The Feasibility of Hydrogen Transportation

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H_2 Transport to the End User

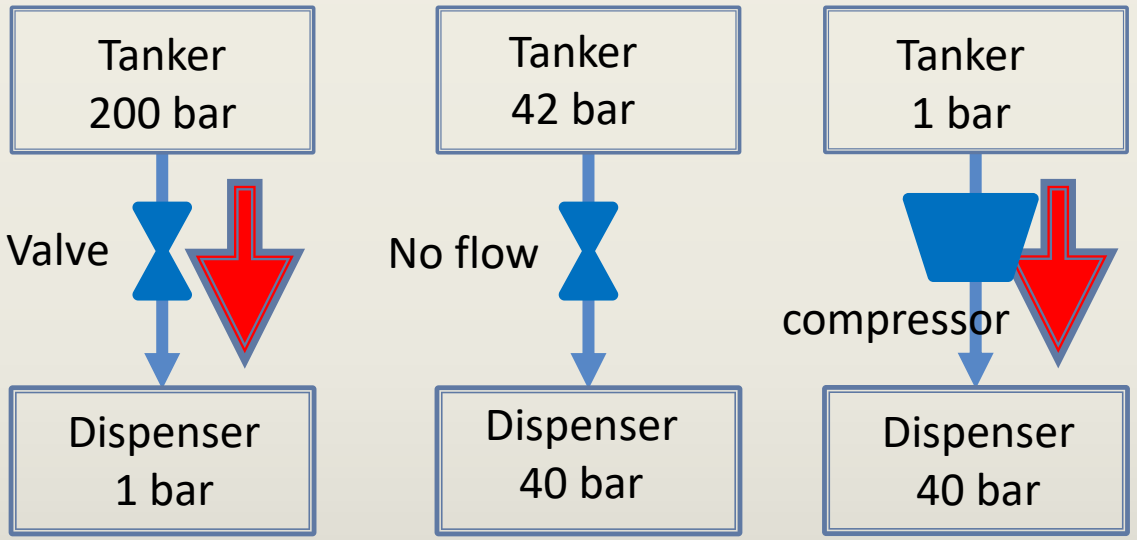
- Road transportation of H_2 using special tankers.
- Pipeline network and pumping.
- In situ production and supply of H_2.

Terms and Conditions

- GVW is 40 tons.
- The material of the tanker and its design depend on the type of fuel and the way it had been processed.
- Liquid fuels are transferred at atmospheric pressure & temperature.
- Gaseous fuels are either compressed or liquified.

Pressurised H_2 Tankers

- Pressures up to 200-700 bar.
- The maximum pressure of the gas in the dispenser is 40 bar.
- The fuel flow stops as a pressure equilibrium is reached between the tanker and the fuel station tank.
- After fuel discharge, 42 bar of fuel remains in the tanker.
- This represents 20% of the fuel delivered.



Cryogenic Transportation of H_2

- Cryogenic H_2 tanker.
- Carries H_2 at 1 bar and -252 °C.
- Very heavy tanker.
- A dual walled tank. The gap between the walls are either evacuated or filled with a special insulator.
- Because of size limitations (36 m^3) and low density of H_2 (70 kg/m^3), it carries less than 4-ton H_2.

A Comparison Between the Transportation Techniques for Different Fuels

The common trucking characteristics:

- A 100 km one directional journey.
- 40-ton tanker.
- 40 lit/100 km diesel fuel consumption for the outbound journey.
- A mid-size fuel station sells 26-ton gasoline per day (36,000 lit/day).
- Nowadays, 1 out of 100 trucks on the road in the EU is a gasoline or diesel tanker.

On Road Hydrogen Transport

	Units	H_2 Gas	H_2 liquid	Methanol	Propane	Gasoline
Pressure	bar	200	1	1	5	1
Outbound journey tanker weight	kg	40,000	30,000	40,000	40,000	40,000
Inbound journey tanker weight	kg	39,600	27,900	14,000	20,000	14,000
Delivered fuel weight	kg	400	2100	26000	20000	26000
HHV of the fuel	MJ/kg	142	142	23.3	50.4	48.1
Energy delivered per tanker	GJ	56.8	298.2	605.8	1008	1250.6
Energy delivered relative to Gasoline		0.045	0.238	0.484	0.806	1.000
Diesel fuel consumption	kg	79.6	57.9	54	60	54
Ratio of diesel consumed to energy delivered	%	6.306	0.874	0.401	0.268	0.194
Relative to gasoline		32.456	4.497	2.064	1.379	1.000
H_2 Efficiency factor (for H_2 vehicles)		0.7	0.7	1	1	1
Energy required at the fuel station	GJ/d	875.42	875.42	1250.6	1250.6	1250.6
No. of tankers required at the fuel station		15.412	2.936	2.064	1.241	1.000
No. of vehicles served	car/d		525			585
Distance travelled by the fuel	km/d		262,500			430,000

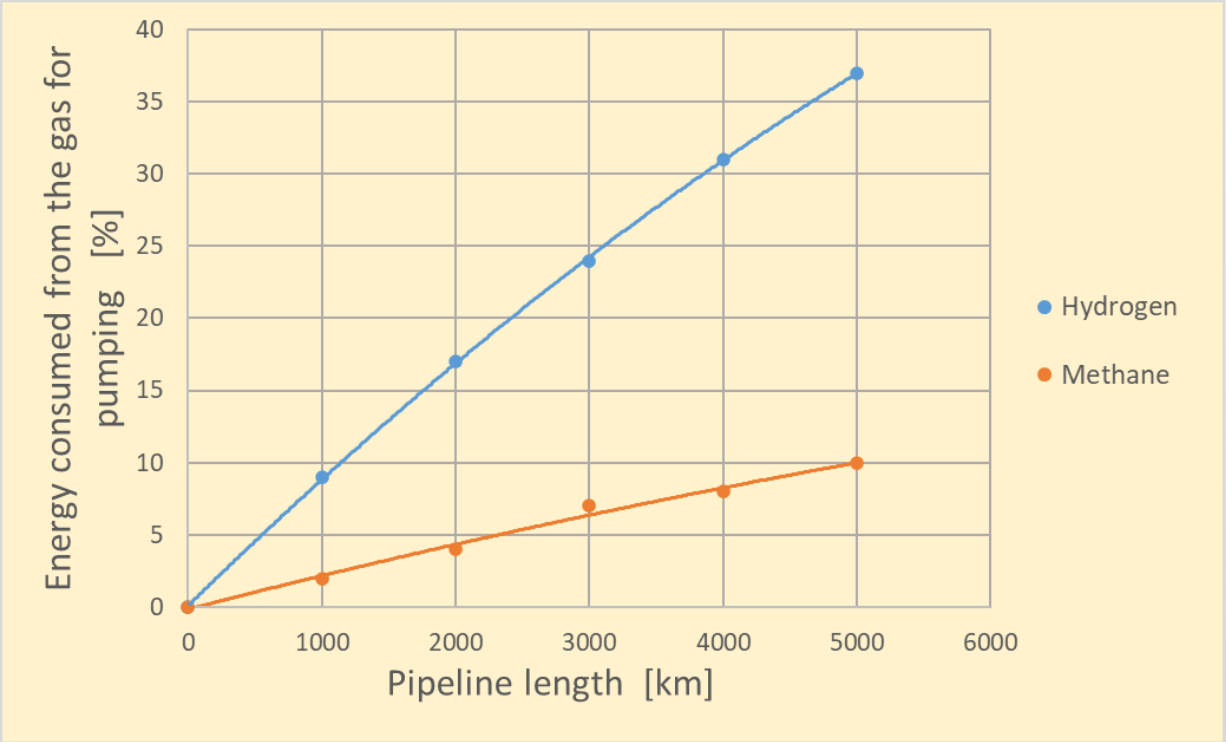
Pipeline Delivery of H_2

- Compressors are needed every 150 km.
- 0.3% of CNG is consumed to energize the compressors.
- The existing CNG pipeline are not suitable for H_2 because of:
- Diffusion losses.
- Brittleness of materials and seals.
- Incompatibility of pump lubrication with H_2.

$$\frac{\mathcal{P}_{H_2}}{\mathcal{P}_{CH_4}} = \left(\frac{\mu_{H_2}}{\mu_{CH_4}}\right)^n * \left(\frac{\rho_{CH_4}}{\rho_{H_2}}\right)^2 * \left(\frac{HHV_{CH_4}}{HHV_{H_2}}\right)^{3-n}$$

Due to the low volumetric energy density of H_2,

- The flow velocity of H_2 should be 3 times that of CNG.
- Higher flow resistance, slightly reduced by the lower viscosity of H_2.
- The pumping power of H_2 is 4.5 times higher than CNG when delivering the same amount of energy.
- Less H_2 reaches the destination.



Onsite Generation of H_2

To produce H_2 in a fuel station;

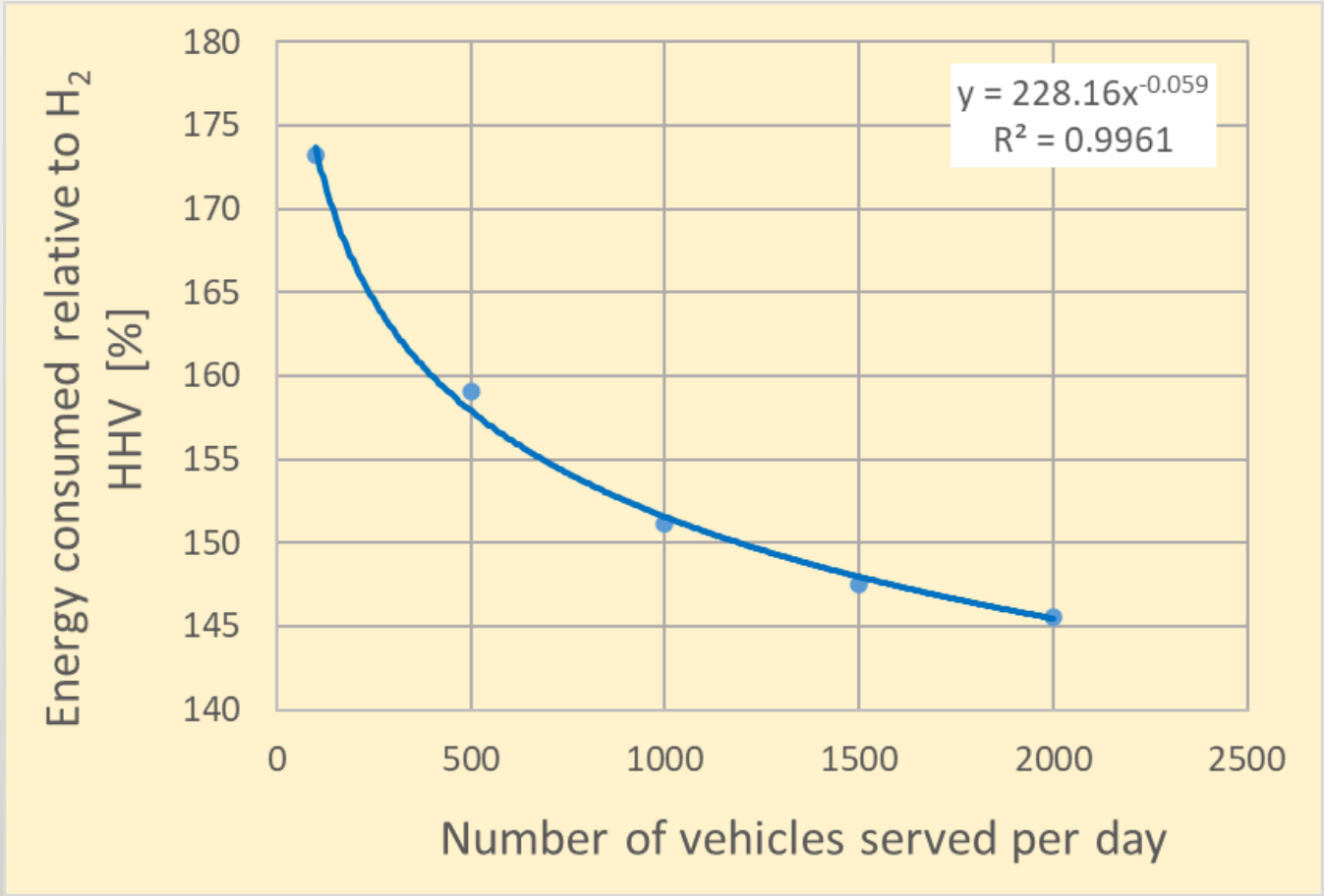
- The station should serve 100 up to 2000 vehicles per day.
- Average vehicle tank capacity is 60 lit or 50 kg fuel.

Energy Analyses

Quantity	Units	Value				
Vehicles served	#/day	100	500	1000	1500	2000
Fossil fuel supplied to each vehicle	kg	50	50	50	50	50
Fossil energy supplied	GJ/day	240	1200	2400	3600	4800
Fuel efficiency factor for FCV	%	70	70	70	70	70
H_2 energy required	GJ/day	168	840	1680	2520	3360
H_2 mass required	kg/day	1183	5915	11831	17746	23662
Electrolizer efficiency	%	70	75	78	79	80
AC/DC conversion efficiency	%	93	94	95	96	96
Energy required for electrolysis	GJ/day	258	1191	2267	3323	4375
Amount of water needed	m^3/day	11	53	107	160	214
Energy for water supply	GJ/day	8	36	68	100	132
H_2 compression to 200 bar	GJ/day	25	109	204	295	384
Total energy needed	GJ/day	291	1336	2539	3718	4891
Total energy relative to H_2 energy	%	173	159	151	148	146
Energy defecit	%	73	59	51	48	46

Energy Deficit

- The energy consumed for in situ H_2 production exceeds the amount of energy obtained from H_2.
- The higher the rate of H_2 production the lower the energy deficit.



Supas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