Clean Tech for the Future

Introduction of HELBIO – Hydrogen & Energy Production Systems

The company

- HELBIO is a **high-tech company** founded in 2001 and based in Patras, Greece
- Specialized in development, manufacturing and marketing of **Hydrogen** & **Energy Production Systems**
- The company possesses **key expertise** in:
  - Catalysis
  - Reaction engineering
  - Process design
  - System integration and control
- The HELBIO team consists **of twelve highly specialized professionals**, with **combined experience of 150 years** in hydrogen generators, power systems, system manufacturing and commercial activities.

Company's experience

- The company has completed **more than 35 projects, with a total revenue of €3.2mn**, and is currently managing projects of **more than €3.0mn in total value**

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Vision statement

HELBIO's vision is

to help the world significantly reduce carbon footprint and emission of pollutants through the development of innovative technological solutions in hydrogen and fuel cell-based energy production

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Mission Statement

HELBIO's mission is
to profitably develop and deploy innovative, environmentally clean, energy efficient Hydrogen Units & CHP systems which serve Industrial, Transportation, Telecommunication and Residential needs

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HELBIO's Products and Services can be divided in two major categories

HYDROGEN GENERATORS

High purity hydrogen generators, suitable for **Refueling Stations**, **Industrial applications and Power Plants**

- Small-Scale Hydrogen Generators (0.3 – 5 Nm3/h H2)
- Industrial Hydrogen Generators (20 – 300 Nm3/h H2)

CHP SYSTEMS

CHP units for utilizing commercially available fuel or bio-fuels, suitable for **residential, remote cabins, telecommunication towers, sailing yachts as a supplementary power generator**

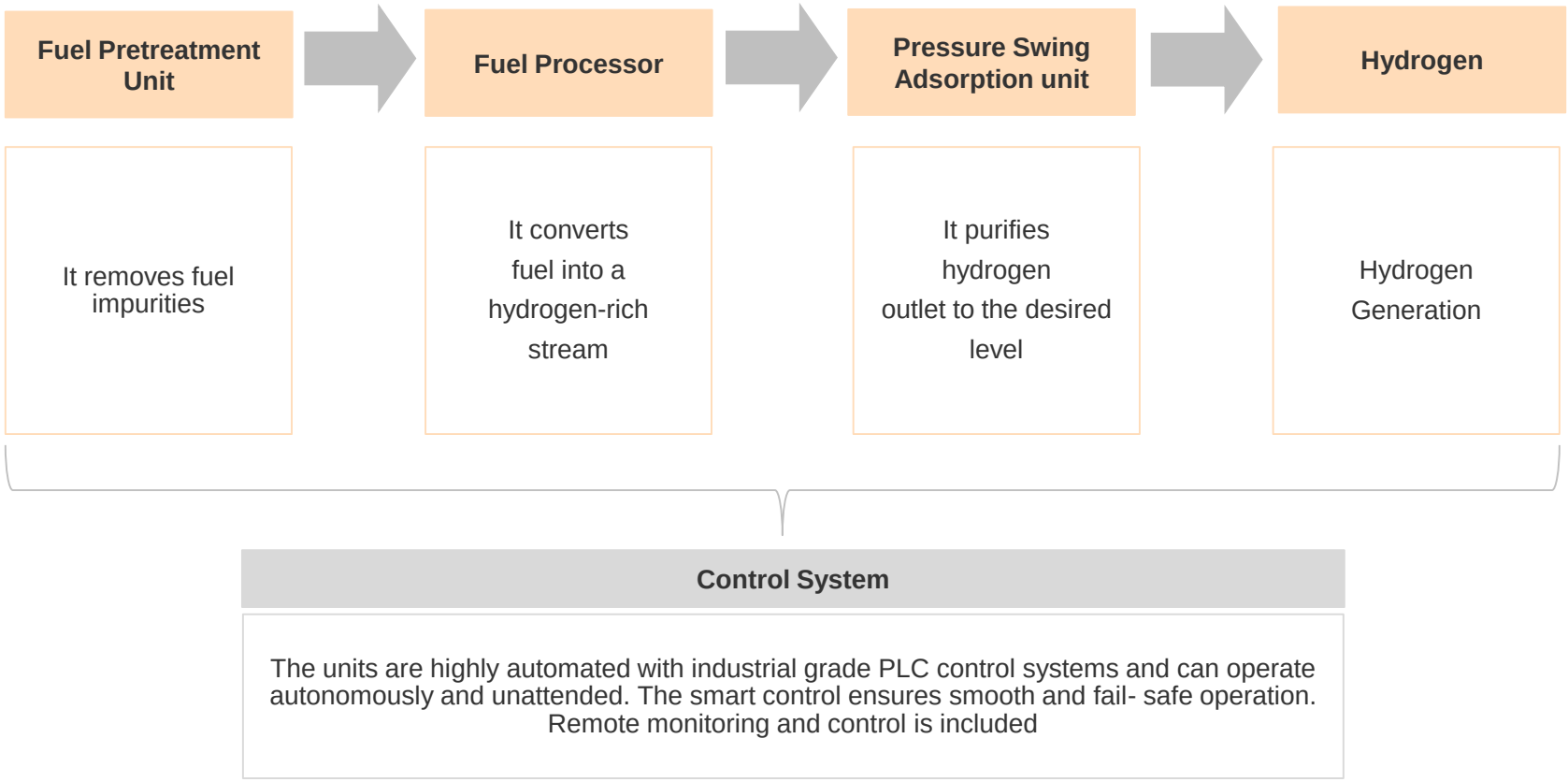
- Auxiliary Power Units(APU) ~0.5kW

Standardized Heat and Power (CHP) Units

- CHP Prometheus-5 (5kWel)
- CHP Prometheus 50 (50kWel)

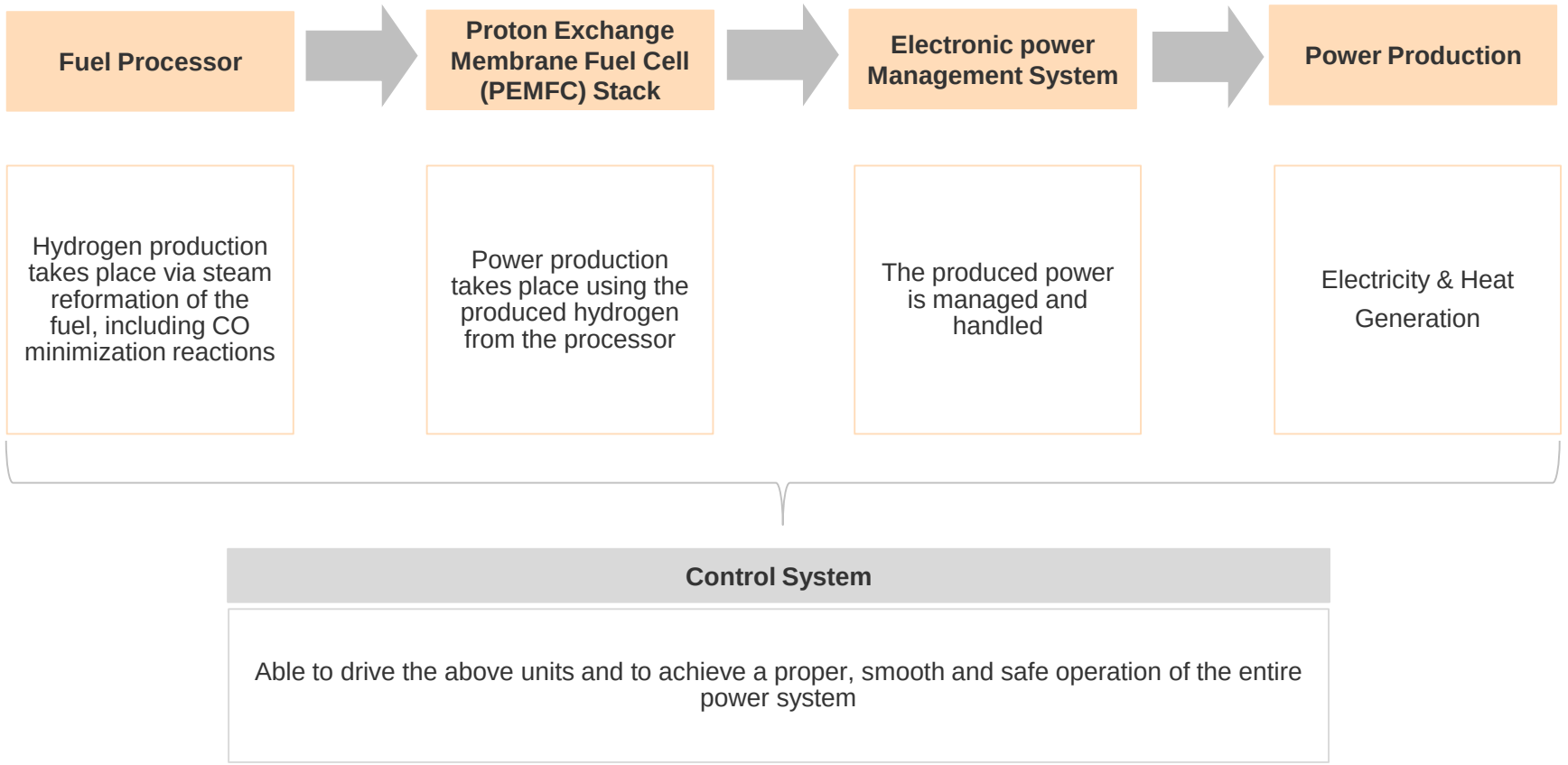
Current HELBIO Products: Hydrogen Generators

Process



Current HELBIO Products: Micro CHP unit - Prometheus 5

Process



Our unique selling points

Intellectual properties

Patent #	Title
1	Process for the production of hydrogen and electrical energy from reforming of bio-ethanol, US 6,605,376 B2
2	Highly heat integrated fuel processor for hydrogen production, PCT/GR2008/000028 - US 20100183487 A1
3	Highly heat integrated reformer for hydrogen production, PCT/GR2008 /000029 - US 20100178219 A1
4	Heat Integrated Reformer with Catalytic Combustion for Hydrogen Production, PCT/GR2012/000004 - US 20140369897 A1
5	Heat Integrated Compact Fuel Processor with Catalytic Combustion for Fuel Cell Applications, PCT/GR2012/000011 - US 20150118123 A1
6	A fuel processor/fuel cell system for providing power to refrigerator at out-of-grid locations and a method of use thereof, US 20120086385 A1

AUTomotive deRivative Energy system (from Aug. 2015 to Aug. 2018)

AUToRE is an i*nnovative fuel cell system at intermediate power range for distributed combined heat and power generation, and it addresses specific challenges: to develop, manufacture and validate a new generation of fuel cell systems with properties that significantly improve competitiveness.*

- ***Project Aim**: to create the foundations for commercializing an automotive derivative fuel cell 50kW system for CHP applications in commercial and industrial buildings.*

- **Coordinator:** Alstom Power LTD (now General Electric)
- **Participants**: Alstom (SCHWEIZ) AG, DAIMLER AG, HELBIO SA, other organizations with smaller participation

The project covers the ***design and construction of a hydrogen generation unit*** (fuel processor) and the integration with the purification subsystem (PSA) so as to meet hydrogen production capacity and purity specifications set by the fuel cell manufacturer (Daimler). *The hydrogen generating unit will be based on* ***Helbio's innovative technology***. Moreover, the necessary ***control software will be also developed by Helbio*** and will be implemented using industrial grade PLCs.

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AutoRE

FCH

European Commission

Helbio - Partner in Major EU Projects

Helbio is partner in important research & innovation projects in the H2 and Fuel cells community

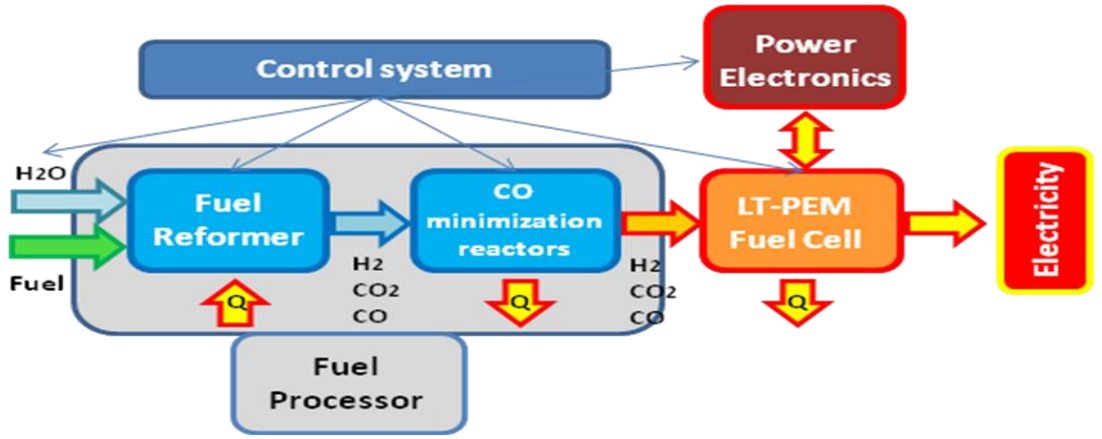
- Prometheus 5 **Horizon 2020, SME Instrument** “Energy efficient and environmentally friendly multi-fuel power system with CHP capability, for stand-alone applications.” Acronym: Prometheus-5**,** http://www.prometheus5.com/ Standardization, field testing and industrialization of Prometheus5, Helbio’s 5kW CHP multi fuel system (operates with LPG, NG or Biogas)

- **Waste2Fuels** **EU Horizon 2020,** test rig for the evaluation of catalysts, able to convert ethanol to butanol. http://www.waste2fuels.eu/

- Other projects i.e. **DemStack, Nonpt-Pem**

Prometheus 5 – A Leading-Edge Combined Heat & Power CHP System 5kW$_{el}$

- Prometheus 5 is a CHP system capable for:
  - **stand-alone power generation system** supplying up to 5kW$_e$
  - **CHP system** supplying up to 5kW$_e$ and additionally up to 7kW$_{th}$
- The system can be used both for **stationary** and **mobile applications**
- The system is **multi-fuel fed**, i.e. it can operate with either Natural Gas, Propane/LPG and Biogas, **converting it to electrical power through an intermediate production of hydrogen** using a Proton Exchange Membrane Fuel Cell (PEM-FC)
- Prometheus 5 is currently **in a pre-commercial stage** (advanced prototype demonstrative units), with **several units having been installed and in operation** in a number of locations around the world.



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Prometheus 5 - Product Claims

- **Electrical Efficiency** of Prometheus 5 is **greater than 35%,** while **Total Efficiency exceeds 85%**
- **Operating cost (Fuel)** of Prometheus-5 is more than **2 times lower** than that of a conventional diesel generator (0.23 €/kWh vs 0.58 €/kWh)
- **50% reduced Maintenance Cost** (compared to the maintenance cost of conventional power generators) due to **simplicity of construction**
- **Dramatically reduced emissions** (Prometheus-5 emits **170 times lower amounts of NOx and HC**, 27 times lower amounts of CO and zero amounts of SOx)
- **Very low noise and vibration** levels
- Improved **safety** (no flames)

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Our customers & application markets for our standardized Heat and Power (CHP) Units

	ON-GRID BUILDINGS	OFF-GRID BUILDINGS	TELECOMMUNICATION STATIONS	TRUCK Auxiliary Power Units	MARINE
					
APPLICATION	• Primary heat and power generation using Natural Gas infrastructure • Backup power generation	• Primary heat and power generation	• Backup electricity generation (on-grid) • Primary heat and electricity generation (off-grid)	• Heat and power for cab conveniences and cold weather starting • Power for refrigeration units	• Supplementary power generation when in harbor
COMPETITION	• Grid • Gen-sets • Specific geographic areas: Concentrated heat and power (CHP) based on solar	• Gen-sets • Renewables • Specific geographic areas: Concentrated heat and power (CHP) based on solar	• Gen-sets • Renewables • Specific geographic areas: Concentrated heat and power (CHP) based on solar	• Engine idling	• Gen-sets • Harbor onshore power supply
BENEFITS	• Reduced CO_2 emissions • Elimination of SOx, NOx and particle emissions • Extremely low noise level	• Steady heat and power generation around the clock • Significantly lower cost of electricity (€/kWh) than gen-sets due to v. low maintenance costs • Increased reliability	• Steady heat and power generation around the clock • Significantly lower cost of electricity (€/kWh) than gen-sets due to v. low maintenance costs • Increased reliability	• Fuel saving • Reduced / zero CO_2 emissions • Elimination of SOx, NOx and particle emissions • Extremely low noise and vibration level	• Fuel saving • Reduced CO_2 emissions • Elimination of SOx, NOx and particle emissions • Extremely low noise and vibration level
ATTRACTIVENESS	• Low price points • Strong incumbency • Dominated by large players	• Low price points • Strong incumbency • Dominated by large players	• Reliability is key • Remote areas without onshore grid infrastructure	• Functional benefits (noise, vibration) are key considerations	• Functional benefits (noise, vibration) are key considerations • Cost of APU vs total cost of boat is extremely small

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AutoRE – Helbio System Constructions

Hydrogen generator process & gas analysis system

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AutoRE – Helbio System Constructions

PSA (Pressure Swing Adsorption), hydrogen purification system

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Current & Potential Markets

Helbio is already in contact with companies that are ready to implement its innovative technology in Telecom, Industrial, and other applications

Country	Project	Application
India	Design & construction of a 5kW APU running on PLG for telecommunication station	Telecom
Russia	Construction of a APU system for use in Pipeline installations	NG Pipeline
Japan	Construction and delivery of 10 m3/h high purity hydrogen fuel processor for refueling stations	HRS
Russia	Construction of Hydrogen Generator 50NMCH for power generators cooling process	Industrial production
Greece	Production Efficiency study and utilization of waste by products	Study
Japan	Use of natural gas for gas engines/ electric generators. Huge amount of H2 to cool down the generators in power production	Power Production
Germany	The new internal Combustion engine H2 alternative, will be the only zero emission ICE engine	Automotive

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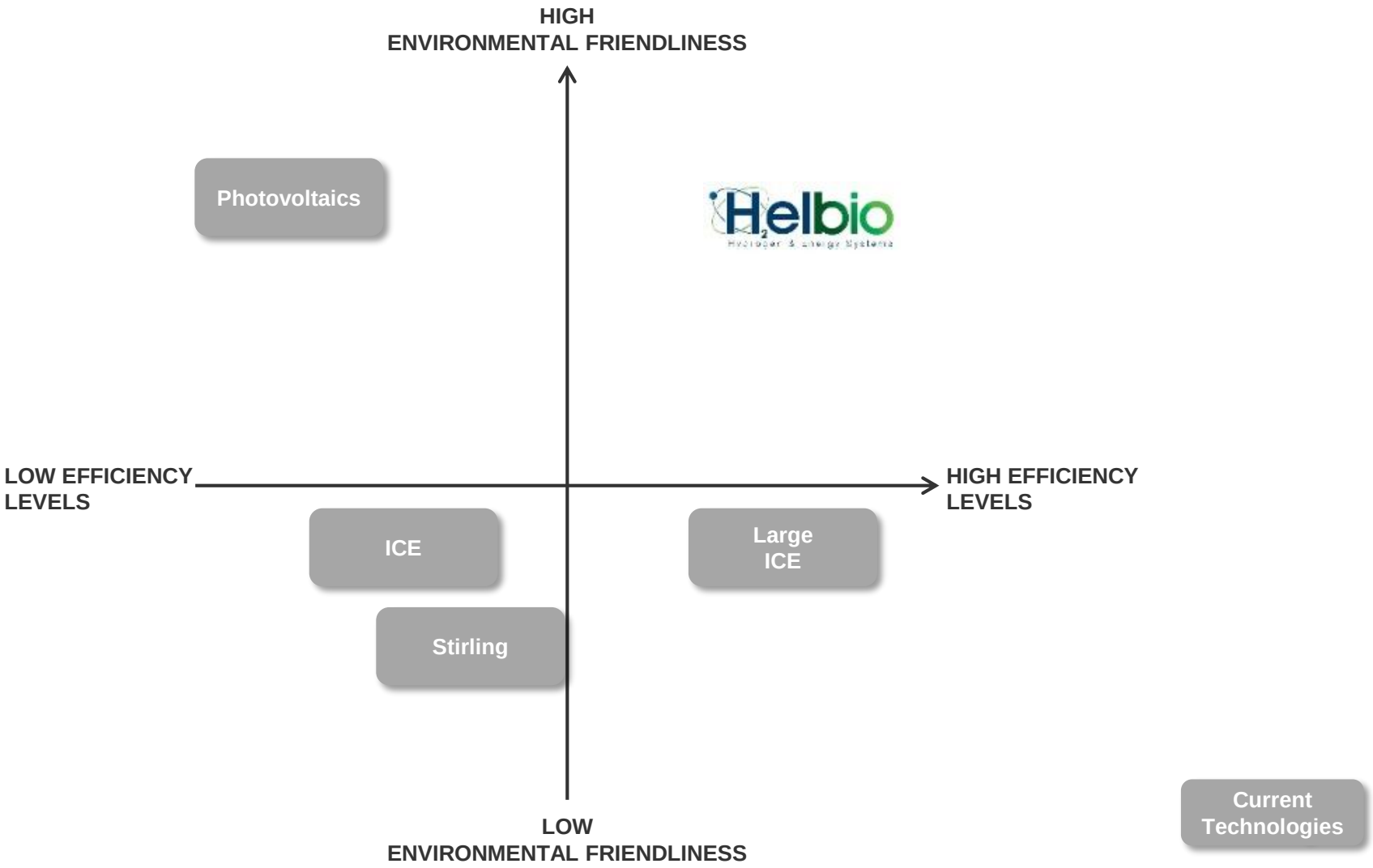
Current Technologies vs Helbio Technology

HELBIO offers the highest efficiency levels in current market, combined with high environmental friendliness



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THANK YOU FOR YOUR ATTENTION

More information available:

www.helbio.com

www.prometheus5.com

APPENDIX

Introduction of HELBIO – Hydrogen & Energy Production Systems

The business model: development, manufacturing and marketing of

a) Hydrogen generators of 5 – 300 Nm3/h capacity

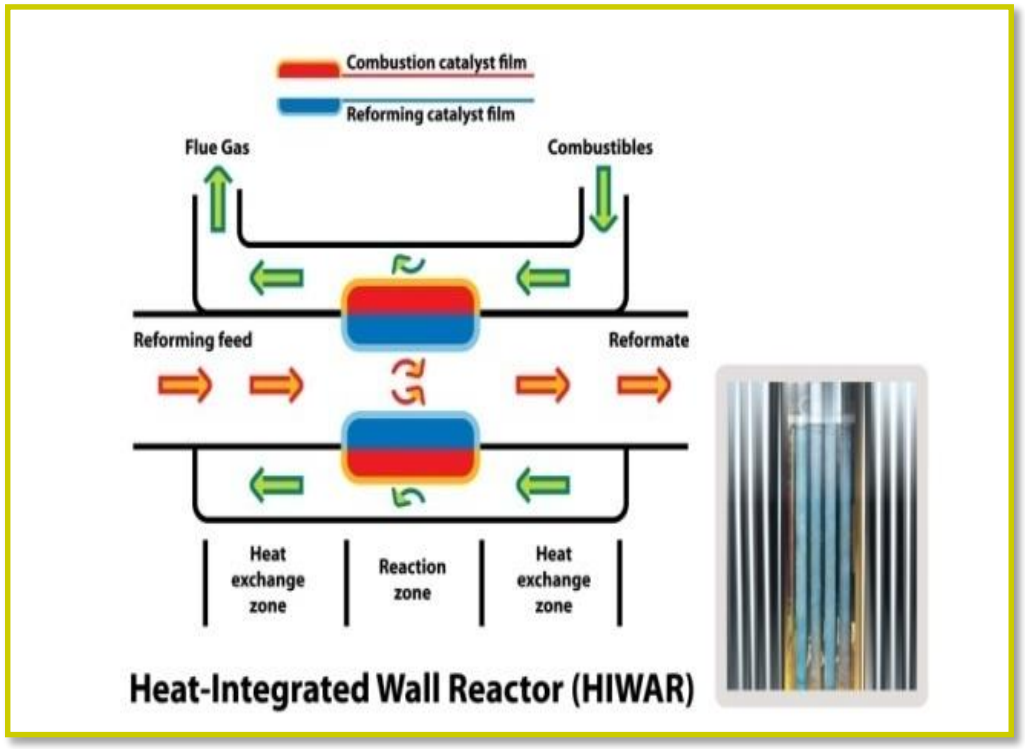
b) Combined Heat and Power (CHP) generation units utilizing fossil fuels or bio-fuels, reforming into H2 for fuel cell power generation in the range 5kW - 200kW

The unique selling point and expertise:

- Products based on I**nnovative Technologies,** developed **In-house (Patras Science Park/Greece)**
- **6 International & European registered patents,** secure Helbio's "freedom to operate" **(FTO)**, enabling a successful Commercialization of existing & new products (Prometheus-5)
- **Advanced** Hydrogen and energy production technologies
- Compact and efficient reactor configurations **(patented HIWAR concept)**
- **A multi-fuel system,** (operates without alteration with three fuels, propane/LPG, Natural Gas and Biogas), a unique characteristic of Prometheus-5, **makes it suitable for operation in various parts of the world.**

Helbio H_2 Hydrogen & Energy Systems

- Helbio has developed the proprietary **Heat Integrated Wall Reactor (HIWAR)** which exhibits numerous advantages over the competition:
  - Very high heat transfer rate
  - Very compact. High power/volume ratio
  - Use of small amount of reforming catalyst
  - Lower operating temperatures / no flames
  - Capacity ranges from a <0.5 kW up to >500 kW
  - Very difficult to replicate by reverse engineering



- HEBLIO has developed proprietary PGM supported (*Pt, Rh & Pd*) catalysts with excellent characteristics for all reforming/combustion processes.

The thin catalytic film deposition both for plates and tubes is achieved following our proprietary method

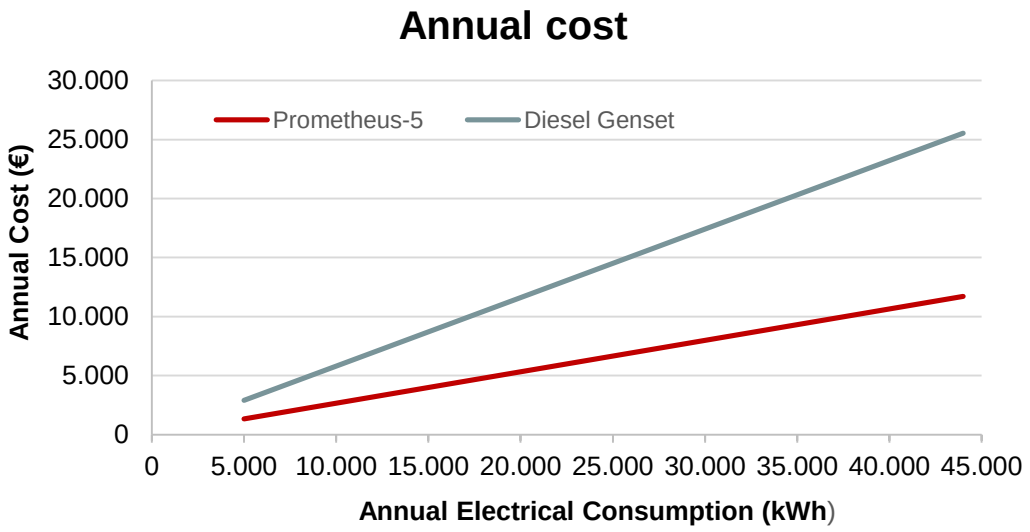
Raw material (FeCrAl)

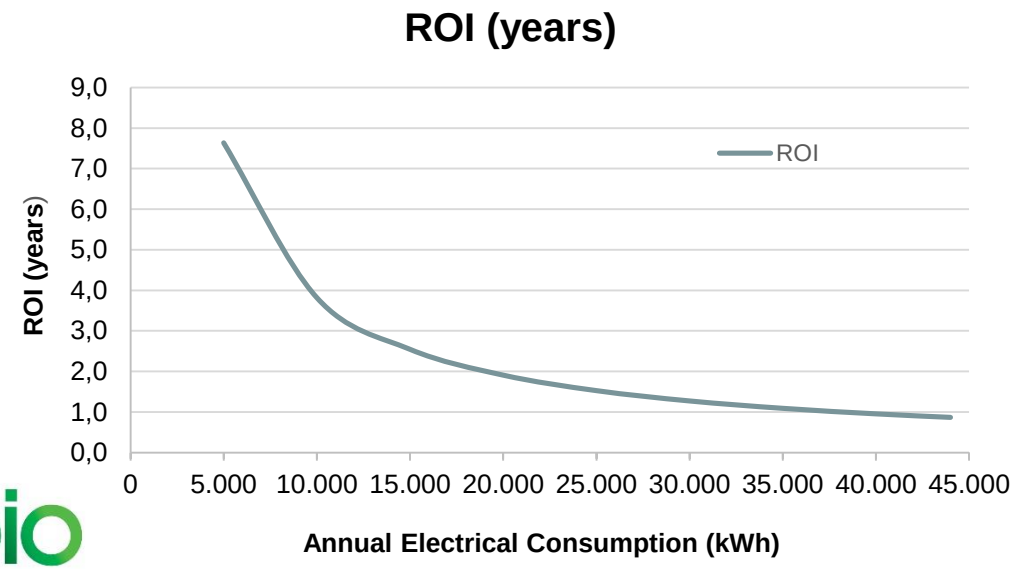
FeCrAl sprayed with Al_2O_3

FeCrAl coated with catalyst

Prometheus 5 – Benefits in off-grid case (power production only)

Comparison of total cost of acquisition and operation of Prometheus-5 with that of a diesel gen-set





- Prometheus-5 operating cost compared to a Diesel gen-set (**0.26 €/kWh vs 0.58 €/kWh**) is **twice** as cheap as a gen-set
- Assuming an annual electrical consumption of 30,000kW-h, Prometheus can be **twice** as economical as a Diesel gen-sets
- Using the same assumption as above, **ROI can be achieved in 1.3 years**.
- In case that the produced heat can be utilized in the installed application ROI becomes extremely attractive (0.98 years for 30,000kW-h).

Assumptions:

LPG: 1,2€/kg Diesel: 0,9€/lt

Annual El. Consumption: 30000kWh

P5 El. Efficiency: 35%

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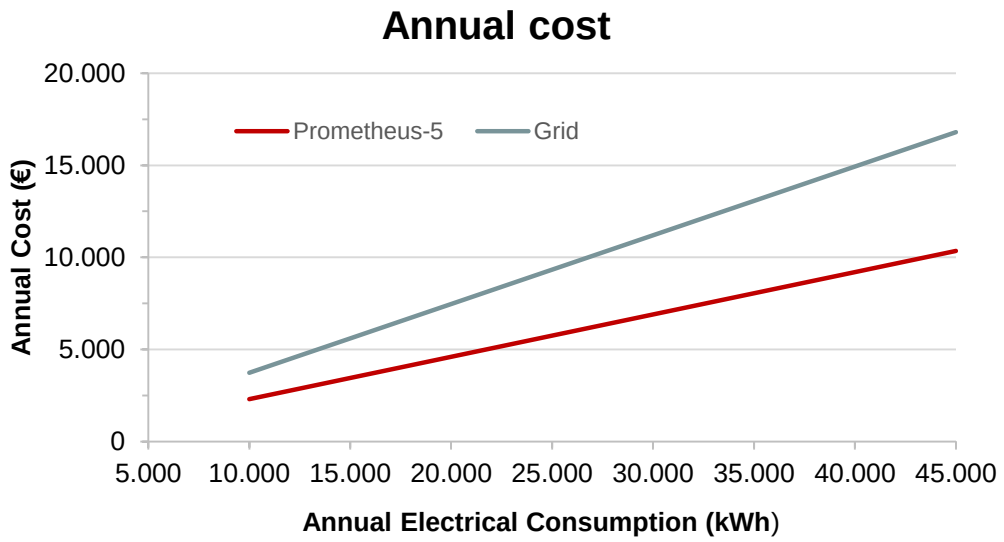
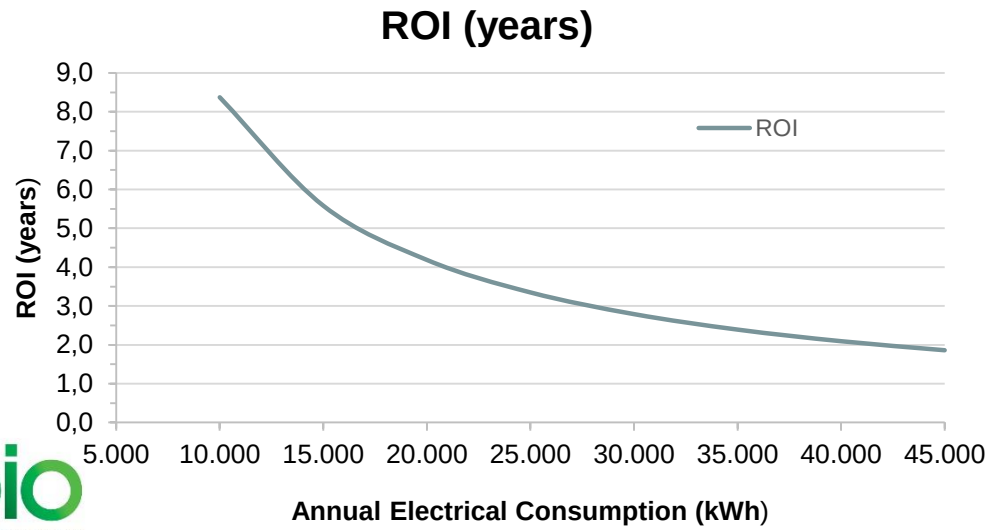
Prometheus 5 – Benefits in on-grid case (CHP case)

Comparison of total cost of acquisition and operation of Prometheus-5 with that of a German grid-connected household.





- Prometheus has an operating cost of **0.23 €/kW-h** (Fuel & Maintenance costs) compared to a grid connected household with a price of **0.28 €/kW-h**
- Assuming an annual electrical consumption of more than 30,000kW-h and utilization of produced heat (CHP), Prometheus can save more than **30%** of annual gas costs
- Additionally, using the same assumption as above, **ROI can be achieved in less than 3 years,** while as annual consumption increases, it can be achieved even faster.

Assumptions:

Annual El. Consumption: 40000kWh

Annual Thermal Consumption: 56000kWh

Power & Thermal Energy

Helbio H_2 Hydrogen & Energy Systems