FutureBridge

METHANE PYROLYSIS: Turquoise Hydrogen

Low-carbon hydrogen production techniques are being investigated as a potential replacement for the existing steam-methane-reforming production of "grey" hydrogen, which is being touted as a promising energy vector for a decarbonized world

Overview of non-electrolyzer technologies

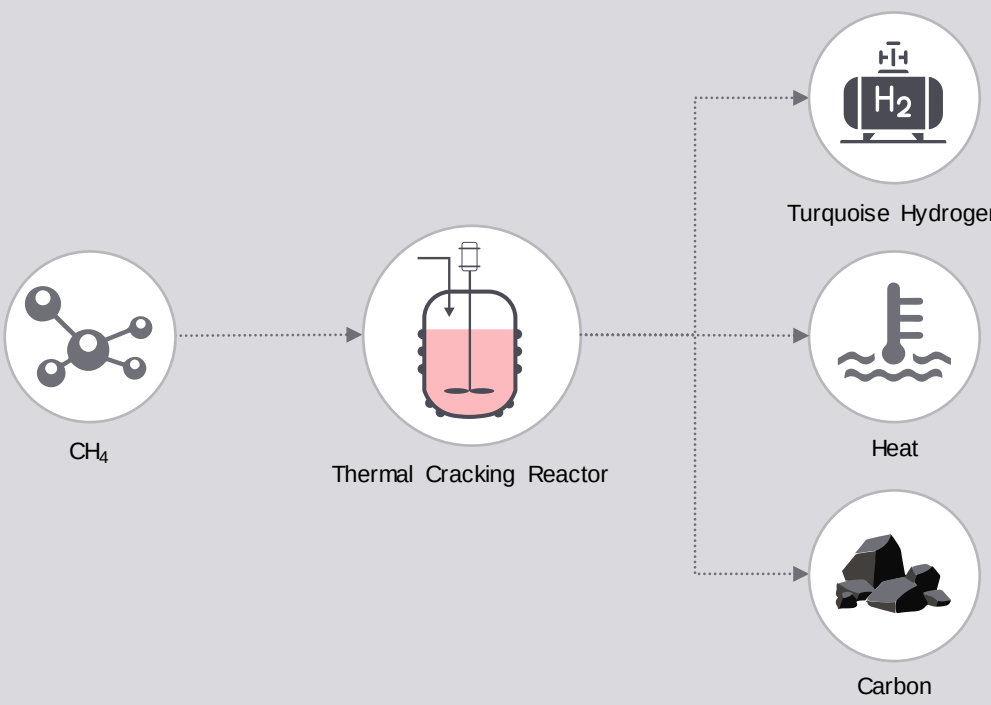
Compared to other non-electrolyser technologies, the cost of the hydrogen produced by methane pyrolysis is lower

H_2 production technologies	Developers	Feedstock	Temperature range (°C)	Overall energy efficiency	Price* ($/Kg H_2)	Emissions (kg/ kg H_2)	Maturity
Methane Pyrolysis	C||ZERO, Gazprom, MONOLITH	**Natural Gas or Biomethane**	**1000 – 1500**	**58%**	**1.6 – 2.2**	**0 – 3.1**	**Commercial**
Thermochemical water splitting	OntarioTech University	H_2O & heat	500 – 1800	20%-45%	3 – 7	–	Early development
Biomass Gasification	SG H2 ENERGY, CACH2	Biomass	500 – 1400	35%-50%	1.77 – 2.05	0 – 11	Near term
Microbial (Fermentation)	MONASH University	Biomass	30 – 80	<20%	2.08 – 2.83	–	Early development
Photo-catalysis	EPFL, SunHydrogen	H_2O	–	<20 %	–	–	Early development
Plasma reforming	Transform Materials, Plenesys	Natural gas or biomethane	~5000	>80%	3 – 6	–	Near term

Note: Near term refers to the technology that has been demonstrated by prototype and getting ready for commercialization.
* Prices are indicative and mostly supported from estimations from simulation models.

Methane Pyrolysis – An Upcoming Non-Electrolysis Technology

Methane pyrolysis is a fundamentally new process technology that splits natural gas or biomethane directly into the components of hydrogen and solid carbon



Methane pyrolysis, also known as **methane cracking or turquoise hydrogen**, is the high-temperature breakdown of methane into hydrogen gas and carbon. Carbon can be safely stored in solid form and used in many industrial areas as a pure substance. The process requires little energy.

ADVANTAGES OVER CONVENTIONAL METHOD OF HYDROGEN PRODUCTION

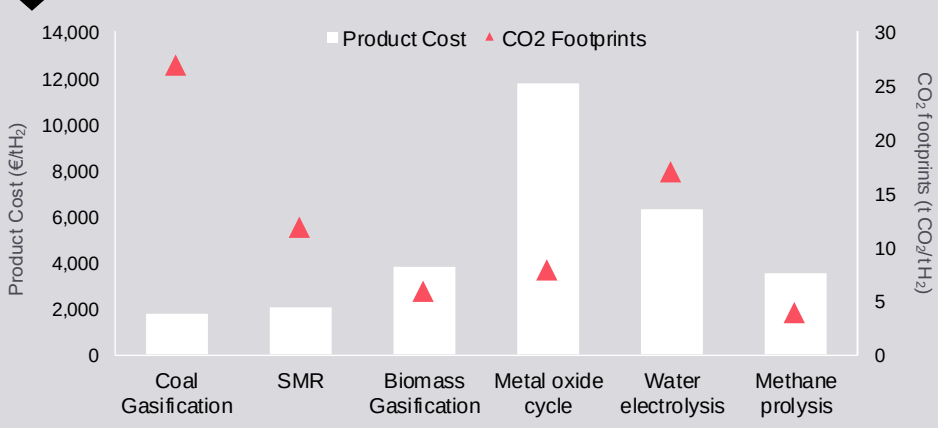
- The costs of producing hydrogen are half of the conventional steam methane reforming processes
- Existing value chain of Methane is utilized for hydrogen production leading to hydrogen production in large quantities, thereby fulfilling the requirement of the industrial use
- Methane retains its value by becoming a clean feedstock for industrial production processes

Economic Analysis of Methane Pyrolysis

PARAMETER		VALUE
Required natural gas capacity (or biomethane)		800 – 980 (kta)
Reaction Temperature (high feed rate)		1000 – 1500 (°C)
Purchased cost of equipment		56 – 64 ($million)
Share of the cost	Electric arc heater	~80%
	Pyrolyzer	~0.3%
	Carbon Bed	~0.2%
	Pressure Swing Adsorption (PSA)	~15%
	Heat Exchanger	~10%
Fixed capital investment		564 – 645 $million
Total cost of H_2 production		1.5 – 1.9 ($/kg H_2)
Tonne CO_2 emitted per tonne of H_2		0 – 3.1

The key advantage of methane pyrolysis over water electrolysis is the availability of feedstock through the existing natural gas infrastructure, whereas electrolysis is heavily reliant on the price and availability of renewable electricity

Product costs and CO_2 footprint of different hydrogen production technologies



Source: Industries and Engineering Chemical Research, FutureBridge Analysis.

KEY PLAYERS

MONOLITH, HazerGroup, EKONA, C|ZERO

About FutureBridge

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