Transitioning Heavy Duty Trucking in Alberta
B. Estimating the Cost and Source of Funds

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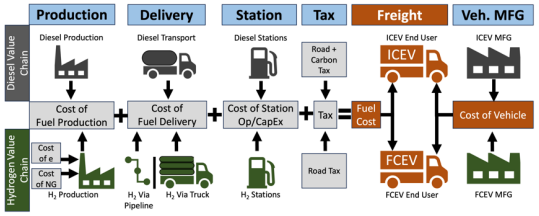
INTRODUCTION

A previous study in this series [1] used historical data on Alberta's heavy duty (HD, Class 8, 15+ t gross vehicle weight) road freight sector to project the magnitude of the changes needed for 95% of new vehicle sales to be zero-emission by 2040. Hydrogen (H_2) fuel cell electric vehicles (FCEVs) were assessed to have the most promise for zero emission long distant, HD trucks but they require the creation of an entirely new H_2 value chain as summarized in **Figure 1.**

This study provides a preliminary incremental cost estimate (compared to Business as Usual (BAU) associated with the transitioning Alberta's long haul HD trucks to H_2 FCEVs while exploring possible sources of the necessary funds.

Figure 1. Value Chains for Diesel & Hydrogen



MODEL PROJECTIONS AND ASSUMPTIONS

Table 1 Cost Assumptions — BAU Diesel / Net-Zero (NZ) Scenario

	A. BAU Diesel ICEVs	Units	2025	2030	2035	2040	2045	2050
1	Canadian carbon tax rate	$/tonne CO_2e	$95.0	$170	$170	$170	$170	$170
2	BAU annual diesel retail price	$/L	$1.65	$1.65	$1.65	$1.65	$1.65	$1.65
3	Annual price per diesel ICEV	000s $/Vehicle			$220			
4	Kilometre cost of insurance	$/km	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07
5	Kilometre cost of maintenance	$/km	$0.13	$0.13	$0.13	$0.13	$0.13	$0.13
6	Kilometre cost of administration	$/km			$0.35			
7	Kilometre cost of labour	$/km	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50
	B. Net-Zero Diesel ICEVs	**Units**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
8	NZ annual diesel retail price	$/L	$1.65	$1.65	$1.50	$1.20	$1.20	$1.20
9	Kilometre cost of insurance	$/km	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07
10	Kilometre cost of maintenance	$/km	$0.13	$0.13	$0.13	$0.13	$0.13	$0.13
11	Kilometre cost of administration	$/km			$0.35			
12	Kilometre cost of labour	$/km	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50
	C. Net-Zero Hydrogen FCEVs	**Units**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
13	Hydrogen fuel transportation method		$CD-H_2$	$CD-H_2$	LH_2+Pipe	Pipeline	Pipeline	Pipeline
14	Cost of low GHG H_2 production	$/kg H_2	$10.0	$6.00	$2.50	$2.00	$1.75	$1.75
15	Cost of H_2 preparation and transport	$/kg H_2	$7.00	$5.00	$4.00	$1.50	$1.00	$0.75
16	Capital and operating cost of FCEV station	$/kg H_2	$5.00	$3.00	$2.50	$4.00	$3.50	$3.50
17	Annual price per hydrogen FCEV	000s $/Vehicle	$650	$500	$300	$220	$220	$220
18	Kilometre cost of insurance	$/km	$0.12	$0.08	$0.08	$0.08	$0.08	$0.08
19	Kilometre cost of maintenance	$/km	$0.13	$0.10	$0.10	$0.09	$0.09	$0.09
20	Kilometre cost of administration	$/km			$0.35			
21	Kilometre cost of labour	$/km	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50

NOTE:

- Fuel costs components
- Vehicle cost estimates
- Total Cost of Ownership (TCO, $/km) for HD truck operations (other than fuel and vehicle costs) from literature

Table 2 Projected Vehicle & Fuel Demand — BAU Diesel / Net-Zero (NZ) Scenario

	A. BAU Diesel ICEVs	Units	2025	2030	2035	2040	2045	2050
1	Annual LH ICEV sales	000s Vehicles/Year	5.39	5.78	6.20	6.65	7.12	7.64
2	Total registered LH ICEVs by year	000s Vehicles	96.9	104	111	119	128	137
3	Total annual VKT driven by LH ICEVs	Billion VKT/Year	10.9	11.6	12.5	13.4	14.3	15.4
4	Annual VKT per LH ICEV	VKT/Vehicle/Year			112,055			
5	Efficiency of diesel use	L/km			0.287			
6	Annual fuel demand per LH ICEV	L/Vehicle/Year			32,115			
7	Annual LH diesel fuel demand	GL/Year	3.11	3.34	3.58	3.83	4.11	4.40
8	Annual LH diesel energy demand	GJ_{HHV} Diesel/Year	120	129	138	148	159	170
9	Tailpipe GHG emissions per litre of diesel	kg CO_2/L			2.689			
10	Total annual tailpipe GHG emissions	Mt CO_2/Year	8.37	8.97	9.62	10.3	11.0	11.8
	B. Net-Zero Diesel ICEVs	**Units**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
11	Annual LH ICEV sales	000s Vehicles/Year	5.33	5.07	2.35	0.33	0.03	0.003
12	Total registered LH ICEVs by year	000s Vehicles	96.8	102	97.6	78.2	54.2	31.4
13	Total annual VKT driven by LH ICEVs	Billion VKT/Year	10.8	11.3	9.89	6.14	2.86	1.07
14	Annual VKT per LH ICEV	000s VKT/Veh./Year	112	111	101	78.5	52.7	34.2
15	Annual fuel demand per LH ICEV	000s L/Veh./Year	32.1	31.7	29.0	22.5	15.1	9.81
16	Annual LH diesel fuel demand	GL/Year	3.10	3.23	2.84	1.76	0.82	0.31
17	Annual LH diesel energy demand	GJ_{HHV} Diesel/Year	120	125	109	67.9	31.6	11.9
18	Total annual LH ICEV tailpipe GHG emissions	Mt CO_2/Year	8.35	8.69	7.62	4.73	2.20	0.83
	C. Net-Zero Hydrogen FCEVs	**Units**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
19	Annual LH FCEV sales	000s Vehicles/Year	0.06	0.71	3.85	6.31	7.09	7.63
20	Total registered LH FCEVs by year	000s Vehicles	0.13	1.85	13.7	41.1	73.7	106
21	Total annual VKT driven by LH FCEVs	Billion VKT/Year	0.03	0.36	2.58	7.24	11.5	14.3
22	Annual VKT per LH FCEV	000s VKT/Veh./Year	198	193	189	176	156	135
23	Daily hydrogen fuel demand	000s t H_2/Day	0.005	0.06	0.47	1.32	2.09	2.60
24	Annual hydrogen energy demand	P_{HHV} H_2/Year	0.24	3.36	24.3	68.0	108	134
25	Efficiency of Hydrogen use	g H_2/km			66.4			
26	H_2 delivered per new station	Tons H_2/Day	2.00	4.00	8.00	14.0	16.0	16.0
27	Capacity factor of new stations	% Capacity	40%	55%	70%	80%	80%	80%
28	Annual new fuelling stations	New Stations	6	11	23	16	10	7
29	Total fuelling stations by year	Total Stations	6	40	134	231	295	335

- These values from the BAU and NZ Scenario for long haul HD vehicles in Alberta (95% of vehicles sales by 2040) in the first study of this series [1]

Table 3 Cost Calcs — BAU Diesel / NZ Scenario

	A. BAU Diesel ICEVs	Units	2025	2030	2035	2040	2045	2050
1	Carbon tax add-on for diesel retail price	$/L	-	$0.20	$0.20	$0.20	$0.20	$0.20
2	Total BAU cost of diesel fuel	$/L	$1.65	$1.85	$1.85	$1.85	$1.85	$1.85
3	Kilometre cost of diesel	$/km	$0.47	$0.53	$0.53	$0.53	$0.53	$0.53
4	Kilometre cost of amortized truck capital expenditure	$/km			$0.24			
	B. Net-Zero Diesel ICEVs	**Units**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
5	Carbon tax add-on for diesel retail price	$/L	$0.00	$0.20	$0.20	$0.20	$0.20	$0.20
6	Total NZ cost of diesel fuel	$/L	$1.65	$1.85	$1.70	$1.40	$1.40	$1.40
7	Kilometre cost of diesel	$/km	$0.47	$0.53	$0.49	$0.40	$0.40	$0.40
8	Kilometre cost of amortized truck capital expenditure	$/km			$0.24			
	C. Net-Zero Hydrogen FCEVs	**Units**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
9	Total cost of delivered H_2 fuel	$/kg H_2	$22.00	$14.00	$9.00	$7.50	$6.25	$6.00
10	Kilometre cost of hydrogen fuel	$/km	$1.46	$0.93	$0.60	$0.50	$0.41	$0.40
11	Kilometre cost of amortized truck capital expenditure	$/km	$0.71	$0.55	$0.33	$0.24	$0.24	$0.24

- Total Cost of Ownership (TCO) for Fuels
- Total Cost of Ownership (TCO) for Vehicles

RESULTS & DISCUSSION

Figure 2. Total Cost of Ownership (C$/km)

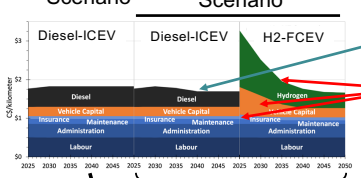
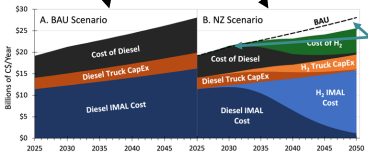


Figure 3. Alberta's HD Freight Sector Investment



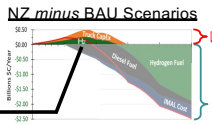
NOTE:

- In a Net-Zero Future, the declining demand for diesel is projected to reduce diesel price, but…
- …the TCO for FCEVs is projected to be much higher than that for ICEV due to higher fuel, vehicle and insurance costs, but these should decline with time and reach cost parity by late 2030s.

When the Results from **Figure 2** were combined with the NZ Scenario projection (**Poster 1** and **Table 2**)…

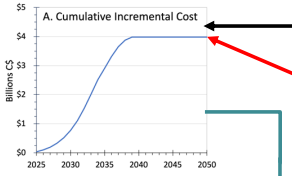
- …The total cost to the freight sector is higher than BAU over the next 10 years, but
- …is then projected to decline to be less than BAU

Figure 4. The cost differential:



- These are real costs that cannot be passed to sector
- Benefit unlikely to be realized (e.g. gas tax replacement)

Figure 5. The Cumulative Incremental Cost



- The incremental cost of the NZ scenario in Alberta is projected to be $4B.

Figure 6. The GHG Benefit of the NZ Scenario

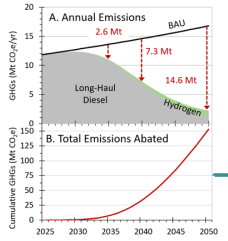
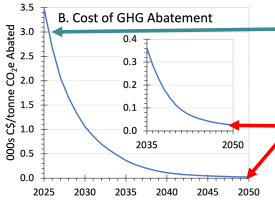


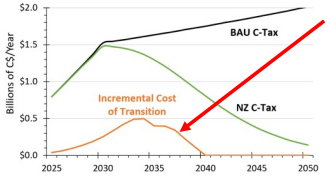
Figure 7. Abatement cost



- The cost of abating GHGs in the NZ scenario is initially very high…
- …but it declines to only $26/t CO_2 by 2050

What could be a potential source of revenue to pay for the incremental cost of transition?

Figure 8. Comparison of incremental cost with C tax income from HD Diesel ICEV in Alberta



- Between 2025 and 2040, the incremental cost of the transition accounts for only 21% of carbon taxes paid by the sector in the NZ scenario.

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[1] Redick Z, Layzell, DB, de Barros, A 2024. Transitioning Heavy Duty Trucking in Alberta: A. Magnitude of the Challenge (Poster presentation)