



HELBIO S.A. Hydrogen and Energy production Systems
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1. Preface

HEL BIO is active in the development and commercialization of a) hydrogen production systems for either industrial applications or for energy – related applications, and b) energy production systems integrated with fuel cells. The main hydrogen carriers utilized include fossil fuels (natural gas, LPG), as well as biofuels such as biogas and bio-ethanol.

HEL BIO's vision is to be the supplier of choice for state-of-the-art, cost effective and efficient hydrogen production systems and power systems integrated with fuel cells. The hallmark shall be innovation in technology development with emphasis on catalyst development, reactor design and system integration.

2. Company Profile

HEL BIO is a high-tech Company which initiated its activities in 2003, with expertise in the areas of catalysis, reaction engineering and process design. The company was founded as a spin-off of the University of Patras, targeting the exploitation and commercialization of innovative processes and reformation technologies which had been developed at the University of Patras.

The primary objectives of the company included the development of Hydrogen Generator demonstration unit and also the early development of Auxiliary Power Units (APU) and CHP systems. In September 2007, Morphic Group (Sweden) became the major shareholder, acquiring 55% of the total shares. Nowadays, the major shareholder of the company is Metacon AB (Sweden).

Helbio S.A. operates in the field of hydrogen and energy production sector. Specifically, HEL BIO develops hydrogen production systems either for industrial use or integrated with fuel cells for Combined Heat and Power (CHP) production. The multi-fuel systems are designed and manufactured for operation with both liquid and gaseous fuels, such as Natural Gas, LPG, propane, biogas and bio-ethanol.

Until now, the Company has focused on the development and commercialization of:

- 1) Hydrogen Production Systems in the range of (10-200 m³/h) for either industrial applications or for energy – related applications, and

2) Energy Production Systems integrated with fuel cells, specifically APU and CHP systems up to 20 kW.

The main hydrogen carriers that are utilized include fossil fuels (natural gas, LPG, propane), as well as biofuels such as bio-ethanol and biogas.

Helbio's technology is based on proprietary and patented reactor – catalyst configurations for reformation processes. The reactor configurations utilize the concept of the Heat-Integrated Wall-Reactor (European Patent 94600005.6/13.07.94. U.S.A. Patent No. 6, 605 376 (Aug. 12 .2003) which offers very rapid heat exchange characteristics.

HEL BIO's Products and Services can be divided in four major groups:

- ✓ Customized systems for hydrogen production
- ✓ Customized systems for power production with CHP capability
- ✓ Participation in R&D co-funded projects
- ✓ Other services

3. Product description

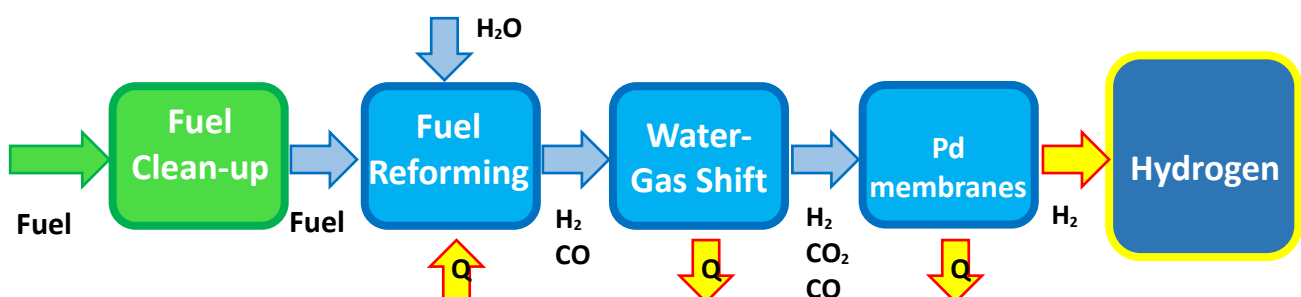
Hydrogen Production Systems

HEL BIO produces high purity hydrogen generators, utilizing conventional fuel and bio-fuel feed stocks. These generators can be divided in two categories:

A) Small scale hydrogen generators (range from 0,3- 5 Nm³/h H₂)

Fuels: NG, methane, LPG, propane, biogas, bio-ethanol

The process includes a fuel clean-up system, a fuel processor that extracts the hydrogen from the fuel and a hydrogen conditioning system that makes the product suitable for low temperature P.E.M. fuel cells.



B) Industrial hydrogen generators (20-200 Nm³/h H₂)

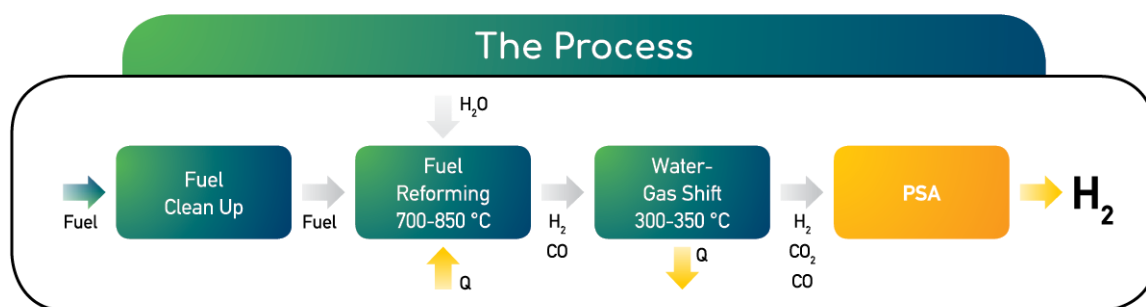
Fuels: NG, methane, LPG, propane, biogas

Helbio has developed a family of Hydrogen Generators designed to meet demanding requirements of small-scale hydrogen supply, using fuels such as Natural Gas, L.P.G or Biogas. The system offers clean, quiet and efficient hydrogen generation under continuous operation with long service intervals. The standards systems HHG-20, HHG-50, HHG-100 and HHG-200 generate normally 20,50,100 and 200 Nm³/h of H₂ respectively. Hydrogen purity ranges from 99,9% to 99,999% upon customer request.

The unit is composed of the following subsystems:

- Subsystem 1: Natural gas compressor¹, natural gas purification unit, reforming reactor, shift reactor, steam generator, associated heat exchangers and peripherals
- Subsystem 2: Pressure Swing Adsorption (PSA) unit for gas purification.
- Subsystem 3: Control hardware with HMI interface and control software

The process diagram of Helbio`s Hydrogen Generators can be seen in the following picture



Energy Production Systems

H₂PS-5 , Combined Heat & Power (CHP) system.

Fuels: NG, methane, LPG, propane, biogas, bio-ethanol

Capacity: up to 5kWe (up to 7kWth in CHP case)

It has a capacity of 5 kW electric power, while in the combined heat and power (CHP) mode, it can also produce up to 7 kW thermal energy in the form of hot water. The system is multi-fuel fed, i.e. it can operate with either Natural Gas, Propane/LPG or Biogas, converting it to electrical power through an intermediate production of hydrogen using a Proton Exchange Membrane Fuel Cell (PEM-FC). The unit is equipped with a power management system delivering electrical energy in the required form

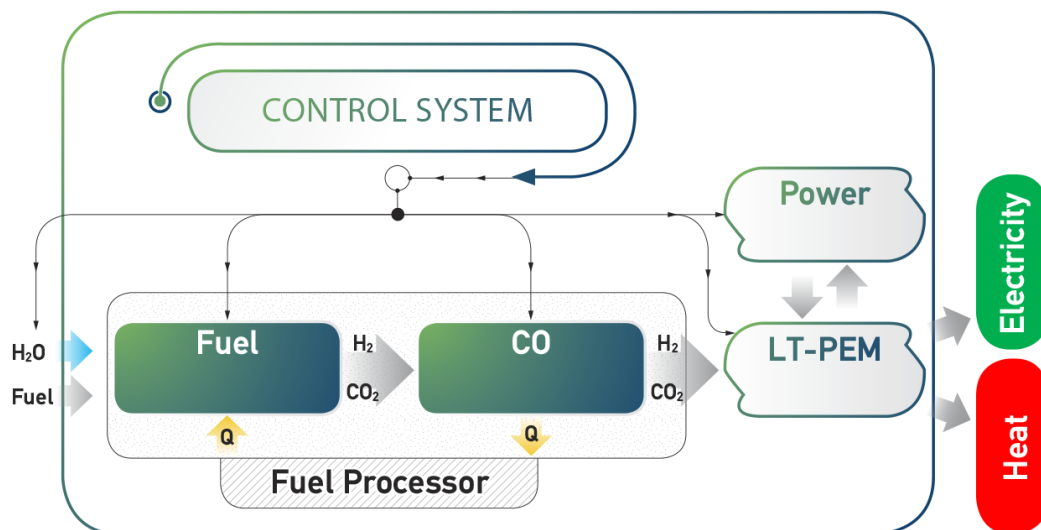
¹ Not necessary if inlet pressure of natural gas is ≥9 bar(g)

(DC or AC, grid connected or stand-alone), depending on the application. It has the ability to operate in the range of 40-100% of its nominal capacity. Its maximum electrical efficiency is greater than 35% (based on LHV), while total efficiency exceeds 85%.

The integrated system consists of the following sub-units:

- **Fuel processor/hydrogen production unit**, where hydrogen production takes place via the reformation of the feeding fuel
- **Low temperature PEM fuel cell stack**, where power production takes place using the produced hydrogen from the fuel processor
- **Batteries and electronic power management systems**, where the excess produced power is managed
- **Control system**, capable to control the unit and to achieve proper, smooth and safe operation of the **H₂PS-5**

A simplified depiction of the integrated system and its sub-units interaction is shown in the following scheme:



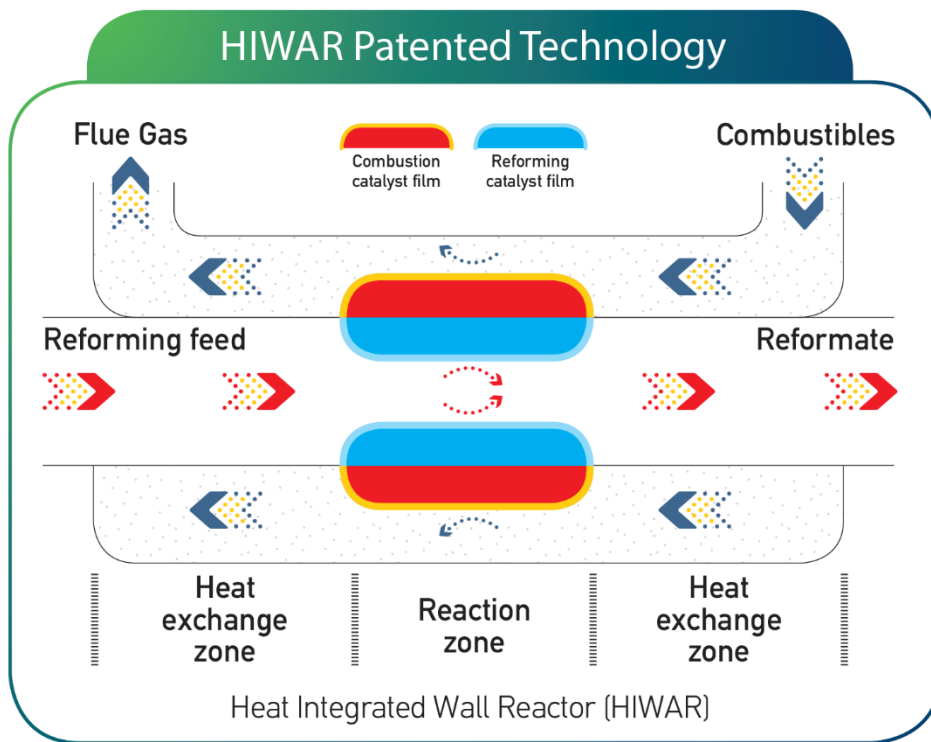
Process Flow Diagram (Fuel steam reforming with LT PEM fuel cell)

4. Heat Integrated Wall Reactor (HIWAR) patented Technology

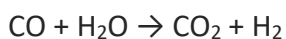
Helbio's technology is based on proprietary and patented reactor – catalyst configurations for reformation processes. The reactor configurations utilize the concept of the Heat-Integrated Wall-Reactor (European Patent 94600005.6/13.07.94. U.S.A. Patent No. 6, 605 376 (Aug. 12 .2003) which offers very rapid heat exchange characteristics.

One of the major advantages of the company are the novel, proprietary catalysts that have been developed for the reformation of fuels, either in the steam reforming or the partial oxidation modes.

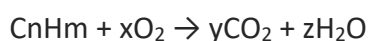
These catalysts exhibit improved characteristics with respect to activity, selectivity towards hydrogen and thermal stability. They are used in the form of thin films deposited on metallic surfaces, or deposited on other structural forms, such as monoliths and foams.



Within the steam reforming process of gaseous fuels, the following reactions take place for the production of a gaseous mixture of hydrogen and carbon oxides:



The steam reforming reaction is an endothermic process which demands heat for its conduction. The independency of the fuel processor is achieved via simultaneously combustion of a part of the fuel, in order to produce the heat required for the reaction of steam reforming:



HELBIO has developed appropriate plate heat exchangers type reactors, inside which both reactions take place simultaneously in separated chambers (HIWAR concept). These reactors are very efficient, compact and exhibit high heat integration.

According to the HIWAR concept, metal plates coated with a suitable catalyst are arranged in such a manner that exothermic and endothermic reactions take place in each side of the sheet. The produced heat, via exothermic combustion, is transferred via conduction through the metallic walls towards the endothermic reaction of steam reforming, which take place at the opposite side of metal plate.

The advantages of CPR (catalytic plate reactors) design over conventional reactors are the superior heat transfer characteristics and minimal intra-catalyst diffusion resistance. The heat transfer mechanism within a CPR is via conduction through the metallic plates and as such is largely independent of the process gas superficial velocity. The catalyst layers within a CPR are thin resulting in minimal diffusion limitations and thus high catalyst utilization. These advantages result in reactors which are smaller, lighter and with a reduced associated pressure drop compared to conventional alternatives.

5. Success Stories

H2020 SME instrument Phase 2 - Helbio SA among the winners

Helbio S.A. is one of the 58 highly innovative SMEs which have been selected and awarded by the European Union's Horizon 2020 SME instrument phase 2, in order to commercialize Prometheus 5, a micro power generating unit. The unit is designed for dual operation, to function either as stand-alone power system delivering up to 5 kW electric power or as a Combined Heat and Power (CHP) system, delivering additionally up to 7 kW thermal energy in the form of hot water. The system is multi-fuel fed, i.e. it can operate with either Natural Gas, Propane/LPG or Biogas, converting it to electrical power through an intermediate production of hydrogen (via steam reforming) using a Proton Exchange Membrane Fuel Cell (PEM-FC). <https://www.prometheus5.com>,

AutoRe EU financed project

The project covers the design and construction of a hydrogen generation unit (fuel processor) and the integration with the hydrogen purification subsystem (PSA) so as to meet hydrogen production capacity and purity specifications set by the fuel cell manufacturer (Daimler) .The validation and testing of the integrated system will be done by GE at their premises in Rugby, UK (<https://www.autore-eu.com>). HELBIO has completed successfully the construction, testing and delivery of a 40m³/h hydrogen system