GreenH2CY Project:

Green Hydrogen Project for Transport in Cyprus

Makis Ketonis
Project Coordinator
Ketonis Holdings

G2HCy Green Hydrogen Cyprus

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ideopsis

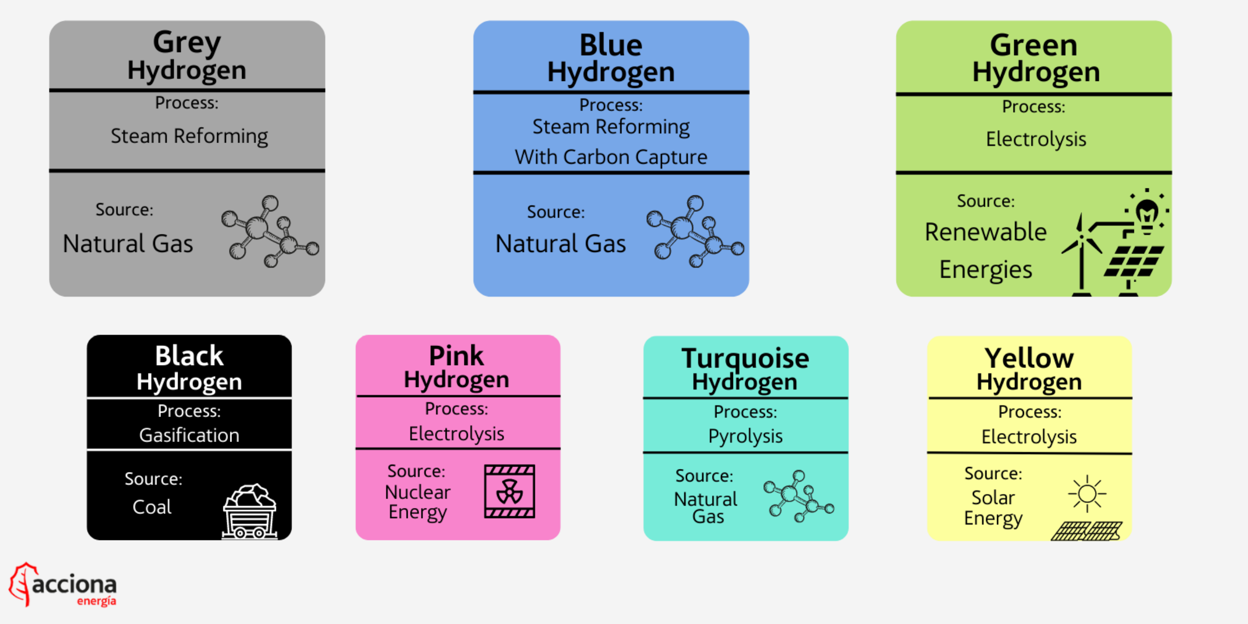
The Fuel of the Future

Energy Transition & Hydrogen

GreenH2CY Project

“Hydrogen Rainbow”

	Colour	Feedstock	Direct GHG emissions ($kgCO_2/kgH_2$)
Using electricity	Green	Renewable electricity	-
	Yellow	Grid electricity	-
	Pink	Nuclear electricity	-
Using Fossil Fuels	Grey	Natural Gas	9-11
	Blue	Natural Gas or coal	0.5-4
	Turquoise	Natural Gas	Solid carbon



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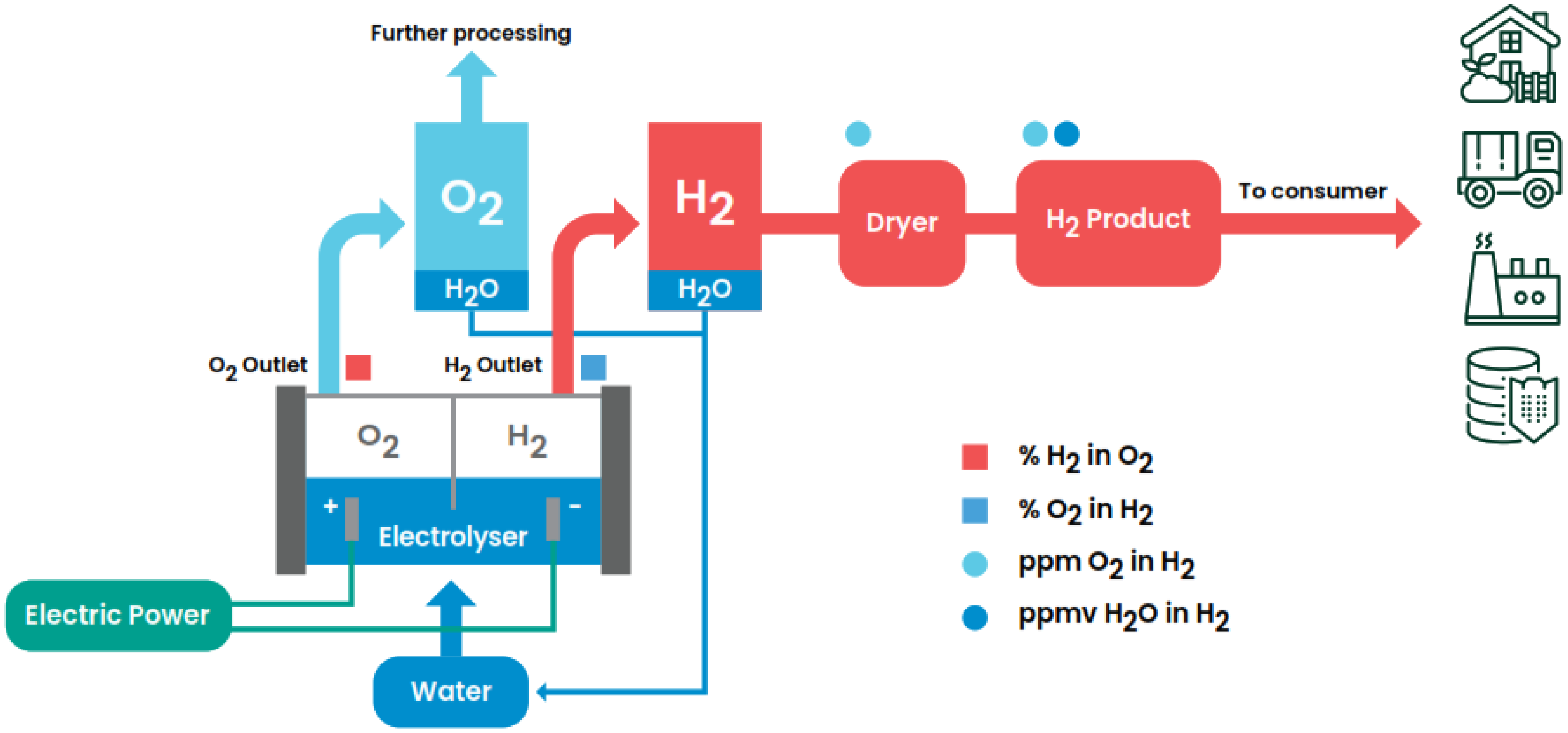
Hydrogen

Typical Electrolyser Process



Typical Electrolyser Process

Source: Water Electrolysis for Hydrogen Production, Ensuring Process Safety and Product Quality Using Oxygen, Hydrogen, and Moisture Analyzers

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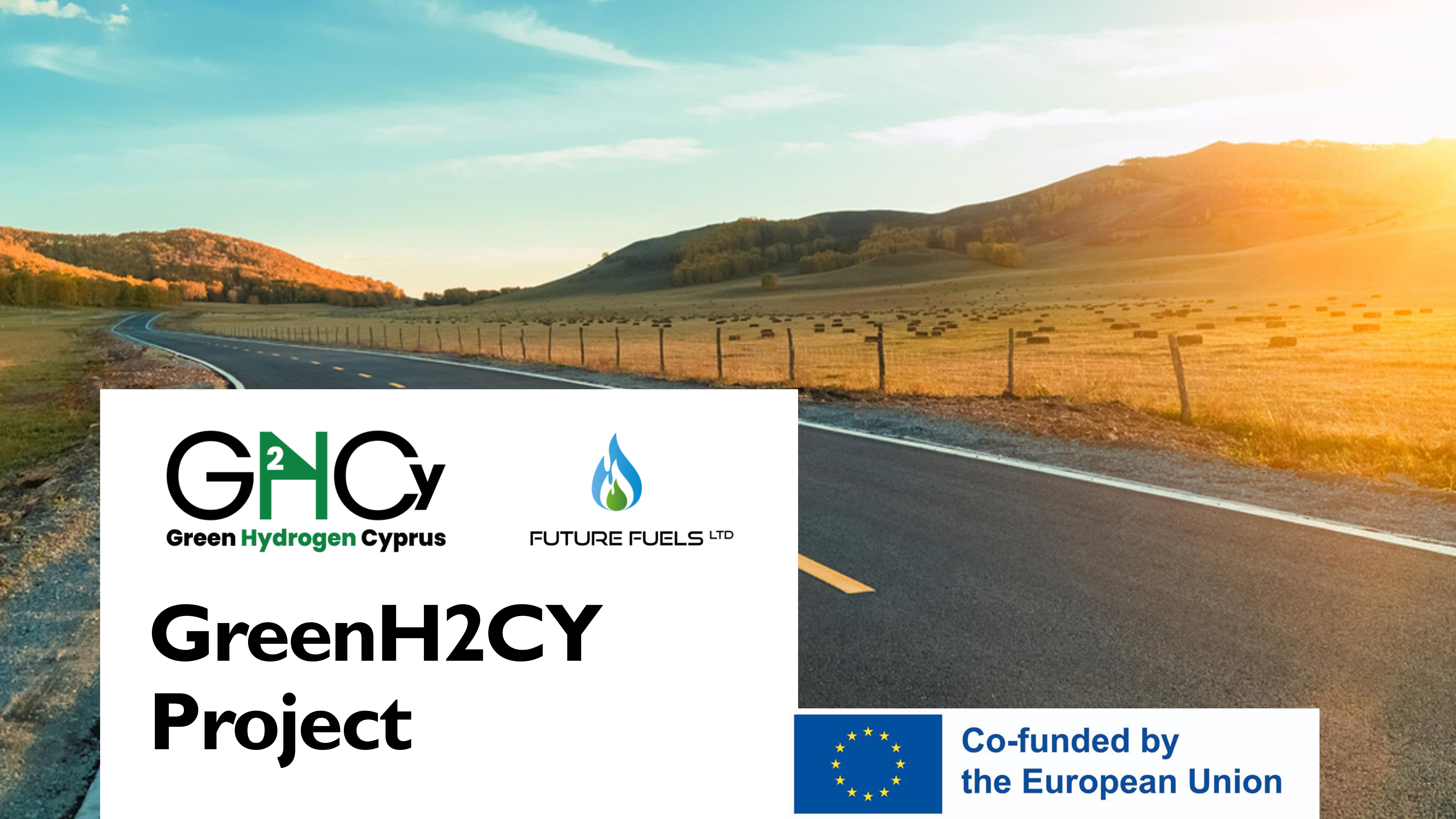

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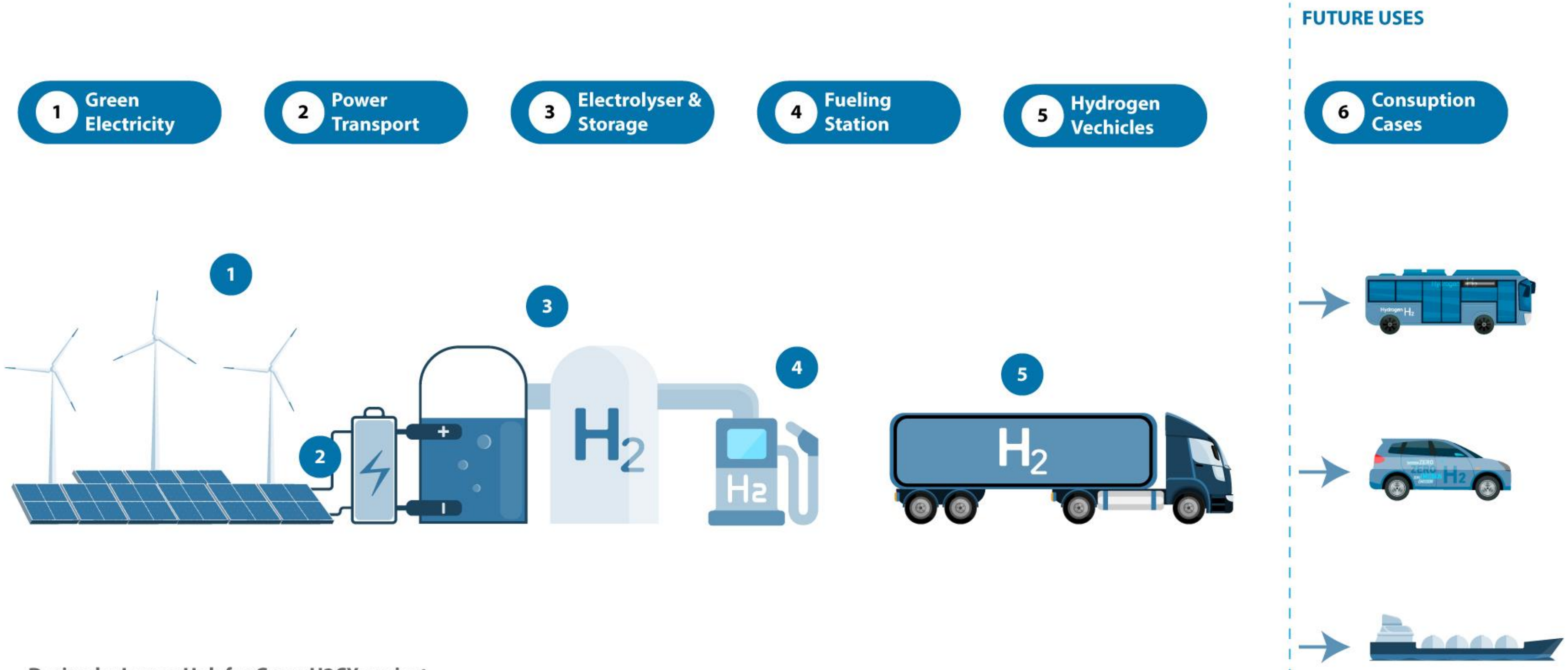

Design by LemonHub for GreenH2CY project

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GreenH2CY - Project 101103240

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<u>Agreement between the following parties:</u>

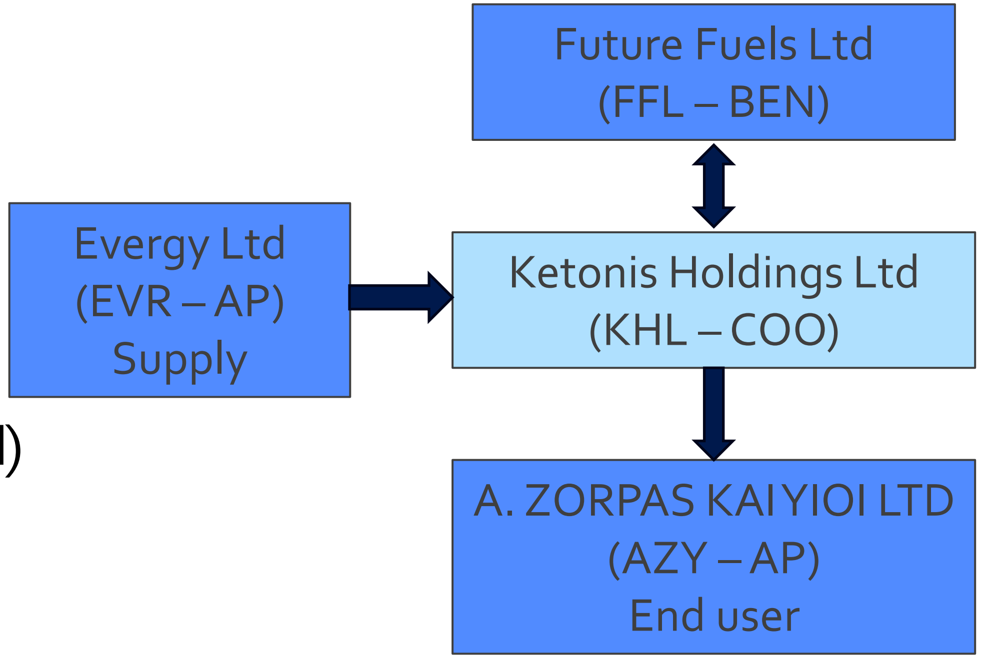
European Climate, Infrastructure and Environment Executive Agency (CINEA)
under the powers delegated by the European Commission

Coordinator: KETONIS HOLDINGS LTD (Ketonis H.)

Beneficiaries: MCK. FUTURE FUELS LTD (Future Fuels)

Associated partners:
A. ZORPAS KAI YIOI LIMITED (ZORPAS)
EVERGY LTD (EVERGY LTD)

Project starting date: 01/06/2023
Project operational date: June 2025 (envisaged)
Project duration: 63 months
Project end date: 31/08/2028



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GreenH2CY - Project 101103240

The GreenH2CY project will produce hydrogen from renewable energy for the transport sector, to re-fuel trucks and replace diesel vehicles.

Includes in the same location:

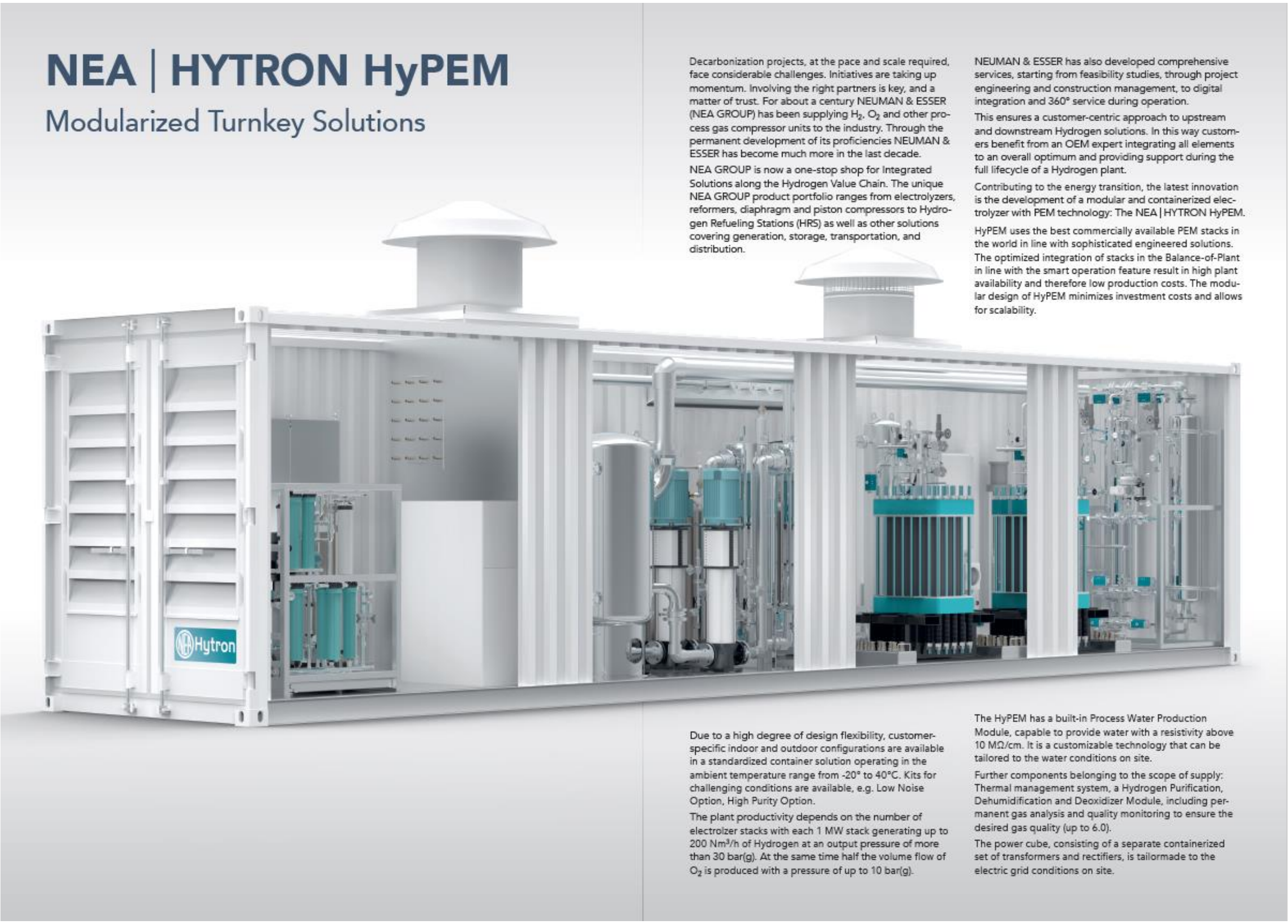
- Installation and operation of a 2-MegaWatt (MW) Proton Exchange Membrane (PEM) electrolyser consisting of 2 electrolysis stacks, 1 MW each
- A hydrogen storage facility – two storage units (2 x 500 kg)
- A re-fuelling station

GreenH2CY Project

Technical Characteristics

The entire equipment and all its components are containerized and easily movable and transported.

Source: NEA group



NEA | HYTRON HyPEM

Modularized Turnkey Solutions

Decarbonization projects, at the pace and scale required, face considerable challenges. Initiatives are taking up momentum. Involving the right partners is key, and a matter of trust. For about a century NEUMAN & ESSER (NEA GROUP) has been supplying H_2, O_2 and other process gas compressor units to the industry. Through the permanent development of its proficiencies NEUMAN & ESSER has become much more in the last decade.

NEA GROUP is now a one-stop shop for Integrated Solutions along the Hydrogen Value Chain. The unique NEA GROUP product portfolio ranges from electrolyzers, reformers, diaphragm and piston compressors to Hydrogen Refueling Stations (HRS) as well as other solutions covering generation, storage, transportation, and distribution.

NEUMAN & ESSER has also developed comprehensive services, starting from feasibility studies, through project engineering and construction management, to digital integration and 360° service during operation.

This ensures a customer-centric approach to upstream and downstream Hydrogen solutions. In this way customers benefit from an OEM expert integrating all elements to an overall optimum and providing support during the full lifecycle of a Hydrogen plant.

Contributing to the energy transition, the latest innovation is the development of a modular and containerized electrolyzer with PEM technology: The NEA | HYTRON HyPEM.

HyPEM uses the best commercially available PEM stacks in the world in line with sophisticated engineered solutions. The optimized integration of stacks in the Balance-of-Plant in line with the smart operation feature result in high plant availability and therefore low production costs. The modular design of HyPEM minimizes investment costs and allows for scalability.

Due to a high degree of design flexibility, customer-specific indoor and outdoor configurations are available in a standardized container solution operating in the ambient temperature range from -20° to 40°C. Kits for challenging conditions are available, e.g. Low Noise Option, High Purity Option.

The plant productivity depends on the number of electrolzer stacks with each 1 MW stack generating up to 200 Nm³/h of Hydrogen at an output pressure of more than 30 bar(g). At the same time half the volume flow of O_2 is produced with a pressure of up to 10 bar(g).

The HyPEM has a built-in Process Water Production Module, capable to provide water with a resistivity above 10 MΩ/cm. It is a customizable technology that can be tailored to the water conditions on site.

Further components belonging to the scope of supply: Thermal management system, a Hydrogen Purification, Dehumidification and Deoxidizer Module, including permanent gas analysis and quality monitoring to ensure the desired gas quality (up to 6.0).

The power cube, consisting of a separate containerized set of transformers and rectifiers, is tailormade to the electric grid conditions on site.

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Specific Objectives

- The hydrogen production plant is expected to produce **150 tonnes of hydrogen** fuel per year.
- This is equivalent to **627 tonnes of diesel** fuel per year.
- The **energy** will be supplied by a **local renewable energy supplier** (EVR-AP) with the use of guarantees of origin (GOs) to prove the use of only renewable energy sources, so that the final product can be classified as green.
- The **water** to be used will be derived from tertiary treatment of wastewater from the Water Development Department of Larnaca, thus it will be contributing to circular economy actions.

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Technical specifications

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Parameter	Details
Electrolysis Technology	PEM (Proton Exchange Membrane)
Electrolyte	Polymer-like. No other liquid substances, besides water, are necessary or found inside the integrated hydrogen production plant
Life Expectancy of the Electrolysis Stacks	90,000 h (about 10 years, according to the assumptions adopted for the End-of-Life conditions)
Power requirements	
BoL (Begin-of-Life):	54.0 kWhDC/kg H2 59.0 kWhAC/kg H2
EoL (End-of-Life):	65.0 kWhDC/kg H2 73.2 kWhAC/kg H2
Process water specific consumption	About to 0.9 L/Nm3 of H2 or 10 lt/kg of H2
Process Water Production Module	Capable to provide water with resistivity above 10 MΩ/cm and TOC < 30 ppb.
Feed Water Specification	The Process Water Purification Module is customizable technology and able to handle the water available at each site.
Waste and Environmental Aspects	Gas exhaust consisting of the oxygen stream (if this stream is not used) and Liquid drainage consisting of the reverse-osmosis and pre-treated rejected water. Regular maintenance results in saturated deionizing resin and water filtration cartridges, harmless for human contact and/or regular disposal. Eventual replacement of UV-lamps, from process water treatment and polishing, will results in lamps to be disposed. Reverse-osmosis membrane and electrochemical cells (used for gas analysis) should be replaced in a 1-2 year interval, without harmful waste. There is no replacement interval for catalysts and molecular sieves used for hydrogen purification, all over the system's lifetime.
System Rated Lifetime	25 years

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Characteristics of Refuelling station

Parts
1 x 30´ Container with Diaphragm Compressor
1 x 20´ Container – Medium Storage
1 x 20´ Container – Medium Storage
1 x 10´ Container – Chiller Unit
1 x 10´ Container – Valve Container
1 x 30´ Container – Dry Cooler Unit
1 x 20´Container – Pipe Material, etc.
Storage
500 kg @ 500 bar
Type 4 Storage Vessel
Operating Volume: ~ 518 kg @ 10-500 barg & 15 °C
Dispensers
1 x 350 bar (up to 700 bar), 0° C Cooling
Compressor
Container consists of two Sections: one Ex-Area for Compressor, one Ex-free Area for
Control etc
Power of Main Driver: ≤ 190 kW
Cooling Unit for Dispenser
Chiller cools Hydrogen on Inlet Side of Dispenser down to ~ -10 °C.
Rated Power: ≤ 80 kW

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Location

The location of the plant and refuelling station was carefully selected at Larnaca District (Aradippou Municipality Industrial Area).

The following criteria were followed for the selection of the location:

- **Access** to major routes and key transportation junctions.
- **Access** to a major transport location/destination such as an airport or port.
- **Availability** of a (commercial) plot of land for the electrolyser, related infrastructure and refuelling station including access to the electrical network.
- **Compliance** with the safety and environmental requirements to install and generate green hydrogen.

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Location

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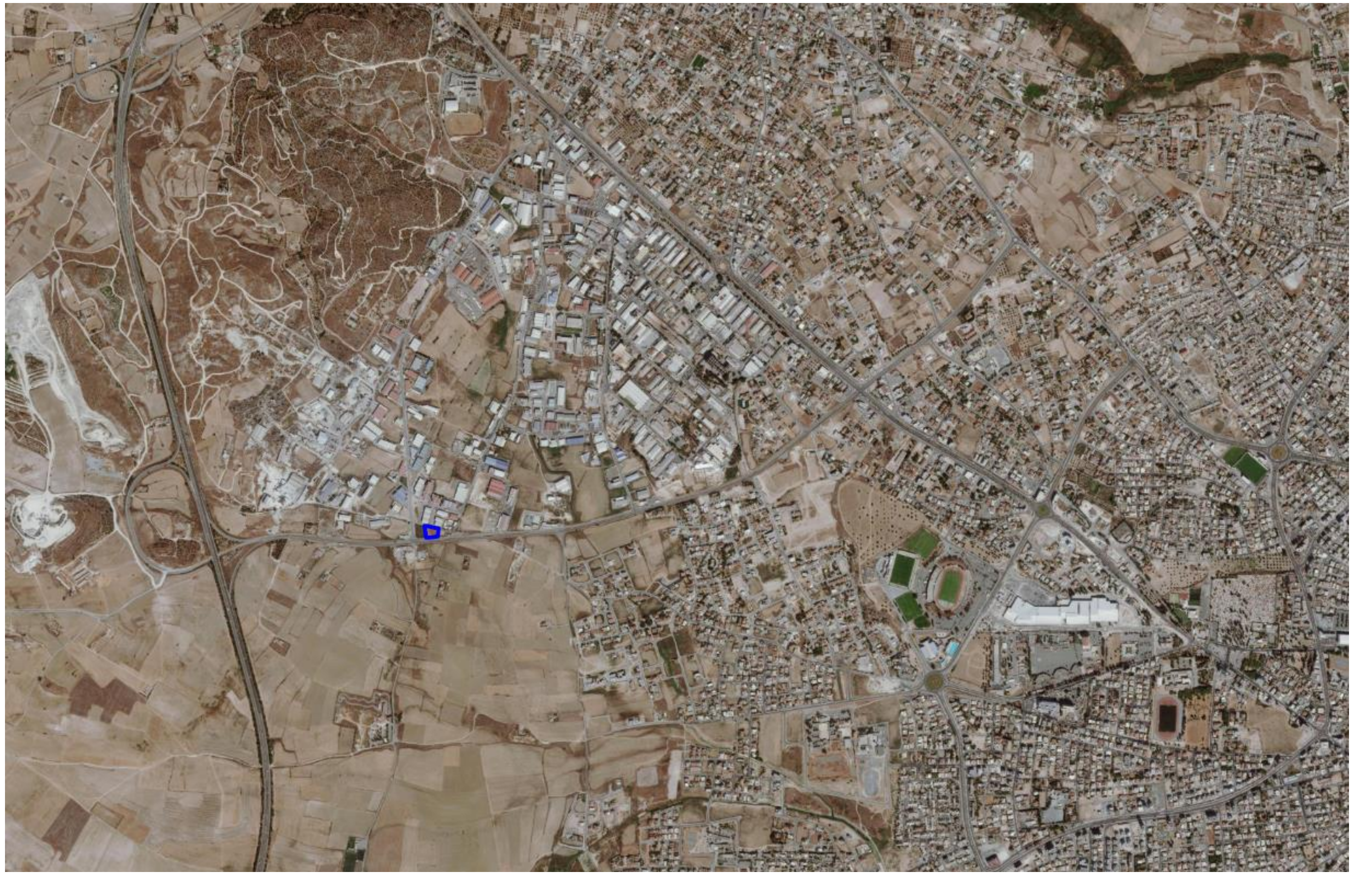
The lease agreement for the selected plot area has been concluded for 15 years with the number 371 (Φ/Σ – 55/25) in the area of Agios Fanourios.

The total area of the plot is **2,077 m^2**.

The plot area is described as a mixed zone with both industrial and economic activity in both the plot area and the wider area. In the wider area there are also agricultural activities occurring.



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Location

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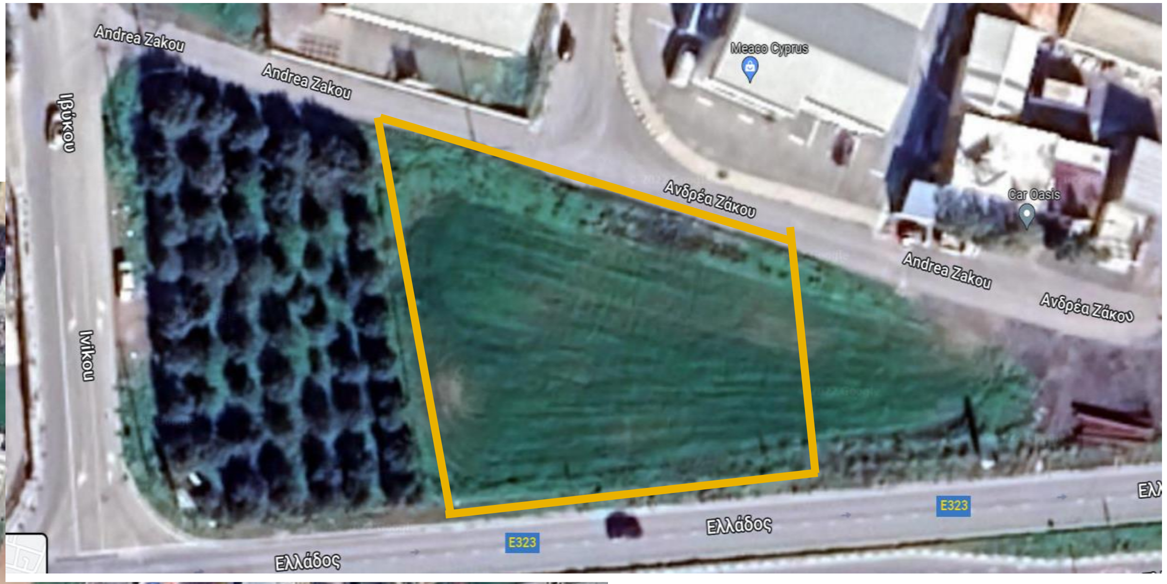

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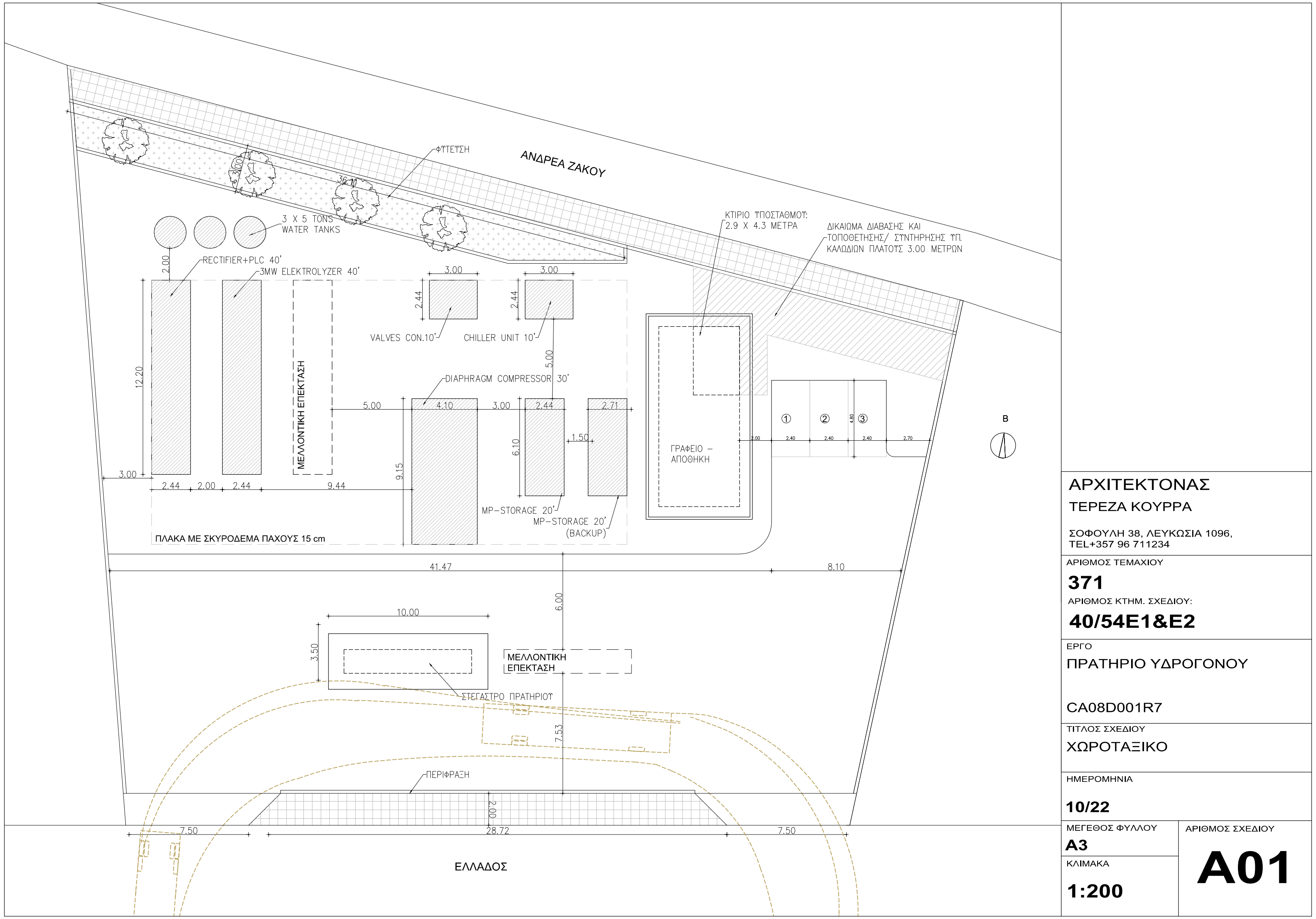

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INPUT

Electricity from Renewable Energy Sources

Tertiary treatment of wastewater (WWTP) from the Water Development Department of Larnaca

CO_2

Reduction of Greenhouse Gas Emissions

0 greenhouse gas emissions from the operation of the plant

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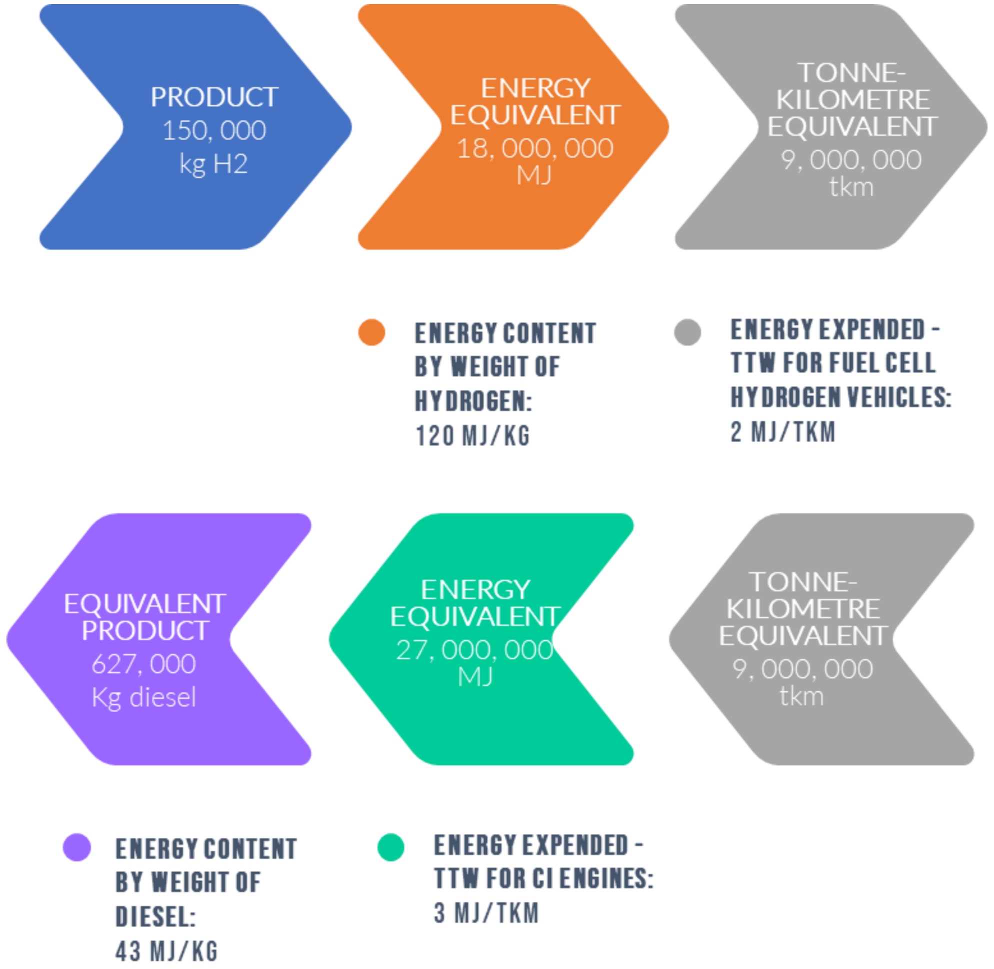

Product and equivalent substitution per year

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OUTPUT

Product: The hydrogen production plant is expected to produce 150 tonnes of hydrogen fuel per year.

Substitute product: That is equivalent to 627 tonnes of diesel fuel per year.

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ENVIRONMENTAL BENEFIT

The substitution of diesel fuel in the road transport results in a reduction of greenhouse gas emissions by 21,676 tons for first ten years of operation.

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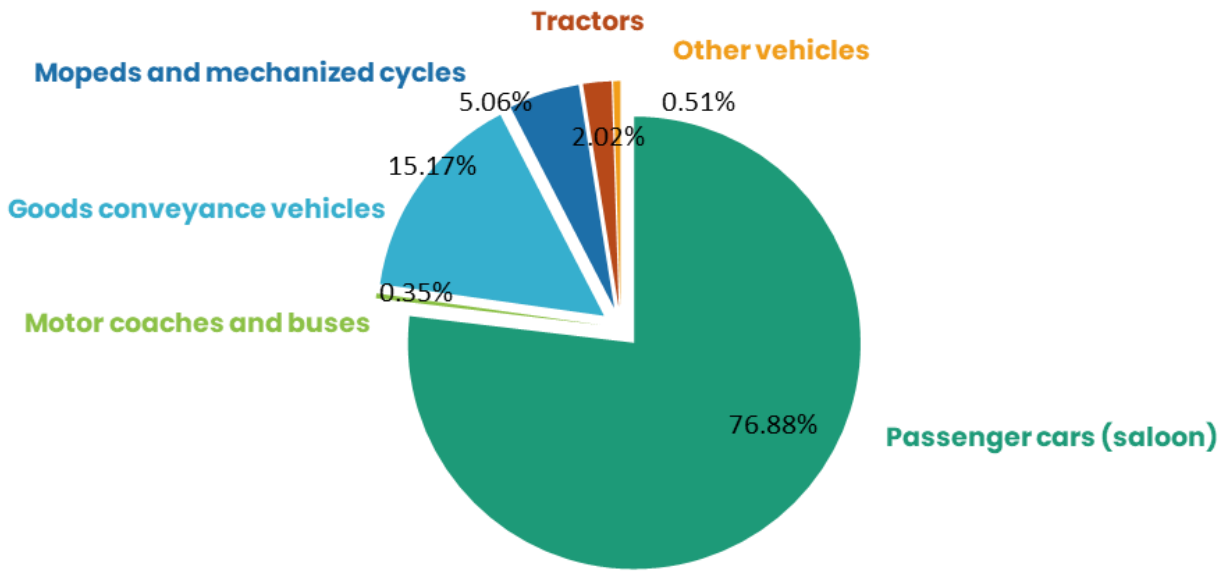
Potential users and Target market



Potential uses of the final product:

(a) heavy goods vehicles,

(b) passenger transport including buses,

(c) return-to-base vehicles.

Key consumers are:

(i) companies with fleet constitute of heavy-duty trucks,

(ii) municipalities (waste collection vehicles),

(iii) Companies providing airport shuttle services and

(iv) public transport organizations.

Possible demand for the product: For the year 2020, according to the data published by Cyprus Statistical Service, the number of licensed vehicles reached the value of 759,268, from which 578,158 are passenger cars (saloon), 2,655 are motor coaches and buses and 116,280 are goods conveyance vehicles.

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FCEV (Fuel Cell Electric Vehicle)

Source: Hydrogen Triple Alliance, Irene García Fernández, 2021

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End User

Zorbas Group maintains a large fleet of supplying vehicles (HGVs), numbering over 70, whilst also maintaining several bus/coaches to transport its employees numbering 2,500 people, to and from its central manufacturing facility located in the vicinity of GreenH2CY project in the Larnaca area.

Ανεφοδιασμός με υδρογόνο

Source: Hydrogen Triple Alliance, Irene García Fernández, 2021

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Ανεφοδιασμός με υδρογόνο

Green

https://www.weh.se/refuelling-components-hydrogen/h2-car-dispensers.html

https://www.fiedlergroup.com/architecture-engineering-project-recaps/shell-opens-san-franciscos-first-hydrogen-stations/

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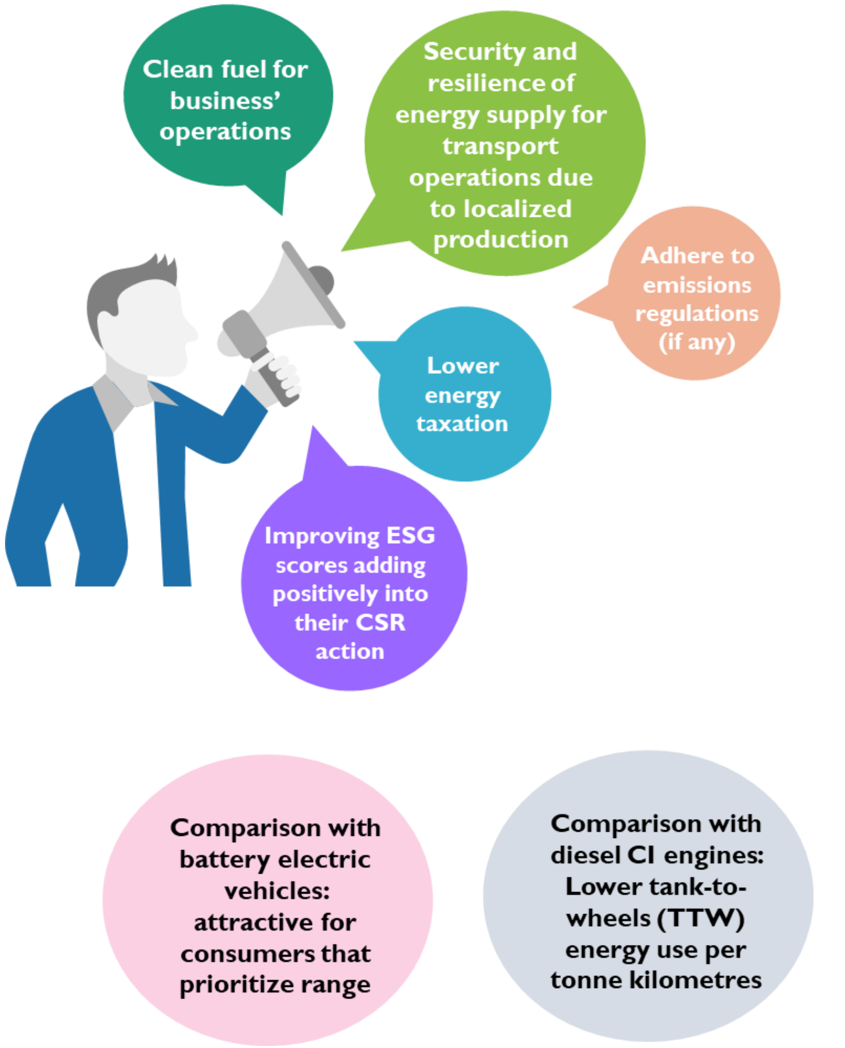
Project value proposition for end-user

- **Clean fuel** for business' operations.
- **Security and resilience** of energy supply for transport operations due to localized production.
- **Lower** energy taxation.
- Comparison with diesel IC engines: **Lower** tank-to-wheels (TTW) energy use per tonne kilometres.
- Comparison with battery electric vehicles: **fast refuelling** and bigger **range**/mileage
- **Adherence** to emissions regulations (if any).
- Improving Environmental Social Governance (**ESG**) scores adding positively into their Corporate Social Responsibility (**CSR**) actions.

Project value proposition



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Comparing Alternatives

In geographic areas that use relatively high-polluting energy sources for electricity generation, such as Cyprus, electric vehicles may not demonstrate a strong emissions reduction benefit.

Considering additionally emissions from manufacturing, FCEVs have an advantage over BEVs, as fuel cells are less energy intense to produce than batteries.

From the environmental perspective, fuel cells, under future developments, could have additionally a lower material footprint than lithium batteries.

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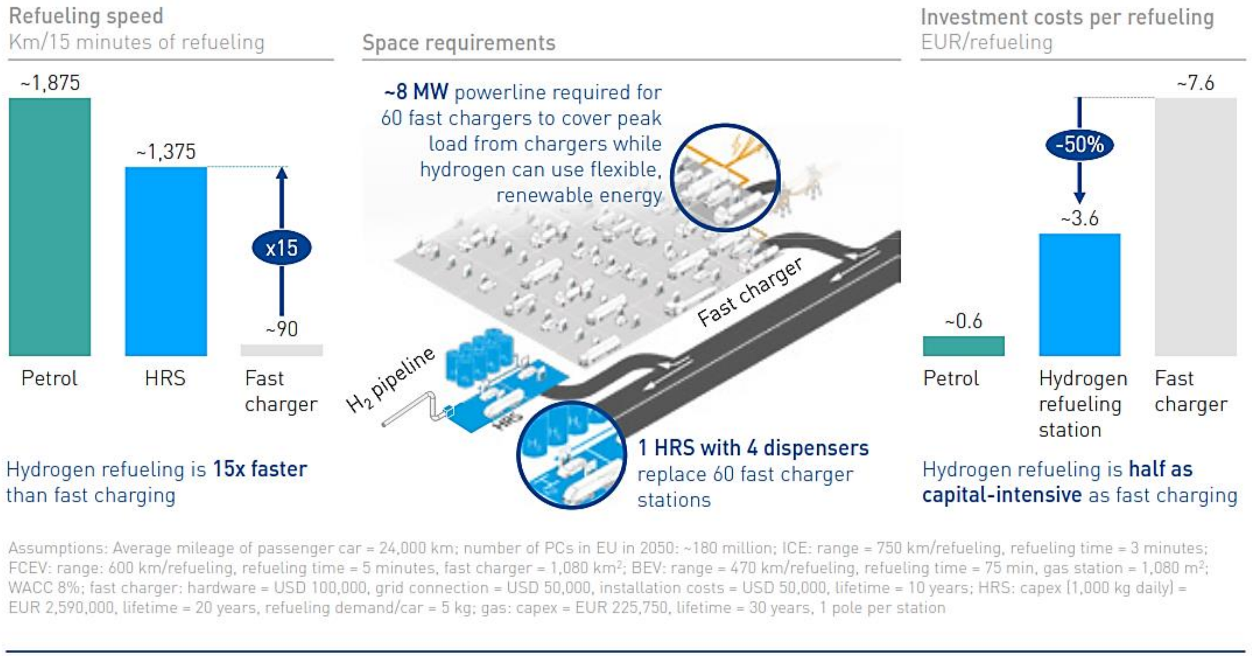
Comparing Alternatives

Source: Fuel Cells and Hydrogen 2 Joint Undertaking. Hydrogen Roadmap Europe: A Sustainable Pathway for the European Energy Transition. 2019



The driving range and pattern of refuelling for FCEVs is similar to internal combustion engine vehicle.

Hydrogen refuelling stations can offer significant advantages, such as faster refuelling, 15 times faster than fast charging and lower space requirements around 10-15 less space.

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The time is right to tap into hydrogen's potential to play a key role in a clean, secure, and affordable energy future.

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- Green hydrogen
  - can help tackle various critical energy challenges
  - offers ways to decarbonise a range of sectors where it is proving difficult to meaningfully reduce emissions (road transport – heavy trucks)
  - can enable renewables to provide an even greater contribution.
- Green hydrogen economy in Cyprus needs to develop as localized production of green hydrogen which will be required for decarbonizing hard to abate sectors.
- Cyprus is endowed with great solar and wind potential which reinforces the argument on localized production.

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