Future of Freight

Zero Emission Diesel Fuel Alternatives for Freight Transportation in Alberta

HEC Webinar
August 18, 2020

Jessica Lof, MSc.
Research Lead, Hydrogen
CESAR Initiative, University of Calgary
E: Jessica.lof@ucalgary.ca; W: www.cesarnet.ca

The Transition Accelerator | L'Accélérateur de transition

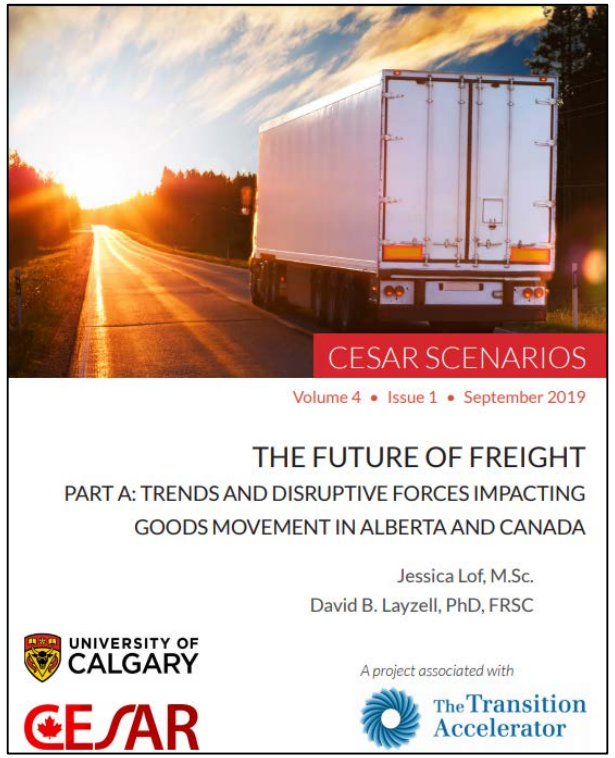
Philosophy of the Transition Accelerator

A new framing on how to achieve deep emission reductions while growing a vibrant economy

- Technological, social and business model innovations / disruptions are transforming sectors and lives;
- But whether disruptions solve our societal problems, or makes them worse, depends on decisions we make today;
- The Accelerator approach is to ***'direct' disruptions***, to foster and drive transitions to novel system configurations that provide multiple superior societal outcomes ... including on the climate front;
- **How?** Work with key actors to co-create positive **Visions** of the future, that lead to the definition of credible and compelling **Transition Pathways** to a better future. The Accelerator then builds industry-led consortia to start the journey.

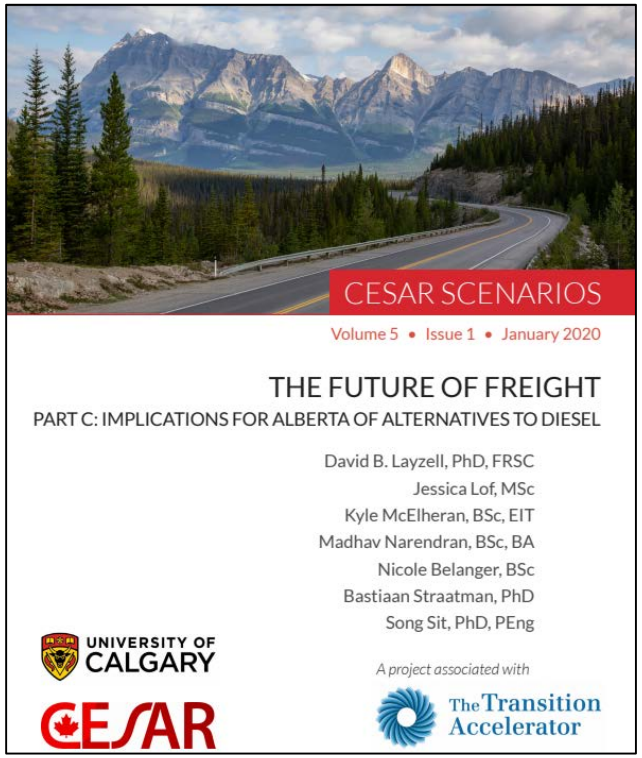
Future of Freight
CESAR Scenarios Reports

A: Trends & Disruptive Forces



B: Assessing Alternatives

C: Energy System Impacts



Future of Freight A Understanding Trends & Disruptive Forces

The Road Freight Sector Today:

- ❑ High GHG emissions
- ❑ Air pollution
- ❑ Facing a labour shortage
- ❑ Low margins
- ❑ Sub-optimal load management (empty km)
- ❑ Congestion & accidents
- ❑ High cost of diesel engine maintenance

The industry wants change and is interested in innovative ideas.

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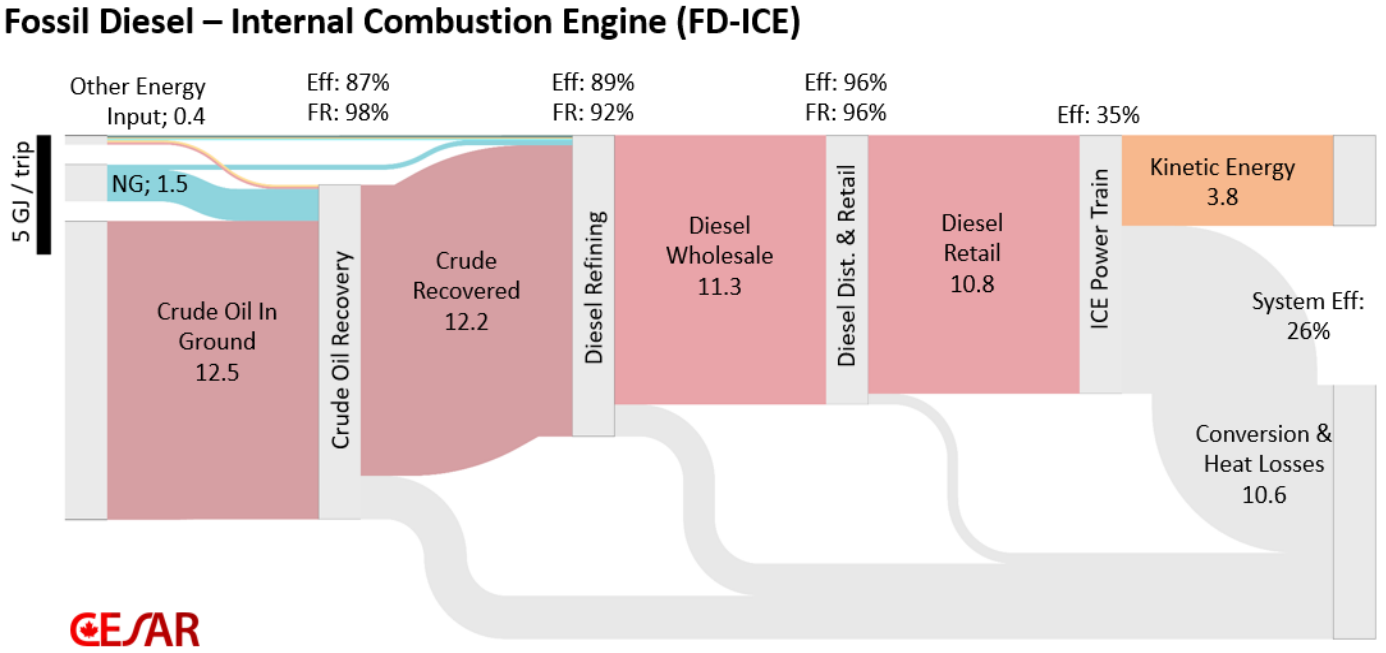
Future of Freight B
Assessing Diesel Alternatives (TEEA)

Future of Freight B
Assessing Diesel Alternatives (TEEA)

Diesel Internal Combustion Systems

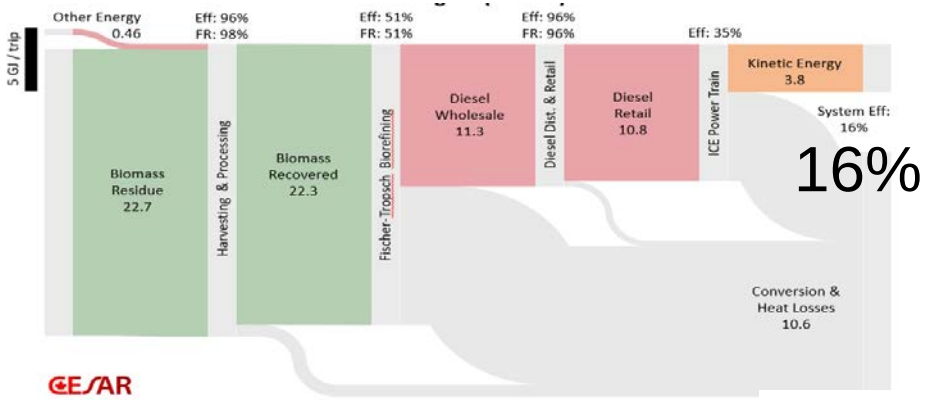
- Dominant (ubiquitous) technology
- Performance is predictable and accepted.
- Fuel supply chain is mature
- Future improvements are likely expensive and limited to incremental performance gains

27 Tonne Truck Travelling 750 km

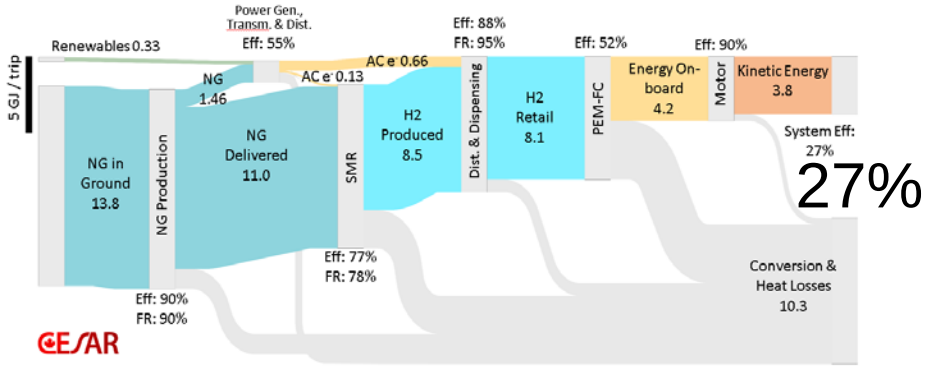


26% Well to Wheel Efficiency

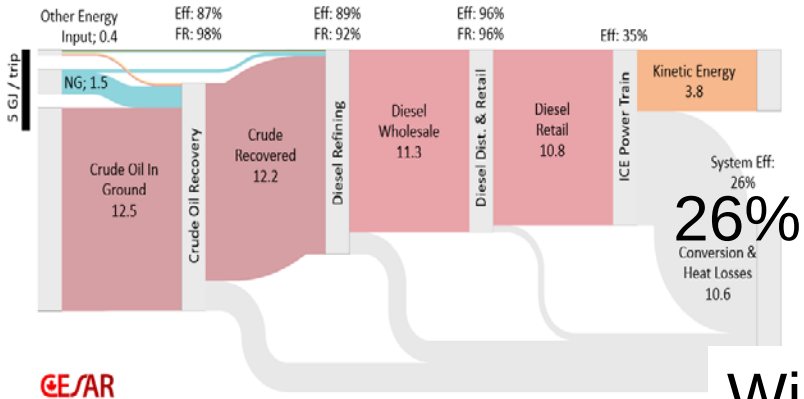
Biodiesel - ICE



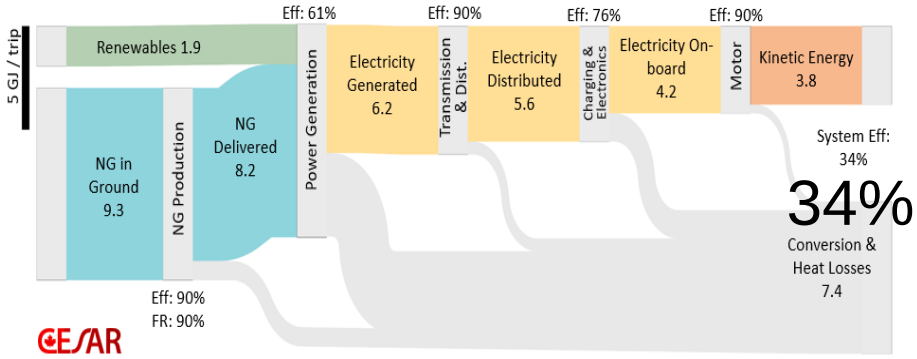
Natural Gas - HFCE



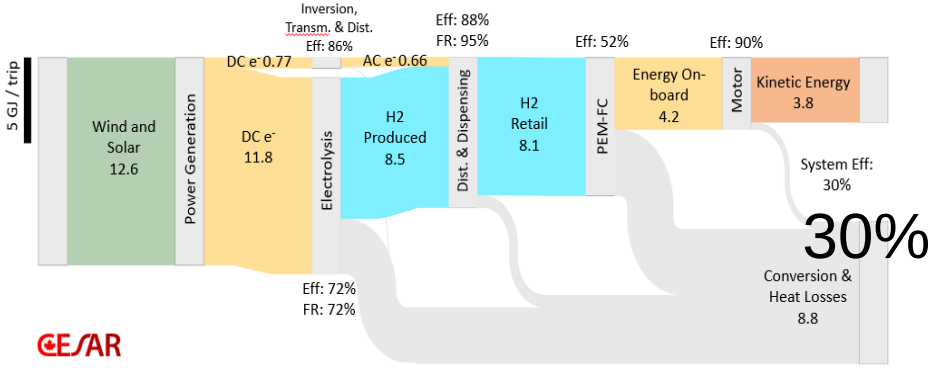
Diesel - ICE



Grid – Battery Electric

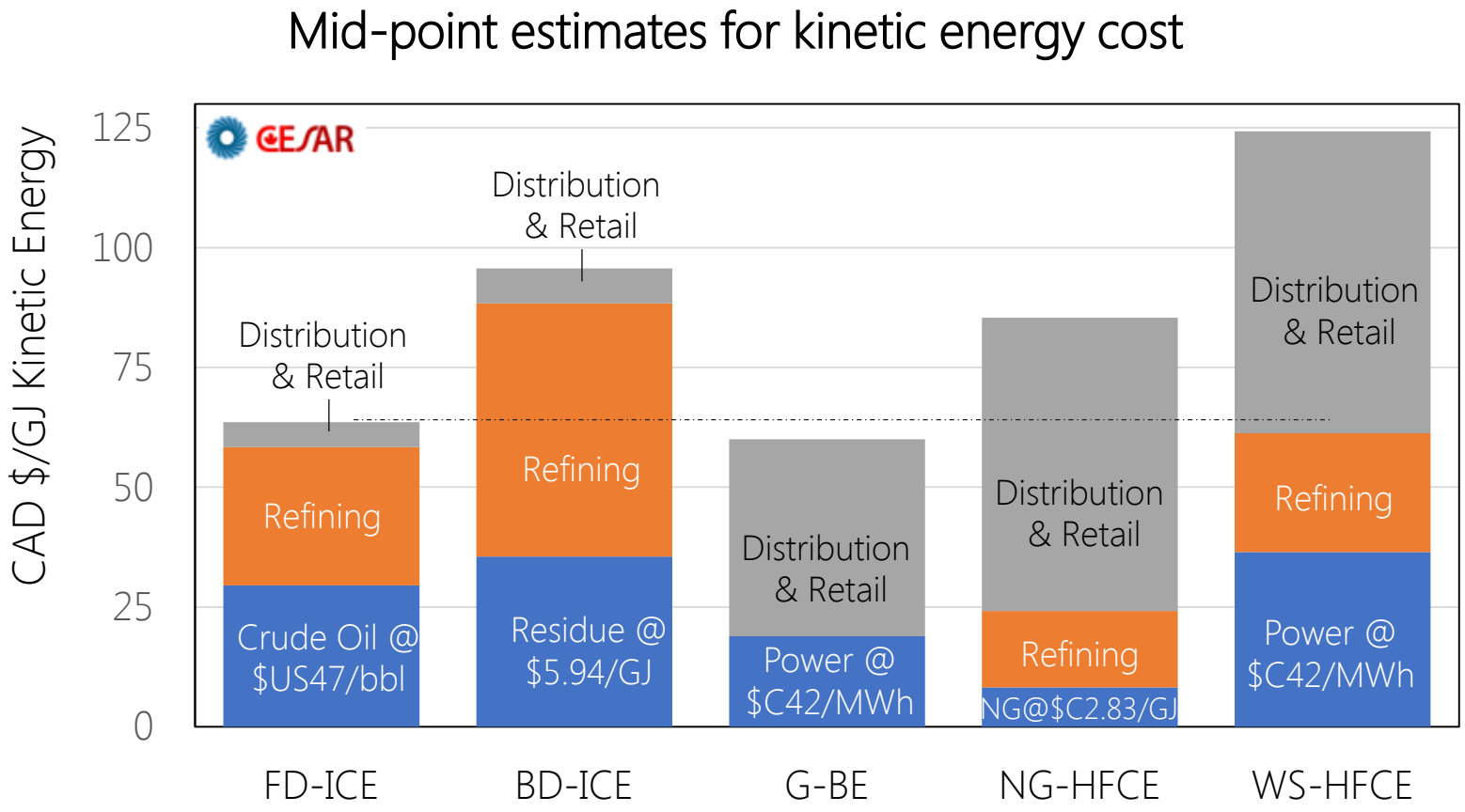


Wind & Solar - HFCE



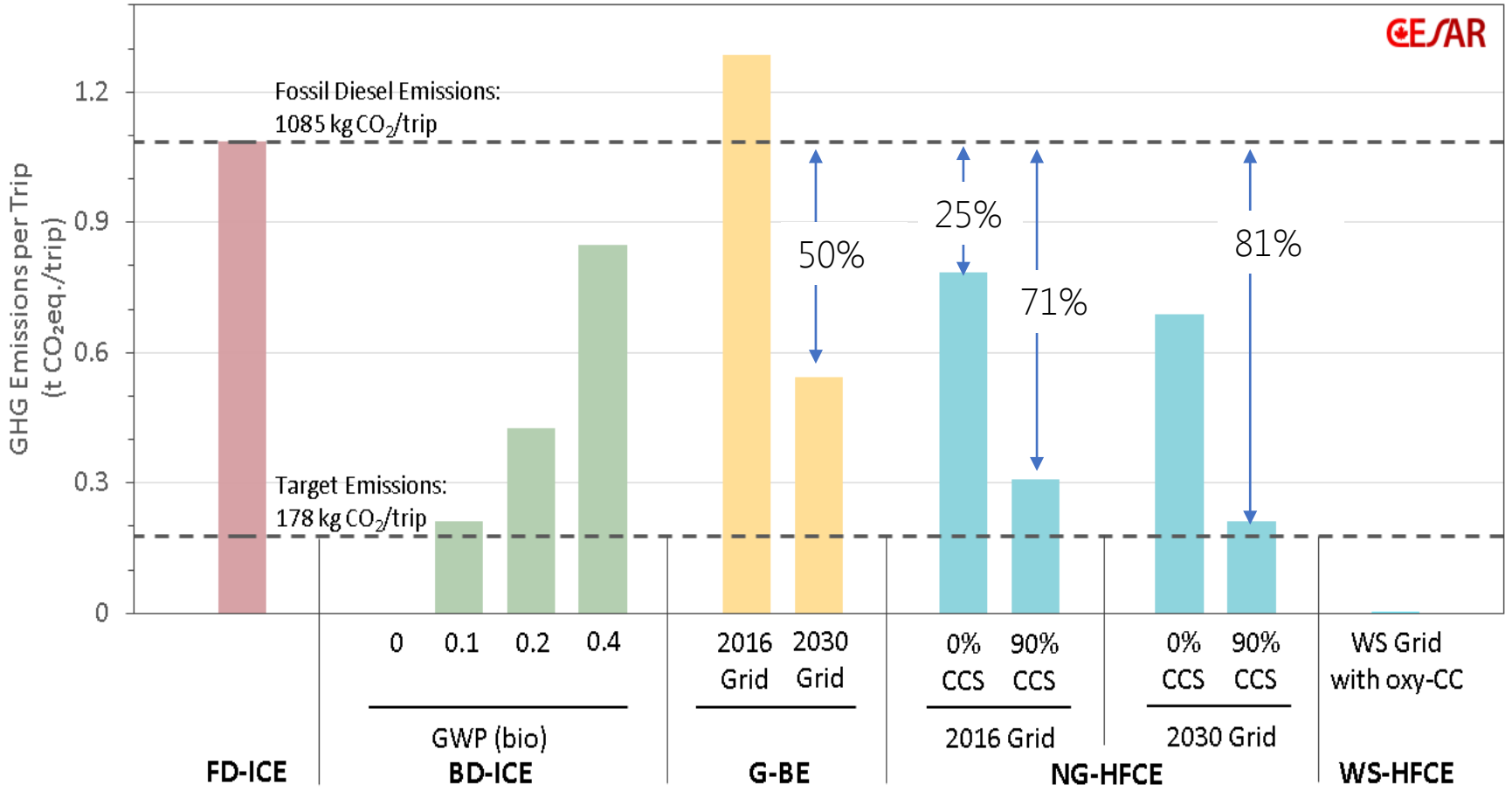
Energy Cost Comparison

- Comparing energy systems based on kinetic energy demand accounts for efficiency differences
- Uncertainty in distribution costs for hydrogen is significant- but suggests opportunity for cost reduction with scale and infrastructure development
- Battery electric option has energy cost advantages



GHG Emissions Comparison

- Diesel HDV's account for 8% of Canada's total GHG emissions
- At current emission intensity, Alberta grid to battery electric has higher emissions than diesel incumbent.
- Blue hydrogen can reduce emissions by ~81%



Goodness of Fit Comparison

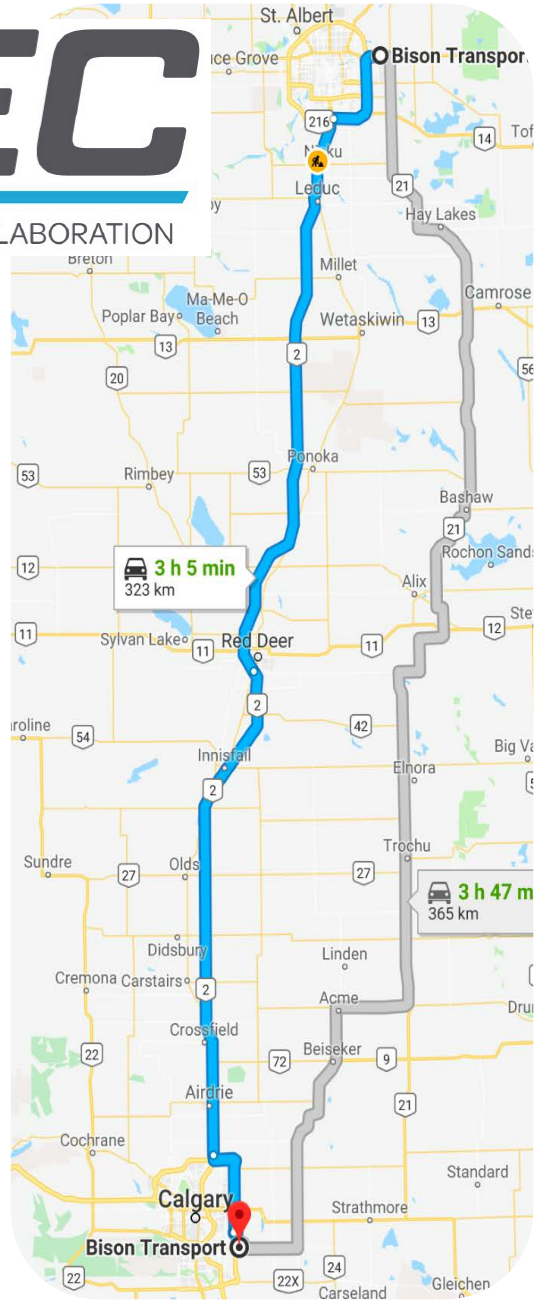
- Technology must meet the needs of the trucking sector
- Range, fueling time, and vehicle weight are important factors for many duty cycles
- Battery electric is likely not suitable for heavy payloads and long distance.
  - 800 kWh of batteries will have a range ~375km and add 6,500kg and 4 cubic meters of space

	Performance Compared to FD-ICE					
	Power, Torque, Driveability	Range & Fueling Time	Tare Weight	Capital Costs	Maintenance Costs	Energy Costs
BE	👍	✋	✋	✋	👍	👍
HFCE	👍	✓	✓	✋	👍	?

👍 Better performance to the FD-ICE HDV
✓ Comparable performance to the FD-ICE HDV
✋ Underperforms to the FD-ICE HDV
? Relative performance uncertain at scale

AZETEC

ALBERTA ZERO-EMISSION TRUCK ELECTRIFICATION COLLABORATION



Two HFCE Class 8 Trucks

- ✓ Heavy Weight (63.5 t gross) B-Train
- ✓ 700 km (Edm→Calg, return) between refueling
- ✓ Zero Tailpipe Emissions

Timetable:

- ✓ Design & Build: July 2019 to Fall 2021
- ✓ Test on Road: Fall 2021 to Spring 2023

H_2 Produced from AB Natural Gas:

- ✓ Steam Methane Reformed (no C mgmt.)
- ✓ Cascade Refueling

Industry Led

AMTA Alberta Motor Transport Association

- ✓ By AB Carriers under real-world conditions

AZETEC

ALBERTA ZERO-EMISSION TRUCK ELECTRIFICATION COLLABORATION

An Industry-Led, $15M Consortia Supported by Emissions Reduction Alberta with $7.3M.

Funding Support:

EMISSIONS REDUCTION ALBERTA

The Transition Accelerator

Lead Applicant:

AMTA Alberta Motor Transport Association

Carriers:

Trimac

Bison Transport

Vehicle Design, Components and Manufacturing:

FREIGHTLINER

nordresa

BALLARD

DANA

Fueling System:

HTEC Hydrogen Technology & Energy Corporation

Research, GHG Accounting and Commercialization:

University of Calgary

CESAR Canadian Energy Systems Analysis Research

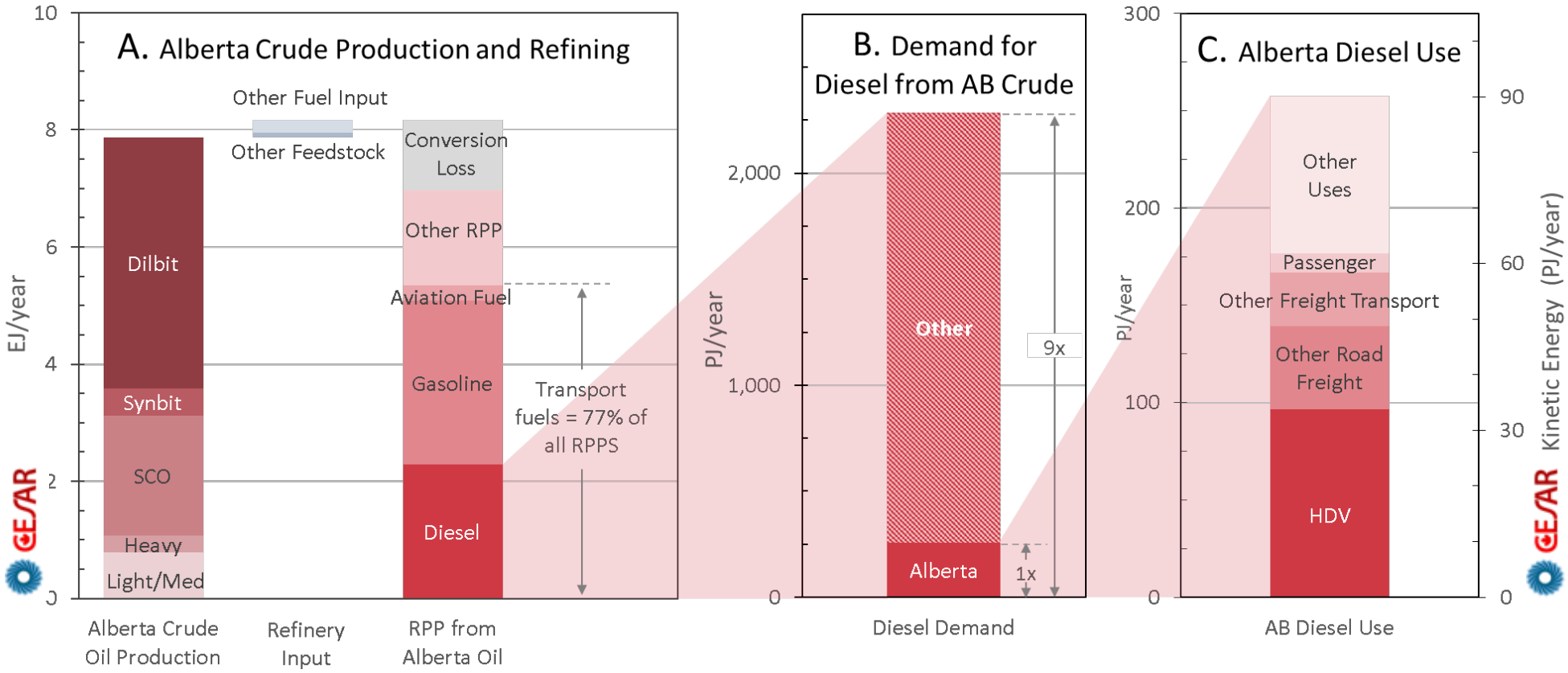
energyfutureslab powered by The Natural Step Canada

Project Management:

ZEN and the art of Clean Energy Solutions

Future of Freight C
Energy System Impacts

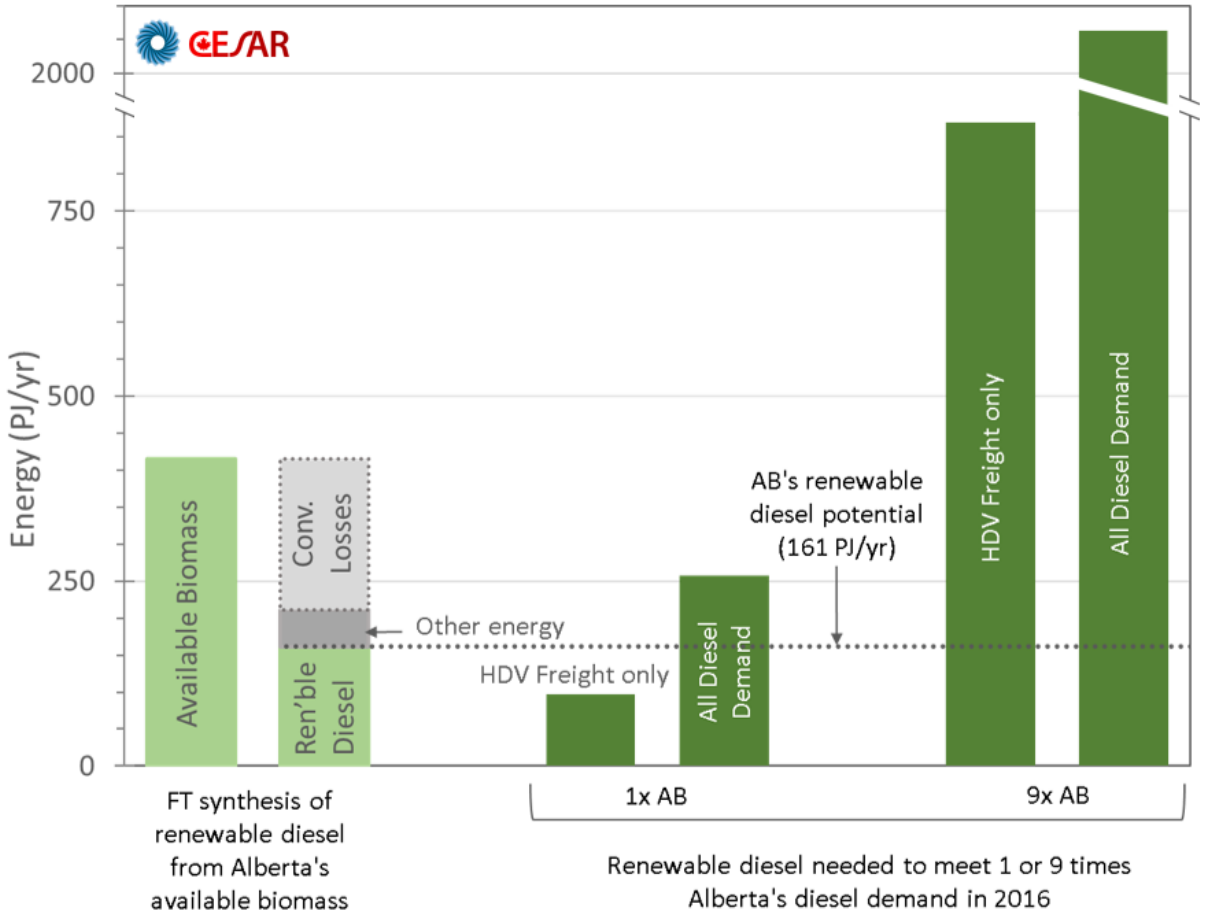
Alberta is in the Transportation Fuels Business



What is the opportunity in a net-zero future?

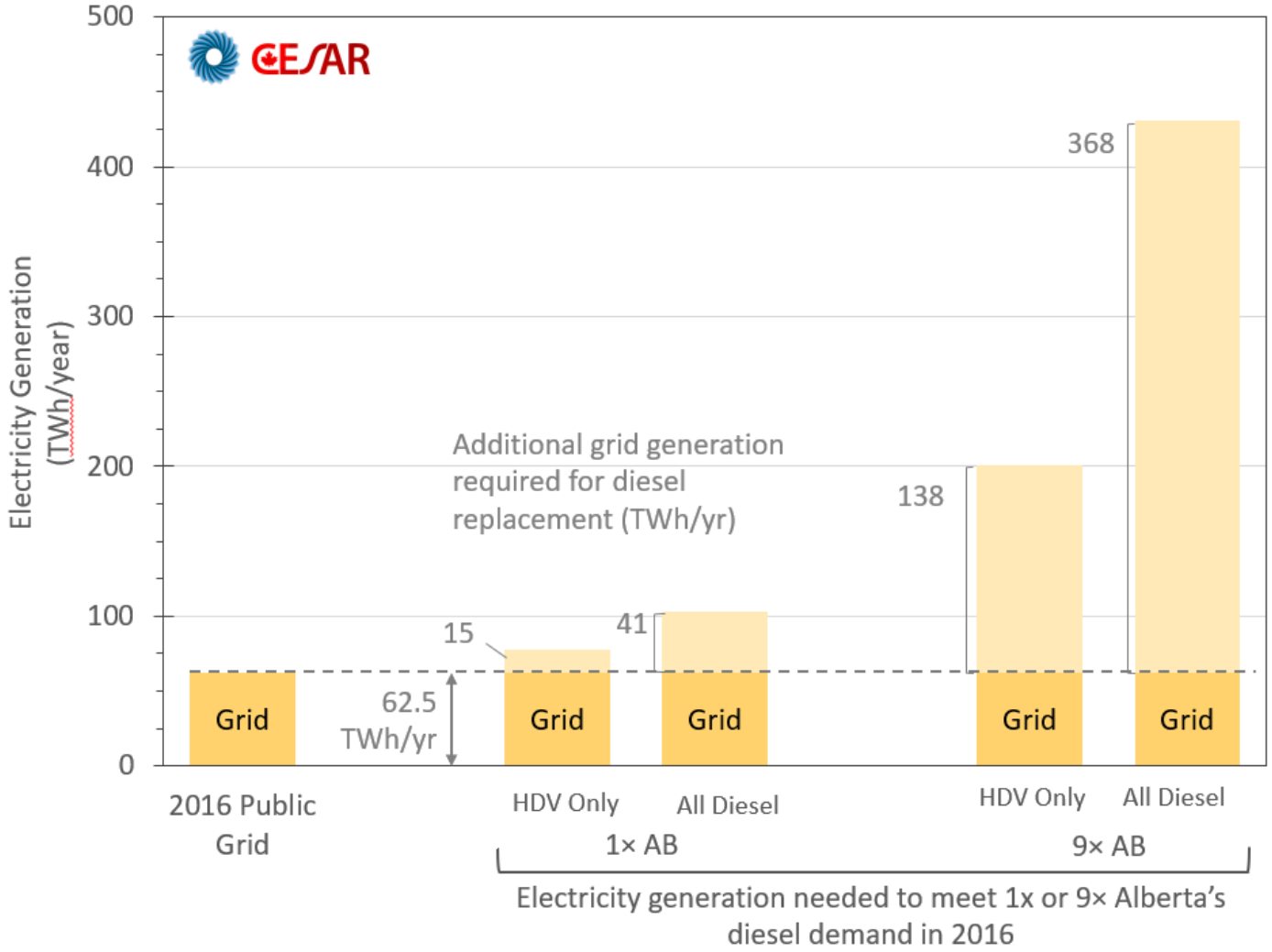
2ND GENERATION BIO-BASED DIESEL RESOURCE POTENTIAL

- Sufficient resources to supply provincial heavy duty vehicle demand
- Insufficient resources to supply all diesel demand
- Cannot supply an export market



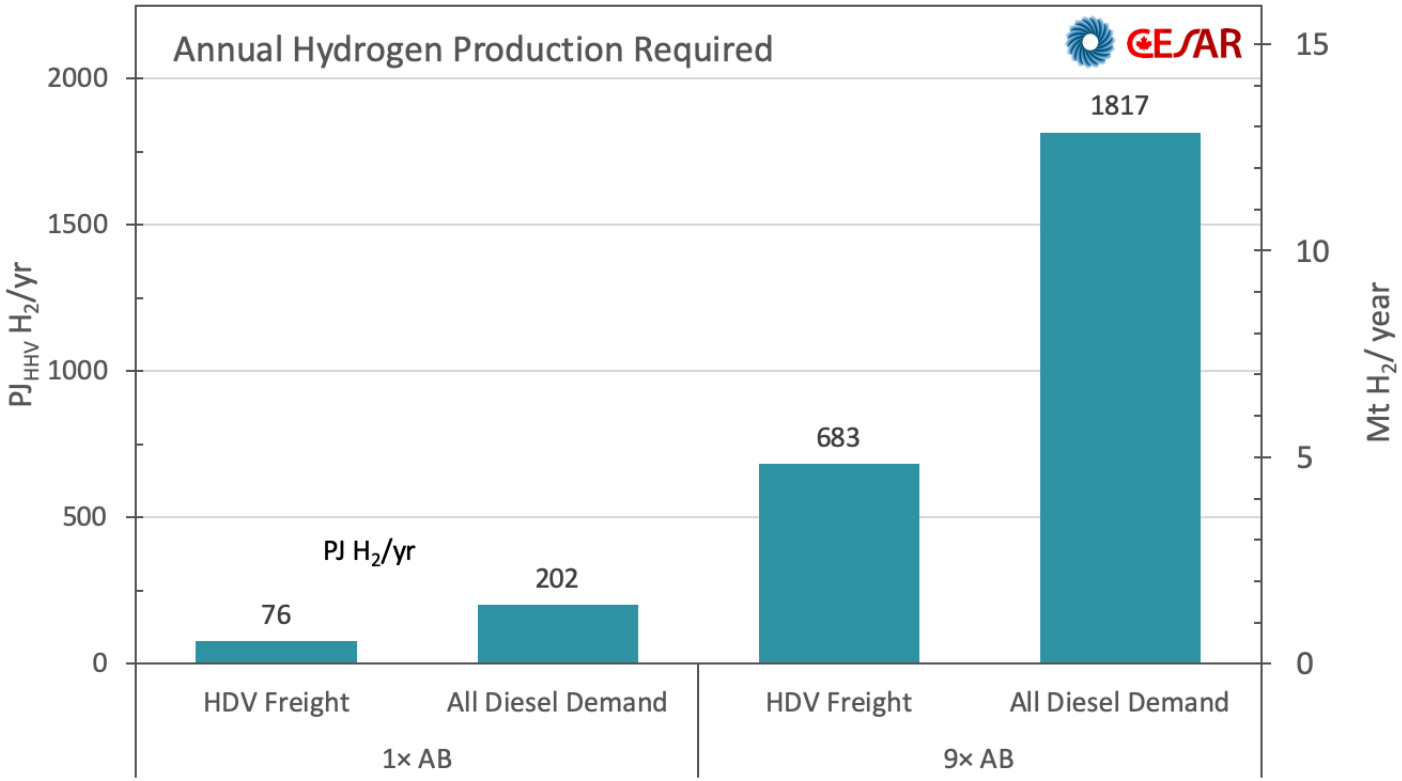
GRID POWER RESOURCE POTENTIAL

- Alberta grid load would increase by 25% to supply the trucking market; 66% for the whole diesel market
- Doubling of the projected annual grid load growth rate to meet additional demand by 2050
- Exporting to a market that is the same size of the current diesel market is not realistic.
- Alberta does not have a strong competitive advantage as a producer and supplier of low cost, low carbon electricity



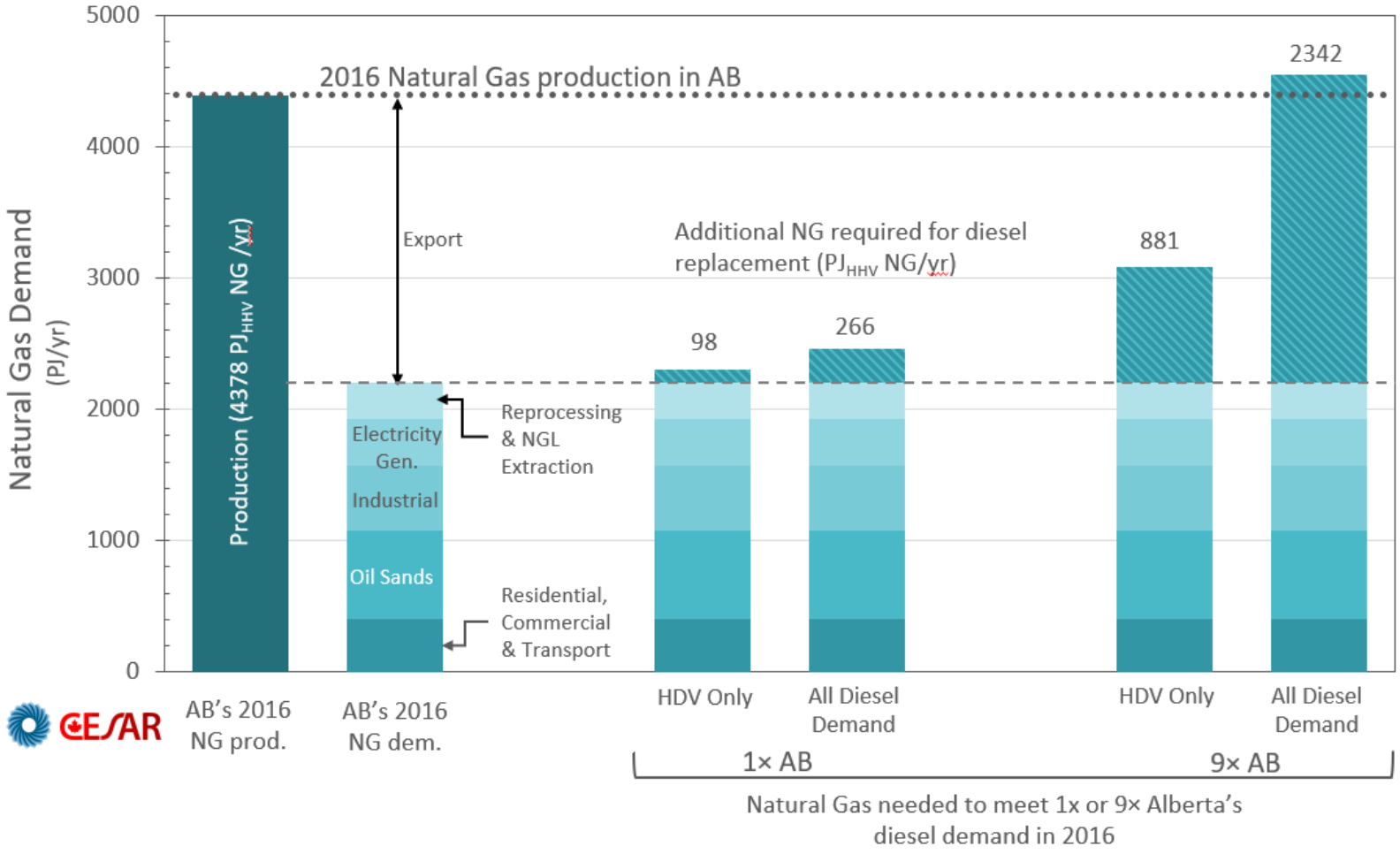
Potential Hydrogen Demand

- The potential provincial demand for hydrogen in Alberta's freight sector is 1.4 Mt H_2/ yr (55% of current H2 production levels)
- 1.4 Mt H_2/ yr @ $5/kg = $7 billion
- To supply a North America market the same size as the diesel market is 13 Mt kt H_2/ yr
- 13 Mt H_2/ yr @ $5/kg = $65 billion



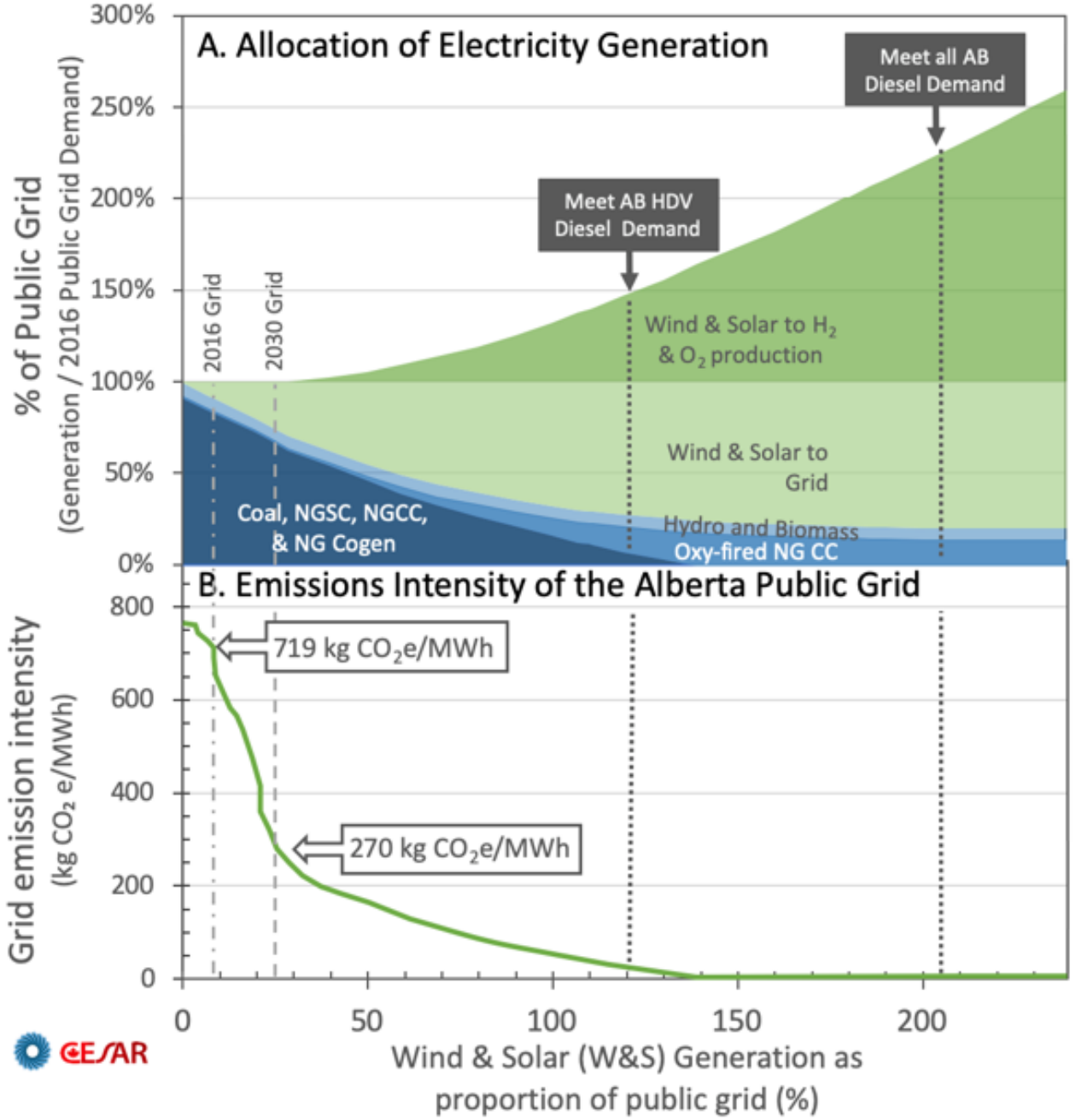
BLUE HYDROGEN RESOURCE POTENTIAL

- Alberta has an abundance of natural gas
- Current production can easily supply the demand of the domestic and export freight markets



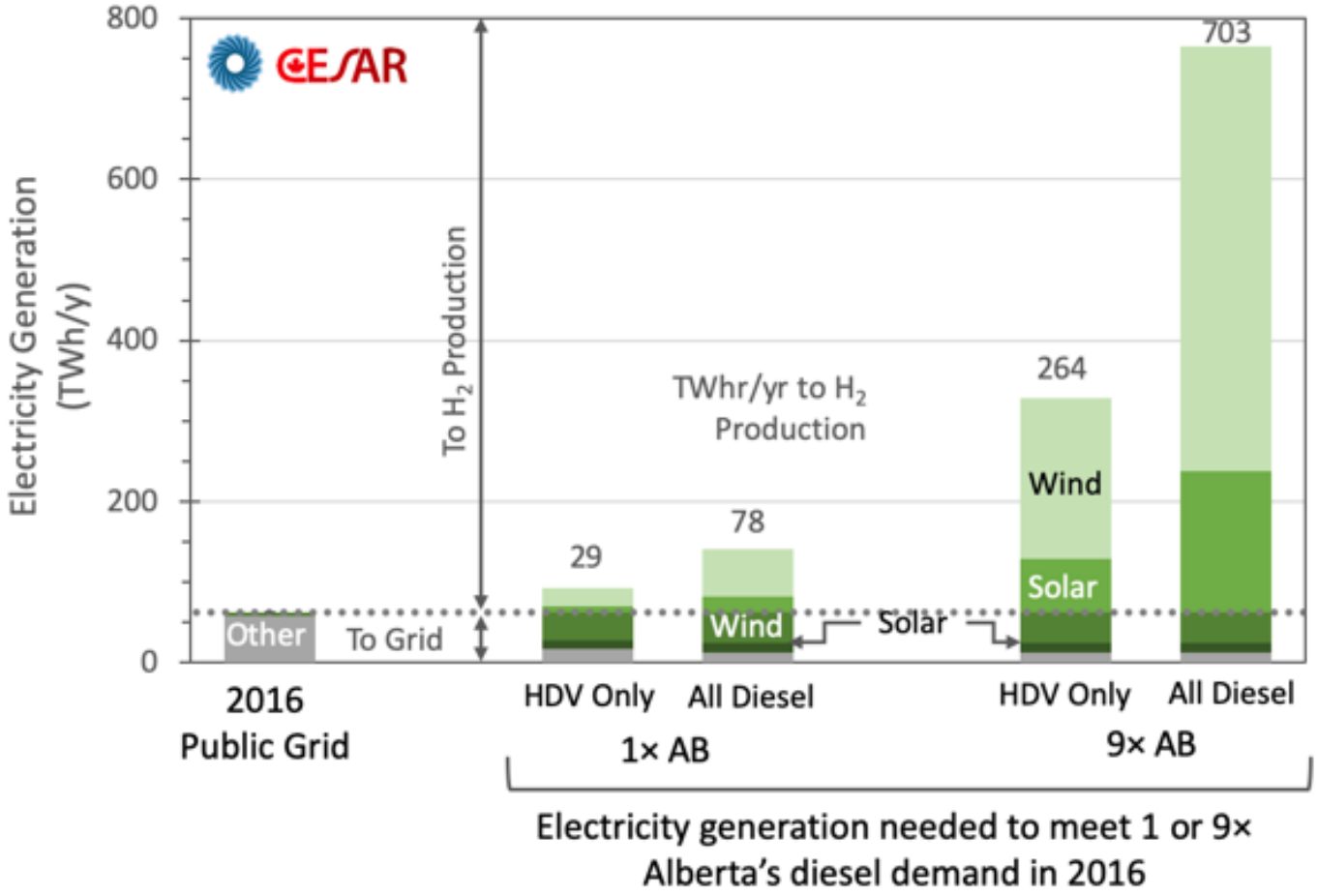
Green Hydrogen Supporting a Low Carbon Grid

- Hydrogen and a low carbon grid are complementary
- Renewables used in public grid when power prices high
- Hydrogen produced when power prices low
- When conditions do not support renewable power generation- Oxy-fired NGCC with CCS is used

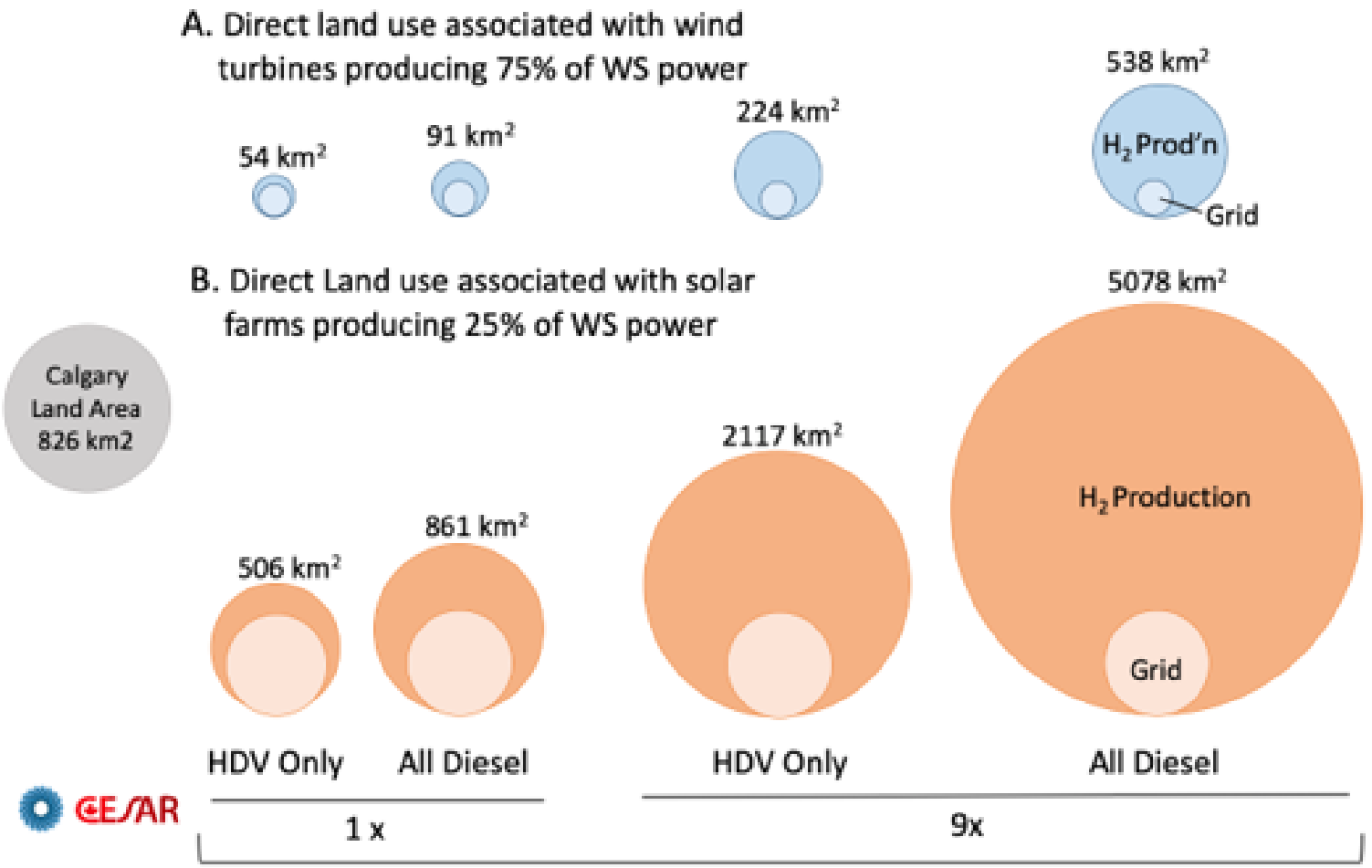


GREEN HYDROGEN- RESOURCE POTENTIAL

- HDV hydrogen demand will increase grid by 150%, ~3700 4.8 MW wind turbines
- To support all demand- grid load would grow by 205%, ~6300 wind turbines
- A 9 times Alberta market size with green hydrogen would increase grid load by 11 times



GREEN HYDROGEN- RESOURCE POTENTIAL



Direct land use for each fossil diesel displacement scenario, relative to Calgary and AB's land area

- What is reasonable?

Key Messages

Points to Remember

- The HDV transportation has high GHG emissions - the sector is poised for change.
- Battery electric and hydrogen fuel cell electric are appealing zero emission options depending on the end-use duty cycle & grid intensity.
- Hydrogen provides an opportunity for Alberta to remain a remain a supplier of transportation fuels in a net-zero future.
- Both blue and green hydrogen can be part of the transition pathway.

Questions?

Jessica Lof, MSc.
Research Lead, Hydrogen
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