

Fuel cell – EHS hybrid module development

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Why bother about EHS technology

1. Electrochemically recycle H_2 in applications where it makes economic sense

H_2 is used extensively in Industry:

1.1. In annealing furnaces

1.2. In NH_3 production

1.3. To Control H_2/CO ratio in synthesis gas produced from coal gasification in petrochemical processes where H_2/H_xC_x ratio is to be controlled.

From these processes, in many cases, there is a lot of H_2 present in the flue gas.

2. Extract H_2 from future natural gas (NG) grid which would contain 2-10% H_2 in CH_4 :

2.1. For production of green electricity (e.g. H_2 was produced from RE sources)

2.2. Production of 5N (99,999% pure) – 7N (99,99999%) H_2 to supply FCEVs.

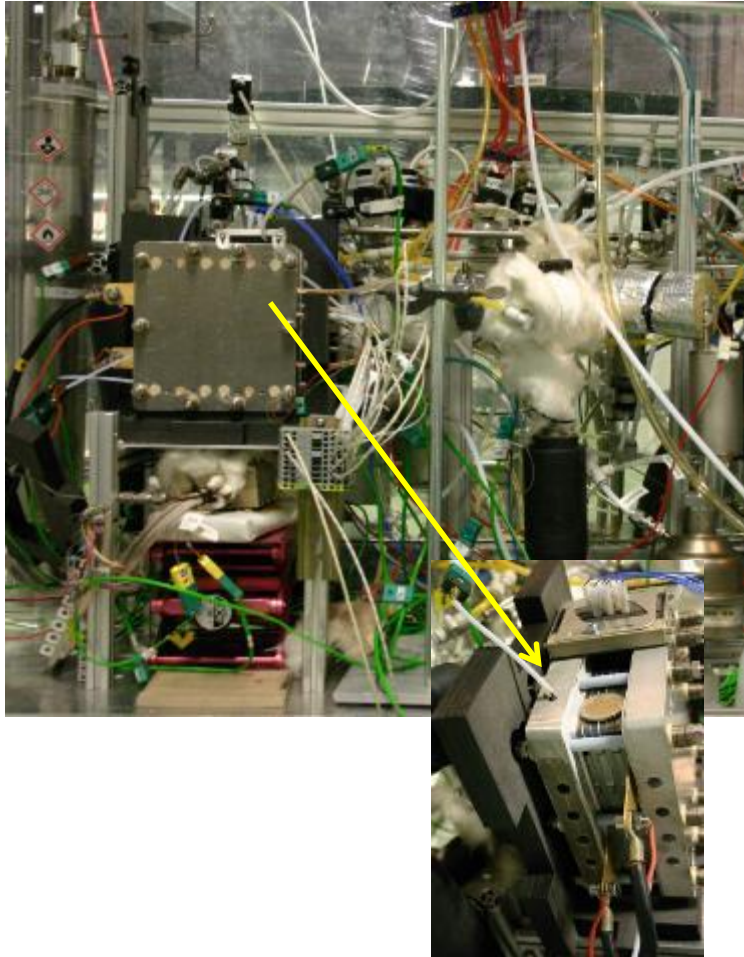
3. Operate the electrochemical cell in EHS mode during off-peak hours and in Fuel Cell mode during normal hours (2 in one operation):

3.1. During evenings and night H_2 extracted from NG grid

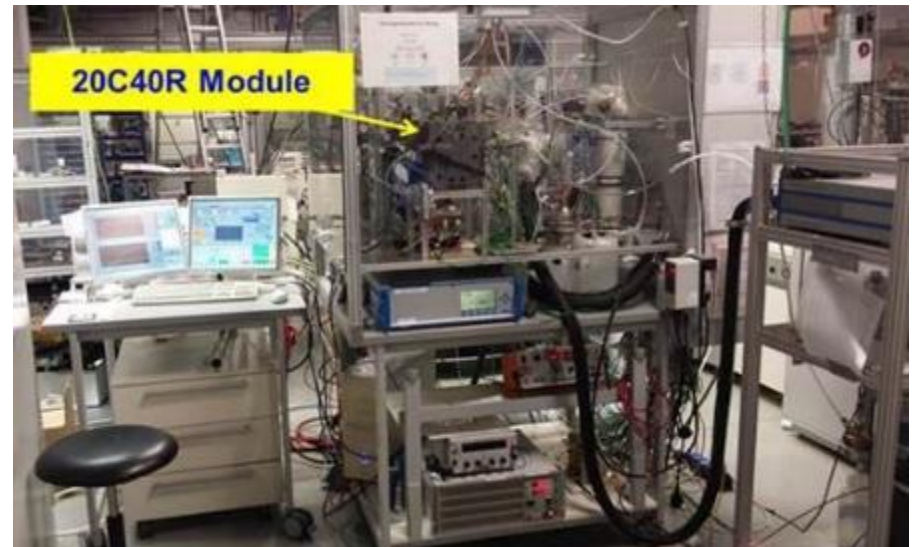
3.2. During the day, bottled H_2 employed in generating off-grid green electricity

Proof of Concept performed at ZBT GmbH

1. Short Module in Teststand

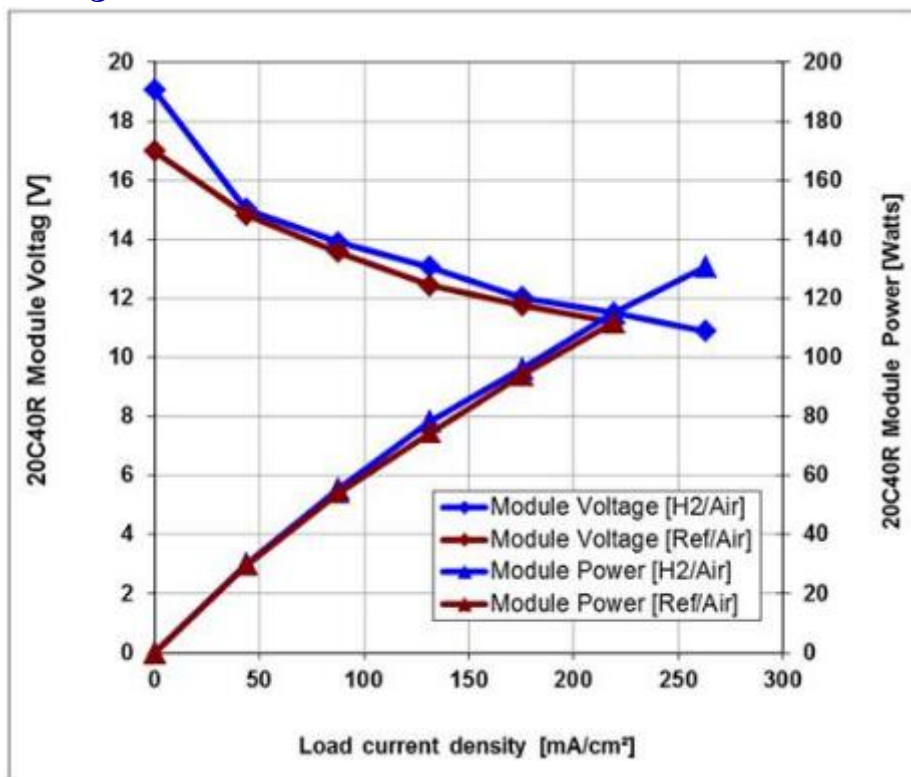


2. Gas analyser, Electronic load, Power supply connected to Large Module



Performance in Fuel Cell Mode

H₂/Air feeds: 1,7/7 litres/min
CH₃OH-H₂O (S/C: 1,5) feed: 200g/h



H₂ content in Reformate:

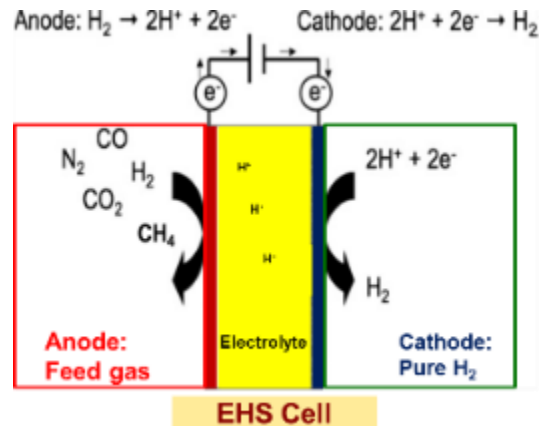
CH ₃ OH-H ₂ O Feed [g/h]	H ₂ content in reformate [ml/min]	H ₂ content enough for load (per cell in 20C40R)	
		I [Amps]	j [mA/cm ²]
100	1104	6,6	144
178	1385	8,2	181
200	2101	12,5	274

Power Output and Cell Resistances :

Load Current [A]	Current Density [mA/cm ²]	Stack Voltage [V]	Stack Power [W]	High Frequency Resistance [HFR]/Cell [Ohm]
10,00	219	11,11	111,1	0,254
9,10	200	11,01	100,2	0,244
4,55	100	12,87	58,5	0,292
2,00	44	14,00	28,0	0,356

At 219 mA/cm² & 190°C, the Module delivered: 115 W (H₂/Air) and 111 W (Ref/Air).

Summary of H₂ species separated



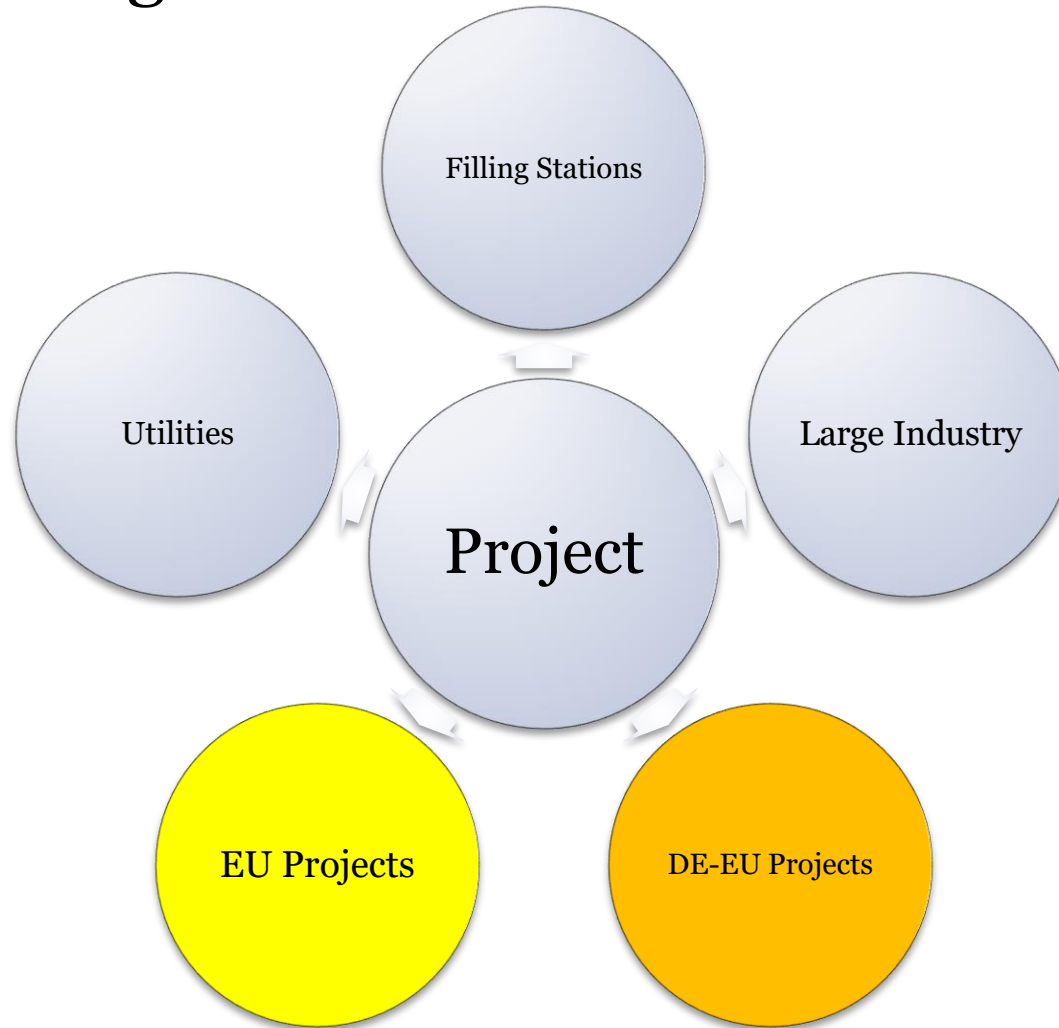
Feed gas	H ₂ in feed	Energy input			Net H ₂ migrated		Energy content	Theoretical H ₂	Conversion η	Energy Demand
		Power	Vol.	Current	H ₂ gas in					
litres/h	litres/h	Wh	V	A	litres/h	kg/hour	Wh	litres/h	Pra./Theor.	kWh/kg of H ₂
102	102	6,63	1,7	3,90	31,300	0,002598	84,51	32,76	95,54%	2,55
102	102	50,40	6,3	8,00	62,192	0,005162	167,92	67,20	92,55%	9,76
163	126	13,72	2,8	4,90	32,546	0,002701	87,87	41,16	79,07%	5,08

H₂ in feed gas: 126 litres/h; ~ 5A supply: 5,08 kWh/kg H₂ produced

(Ref: 55 kWh/kg in case of water electrolysis)

FC – EHS Hybrid concept was evaluated in the Lab.

Partners sought:





Thank You

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