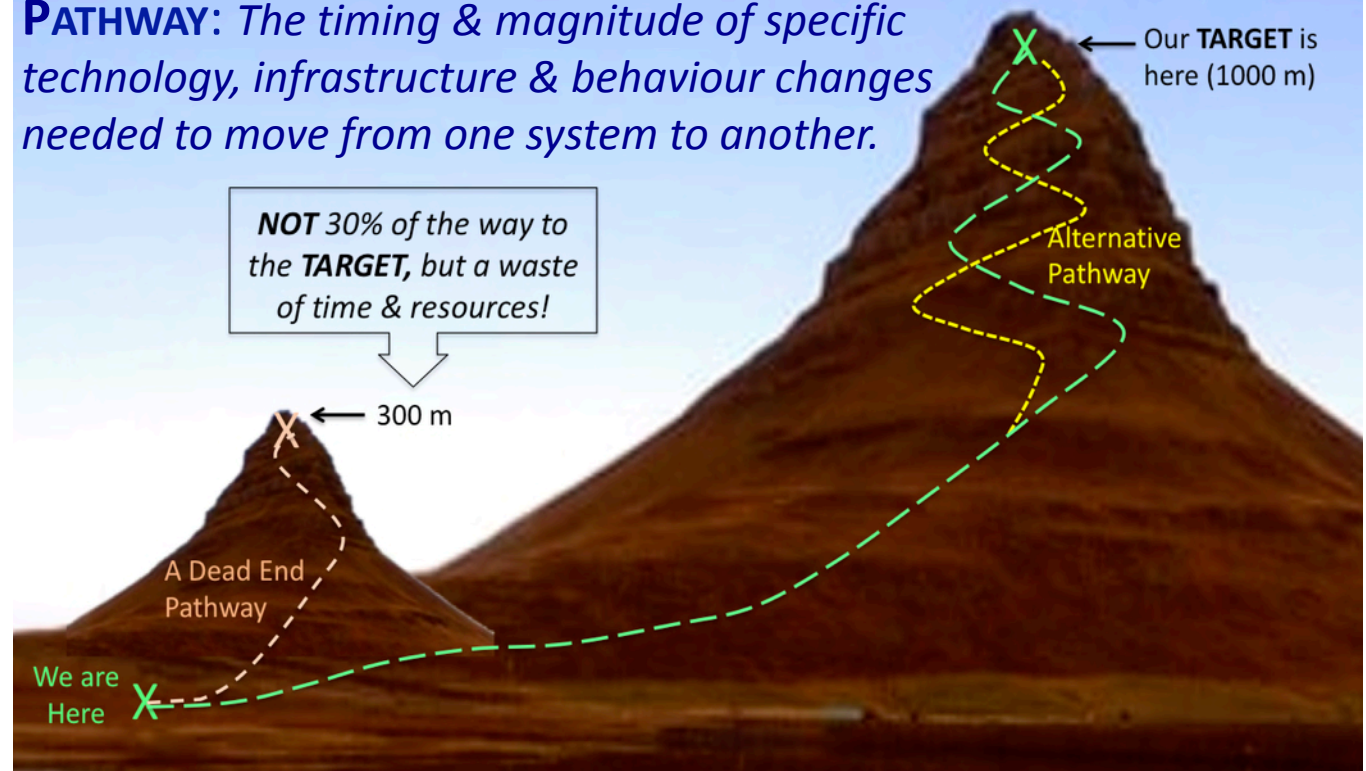
- Technically, economically, socially

2. COMPELLING

- Desirable by key stakeholders

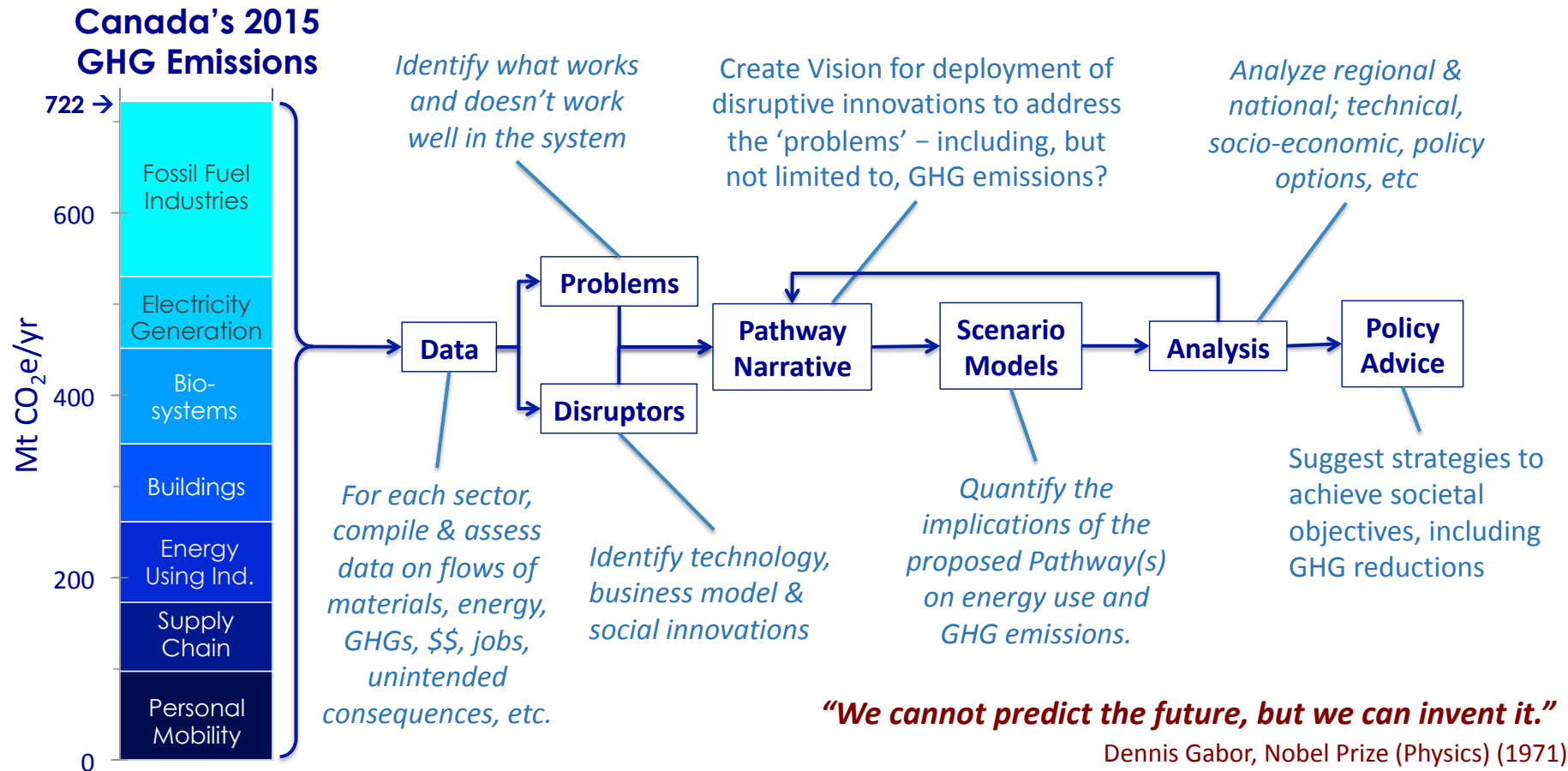
3. CAPABLE of achieving the target.

PATHWAY: *The timing & magnitude of specific technology, infrastructure & behaviour changes needed to move from one system to another.*



Kirkjufel Mountain (Iceland) in two sizes. Modified from https://www.west.is/static/toy/images/Place_308_3_Selected.jpg

The CESAR Pathway Project

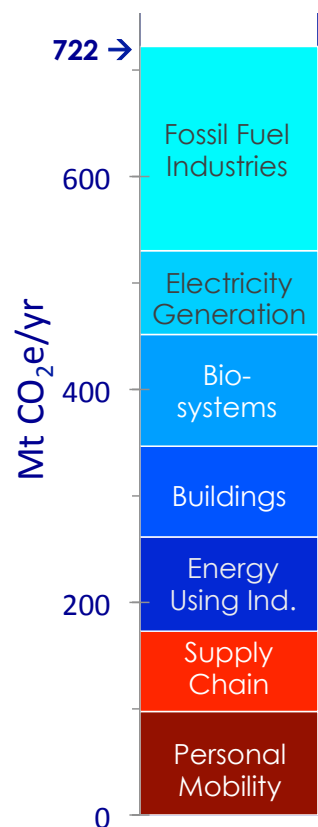


Outline

1. *Directing Disruption: A new evidence-based approach to climate policy making*
 - aka “CESAR Pathways Project”
2. **Transportation as an example**
 - A. **Personal Mobility**
 - B. **Supply Chain**
3. **Conclusions**

Why Focus on Transportation?

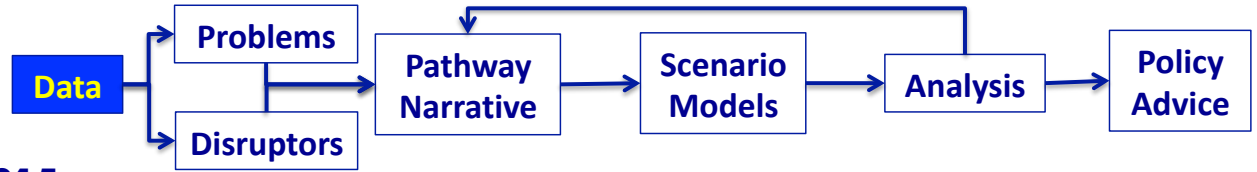
Canada's 2015
GHG Emissions



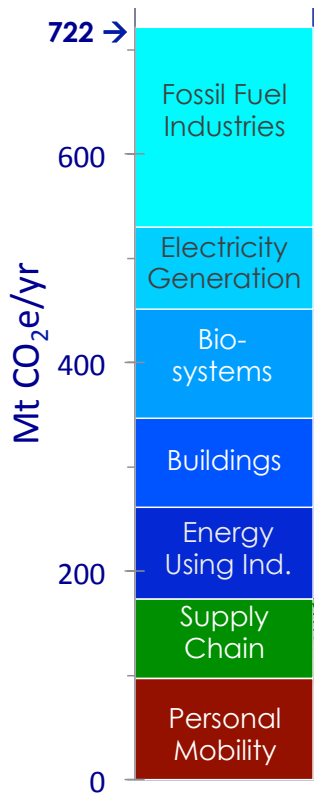
Transportation is the critical 'Linchpin' in Canada's GHG management strategy:

- ❑ ~24% of Canada's GHG emissions;
- ❑ Creates demand for oil:
 - ❖ Transportation fuels = 70% of each barrel of oil;
 - ❖ Contributes another ~23% of Cdn GHGs (incl. exports);
- ❑ Defines urban form (esp. Sprawl);
- ❑ Alberta is in the Transportation business!

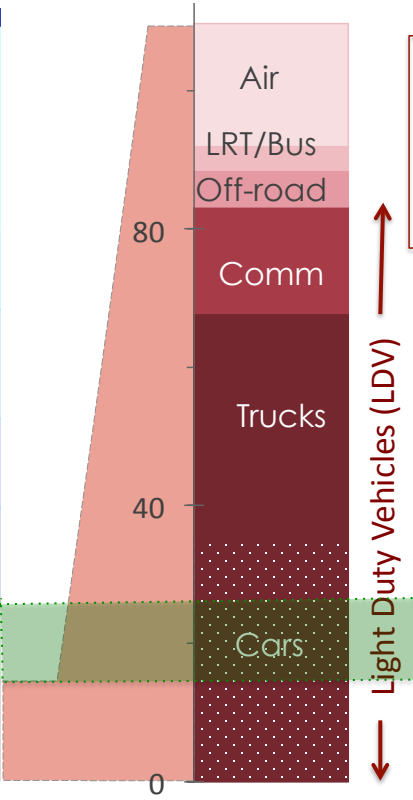
Transportation is a century-old ecosystem that is ripe for disruptive change



Canada's 2015 GHG Emissions



Personal Mobility

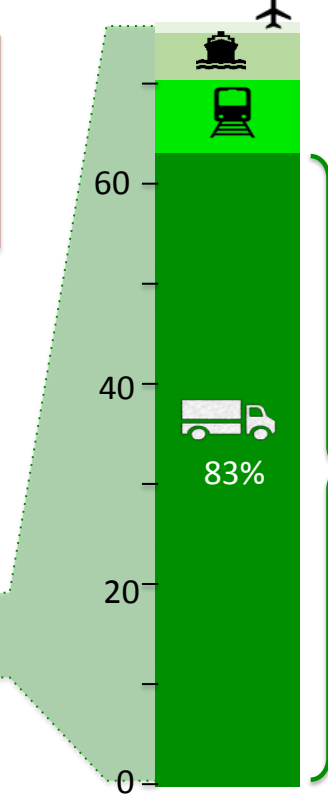


pLDV: most important.
Compile & Analyze data to build technology- and behaviour-rich simulation models.

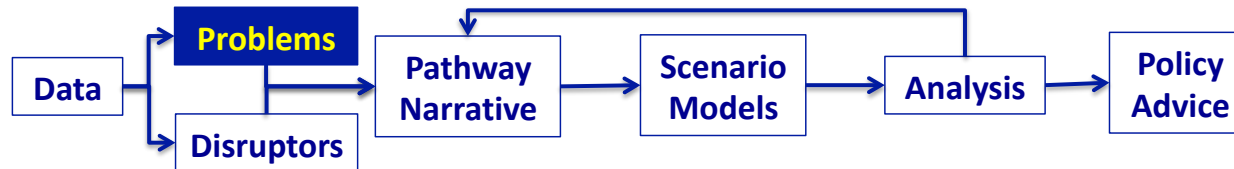
- Trip type, #, length & mode;
- City vs. hwy driving
- Vehicle type, fuel effic., age
- Fuel use;
- Cost of ownership
- Unintended consequences
- Etc...

Light Duty Vehicles (LDV)
Personal (pLDV)

Supply Chain



The majority of the fuel use & emissions are from large Class 7 and 8 semi-trailer trucks that burn diesel fuel.



A. Accidents

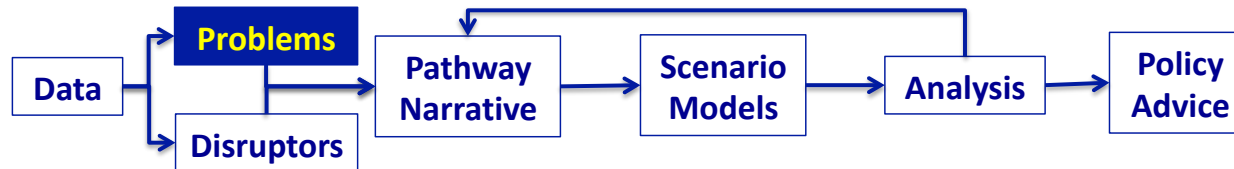
- ~94% are the result of human error;
- ~2000 fatalities + 10,000 serious injuries/yr in Canada
- Societal cost of \$62 billion in 2007, or the equivalent of 4.9% of GDP (Conf. Board of Canada)



B. Congestion

- 11.4M Canadians commute an avg. 24 min to & from work about 240 d/yr = 4700 person years of unproductive time EVERY DAY
- RethinkX (US think tank) estimated commuting reduces the US GDP by ~\$1T/yr.





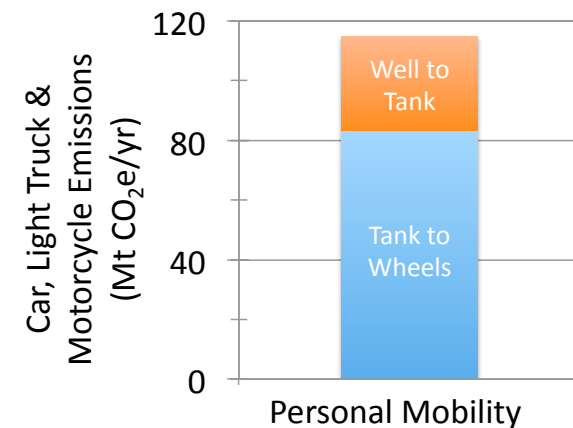
C. Air Pollution

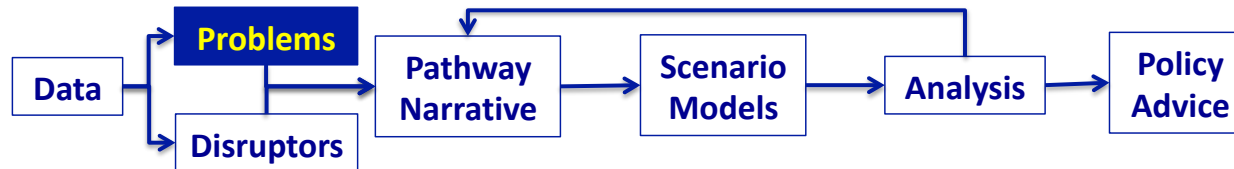
- Ground level ozone and PM; mostly from vehicles – estimated to cost \$36B/yr in Canada (Robert Smith & Kieran McDougal 2017)



D. Greenhouse Gases

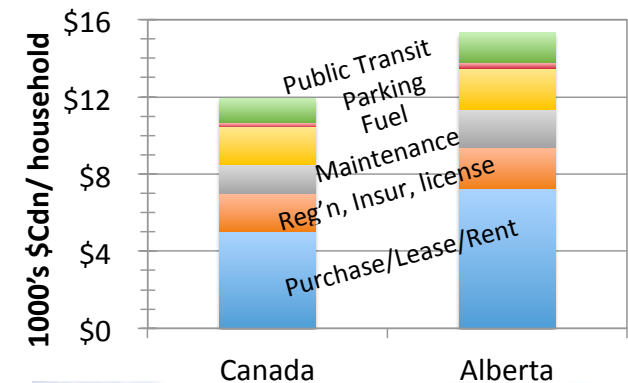
- Well-to-Wheels for all road Transportation: 240 Mt CO_{2e}/yr or ~33% of Canada's GHG emissions.
 - @ \$30/ t CO₂ = \$7.2B /yr
- Well-to-Wheels for Personal vehicle transport: 115 Mt CO_{2e}/yr or 16% of Cdn emissions.





E. Value for Money

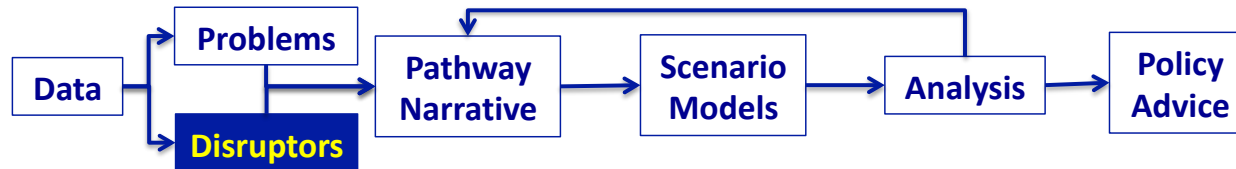
- In 2016, pLDV consumed ~18% household consumption [\$10.6K/yr (Canada) - \$13.8K/yr (AB)];
- pLDV used only ~4% of the time, and then with only 1.5 people/vehicle when there are seats for 5-7;
- These are **not** well-used assets.



F. Parking, Urban Form and Taxes

- Cars are parked 96% of time, using valuable land.
- In USA, 8 parking spots / vehicle on road
- Urban sprawl encouraged by pLDV
- Highly subsidized: Gas taxes, licensing fees, fines etc only pay for ~2/3rds of infrastructure cost



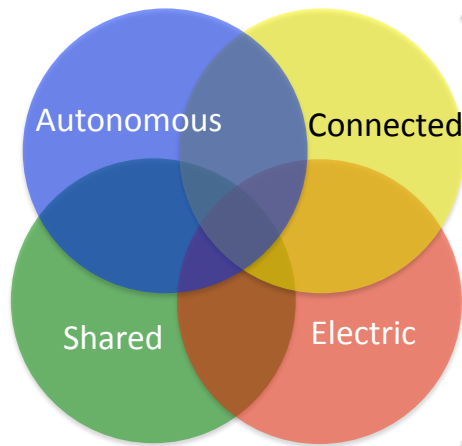
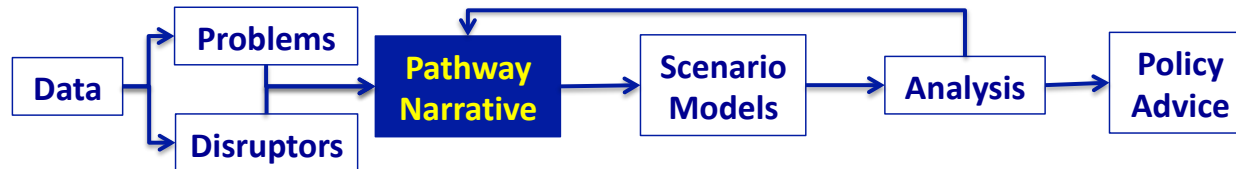


Problems in Canada's Personal Mobility System

Disruptive Innovations:	Accidents	Congestion	Value for \$	Parking	Air Pollution	GHGs
Autonomous (A)	+++	---	--	+	---	---
Electric (E)					+++	+++
Connected (C)	++	++		+		
Shared (S)			+	+	+	+
Mobility-as-a-service (ESAC vehicles)	+++	++	+++	+++	+++	+++

Business model innovation that has the most promise of addressing the problems of the personal mobility system.

- ❑ *How Innovations are deployed will determine what problems are addressed.*
- ❑ *Policy can encourage, discourage, nudge or direct innovations.*



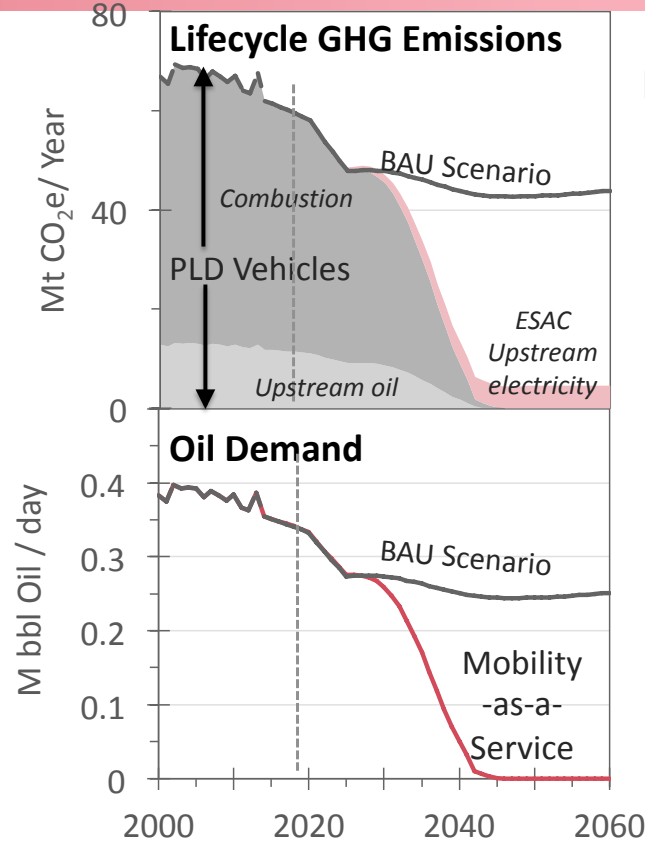
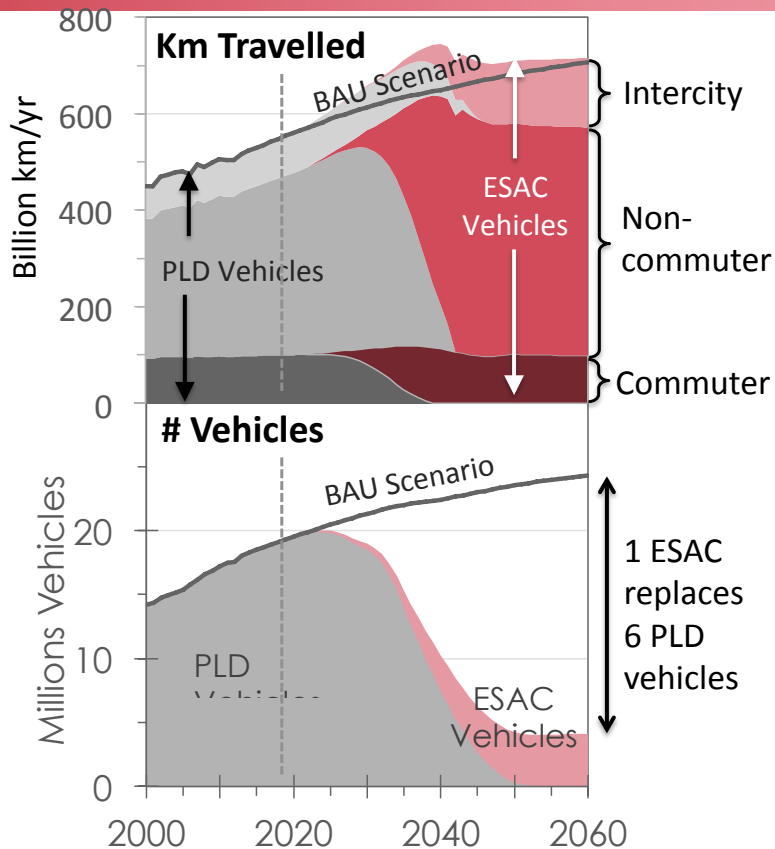
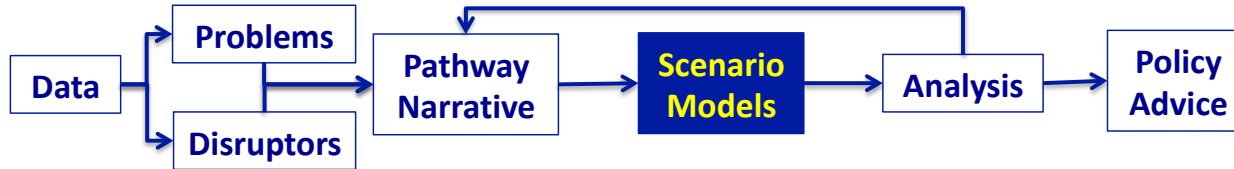
Mobility
-as-a-
Service

- ~6-8 personally-owned → 1 shared vehicle;
- Vehicle use: 4% → ~35% of the time;
- Avg. family pers. mobility cost: \$12K → \$6K/yr;
- Parking demand dramatically reduced;
- More walkable, people-friendly communities;
- Reduction in crude oil demand;
- Reduction in vehicle accidents / fatalities;
- Loss of some jobs, but creation of others

Taxi drivers, car salesmen, vehicle repair,
oil workers, parking lot attendants,
traffic police, insurance agents.

Digital technologies, sensors,
software development, big data
management, grid enhancements,

This is only one vision for a Pathway to sustainability. There may be others that are more CREDIBLE, COMPELLING & CAPABLE of achieving societal objectives.

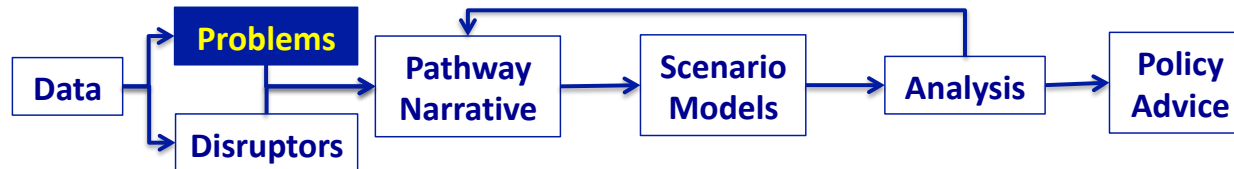


Note:

- ☐ This Scenario run was able to achieve a ~90% reduction in 2005 levels of GHG emissions by 2050.

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For Supply Chain Only

G. Load Factor

- Many empty or partially empty trucks
- Highly fragmented sector, lacks unified voice
- Potential for business model innovation

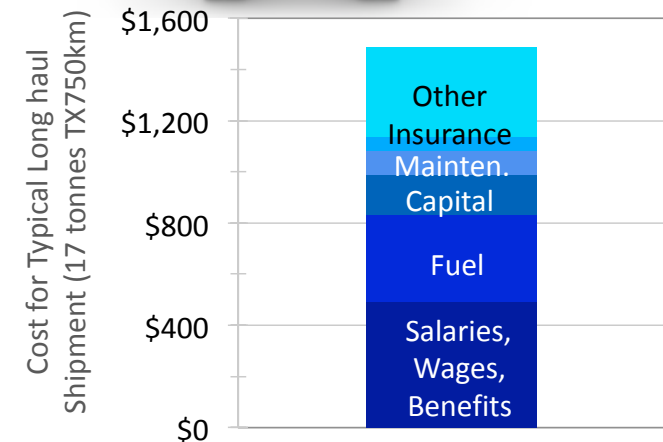
H. Truck Use Rate

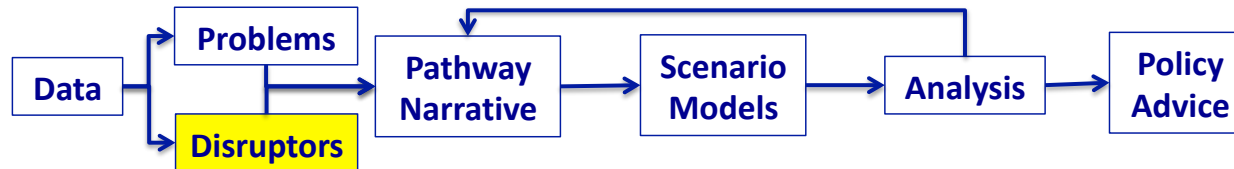
- Typically <<12 hr/day
- Asset idle



I. Maintenance and Operational Costs

- Repairs, fuel and salary costs account for a major part of the cost of transport.





Problems in Canada's Supply Chain System

Disruptive Innovations:	Accidents	Congestion	Air Pollution	GHGs	Load Factor	M&O	Use Rate
Autonomous Truck	+++	--	--	--		+++	+++
Electric Truck			+++	+++		++	
Connected Truck	++	++	+	+	++	+	+
Big Data/ Physical Internet	+	+	+	+	+++	++	+++
Robotics / Drones					++	++	++
Strategic combination	+++	++	+++	+++	+++	+++	+++

CESAR is currently exploring various Pathway narratives to identify those that are **CREDIBLE, COMPELLING & CAPABLE** of reaching the target.

Key Question:

In an autonomous, connected, big-data world, what kind of electric truck is better for Canada?

The War of the Electric Trucks

H₂ Fuel Cell Electric (HFCE)



- Needs major infrastructure;
- Could help with green grid



Battery Electric (BE)

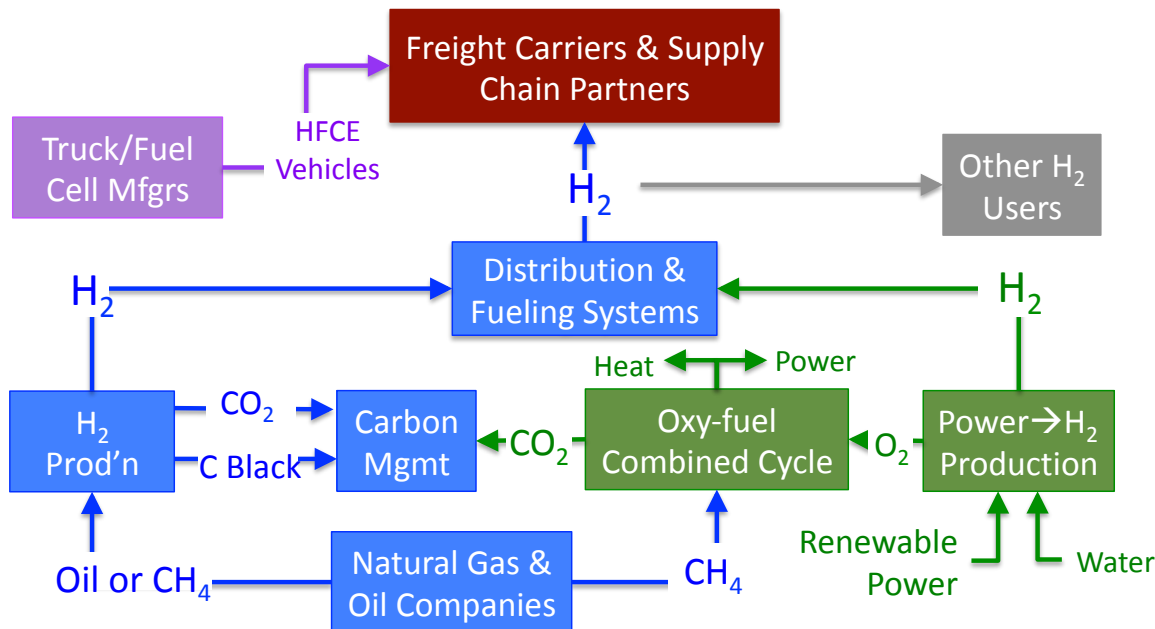


- Range concerns
- Could significantly increase the challenge of greening the grid



Our analysis suggests that HFCE may be an advantage for Canada...

A Hydrogen Economy Ecosystem



W Canada could lead this transformation and remain in the 'transportation business' for decades to come.

TRANSPORTATION

- Associated with performance & low total cost;
- Complements autonomy shift;
- The 'Anchor Tenant' in the H₂ ecosystem 'mall'

MANUFACTURING

- An opportunity to attract new growth industries to Canada
- Special opp. for ON (vehicles) & AB + BC (HFC)

OIL & GAS

- Engages existing energy industry, infrastructure, resources & tech. expertise, esp. in AB, SK, BC;
- Lowest cost, existing technologies; NG pipelines can carry 15% H₂; CO₂ storage options.

POWER

- H₂ from excess, low cost renewables while providing energy storage & 'dispatchable' power.
- Special opportunity for BC, MB, QC, NL + SK & AB

OTHER

- Creates low carbon opportunities for other sectors (fertilizer, oil and gas, steel, biofuels, home heating, etc.)

List of Countries Banning Fossil Fuel Vehicles

Country	Ban announced	Ban commences	Scope	Selectivity
Norway	2016	2025 ^[4]	Gasoline or diesel	new vehicle sales
Britain	2017	2040 ^[5]	Gasoline or diesel	new vehicle sales
France	2017	2040 ^[6]	Gasoline or diesel	new vehicle sales
India	2017	2030 ^[7]	Gasoline or diesel	new vehicle sales
Ireland	2018	2030 ^[8]	Gasoline or diesel	new vehicle sales
The Netherlands	2017	2030 ^[9]	all vehicles emission free	new vehicle sales
China	-	"in the near future" ^[10]	Gasoline and diesel	production
China	2018	2018 ^[11]	Gasoline and diesel	533 specific models
Germany	-	"2030" ^[12]	combustion engine	new vehicle sales
United States of America (California)	2017	2040 ^[13]	Gasoline or diesel	new vehicle sales

From Wikipedia: https://en.wikipedia.org/wiki/List_of_countries_banning_fossil_fuel_vehicles

Conclusion

1. **Pathways to climate change targets become more CREDIBLE, COMPELLING and CAPABLE** of reaching the targets when they are integrated with other societal objectives (economic, health, social, convenience/comfort);
2. **Transformative technology, business model and social innovations** exist in many sectors, but policy makers may need to *'direct disruption'* to achieve societal goals;
3. **The Transportation sector is poised for disruption** and given the potential benefits of the new business models, the transformation could be rapid;
4. **As an oil producer**, Western Canada needs to recognize that it is in the **Transportation business**, and in the face of disruptive change, figure out how to stay in that the Transportation business (H₂ economy?)
5. *'Invent the future'*.



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Discussion

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