DOCKETED	
Docket Number:	23-IEPR-06
Project Title:	Hydrogen
TN #:	252174
Document Title:	Presentation - Hyundai's US Market Considerations for Class 8 FC Trucks
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Organization:	Hyundai
Submitter Role:	Public
Submission Date:	9/7/2023 3:32:31 PM
Docketed Date:	9/7/2023

Hyundai's US Market Considerations for Class 8 FC Trucks

IEPR Commissioner Workshop on the Potential Growth of Hydrogen

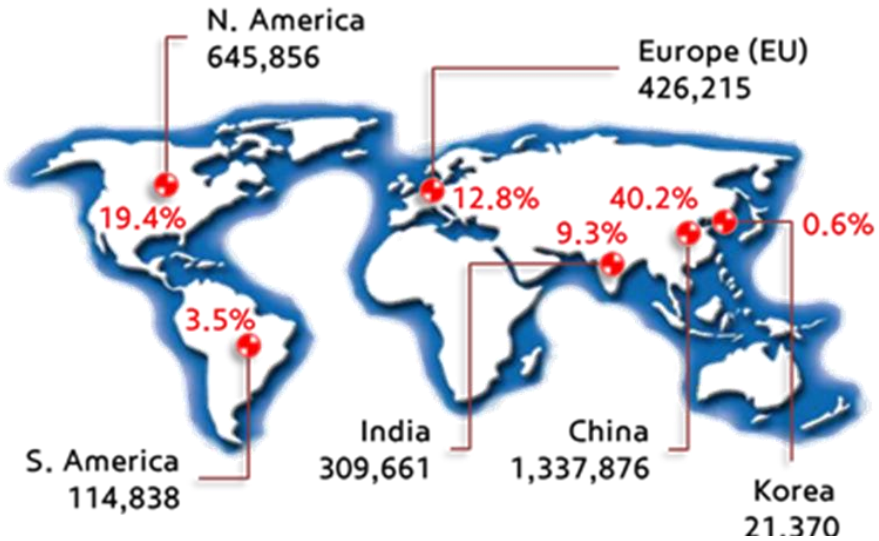
Dr.-Ing. Benjamin Happek, Senior Manager Electrified Commercial Vehicles, Hyundai Translead

Sacramento, September 8th, 2023

Transition to Zero Emission Trucking in North America

North America is a Top 2 Global Commercial Vehicle market

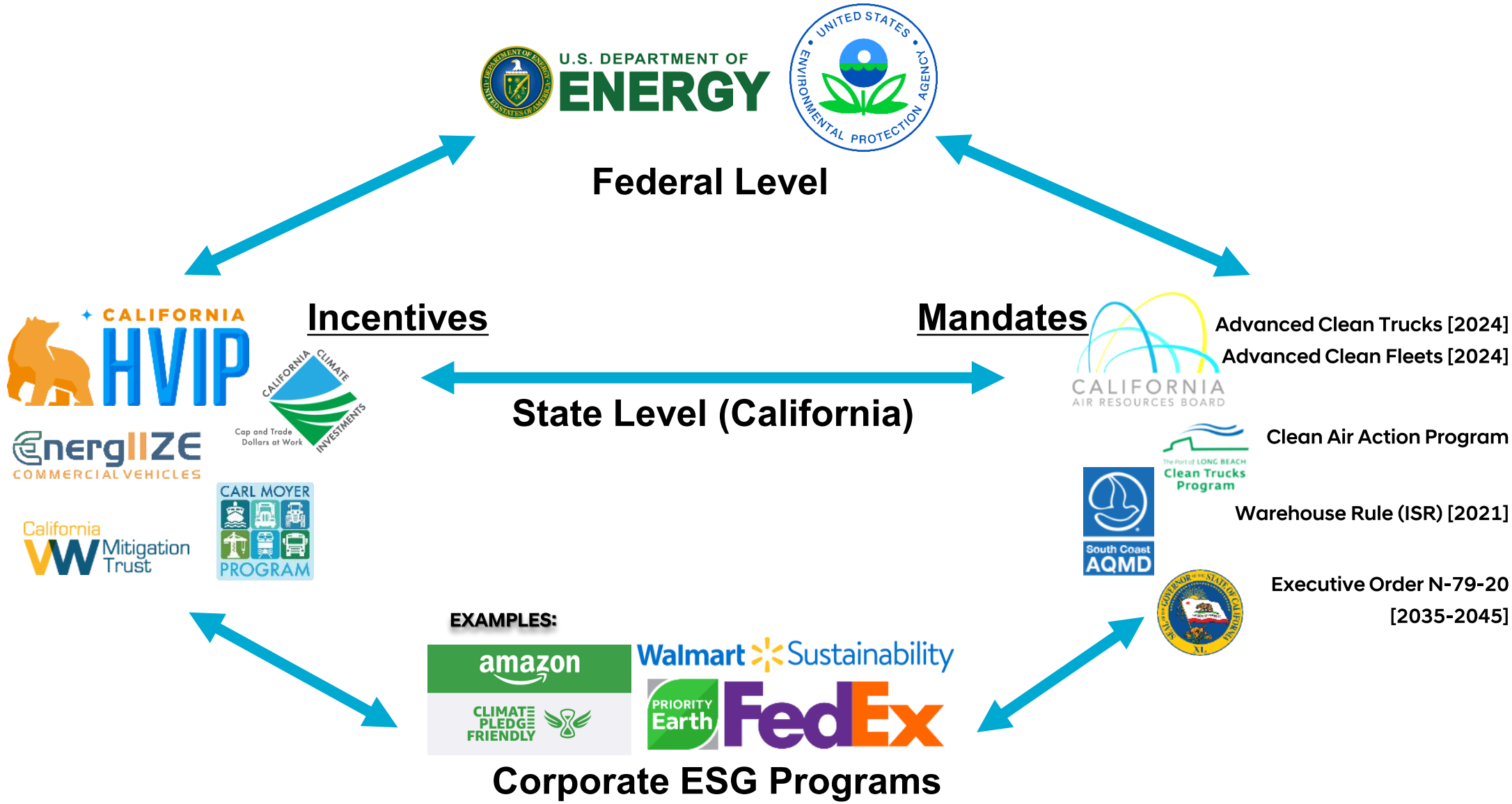
- Class 8 dominates North America
  - 240,000 units per year overall
  - Class 3 is #2 (though most, 69%, Class 3 are Pickups)
- U.S. sales dominated by USMCA-production
  - Only Classes 4 & 5 have any measurable Imports



Both National & Sub-national policies emerge in push for Zero Emission CVs

- Policy measures both “push” industry & create a Market “pull”
  - **National:** Limited by stronger partisan division → Focus on incremental reform through tax credits & subsidies
  - **Sub-national (State/Local):** Driven by stronger consensus → Establish more stringent requirements & incentives programs
- Policies emerging to encourage adoption of FCEV (including development of infrastructure to support FCEV)

US Incentives & Regulations ("Push and Pull")



Market Potential for ZE Trucks

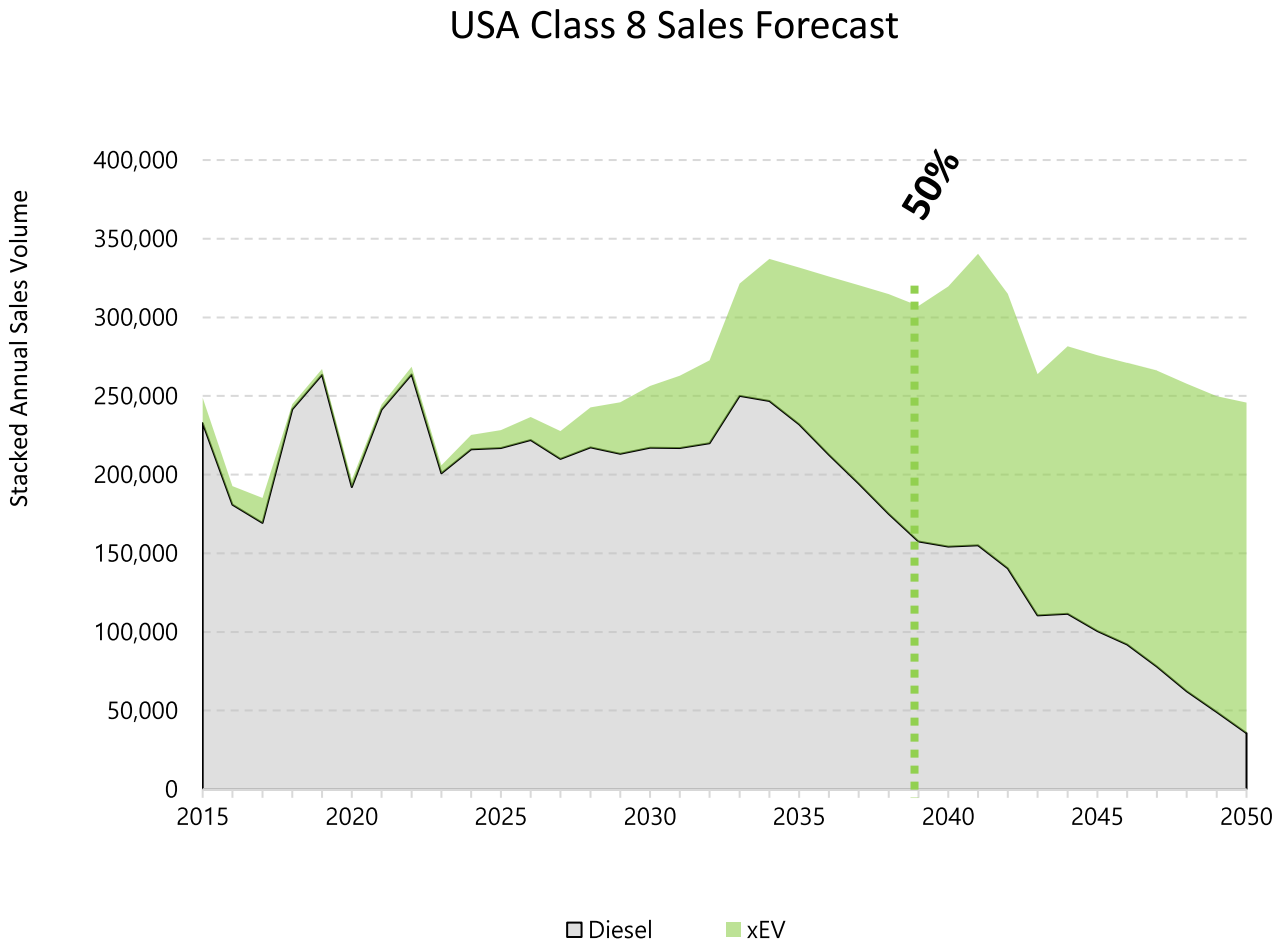
Bottom-Up Analysis: 15 States Committed to California ZEV Mandate

California ZEV Alignment Status & Current C8 Unit Sales					ZEV Mandated Class 8 Unit Sales								
				2022A	2023E	2024E	2025E	2026E	2027E	2028E	2029E	2030E	2031E
				0%	0%	5%	7%	10%	15%	20%	25%	30%	35%
State	Current ZEV	Bill Approved ZEV	Likely Future ZEV	Total CL8 Unit Sales	ZEV Class 8 Unit Sales	ZEV Class 8 Unit Sales	ZEV Class 8 Unit Sales	ZEV Class 8 Unit Sales	ZEV Class 8 Unit Sales	ZEV Class 8 Unit Sales	ZEV Class 8 Unit Sales	ZEV Class 8 Unit Sales	ZEV Class 8 Unit Sales
CA	X			17,370	-	868	1,216	1,737	2,605	3,474	4,342	5,211	6,079
CT	X			2,951	-	148	207	295	443	590	738	885	1,033
ME	X			1,929	-	96	135	193	289	386	482	579	675
MD	X			5,903	-	295	413	590	885	1,181	1,476	1,771	2,066
MA	X			5,564	-	278	389	556	835	1,113	1,391	1,669	1,947
NY	X			9,537	-	477	668	954	1,431	1,907	2,384	2,861	3,338
NJ	X			6,471	-	324	453	647	971	1,294	1,618	1,941	2,265
OR	X			4,200	-	210	294	420	630	840	1,050	1,260	1,470
RI	X			795	-	40	56	80	119	159	199	239	278
VT	X			1,363	-	68	95	136	205	273	341	409	477
CO		X		3,632	-	182	254	363	545	726	908	1,090	1,271
VA		X		6,017	-	301	421	602	903	1,203	1,504	1,805	2,106
MN			X	6,017	-	301	421	602	903	1,203	1,504	1,805	2,106
NM			X	1,817	-	91	127	182	273	363	454	545	636
OH			X	10,218	-	511	715	1,022	1,533	2,044	2,554	3,065	3,576
		Total		**83,786**	**-**	**4,189**	**5,865**	**8,379**	**12,568**	**16,757**	**20,946**	**25,136**	**29,325**

Source: McKinsey & Company: Implications of the Inflation Reduction Act: PTC, August 2022; ATD Truck Report 2022

Transition to Zero Emission Trucking in North America

- Adoption of zero emissions trucks will accelerate after 2030, according to Standard & Poor (IHS Markit) forecasts
- In most progressive modeling, ZEV[1)] grows significantly after 2032, overtaking diesel by 2037
  (California much earlier than that)
- Even most conservative modeling shows ZEV overtaking diesel by 2047
- Being on the forefront of this technology change offers advantages for regional development
- Early customer feedback indicates a lack of feasibility of battery electric solutions, suggesting that there will be a significant demand in hydrogen in order to power fuel cell electric vehicles with higher range and payload compared to BEV
- Hyundai has around 70 FCEV trucks in customer operation worldwide with over 4M miles driven



[1)]'ZEV' label includes both BEV/FCEV
Source : 2021 Reinventing The Truck report (IHS Markit)

FCE Technology Benefits

Hydrogen technology for heavy duty trucks delivers distinctive advantages

- **Battery technology is a viable solution for passenger cars and low GCW commercial vehicles with small operating radius**
- **For heavy duty trucks, hydrogen fuel cells are the more suitable technology**

Higher Payload

- Payload is a critical economical factor of truck operation
- Hydrogen FCEV technology is lighter than battery technology → higher payload

Longer Driving Range

- Higher energy density of hydrogen enables long driving range
- Minimal impact of driving range by low ambient temperatures

Shorter Recharging Time

- Minutes to recharge hydrogen tanks while it takes hours for recharging batteries

No Impact on Grid Capacity

- Battery technology puts immense stress on the grid
- Difficulties for fleets to install EV chargers at their locations

Market Challenges

Hydrogen ecosystem development in the U.S. faces challenges of high costs and nascent infrastructure

FCEV operation still expensive

Small numbers of trucks; service needs to be developed

Clean H_2 is expensive

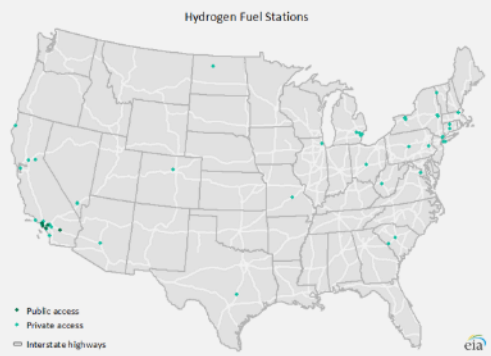
Levelized cost of clean hydrogen can be up to 4x cost of diesel

Midstream is early-stage

Only 1,600 miles of hydrogen pipelines in the USA

Minimal infrastructure

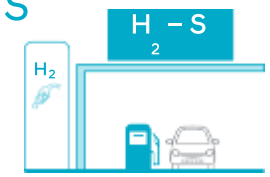
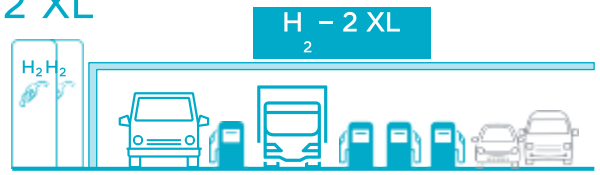
<100 hydrogen fuelling stations vs. ~150,000 gas/diesel in USA



Hydrogen Refueling Station in CA - Network Status

HRS structure for commercial vehicles is immature in California; Development of larger stations with >1 metric ton capacity per day necessary

Size definition of different HRS

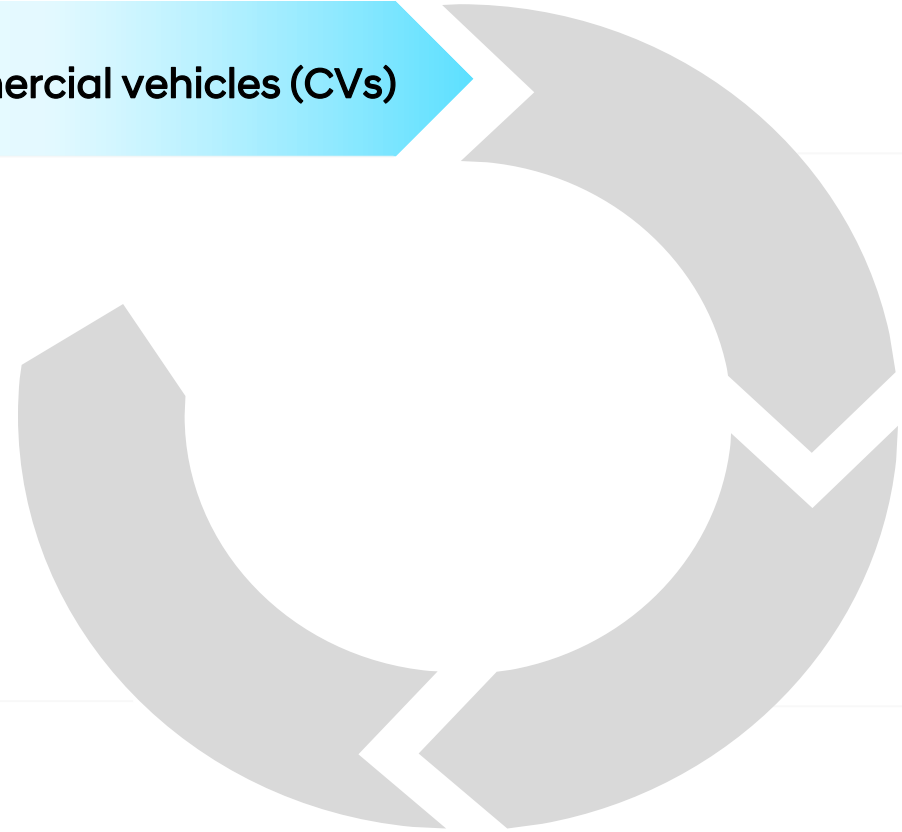
Size	S 	M 	L 	2 XL 
Max. hydrogen throughput / day	200 kg	500 kg	1,000 kg	4,000 kg
Vehicle	PV, LCV	(PV, LCV, busses), MDV	(PV, LCV, busses), MDV, HDV	(PV, LCV, busses), MDV, HDV
Average hydrogen throughput / day	150 kg	350 kg	700 kg	2,500 kg
Annual demand	1-10 t	100 t+	500 t+	900 t+
Refueling nozzle	1	2	2-3	2-4
Size components area	80-250 m²	200-350 m²	250-800 m²	depending on HRS technology
Indicative number of trucks to reach H_2 throughput per day[1)]	2.5	~6	~12	~42
California today (Public HRS)	65 opened (42 in development)		3 (9 announced: 4 in construction, 5 funded)	NorCAL ZERO Project (FEF)

Synergies of Introducing FC CV to the Market

Trucks & buses are an ideal starting point to address the H2 supply / demand dilemma

Introduction of fuel cell commercial vehicles (CVs)

Fosters investments for hydrogen infrastructure



FC Commercial Vehicles

Enable hydrogen refuelling stations (HRS) to be economically operated

H_2 refueling Infrastructure

Higher request for H_2 passenger cars

Fuel cell passenger cars

Hyundai FCE CV in South Korea

Hyundai's efforts in Korea further demonstrate the feasibility of hydrogen buses and Class 8 trucks

355 FCEV trucks & buses on the road (Mar. '23)

- Bus : Elec City FCEV (City bus), Universe FCEV (Coach)
- Truck : Xcient FCEV (Rigid Truck)
- NEXO FCEV (Passenger Car) sales : 31,258 units

153 HRS network in operation (Mar. '23)

- Truck and Bus dedicated HRS : 19
- Full support and demand (bus) from government

Hyundai FCE Efforts in Korea

H_2 refuse trucks and usage of renewable biogas provide an example of a circular hydrogen solution already underway in Korea

HYUNDAI

Hydrogen Garbage Truck

Hydrogen refueling station

HYUNDAI ENGINEERING & CONSTRUCTION

"Collect – Produce - Fuel"

Process optimization

Biogas production plant

HYUNDAI ENGINEERING & CONSTRUCTION

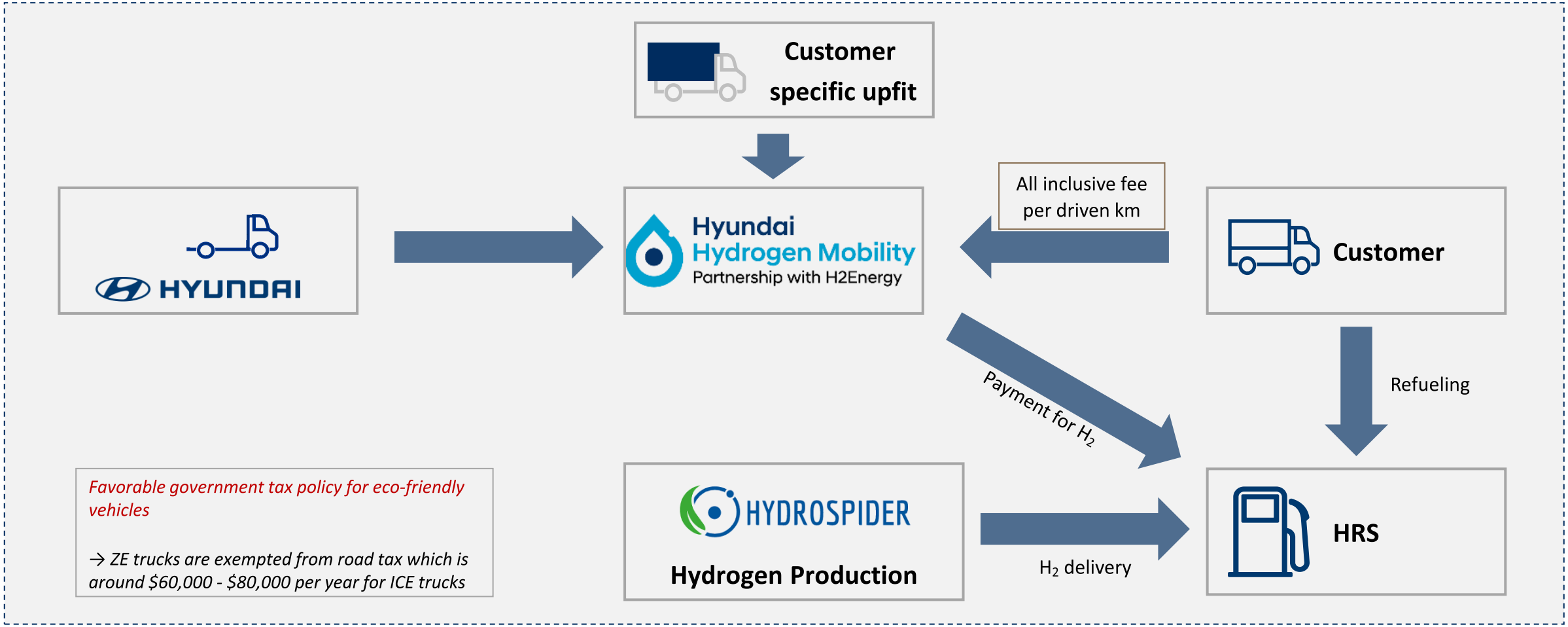
Hydrogen production plant

HYUNDAI HYUNDAI Rotem

- Hyundai is demonstrating a waste-to-energy hydrogen production project in Chung-Ju since March '22
- Waste disposal issues in the region lead to producing eco-friendly hydrogen at a low cost
- Biogas from food waste; could also be from livestock manure or sewage sludge
- Process being upgraded to biomethane to hydrogen with carbon capture

Hyundai FCE Efforts in Switzerland - HHM JV & Hydrospider collaboration

Hyundai has built its hydrogen ecosystem in Switzerland through collaboration with local value chain partners



Hyundai FCE Truck Business in Switzerland

Class 8 hydrogen trucks are readily being deployed in Switzerland

Hydroelectric power plant
Renewable electricity for H_2 production

Hydrogen production & container
H_2 production nearby power plant

Hydrogen transport
350 kg @350 bar

Hydrogen refueling

24 different fleet customers
47 vehicles in real operation
Over 4.2 million cumulated miles

NorCAL Zero Update

- First 10 trucks arrived and are in revenue service as of July 7, 2023
- Remaining 20 vehicles shipped as of August 25

Thursday, April 27, 2023 : Shipment of first 10 trucks out of Gwangyang, Korea

Friday, July 7: Job #1 at Glovis in Oakland (TraPac Oakland to Lathrop, 1TEU)

Thank you