TCO Analysis of Commercial FCEV by NWP

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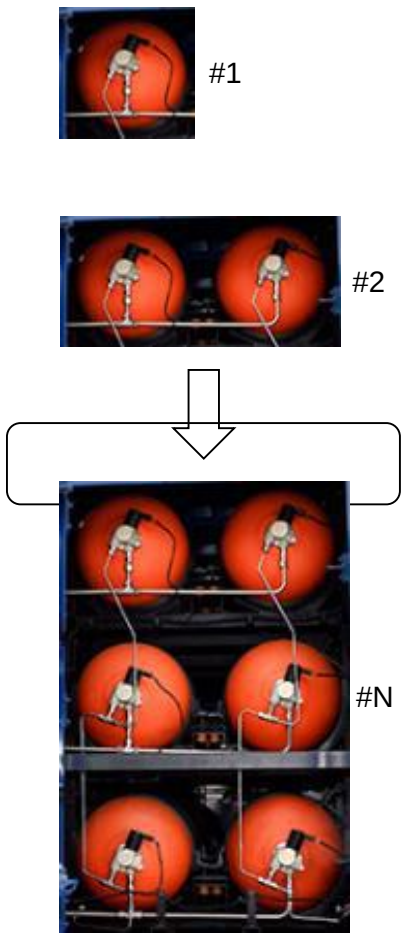
TCO Analysis of Commercial FCEV by NWP

※ AER : All Electric Range
※ TCO : Total Cost of Ownership
※ HSS : Hydrogen Storage System

Vehicle unit efficiency analysis (1/2)

- [Object] Bus, Truck, Tractor of HMC
- [Method] ① Same HSS packaging space for each vehicle model
  ex) Tractor HSS Volume : 35MPa sys = 70MPa sys
  ② The # of tanks increases from 1 to the # of vehicles installed, and the change of AER is analyzed.
  ③ HSS cost without tanks is adjusted to account for the tank increase.



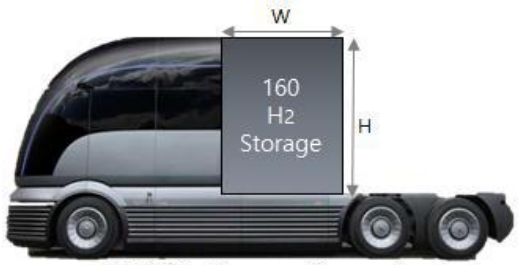
TCO Analysis of Commercial FCEV by NWP

※ HSS : Hydrogen Storage System
※ C/S : HSS Cost per H_2 Storage ($/kg)

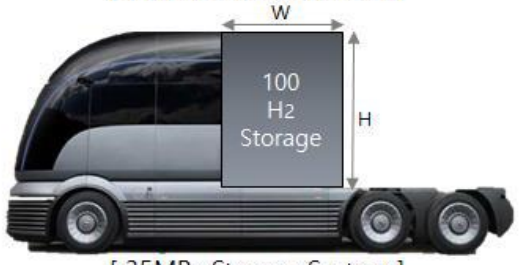
Vehicle unit efficiency analysis (2/2)

– [Result] ① Regardless of vehicle model, 70MPa sys compared to 35MPa sys : C/S 30%↓, AER 50%↑.
② 35MPa sys : Impossible to increase the # of tanks more than a certain amount due to the limited space.
③ When investing same amount, the AER of 70MPa sys becomes 1.2 times of 35MPa sys.

Vehicle model	35MPa sys		70MPa sys	
	AER (km)	C/S (coeff)	AER (km)	C/S (coeff)
Bus	250	1.43	390 (50%↑)	1.00 (30%↓)
Truck	400	0.85	600 (50%↑)	0.60 (30%↓)
Tractor	500	1.33	780 (50%↑)	0.93 (30%↓)



[70MPa Storage System]



[35MPa Storage System]

TCO Analysis of Commercial FCEV by NWP

※ VDR : Vehicle Driving Range
※ HRS : Hydrogen Refueling Station

HRS unit efficiency analysis (1/2)

- [Object] 70MPa/35MPa HRS
- [Method] ① Calculation of the required quantity of HRS to provide the same VDR for each NWP sys.
  ② The radius of the circle is defined in proportion to 1.5 times considering the difference in AER.
  ③ 1st assumption : durability - 10yr/1million km
  fuel efficiency – 11.2km/H_2kg
  ④ 2nd assumption : life of HRS – 20 years
  residual value, subsidy – none
  ⑤ 3th assumption : 600 commercial FCEVs in the same area for 20 years.

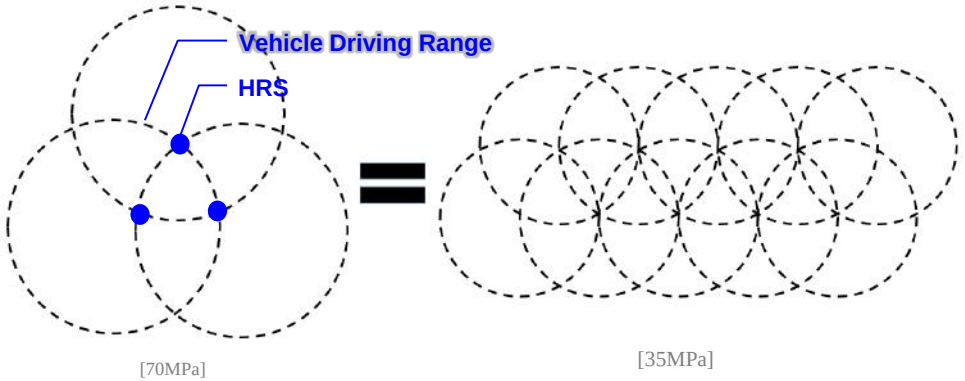


Figure 1. Model for analyzing the # of HRS required to provide the same driving range

TCO Analysis of Commercial FCEV by NWP

※ LCOH : Levelized Cost of Hydrogen

HRS unit efficiency & TCO analysis (2/2)

– [Result]

① #3 70MPa HRS(7,714kg/day) and #10 35MPa HRS(2,314kg/day) provide the same driving range.

② 1.024 times higher LCOH of 35MPa charging stations than 70MPa charging stations.

Item		35MPa HRS	70MPa HRS
Compressor	kg/hr	96.4	321.4
Daily charge	kg/day (24hrs)	2,314	7,714
# of HRS required to provide the same driving range		10	3

TCO Analysis			
Item ($/vehicle)	**35MPa**	**70MPa**	**Etc**
HSS Cost (Tractor)	D	1.044 D	Assume that the price of parts other than HSS is same
Charging Cost	1.024 E	E	Reflect CAPEX/OPEX
Cost per Distance ($/km)	**0.1474**	**0.1473**	100,000 km/yr

HRS CAPEX		
Item	**35MPa**	**70MPa**
Refueling equipment	a_1	3.58 a_1
Civil & Construction	a_2	2.13 a_2
Etc	a_3	2.89 a_3
Total	**A**	**3.26 A**

HRS OPEX		
Item	**35MPa**	**70MPa**
Labor	b_1	1.42 b_1
Electricity	b_2	5.13 b_2
maintenance	b_3	2.22 b_3
Etc	b_4	3.08 b_4
Total	**B**	**3.26 B**

HRS TCO Analysis		
Item	**35MPa**	**70MPa**
Operating period(yr)	20	20
Annual H_2 sales (kg/yr)	844,610	2,815,610
Discount rate	0.06	0.06
Capital recovery factor ($)	0.087 A	0.087*3.26 A
Annual operating Cost ($)	B	3.26 B
LCOH ($/kg)	**1.024 C**	**C**

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Conclusion

- In the European market, considering the existing 35MPa hydrogen refueling station, Hyundai Motor Company launched a hydrogen fuel cell electric truck at 35MPa.
- In Korea, a commercial hydrogen refueling station is being built at 70 MPa under the government's initiative, and in the US, a commercial hydrogen refueling station is being built at 70 MPa under the leadership of the private sector.
- The Cost of Hydrogen Storage Systems are dependent on initial market scenario, having similar costs between 35MPa and 70MPa system in TCO point of view
- For Commercial Vehicle, Mileage is one of the most important element for vehicle productivity.
  From a short-term perspective, a 35MPa system is applied considering the current refueling station, and from a long-term perspective, 70MPa is desirable to satisfy customer needs.