Enclosure 2

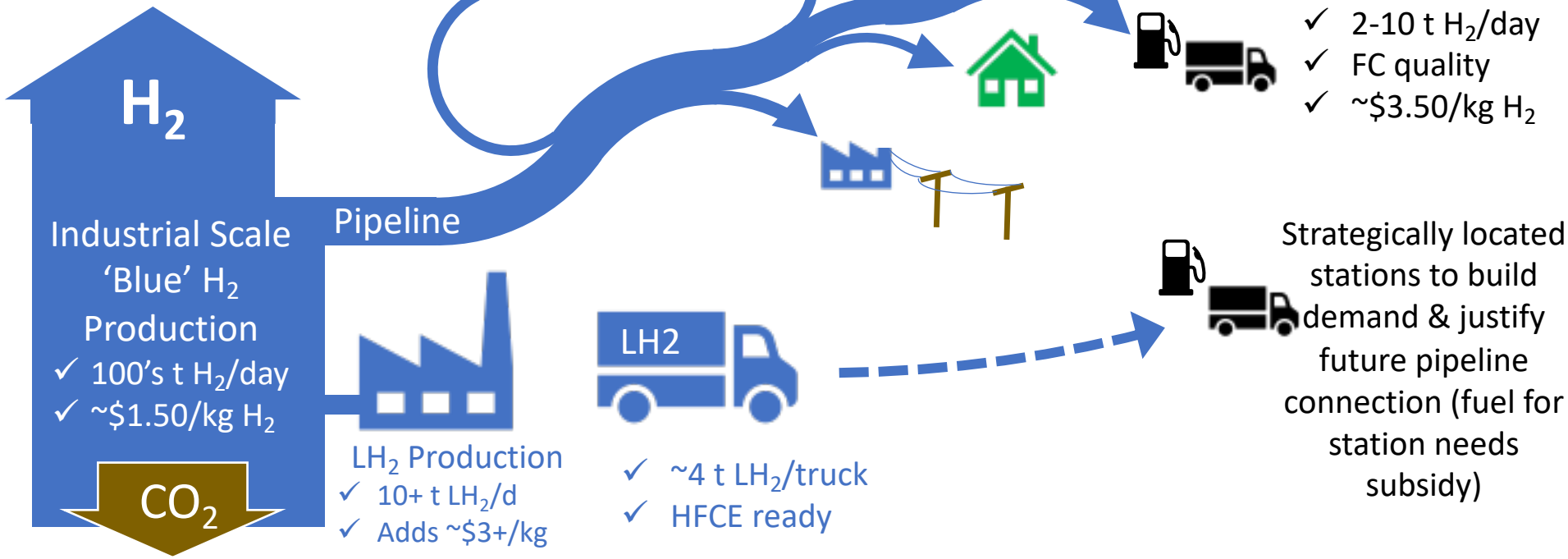
Leaders Status Report

The Alberta Industrial Heartland Hydrogen Task Force

Sept 30 2020

Proposed Deployment Strategy

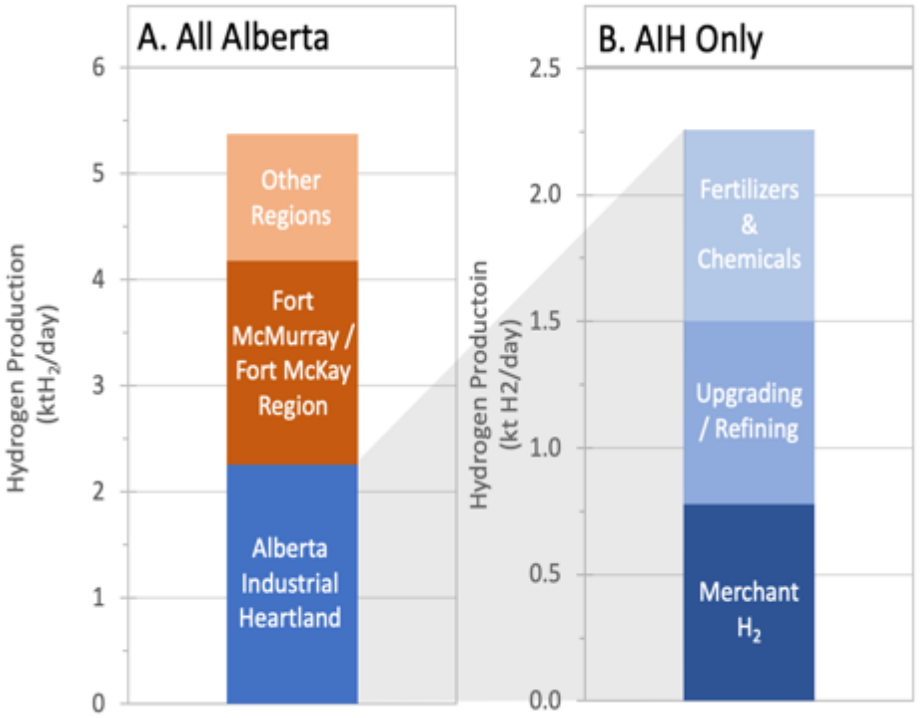
Existing or New Industrial Feedstock Demand

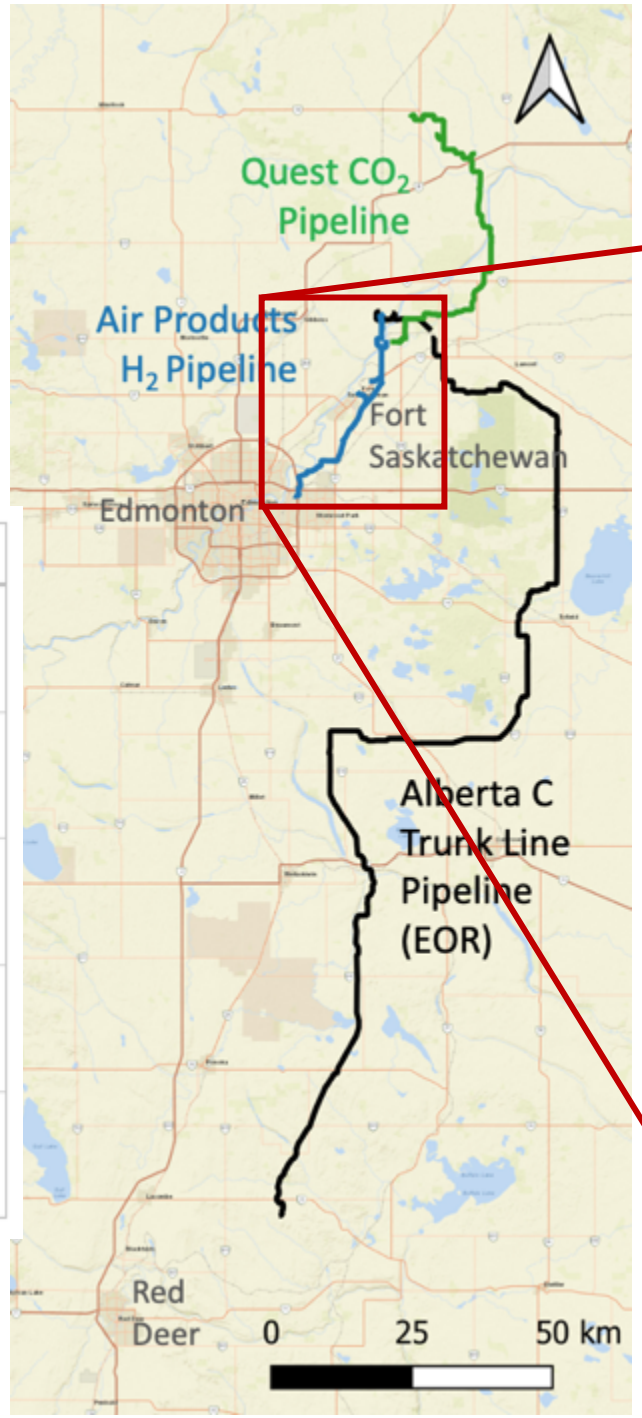


Scale Needed to achieve price targets:

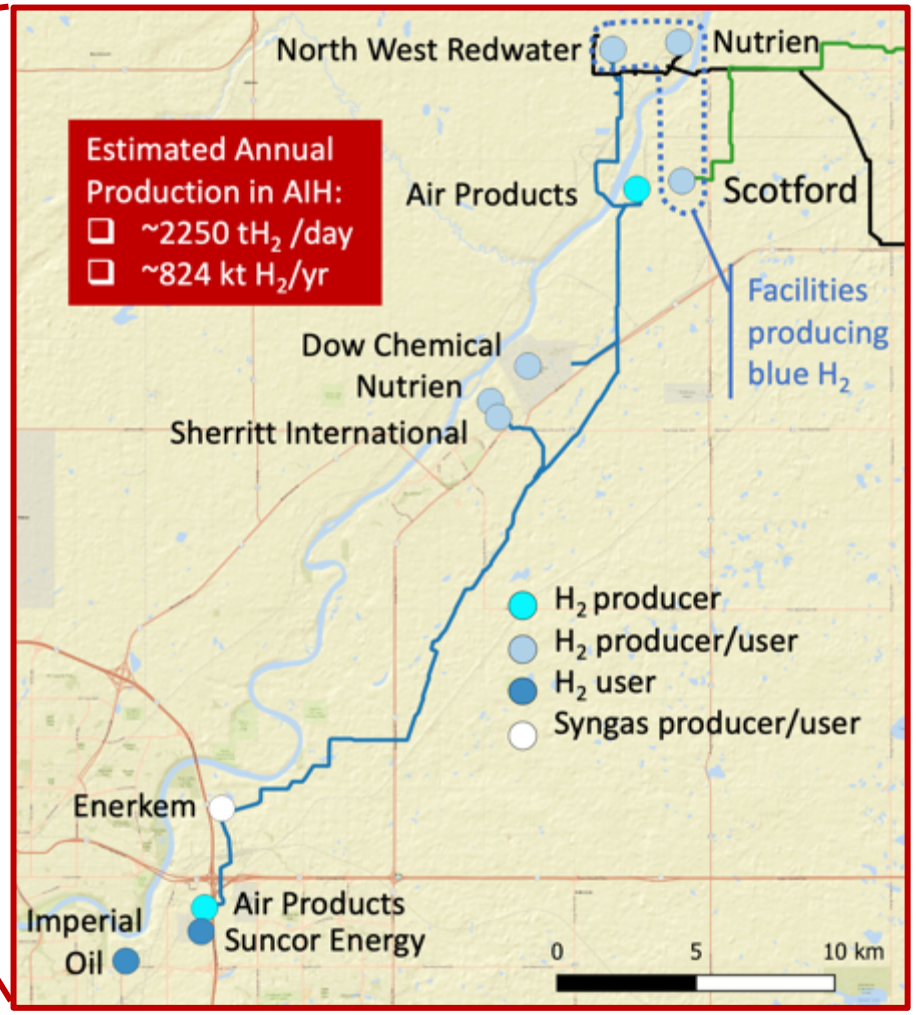
	t H_2/day
H_2 Production	~350
Pipelines	10-100s+
Buildings	1-10+
Fueling Stn	2-10
Bus	0.02-0.05
Truck	0.03-0.1
Train	0.1-1
Heavy Hauler	0.5-1

Centres for H_2 Production in Alberta

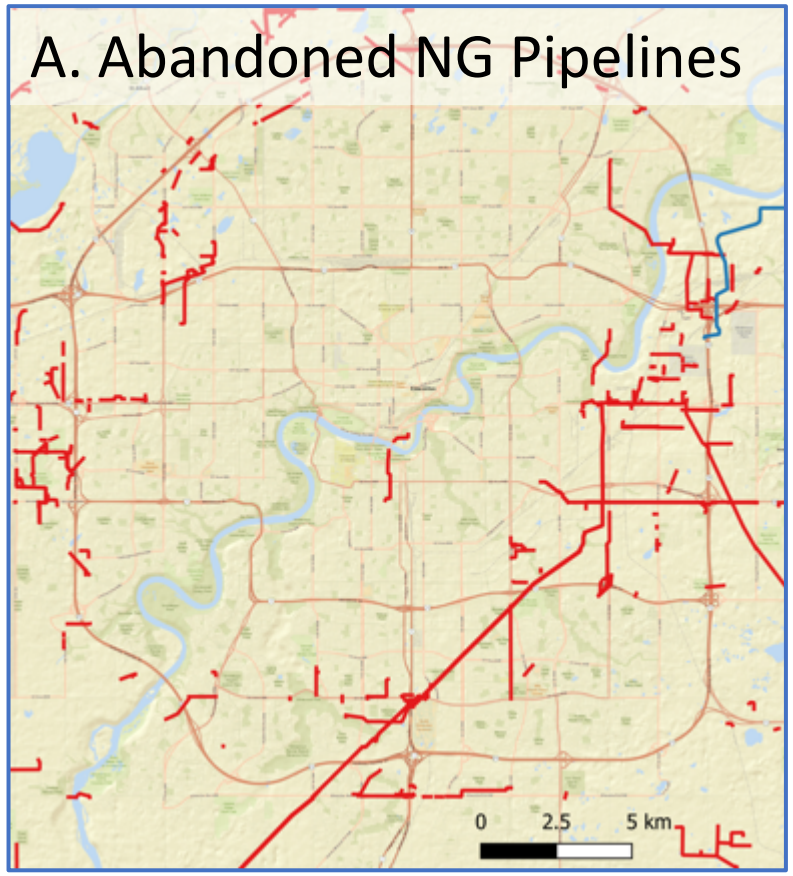


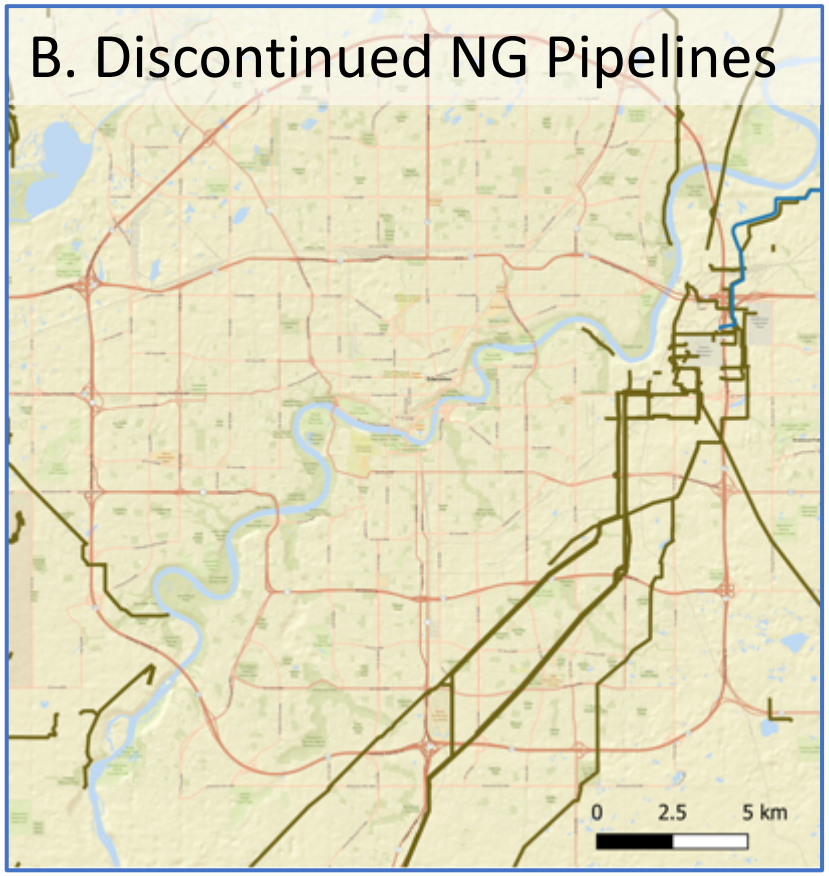


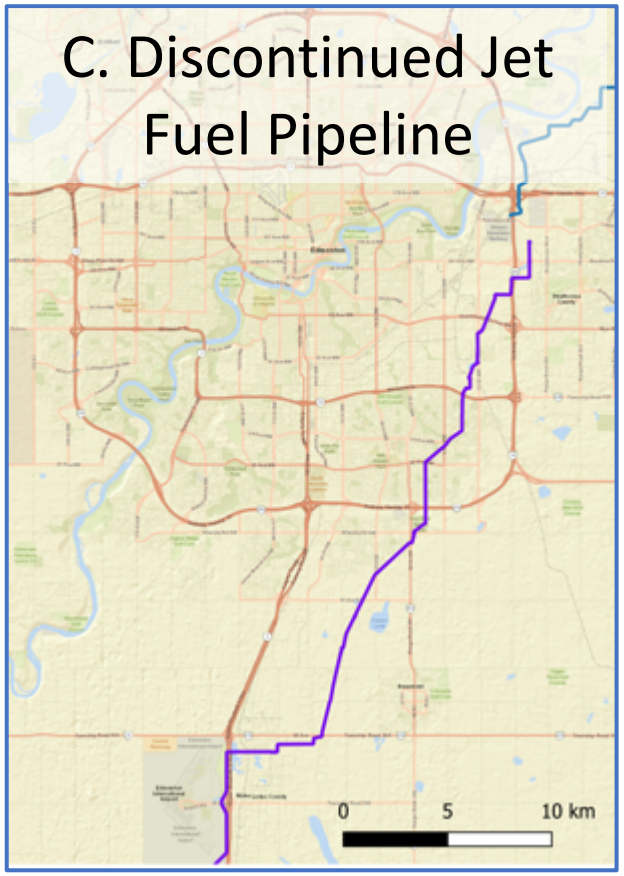
The Alberta Industrial Heartland (AIH)



Potential to Use Abandoned or Discontinued Pipelines

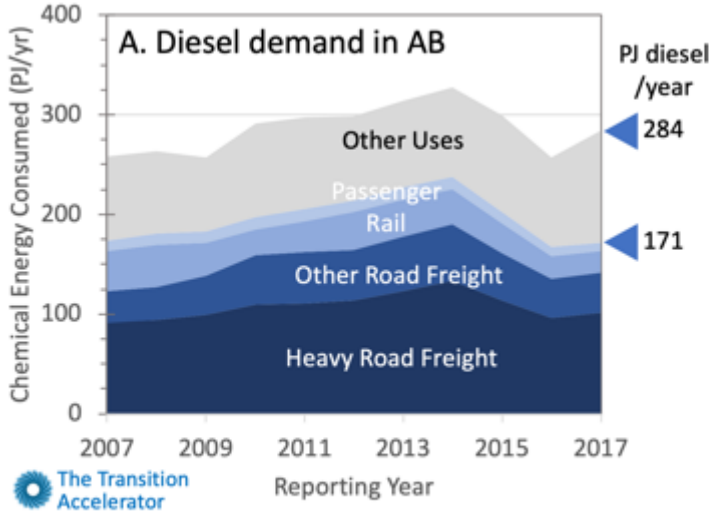


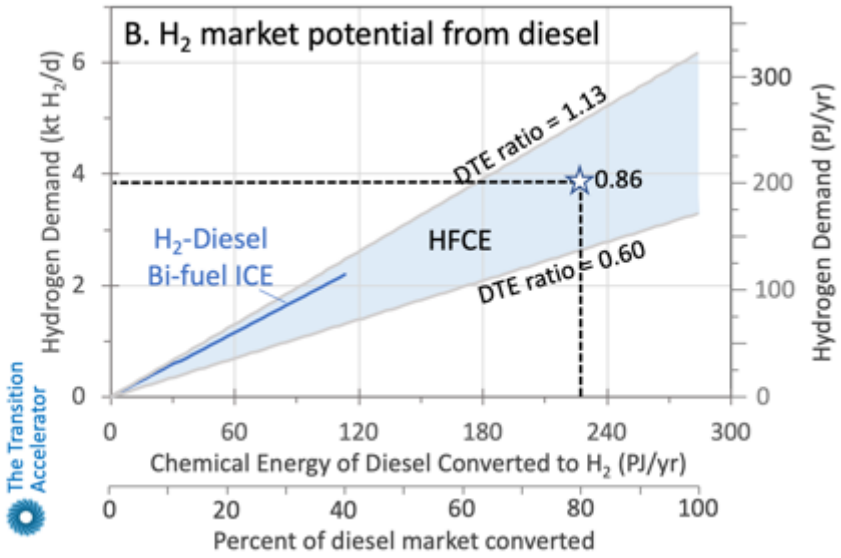




Alberta Market Opportunity for Hydrogen: Transportation Fuels

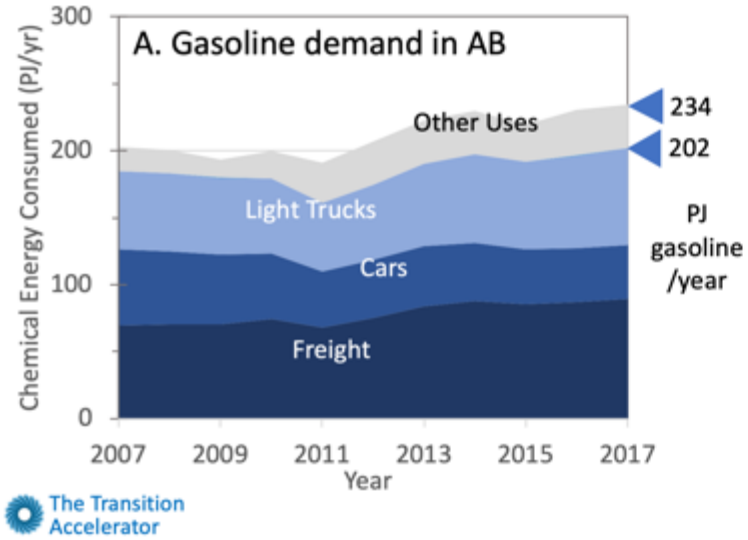
DIESEL

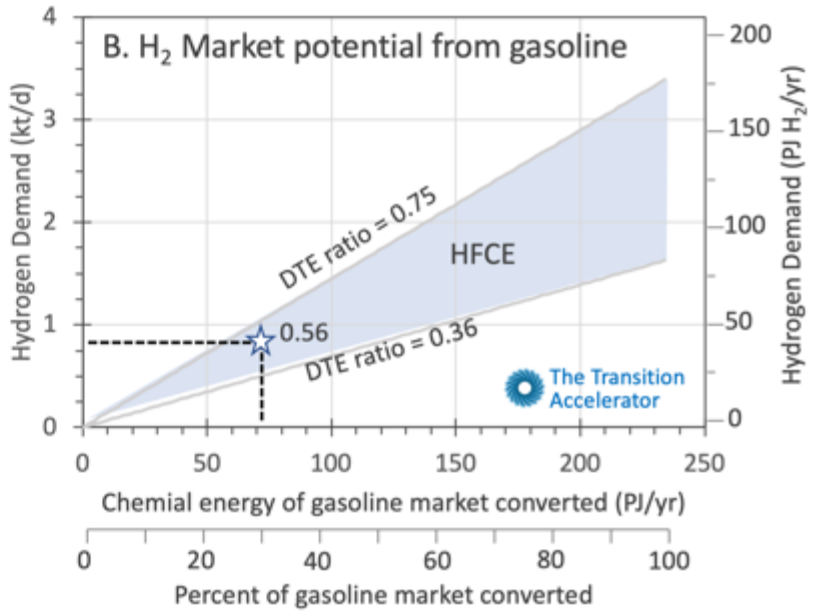




3773 t H_2/d

GASOLINE

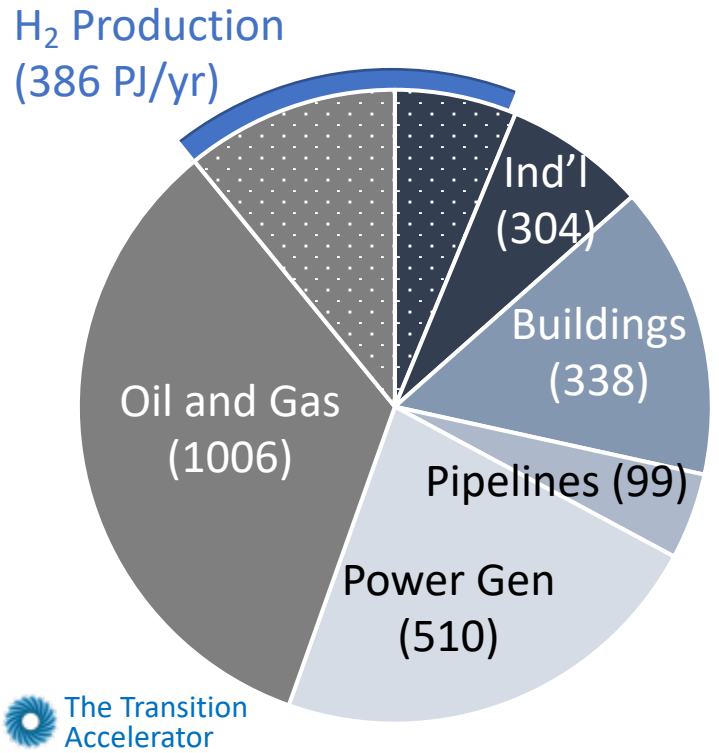




760 t H_2/d

Alberta Market Opportunity for Hydrogen: Natural Gas

Natural Gas Demand in AB
2257 PJ NG/yr



Annual demand (2017) for natural gas in Alberta by end-use demand (A).
Source: AER ST 98 Statistical Report;
SMR: Steam Methane Reform.

Estimate of demand for hydrogen by proportion of the natural gas market converted to hydrogen.

		A	B	C	D	E	F	G
Sector		Natural Gas Use (2017)	Market Share to H_2 (a)	Conversion Factor (b)	New H_2 Economy			
					Gray to Blue H_2 (c)	New H_2 Market (c)	Gray H_2 to Blue H_2 (d)	New H_2 Market (d)
		PJ NG/yr	%	PJ H2/PJ NG	PJ H_2/yr		t H_2/day	
1	Industry - SMR	140	100%	0.72	101	-	1,953	-
2	Industry - other	164	80%	1.0	-	131	-	2,532
3	Buildings	338	80%	1.0	-	270	-	5,228
4	Pipeline Transport	99	80%	0.86	-	68	-	1,321
5	Power Gen	510	50%	1.0	-	255	-	4,930
6	Oil&Gas - other	760	50%	1.0	-	380	-	7,347
7	Oil&Gas - SMR	246	100%	0.72	177	-	3,425	-
8	**AB Domestic Mkt**	**2,257**	**-**	**6.3**	**278**	**1,105**	**5,378**	**21,358**

Footnotes

(a) Given forces to move to net zero emissions, we assumed a conversion to Hydrogen use as a fuel for all existing natural gas demand except the building sector (20% to electrification), other oil and gas (20% to electrification, 30% to Renewable natural gas), power generation (50% remaining on natural gas), other industry (20% to electrification). For pipeline transport (20% remaining on natural gas).

(b) Amount of hydrogen produced per energy unit of natural gas. Ratios from CESAR's Future of Freight Part D report.

(c) Calculated as NG Gas Use X Market share to Hydrogen X Conversion Factor

(d) Calculated as H_2 Energy divided by a higher heating value of 141.7 PJ/Mt H_2 times 1000 kt/Mt divided by 365 days/yr

Alberta Market Opportunity for Hydrogen: Total (within Province)

Summary of potential hydrogen demand in Alberta.

	Potential Markets for Blue H_2 made in Alberta	A Potential Domestic Market Demand for H_2 in Alberta PJ H_2/yr	B kt H_2/yr	C t H_2/day
Converting Existing Gray Hydrogen to Blue Hydrogen				
1	**Existing Ind'l Feedstock Mkt (a)**	**278**	**1,963**	**5,378**
New Hydrogen Fuel Markets				
2	From Diesel market (b)	195	1,377	3,773
3	From Gasoline market (c)	39	278	760
4	From Natural Gas market (d)			
5	Industry	131	924	2,532
6	Buildings	270	1,908	5,228
7	Pipeline Transport	68	482	1,321
8	Power Generation	255	1,800	4,930
9	Oil and Gas	380	2,682	7,347
10	**Total New Hydrogen Fuel Mkt**	**1,339**	**9,451**	**25,891**
Market Potential for Hydrogen Demand in Alberta				
11	**Total**	**1,617**	**11,414**	**31,269**

Converting existing Gray H_2 to Blue H_2

80% diesel & 30% gasoline to H_2

Natural gas markets to H_2

- ~6X current gray H_2 production in Alberta
- Does not include export potential

Footnotes

(a) From Table 2.1, Item 8, Column D and F (Gray H2 to Blue H2)

(b) From Figure 2.2B, assuming 80% of the Alberta 2017 diesel market converts to Hydrogen

(c) From Figure 2.3B, assuming 30% of the Alberta 2017 gasoline market converts to Hydrogen

(d) From Table 2.2, Item 2 to 6, Column E and G

Implications of New (blue) H_2 Markets for NG Demand and CCS

Table 2.3. Summary of carbon capture & storage (CCS) and natural gas demand in a hydrogen economy

		A	B	C	D
Potential Markets for Blue H_2 made in Alberta		CCS Capacity Needed if Blue H_2 (a)	Natural Gas Demand		
			For H_2 Production (b)	Conventional uses (c)	Total
		Mt CO_2/yr	PJ NG/yr		
Converting Existing Grey Hydrogen to Blue Hydrogen					
1	**Existing Ind'l Feedstock Mkt**	**17.5**	**386**	**-**	**386**
New Hydrogen Fuel Markets					
2	From Diesel market	12.2	271	-	271
3	From Gasoline market	2.5	55	-	55
4	From Natural Gas market				
5	Industry	8.2	182	33	215
6	Buildings	17.0	376	0	376
7	Pipeline Transport	4.3	95	20	115
8	Power Generation	16.0	354	255	609
9	Oil and Gas	23.8	528	228	756
10	**Total New Hydrogen Fuel Mkt**	**84**	**1,860**	**536**	**2,396**
Market Potential for Hydrogen Demand in Alberta					
11	**Total**	**101**	**2,246**	**536**	**2,782**

Footnotes

(a) Calculated from Table 2.2 Column A X 9.88 t CO2/t [illegible]% capture

(b) Calculated using same logic as Table 2.1.

(c) Calculated from Table 2.2 Column C ÷ efficiency of S[illegible] methane reforming (0.72)

Natural gas demand increases to 2782 from current 2257 PJ/yr

CCS required: 101 MT CO_2/yr
Current: 2 Mt CO_2/yr

The Transition Accelerator | L'Accélérateur de transition

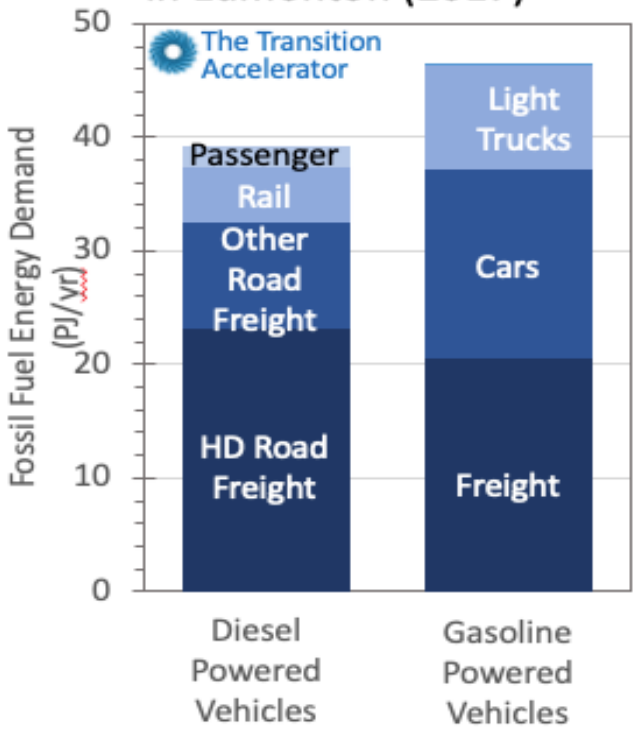
So we know <u>where</u> & <u>how</u> to produce low-cost blue H_2.

We now need to develop:

- ❑ *The markets for hydrogen as a fuel, and*
- ❑ *The means to connect supply to demand at a cost-effective price*
- ❑ *Domestic AND Export*

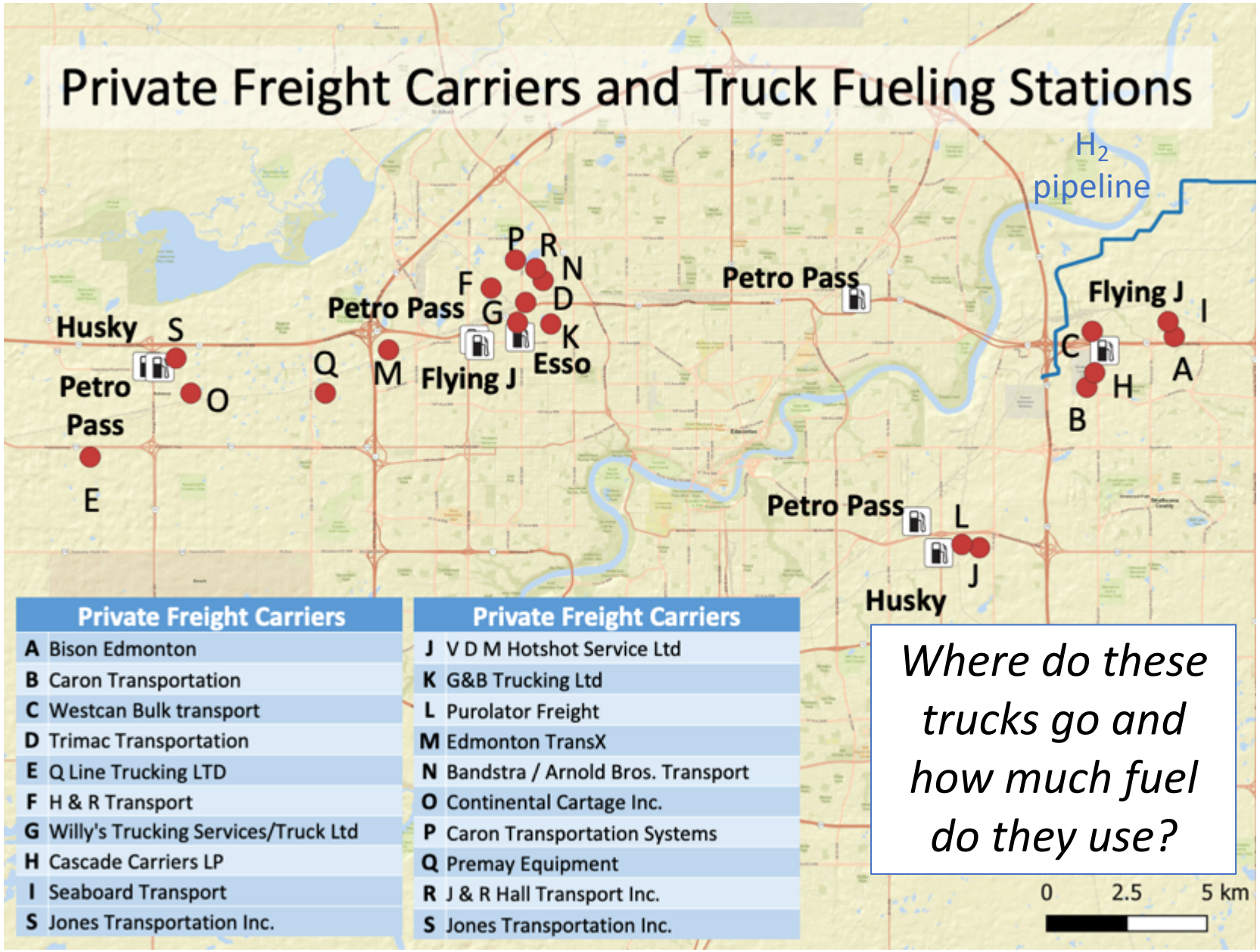
Road Fuel Requirements & Freight Carriers

A. Diesel and Gasoline Demand in Edmonton (2017)



If 80% and 30% to H_2…

= 672 t H_2/day



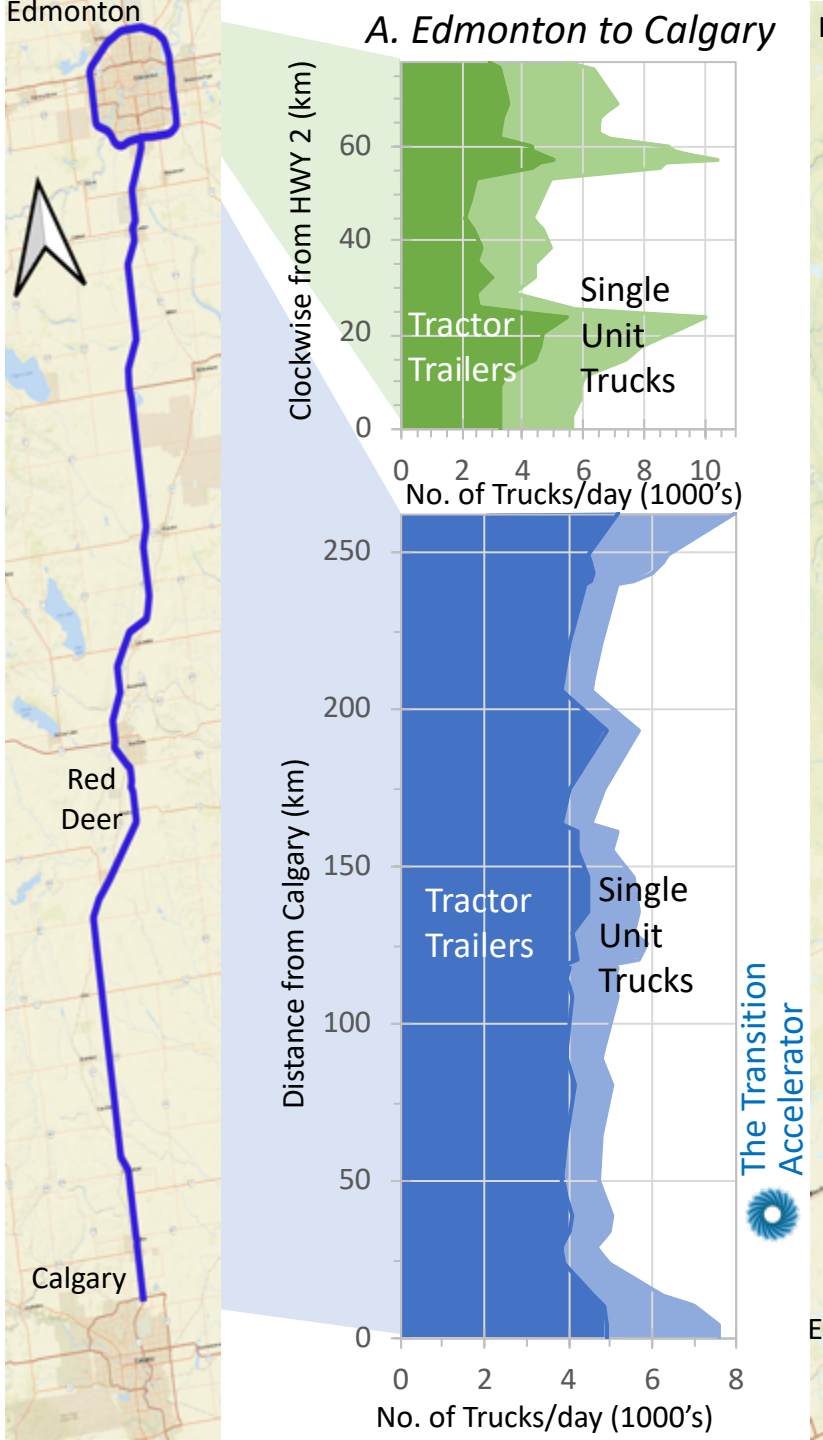
Private Freight Carriers	
A	Bison Edmonton
B	Caron Transportation
C	Westcan Bulk transport
D	Trimac Transportation
E	Q Line Trucking LTD
F	H & R Transport
G	Willy's Trucking Services/Truck Ltd
H	Cascade Carriers LP
I	Seaboard Transport
S	Jones Transportation Inc.

Private Freight Carriers	
J	V D M Hotshot Service Ltd
K	G&B Trucking Ltd
L	Purolator Freight
M	Edmonton TransX
N	Bandstra / Arnold Bros. Transport
O	Continental Cartage Inc.
P	Caron Transportation Systems
Q	Premay Equipment
R	J & R Hall Transport Inc.
S	Jones Transportation Inc.

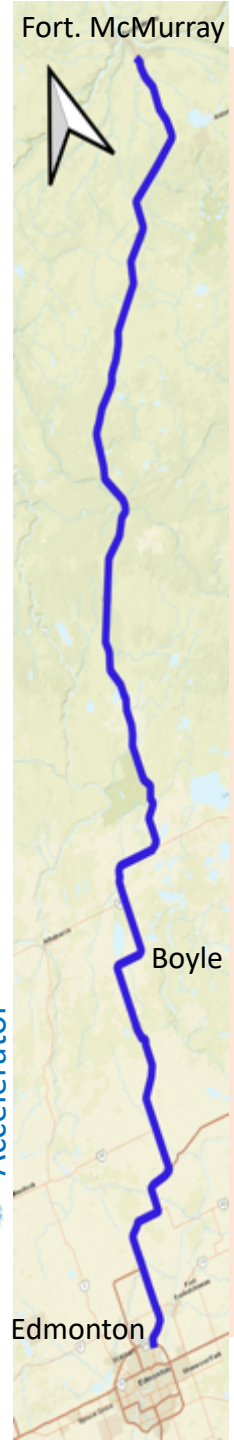
Where do these trucks go and how much fuel do they use?

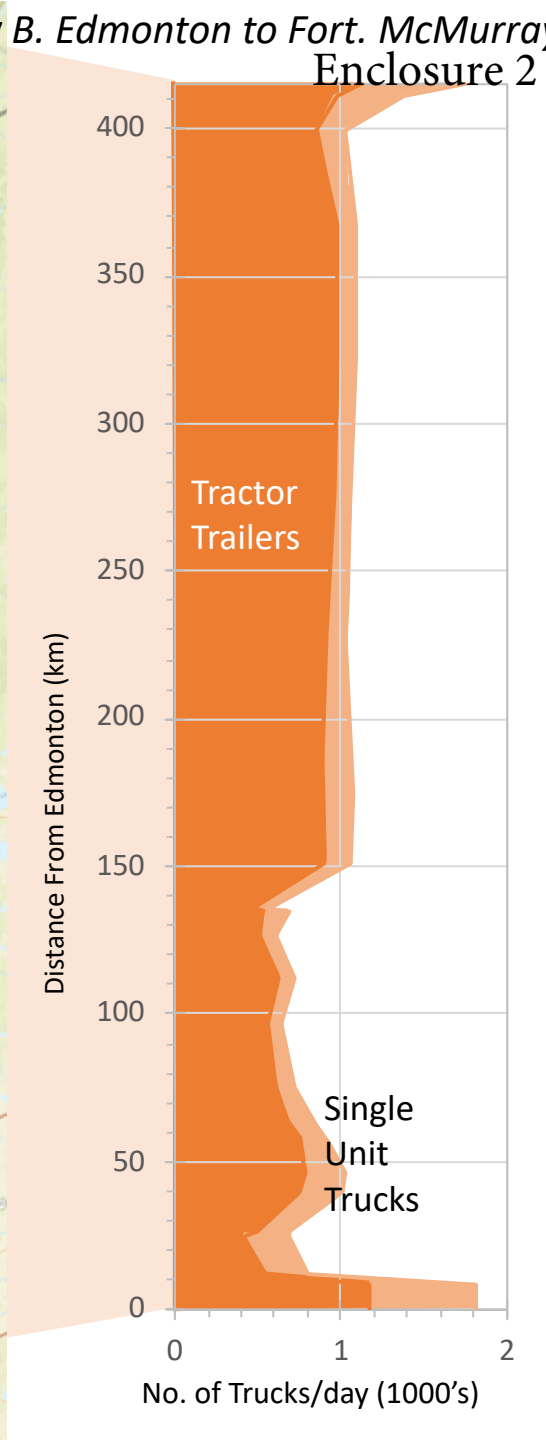
Daily Truck Traffic on Major Trucking Corridors leaving Edmonton

Data extracted from Alberta Transport Models

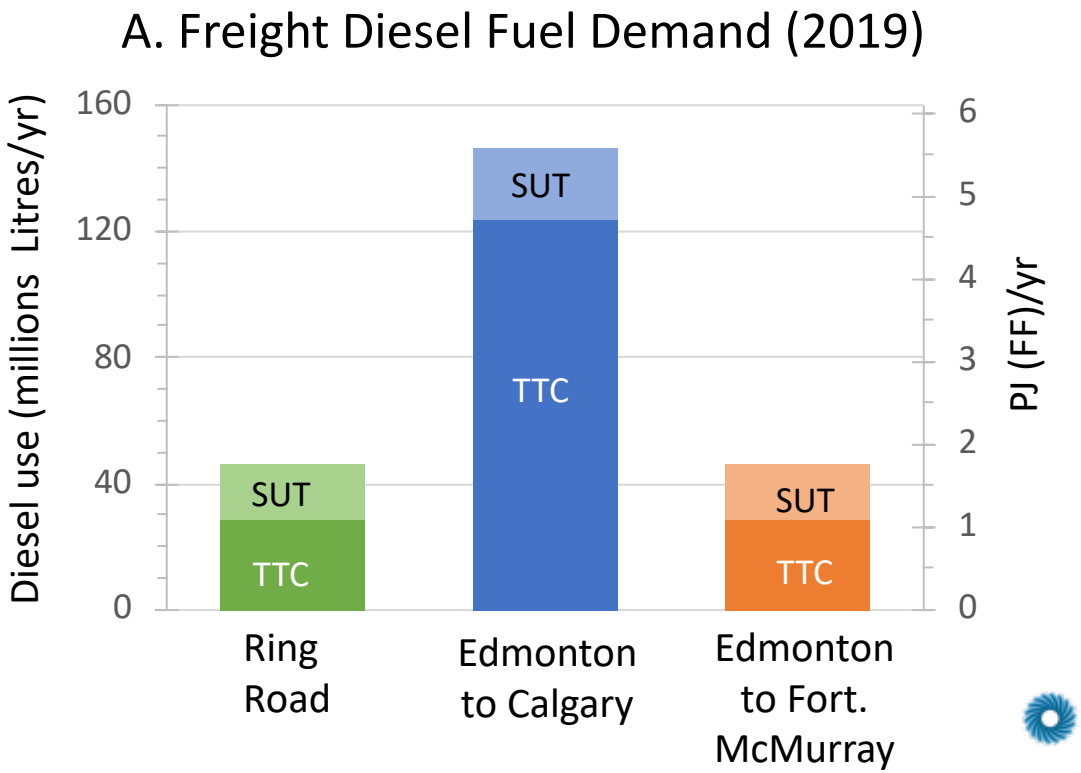


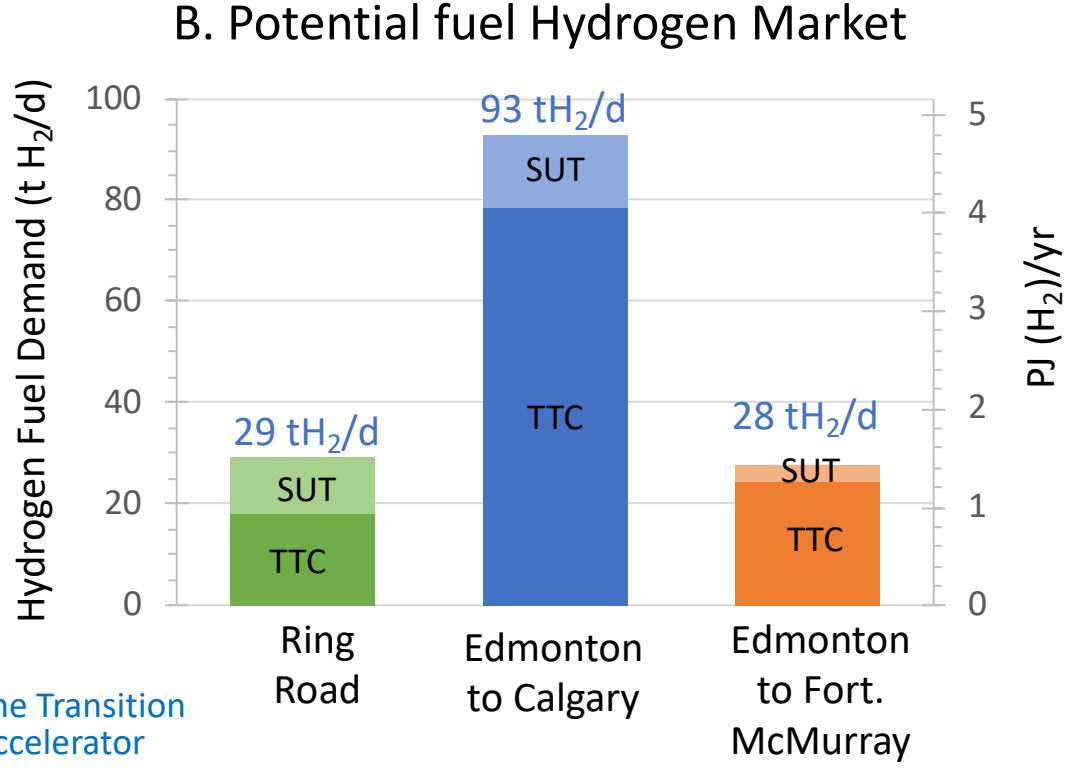
The Transition Accelerator





Estimated Diesel Fuel Use on Major Trucking Corridors Leaving Edmonton





The Transition Accelerator

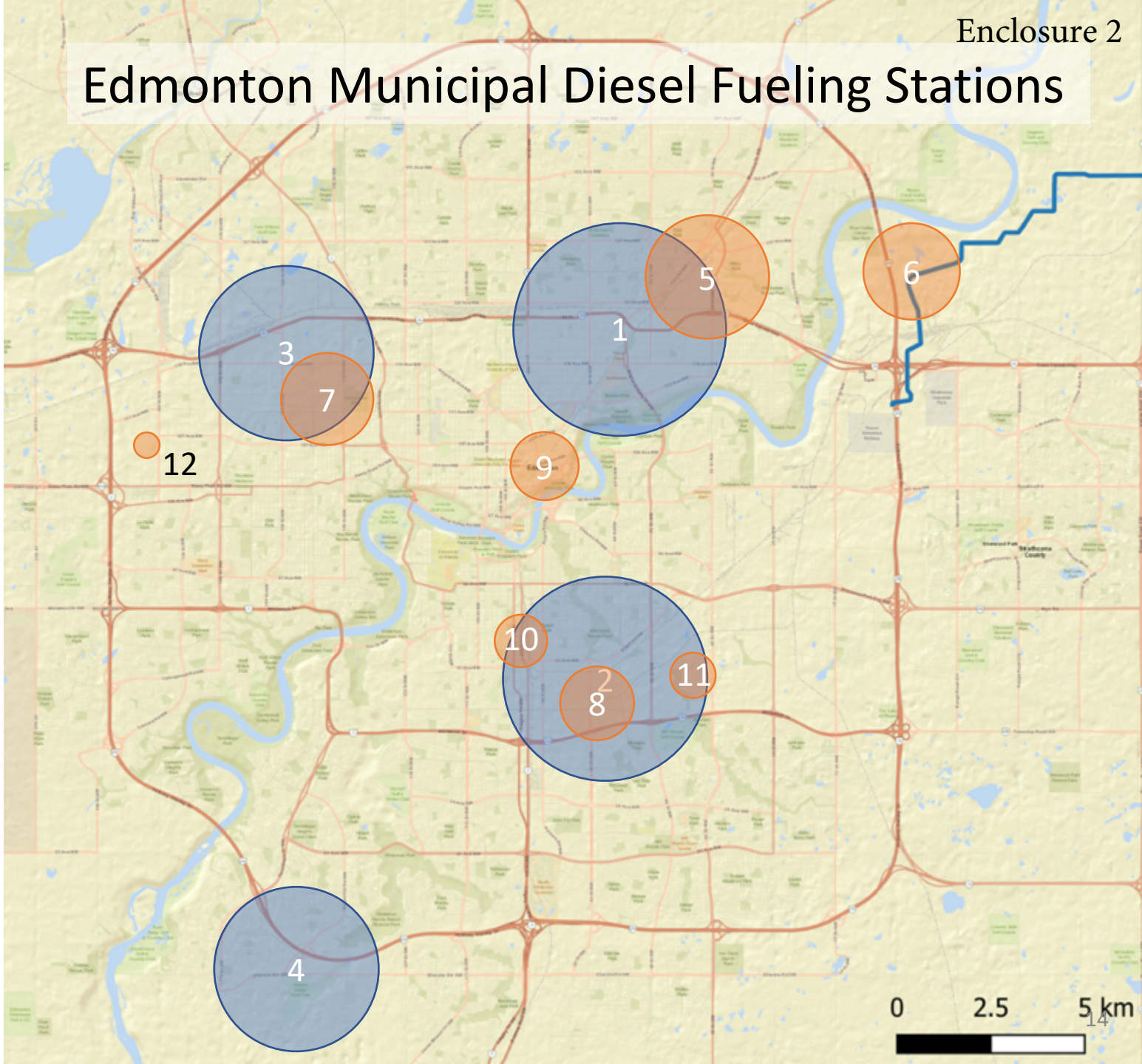
Potential hydrogen market for these trucks only: ~150 t H_2/day
(Sufficient to support 15+ large fueling stations)

TTC: Tractor Trailer Truck
SUT: Single Unit Trucks

Edmonton Municipal Fleets and Refueling Locations

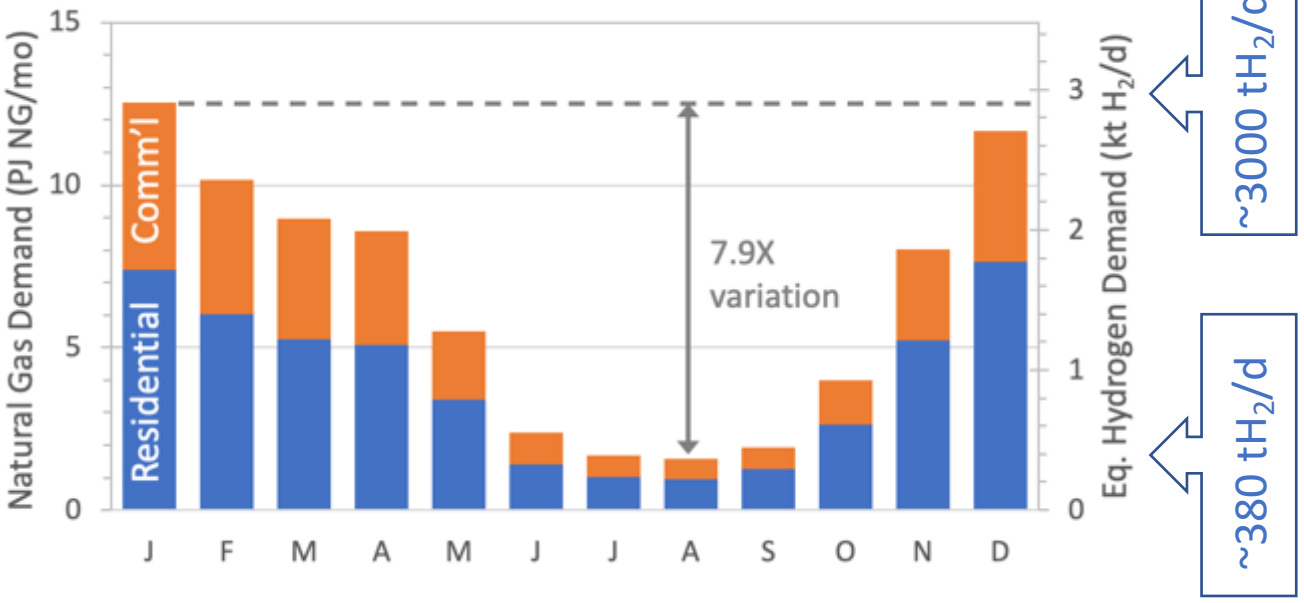
Edmonton Municipal Diesel Fueling Stations		kL diesel/yr	TJhhv diesel/yr	kt H2/yr	t H2/d
Public Transit		**23,704**	**915**	**6.46**	**17.69**
1	Kathleen Edwards	7,414	286	2.02	5.53
2	Ferrier	6,822	263	1.86	5.09
3	Mitchell	5,027	194	1.37	3.75
4	Centennial	4,442	171	1.21	3.32
Other Municipal Fleets		**8,257**	**319**	**2.25**	**6.16**
5	Kennedale	2,486	96	0.68	1.86
6	EWMC	1,526	59	0.42	1.14
7	West End	1,407	54	0.38	1.05
8	Davis	876	34	0.24	0.65
9	Main Central	757	29	0.21	0.56
10	SE Transportation yard	764	30	0.21	0.57
11	SE Transportation yard	331	13	0.09	0.25
12	Fire Service Center	111	4	0.03	0.08
TOTAL		31,962	1,234	8.7	23.9

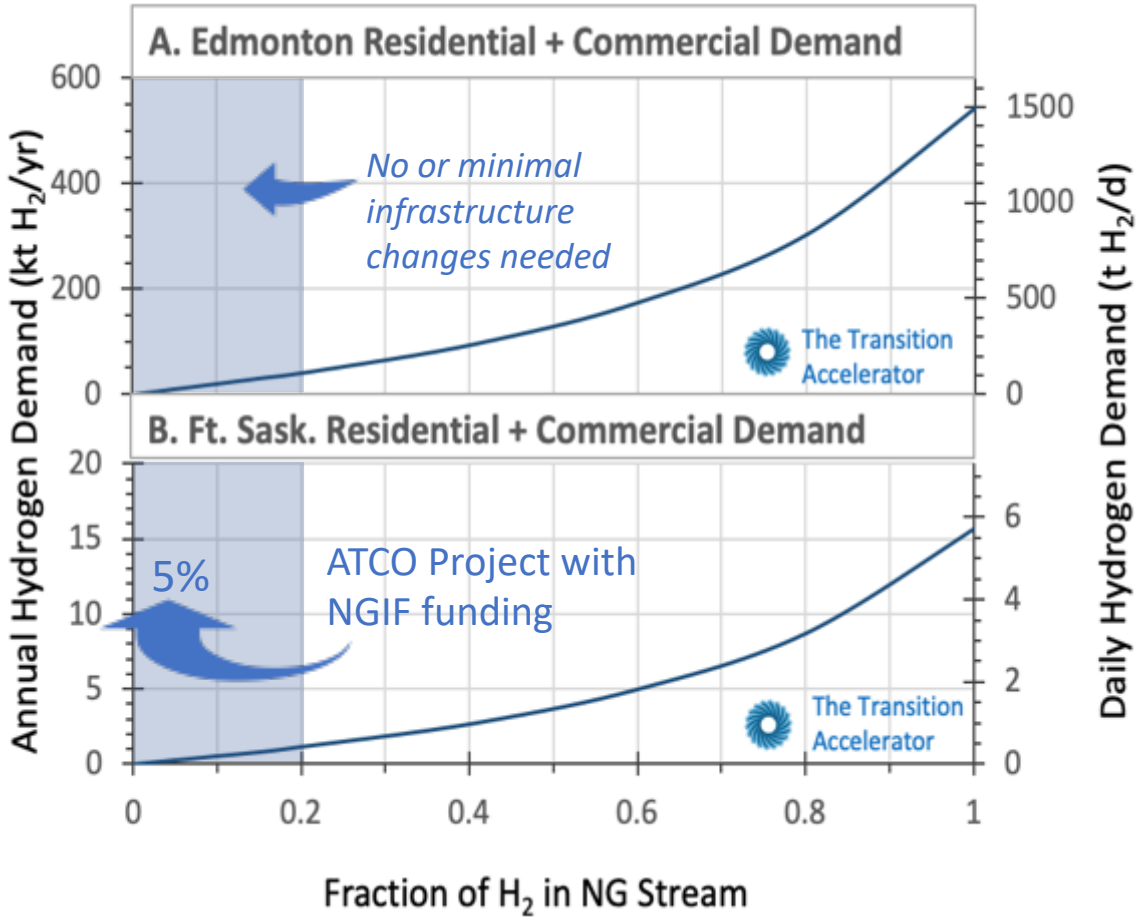
4.6% of all diesel demand in Edmonton



What About Using Hydrogen to Decarbonize Natural Gas?

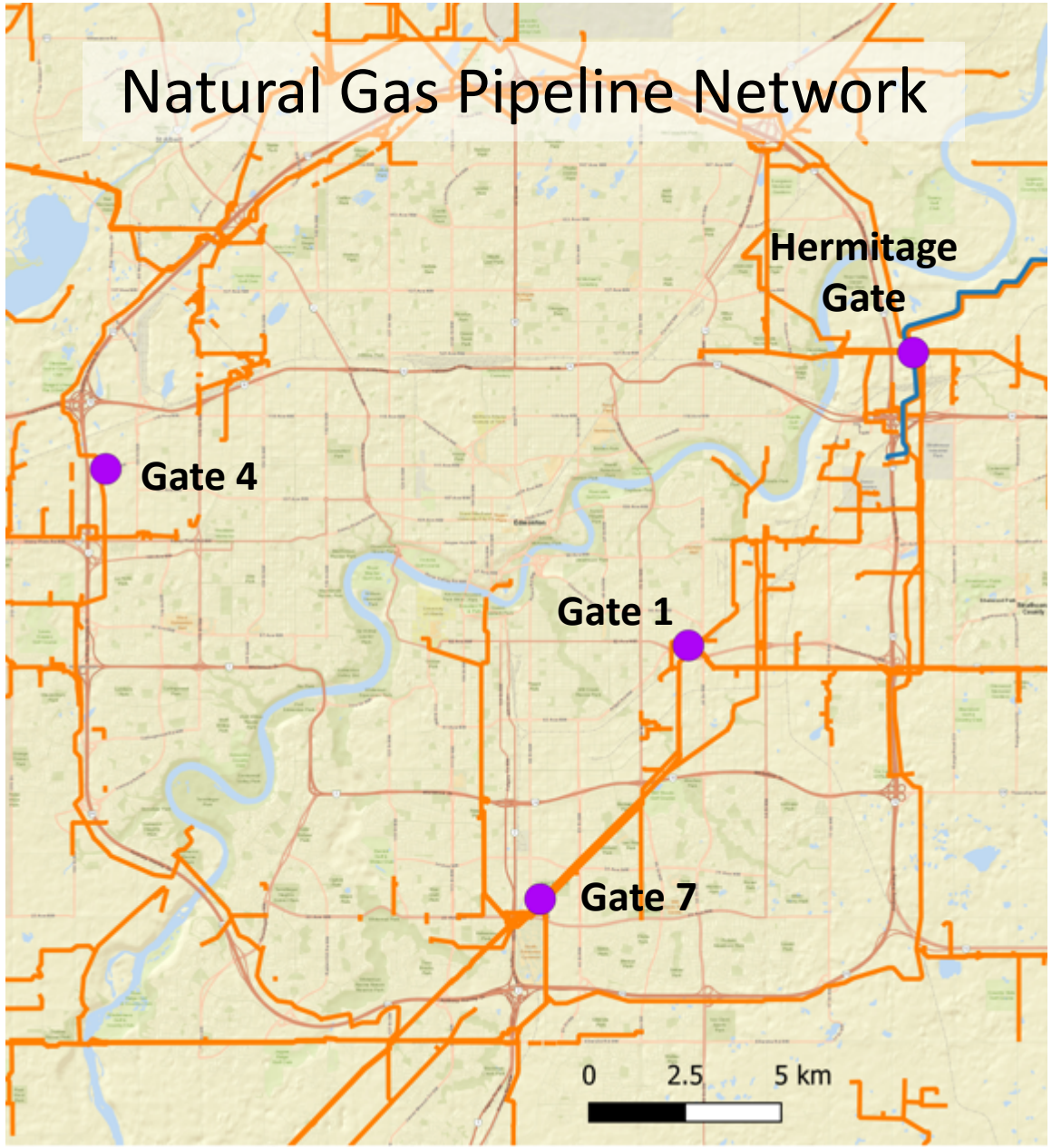
Seasonal Variability in Natural Gas Demand in Edmonton



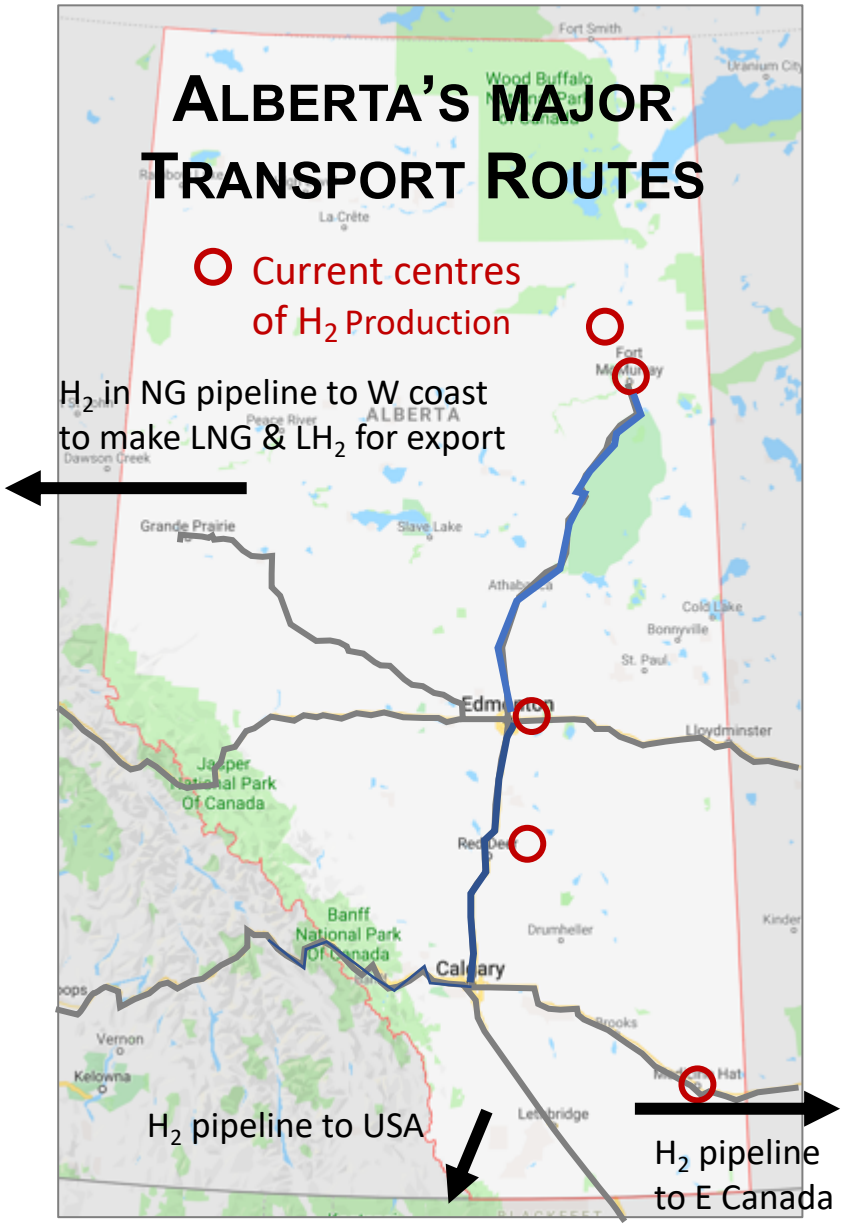


Where Would the Hydrogen be Added to the NG Distribution System?

Note:
These are in the same regions of the city as the municipal and private fueling stations, so one or two pipelines could serve all.



What's next?



Greater Edmonton H_2 Node

- ❑ Get mandate to work across sectors to create a value chain linking blue hydrogen production to new 'fuel' markets
  - ✓ 10s to 100s of vehicles (trucks, buses, trains);
  - ✓ 1 to 3 strategically located fueling stations, pipeline connected;
  - ✓ H_2 into NG pipelines for space/water heating;
  - ✓ Launch industry-led consortia with PPP

Fort McMurray/ Fort Mckay H_2 Node

- ❑ Identify cost effective source of blue hydrogen
- ❑ Get mandate to work across sectors to create a value chain linking blue hydrogen production to new fuel markets
  - ✓ 10s to 100s of vehicles (heavy haulers, trucks, trains etc);
  - ✓ Strategically located fueling stations, pipeline connected;
  - ✓ Create Edmonton – Fort McMurray corridor
  - ✓ Launch industry-led consortia with PPP

Calgary H_2 Node (as above)

- ❑ Create Edmonton – Calgary Hydrogen Corridor

Export Market

- ❑ Other provinces, USA, Asia