

CO₂-free pyrolysis as an alternative to electrolysis

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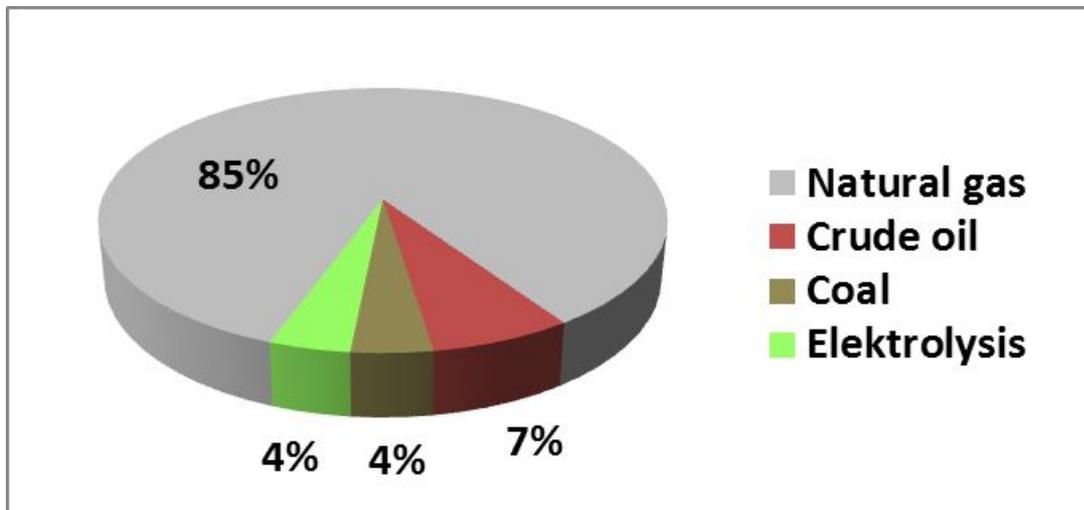


BIG numbers 😊

The world currently uses about **75 million tons of hydrogen**.

More than 3/4 of hydrogen is produced from natural gas, for which more than **205 billion m3 of gas** is consumed.

The production of hydrogen from natural gas releases approximately **830 million tons of CO2** into the atmosphere.



The concept of hydrogen energy promoted in the EU and all over the world implies the industrial production of hydrogen — which means **mass production** and **low cost**.

Main hydrogen production methods



1. STEAM METHANE REFORMING (SMR)

Methane is the main component of natural gas, **concentration from 77 to 99%**. The high content of methane in associated petroleum gases is from 31 to 91%. Methane is actually a large hydrogen molecule that consists of one carbon and four hydrogen atoms. The chemical formula clearly indicates that methane is “highly enriched” with hydrogen.

Consequently, hydrogen production from methane should be the most cost-effective!

The cost price is 1,5-3 EUR/kg.

The main disadvantage of the method is the release of a large amount of CO₂:

1 kg of produced hydrogen = about 10 kg of CO₂!

2. ELECTROLYSIS OF WATER

By acting on distilled water with an electric current, it is possible to decompose it into its components — oxygen and hydrogen. The method is simple and convenient in operation, having a high purity of the produced hydrogen.

But electrolysis is a rather expensive technology for producing hydrogen.

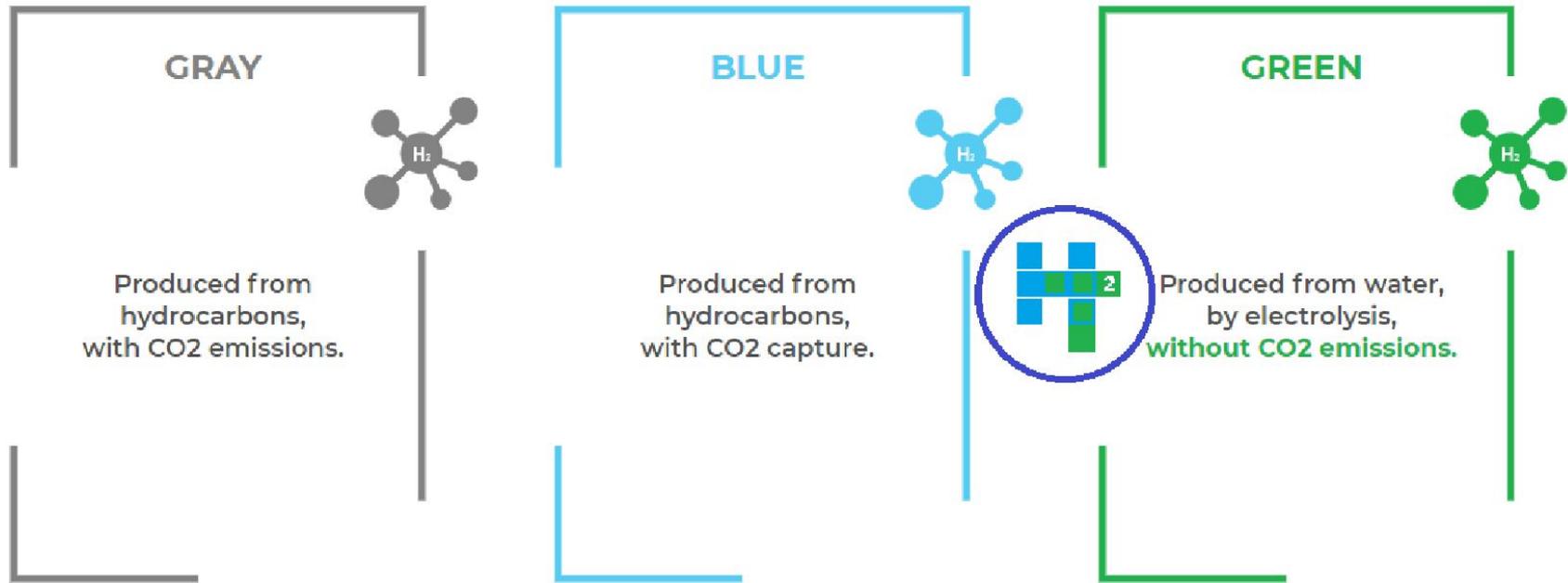
The cost price is 5+ EUR/kg.

The main thing is that electrolysis of water is a very promising method for environmentally friendly production of hydrogen using renewable or nuclear energy sources.

Do we have alternatives?

Yes! ... CO₂-free pyrolysis of methane!

„Green“ or „Pure“?



The terms “green hydrogen” and “pure hydrogen” are often used interchangeably and are understood by the public as synonyms, but this is not correct. Whether hydrogen is pure or not should not depend on the presence of “CH₄” and “H₂O” molecules at the entrance to the process, but primarily on the presence or absence of CO₂ emissions at the exit from this process.

Hydrogen obtained from methane by the SMR technology without CO₂ capture is not “pure.”

Hydrogen obtained from methane by plasma pyrolysis and/or other technologies without CO₂ emissions, is “pure” indeed. Production does not require additional costs associated with CO₂ capture. It fully complies with EU decarbonization and carbon neutrality requirements.

Project

The goal of our project:

To create a pilot plant (PP) for the production of „PURE“ hydrogen. Clarification of the previously announced technical and economic indicators. Definition of technical and technological solutions for scaling.

The method specific nature:

The method is based on the thermal destruction of methane molecules by the thermal energy of an AC electric arc. The produced hydrogen and carbon black are separated at various stages in the process. For stable operation of the plasma torch an additional inert gas is used. After purification, inert gas is returned to the chemical process.

Experimental facility parameters:

Power of the plasma torch: ~ 200 kW

Methane flow rate: 56,6 kg/h

Inert gas flow rate: 113,2 kg/h

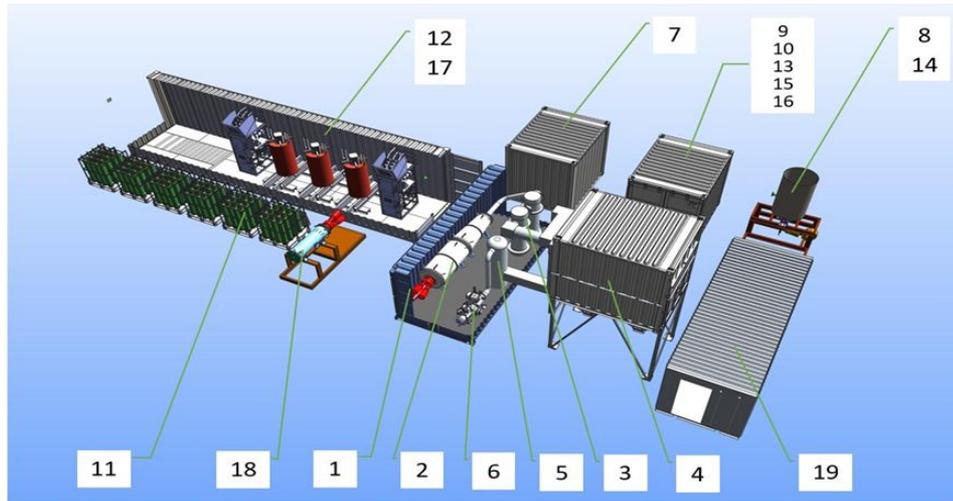
Inert gas + methane mixture: 169,8 kg/h

Hydrogen flow rate: 14 kg/h

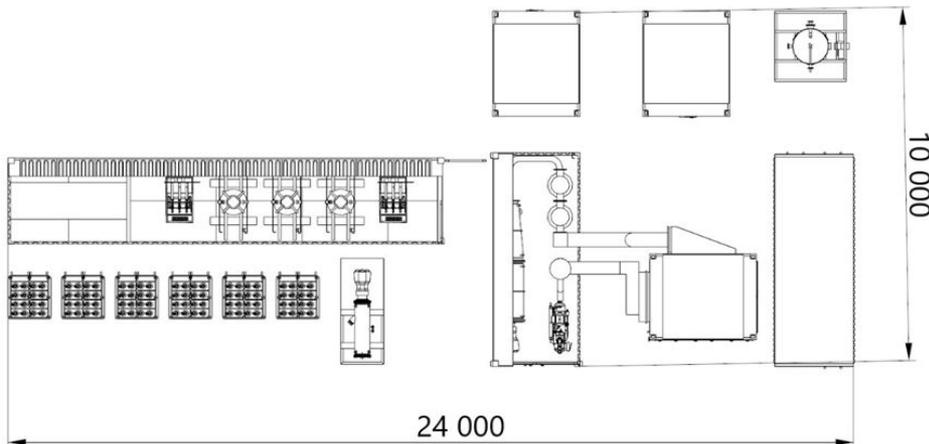
Carbon black flow rate: 42 kg/h

The purity of hydrogen: not lower than 95%

Pilot plant



- 1) Plasma torch with power supply system
- 2) Plasma-chemical reactor
- 3) Heat exchanger
- 4) Bag filter
- 5) Acid gas adsorber
- 6) Compressor
- 7) PSA for hydrogen separation
- 8) Combustion chamber
- 9) Compressor
- 10) Gasholder
- 11) Gas supply facility
- 12) System of hydraulic and gas supply and plasma torch control
- 13) Cooling system
- 14) Fan
- 15) Measurement of hydrogen flow rate and quantified analysis
- 16) Receiver
- 17) Plasma torch power supply
- 18) Diagnostic chamber
- 19) Control panel



Main application of the technology



Storage and transportation of hydrogen in any form (gaseous, liquefied, etc.) is a rather complicated process and requires many new technical and technological solutions. Therefore, in the near future hydrogen will most likely not be stored and transported in large volumes (such as oil, gasoline, natural gas, etc.). **Hydrogen will be produced in exactly the same volumes as consumed and as close as possible to the place of consumption.**

Natural gas logistics in the EU is already well developed (pipelines, transport, storage, filling stations, etc.), which greatly facilitates the transition to hydrogen. There is also no need to build all the accompanying infrastructure.

From our process we have 2 market products:

- 1) **HYDROGEN**
- 2) **CARBON BLACK** (according to ASTM D1765 - N880, N770)

Both of them are „PURE“, ie without CO2 emissions!

About **20 mln tons of carbon black are produced per year** and its consumption is growing rapidly. All the carbon black is produced with CO2 emissions (by burning natural gas, coal and oil etc.)

So we solve 2 problems at once!

Comparison of technologies

PARAMETER	Units	ELECTROLYSIS			SMR	PLASMA
		ALK	PEM	SOEC		
Energy consumption	kWh/m ³	4,5-5,5	3,5-4,5	2,5-4	1,5-2	1,5-2
	kWh/kg	50-60	40-50	28-44	15-20	15-20
Temperature	°C	47-97	77-97	797-997	750-850	1200
Process efficiency	%	50-70	80-90	≥ 85	70-80	≥ 80
Cost price	EUR/kg	4,5-6	5-7	5,5-8	1,5-3	2-3
- with carbon black	EUR/kg					1-1,5

Our goal is to reduce energy consumption for hydrogen production to 10-11 kWh per 1 kg of hydrogen, which will reduce the cost of hydrogen production **below 1 euro per 1 kg!**

Comparison of costs

Hydrogen cost components		ELECTRO- LYSIS	SMR	PLASMA
ELECTRICITY	EUR/kg	4,20	0,70	1,05
CO2 EMISSIONS	kg/kg	18	13	5
Per 1kg of hydrogen:	EUR/kg	0,54	0,39	0,14
NATURAL GAS	EUR/kg	0,00	0,83	1,38
CLEAN WATER	EUR/kg	0,025	0,004	0,00
CARBON BLACK	EUR/kg	0,00	0,00	1,50
MAINTENANCE COSTS	EUR/kg	0,10	0,10	0,10
CAPITAL COSTS	EUR/kg	0,50	0,20	0,50
TOTAL COST OF HYDROGEN:	EUR/kg	5,37	2,23	1,66

Electricity is produced mainly by «dirty» methods, then it is impossible to talk about electrolysis as a «clean» method of producing hydrogen. Now even the SMR is cleaner in total emissions. **And if we compare Plasma and Electrolysis, then Plasma will always be both cleaner and cheaper than electrolysis!**

Hydrogen filling station concept



The fastest transition to hydrogen will presumably be in the **transportation sector**.

The solution we have been developing (PP) is, in fact, a **ready-made mini plant**. The technology can be scaled up based on the needs of various consumers, including wholesale fuel depots and filling stations for vehicles.

In the future, we will be able to install our production modules right next to a filling station. Our solution for the production of hydrogen is an integral part of the value chain, and due to the low costs of hydrogen production + the already existing infrastructure of natural gas. **Our solution is much more convenient and profitable compared to any other hydrogen production technologies, especially in comparison with electrolysis.**

Mobile solutions for filling stations (CNG tank + hydrogen production module on one semitrailer) also look very promising.

The technological solution we have been developing will also make it possible **to produce hydrogen from bio-methane**, which production is also actively developing. Under today's standards, this will make the entire process of hydrogen production 100% "green" according to EU criteria.

The main advantages of the technology



1) Clean production - no CO2 emissions!

The possibility of producing hydrogen also from bio-methane in the future will make the entire production process 100% «green»

2) Production at the point of consumption.

Hydrogen is a complex fuel and requires specialized logistics. Our plants will allow the production of hydrogen for the end user directly at the point of its consumption.

3) Low cost of production

The technology we are developing will be the cheapest way to produce «pure» hydrogen! The associated «clean» production of carbon black also has great prospects and reduces the cost of the entire process.

4) Minimal competition

The technology we are developing has no competitors on an industrial scale today. The developed analogues will be released to the masses only after a decade.

5) Mobility

The main part of the equipment of the technological unit will be manufactured taking into account the possibility of transportation by land, air and sea transport, which will allow the process of hydrogen production to be launched quickly, wherever it is needed.

Thank You!

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