GREEN HYSLAND

Deployment of a H2 Ecosystem on the Island of Mallorca

End user applications – Energy: Palma Hotel FC - Layout and preliminary engineering design

Deliverable 2.11

March 2022

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Preface

The aim of **GREEN HYSLAND** is to **deploy a Hydrogen ecosystem on the island of Mallorca**. The initiative is receiving **10 Million Euros of funding** from the European Commission through the **Clean Hydrogen Partnership**. It is a 5-year-project that started on the 1st January 2021, and will end on 31st December 2025. The consortium is formed by **30 partners from 11 countries**, 9 from the European Union, as well as Chile and Morocco. The project will deliver the **first hydrogen valley of the Mediterranean**, developing a fully functioning hydrogen (H_2) ecosystem covering all the value chain, from the production to the distribution and consumption of, at least, 330 tonnes per year of green H_2, traced through a Guarantee of Origin System. This hydrogen will be used in six different applications, as follows:

- The **H_2 pipeline and the injection point** of part of the H_2 produced at the Lloseta plant into the island's natural gas network operated by Redexis.
- The **100 kWe fuel cell** that will supply electricity to the maritime station of the **Balearic Port**.
- The **50 kWe CHP** system to be located in the **Iberostar Bahía de Palma hotel** (4*), which will cover part of the hotel's energy demand.
- The **25 kWe CHP** system to be located at the **Municipal Sports Centre in Lloseta**, which will cover part of the site's energy demand.
- The integration of **5 hydrogen buses to the EMT** city bus fleet of Palma de Mallorca.
- The integration of **H_2 vans** in the Alfill Logistics vehicle fleet as well as the search for rental car companies to incorporate H_2 vehicles in their **rental car fleets**.

The infrastructures which will be developed within the project are:

- The **green H_2 production plant** located on CEMEX land in Lloseta.
- The deployment of a **Hydrogen Refuelling Station** (HRS) at the EMT facilities.
- The development of tube trailers which will transport the H2 produced in Lloseta's plant to the different applications.

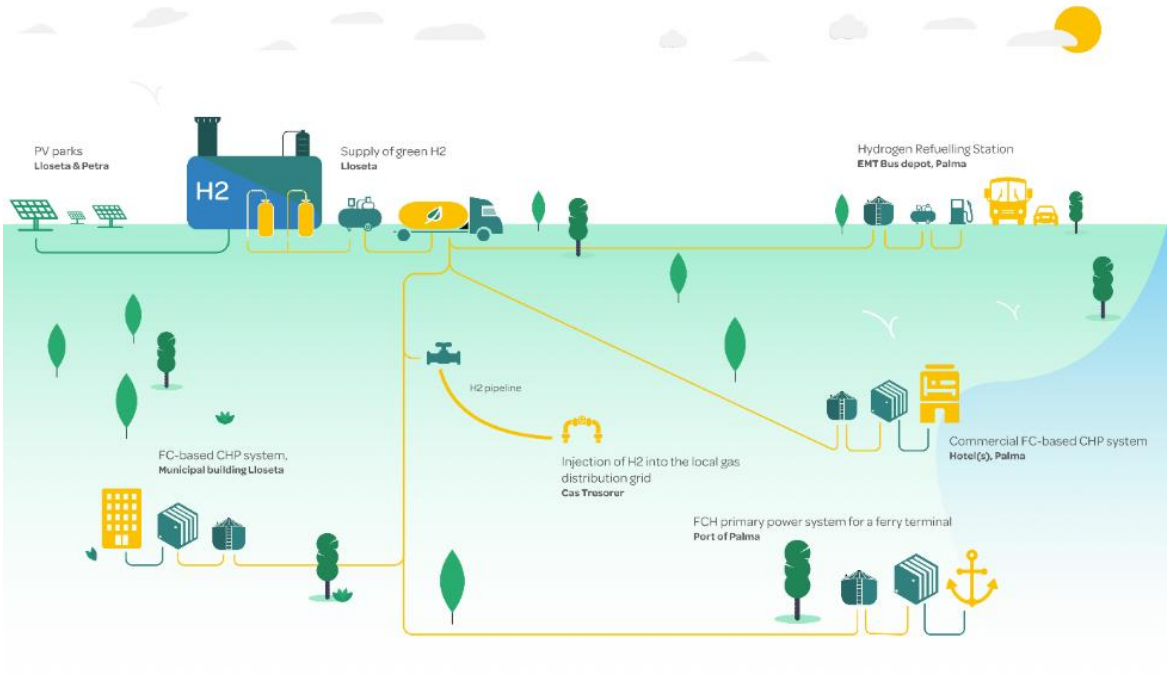
This initiative aims to reduce the CO_2 emissions of Mallorca up to 20,700 tonnes per year by the end of the project.

The project will also deliver **a roadmap towards 2050** that compiles a long-term vision for the **development of a widespread H_2 economy in Mallorca and the Balearic Region**, in line with the **environmental objectives set for 2050.** This long-term roadmap will be an evolution of the current regional roadmap for the deployment of renewable energies and the energy transition, and will involve local and regional stakeholders through public consultations.

In addition, GREEN HYSLAND contemplates the **development of replication experiences** in five other EU islands: Madeira (PT), Tenerife (ES), Aran (IE), Greek Islands and Ameland (NL) as well as Chile and Morocco. Within the project, the impact of deployment of H_2 technologies at regional level (Mallorca and Balearic islands) at technical, economic, energy, environmental, regulatory and socioeconomic levels will be analyzed. Additionally, detailed techno-economic studies for scaling-up renewable H_2

production, interconnecting infrastructure and local H_2 end-uses, both within the island of Mallorca and beyond, will be developed to facilitate and de-risk future sector investment.

The infrastructures for the hydrogen production and distribution, together with the end-users' pilot sites and the logistics required for the green hydrogen distribution will be developed as follows:



No	Participant Name	Short Name	Country Code	Logo
1	ENAGÁS S.A.	ENAGAS	ES	
2	ACCIONA ENERGIA S.A.	ACCIONA ENER	ES	
3	REDEXIS GAS S.A.	REDEXIS GAS SA	ES	
4	Empresa Municipal de Transports Urbans de Palma de Mallorca S.A.	EMT-PALMA	ES	
5	CALVERA MAQUINARIA E INSTALACIONES S.L.	CALVERA	ES	
6	AJUNTAMENT DE LLOSETA	Lloseta Council	ES	
7	AUTORIDAD PORTUARIA DE BALEARES	PORTS BALEARS	ES	

8	CONSULTORIA TECNICA NAVAL VALENCIANA S.L.	COTENAVAL	ES	
9	BALEARIA EUROLINEAS MARITIMAS S.A.	Balearia	ES	
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11	UNIVERSITAT DE LES ILLES BALEARS	UIB	ES	
12	FUNDACION PARA EL DESARROLLO DE LAS NUEVAS TECNOLOGIAS DEL HIDROGENO EN ARAGON	FHa	ES	
13	CENTRO NACIONAL DE EXPERIMENTACIONDE TECNOLOGIAS DE HIDROGENO Y PILASDE COMBUSTIBLE CONSORCIO	CNH2	ES	
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30	Association Marocaine pour l'Hydrogène et le Développement Durable	AHMYD	MA	

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1. Executive Summary

This document "Site layout and preliminary engineering design" is an introduction and overview of the subtask 2.4.3, Preparation for deployment of a Combined Heat and Power (CHP) Application at Hotel in Palma, managed by REDEXIS to define the preliminary design and prepare the detailed engineering.

The guideline contains the management and execution processes of REDEXIS projects that are adaptable and applicable to the reference project, as well as other projects that may arise in the future. The main objective of these guidelines is to ensure a consistent and high-quality project delivery that meets or exceeds European Commissions expectations. It will present a brief review of the location, layout, main equipment, and process description.

2. Introduction

GREEN HYSLAND Project is part of a general initiative to decarbonise islands and island regions through innovative solutions based on green hydrogen technology.

This project contemplates the production of green hydrogen (with an electrolysis equipment) with the use of renewable electricity generated by two photovoltaic plants.

This hydrogen is a versatile "energy vector" that gives the opportunity to be stored as a pressurized gas, be transported by tube trailers, and be used to produce green energy at selected points with fuel cell devices. In this way, it is possible to efficiently manage the variability and intermittence of renewable generation, being able to meet the energy demand in a sustainable way and without depending on the climatic conditions of the moment.

In this sense, this subtask contemplates the installation of a hydrogen fuel cell system at Iberostar Bahia hotel in Palma de Mallorca (see Appendix 1). The device will consume green energy in the form of hydrogen and will be integrated into the hotel facilities, providing electricity and heat to the hotel, and contributing to the decarbonization of the hotel's energy consumption.

The work carried out in the definition of the CHP application at hotel has been as follows:

- Establish contact with the Tourism sector and find a Hotel chain interested in the development of the H2 market.
- Site selection and analysis of consumption data
- Definition of process conditions
- Definition of the P&ID process and equipment implantation

3. Description of work

3.1. Fuel Cell installation at the hotel in Palma

3.1.1. Site selection

The IBEROSTAR, one of the most important hotel company in Europe, is committed to the protection of the environment and cultural heritage and promotes the social and economic well-being of destinations where IBEROSTAR hotels are.

In this sense, and after the presentation of the proposal of the GREEN HYSLAND project (June of 2021), REDEXIS and IBEROSTAR immediately contacted each other for the installation of the CHP in a hotel of that company.

IBEROSTAR has several hotels on the island of Mallorca but unfortunately only one has the necessary access for the H2 tube trailers.

In addition to a direct access to main roads to receive the hydrogen supply, other aspects must be considered for the selection of the site:

- Sufficient space required for the location of the facilities and the unloading area.
- No interferences with the H2 unload process.
- Electric service and boiler collector line close to the area where the cell is located.
- Energy consumption (electricity and heat).

The chosen hotel for the installation of the CHP system has been IBEROSTAR BAHIA and it will be placed in the hotel service and suppliers parking slot, due to the space requirements for carrying out the process of hydrogen dispatching the tube trailer and installing the hydrogen storage. Being this equipment the ones that require the most space within the facility.

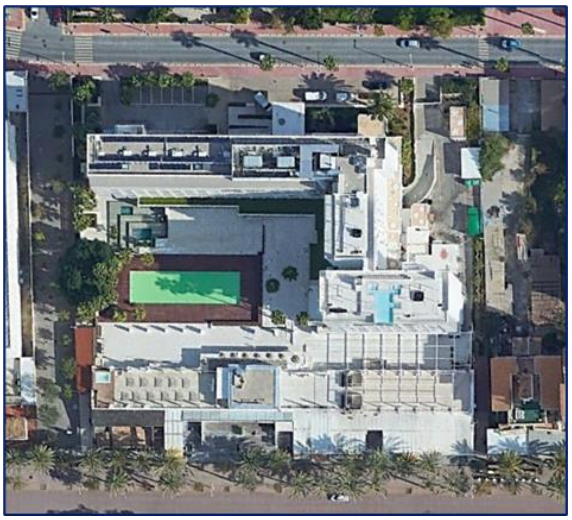

Figure 1: Overview the Iberostar Bahía de Palma hotel

Subsequent to the final site selection, a site visit was undertaken by REDEXIS personnel and an external consulting engineering company (August of 2021) to ensure the site is the right size and services needed. Based on this, the Hotel´s facilities manager provided an official plan of the and a layout drawing was prepared for the site (see Appendix 5).

Figure 2: Hotel service parking slot. Tube trailer and FC facilities shown

3.1.2. Installation and process description

As part of GREEN HYSLAND project, a 50 kWe fuel cell system must be installed at one hotel with a consumption of 20 tons per year of Hydrogen. The fuel cell will be integrated into the hotel facilities, providing electricity and heat to the hotel and demonstrating the technical and economic viability of Fuel cells for this type of tourist sites.

Economic viability, regardless of the price of H2, is only achieved with the extension of the Fuel cell life and this is only achieved by reducing the degradation of its components. If the fuel cell system operates in a constant range below the nominal power, it does not operate in extreme conditions and the components life will be increased.

For this reason, it has been decided to install a 70 kWe fuel cell that will be operated at a normal power of 50 kWe, achieve the task of the project. The installation can reach peaks of 70 kWe if the electrical installation of the hotel requires it. With the installation of a 70 kWe fuel cell, an increase in consumption of H2 is estimated, reaching more than 25 tons per year.

The fuel cell system requires the following elements

- A tube trailer parking area
- A tube trailer connection point

- High pressure storage
- Pressure regulation system
- A 70 kWe fuel cell
- Fuel cell cooling system
- PLC Control system
- Electrical installation to supply power to the Hotel in Palma
- Heating piping to the Hotel in Palma
- Internal plumbing within the Hotel in Palma
- Radiators to be installed in the Hotel in Palma

The site layout in drawing ABG11890-C-05-EN (see Appendix 5) shows an entrance to the site close to Carrer de Marbella, a one-way path to the unloading bay. Behind the supplier's entrance, there is a parking area for the tube trailers, high pressure hydrogen storage system and the fuel cell facilities.

HYDROGEN SUPPLY

The hydrogen will be supplied in a tube trailer, featuring indicative dimensions of 13,8 m x 2,44 m. The tube trailer will have a transport capacity of 462 kg of H2 (@15 °C) at 300 bar. The supply will be scheduled depending on the consumption needs of this fuel cell and the rest of end-users defined in GREEN HYSLAND Project. A daily supply has been estimated every 24 hours for actual data of consumption and storage conditions, although it is to define the H2 supply logistic.

HYDROGEN STORAGE

The receiving and storage facility will consist of a hydrogen storage cylinder rack integrated in a 20-foot iso-container. The refilling operation of the cylinders will be carried out using an unloading pannel connected to the hydrogen tube trailer. A trucking area will be delimited for the tube trailer unloading process. The frequency and quantity of the hydrogen supply will be adjusted to the operating electrical and thermal conditions of the hotel, and to the logistics of the supplier.

The hydrogen storage unit will be designed using a cascade system with high and medium operating pressure. According to the preliminary engineering design, each stage of the cascade storage system will have a capacity of 75 kg, 150 kg of hydrogen storage in total. The discharge of H2 will be carried out by differential pressure until an equilibrium pressure (defined in a range of 200-250 bar maximum) is reached.

The hydrogen storage system will be located close to the fuel cell stack in the suppliers parking area of the hotel as shown on the layout scheme in the annex.

A regulation stage will be implemented before the hydrogen is supplied to the cell in order to adequate the pressure of the storage to the fuel cell system pressure ranges. The expansion process will have a cooling stage if required, to control the hydrogen temperature within the operation ranges.

HYDROGEN FUEL CELL

The energy will be produced in a hydrogen fuel cell unit. The system will be dimensioned to produce a peak power of 70 kWe and an operating power of 50 kWe by using hydrogen and oxygen from the air as fuel, generating hot water (around 60 °C). This power will be supplied to the hotel's electrical network. In addition, the heat generated in the reaction, will be used for injection into the collector of the domestic hot water production boiler of the hotel.

The process will be controlled by a PLC (connected to the hydrogen production plant managed by ENAGAS) integrated with the fuel cell system and will be provide with the required atmosphere vents located preferably on the surface of the roof. Hydrogen and fire detectors will be installed too for security reasons.

The fuel cell module hydrogen system is comprised of hydrogen shut-off, hydrogen pressure regulation, and hydrogen recirculation equipment. A purge valve used to remove impurities is also included. The purge valve outlet is connected to the process air exhaust, and the purge gas is diluted to a safe concentration when mixed with exhaust air. If the internal module hydrogen circuit is over-pressurized, a mechanical pressure relief valve (PRV) will safely relieve the pressure.

The air delivery system will include an air compressor and motor. During the start-up of the fuel cell, the compressor will require electrical input. After that, the system will automatically supply the necessary air to the fuel cell module during operation being powered directly by the fuel cell stack. To prevent particle and chemical contamination to the fuel cell stack, an air filter before the compressor will be installed.

The air exhaust stream will contain oxygen-depleted air, water in liquid and vapor form, and a small amount of hydrogen.

HEAT INTEGRATION SYSTEM

The heat integration system is proposed, as a "boost" of calorific contribution to the domestic hot water facilities of the hotel reducing the dependence of the boiler system of the installation.

The main equipment will be an exchanger that will provide the heat transported by the coolant circuit of the fuel cell to the domestic hot water circuit from the hotel's generation facility. This exchanger will be located next to the cogeneration module and will be connected by a 2" PVC pipe with the primary accumulator of the hotel's domestic hot water installation. The pipe will have a thermal insulation of glass wool with a external aluminium reinforcement to avoid heat losses in the circuit.

The exchanger will be designed for a maximum heat input of 105 kW, using 50% water and ethylene glycol with a temperature range of 75 °C at the inlet and 60 °C at the outlet.

See Appendix 3 and 4 for drawings.

3.1.3. Main equipment and specification

DISCHARGE PANEL

The discharge panel will connect the tube trailer supply to the hydrogen storage and the fuel cell stack, supplying both systems during the storage refill and allowing a continuous operation of the cell. The temperature and pressure will be monitored through the discharge process. The discharge panel will include the required safety instrumentation to ensure mechanical integrity.

HYDROGEN STORAGE UNIT

The hydrogen storage unit will consist of a modular rack of interconnected bottles at 300 bar. A discharge panel will allow the refill of the bottle from the tube trailer. This panel will control the temperature and pressure during the process.

PRESSURE REGULATOR SKID

The pressure regulator will reduce the pressure from the storage to adjust it to the pressure range of the fuel cell. From a maximum design pressure of 300 bar to 15 bar. The system will have a multi-stage configuration with intercooling to maintain the temperature of the hydrogen in the operational range.

VENT SYSTEM

Hydrogen is a colourless, non-toxic gas that does not generate any danger to the environment. Its characteristics indicate that it is a product that does not damage the ozone layer and does not contribute to the greenhouse effect. Although it does not generate any risk for the environment, it is necessary to consider the dangerous zone that it generates when it is expelled.

All hydrogen equipment contents a hydrogen vent system to relief to atmosphere the excess pressure of a deviation design or for purging a system. Outlets are vertical upwards redirected to the surface of the container.

HYDROGEN FUEL CELL

The hydrogen fuel cell will be installed in a compact rack containing the regulation, control and refrigeration system on it.

The selected technology for the cell will be a liquid cooled PEM (Proton Exchange Membrane) with a Net System Power of 70 kWe, working at 7-10 bar and 70°C and consuming around 1.3 g/s of hydrogen at steady state operation.

BASIC DATA SHEET	
FCH	Liquid cooled PEM (Proton Exchange Membrane)
Net system power	70 kWe
Operating system voltage	250 – 500 V
Operating system current	20 – 240 A
Fuel flow rate	Max: 1,5 g/s Continuous: 1,3 g/s
Inlet pressure	7 – 10 bar
Approximate dimensions (L x W x H)	1800 x 900 x 400 mm

Table 1: Fuel cell basic date sheet

ELECTRICAL AND COMMUNICATION SYSTEM:

The electrical system will consist of two circuits:

- The low voltage circuit of 24 V will power the fuel cell auxiliar systems and control PLC. This power will be supplied by the hotel facilities.
- The high voltage circuit will transfer the electrical power generated by the fuel cell to the general circuit of the Hotel for use in its facilities. The electrical current will be converted from DC to AC current using a power inverter. This circuit will be connected to the Hotel's electrical connection point.

The Fuel Cell PLC control system will be connected by internet to the hydrogen production plant managed by ENAGAS.

HEAT INTEGRATION SYSTEM

The heat exchange circuit will be dimensioned to heat the water in the primary boiler with a maximum heat flow of 105 kW provided by the cell stack.

The unit will heat a flow of water (to be determined) to a temperature of 55-60 ºC. The coolant fluid, coming from the cell cooling system, will be Ethylene Glycol in a ratio of 50 - 50% with deionized water.

An auxiliary air-cooling system will check that the ethylene glycol temperature does not exceed 60 ºC before entering the cell again ensuring correct cooling of it in case the heat is not being used by the boiler collector.

See Appendix 3 and 4 for drawings.

4. Conclusions

Iberostar Bahía de Palma Hotel has been selected to install the Hydrogen Fuel Cell on its parcel. The annex parking to the hotel used for suppliers and hotel staff has enough area for the necessary equipment and it is close to the hotel boilers collector which is highly recommended to integrate the heat system with the lowest heat loss. The critical stage is hydrogen transfer and the maneuvering of the tube trailer (approaching and parking into the slot). Due to site restrictions, there is no other available options for hydrogen discharge.

Summarizing, although the GREEN HYSLAND project contemplates the installation of a HFC of 50 kWe, a 70 kWe stack will be installed. The CHP system will provide electricity in addition to the heat generated by the cell (around 100 kW), increasing the efficiency of the system, with a hydrogen consumption of 20 tons per year.

Currently, REDEXIS is preparing the detailed engineering and the technical specifications of the facility and each equipment to proceed with the tender, processing, and construction of the facility.

Appendix

No.	Document	Description	Rev.
1	ABG11890-C-01-EN	Location map	0
2	ABG11890-C-02-EN	PFD System layout	0
3	ABG11890-C-03-EN	P&ID Hydrogen storage system	0
4	ABG11890-C-04-EN	P&ID Hydrogen fuel cell	0
5	ABG11890-C-05-EN	Layout scheme Iberostar Bahia	0

								FIRMA	FECHA
							REALIZADO		SEP-21
							COMPROBADO		SEP-21
0	SEP-21	PARA INFORMACIÓN Y/O COMENTARIOS					APROBADO		SEP-21
REV.	*FECHA*	*DESCRIPCION*	*REALIZ.*	*COMP.*	*APROB.*	*Gª. Cª.*	G. DE CALIDAD		SEP-21

SEGULA TECHNOLOGIES

PROYECTO: 25070

ESCALA (S): S/E

SITUATION MAP

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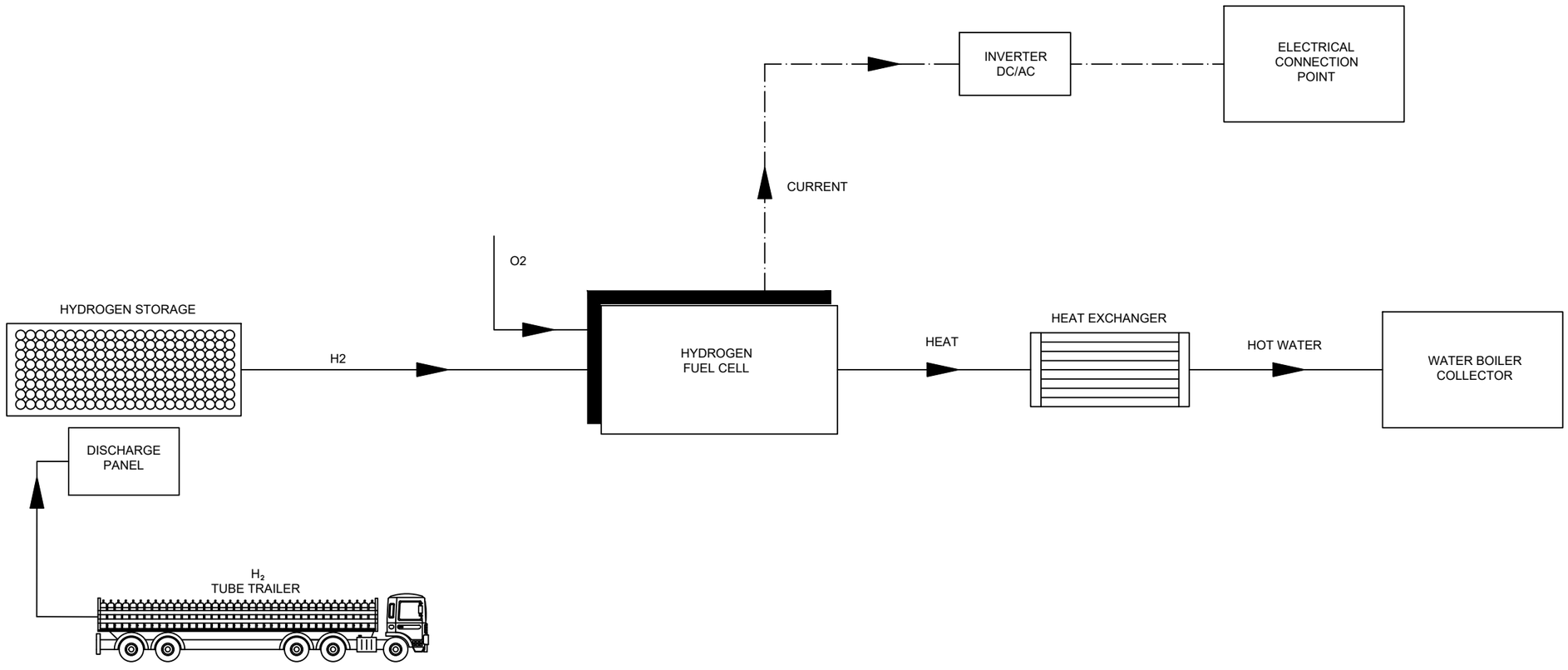
GREEN HYSLAND PROJECT:
CHP APPLICANTION AT HOTEL IN PALMA

ANEXO	ESP.	PLANO Nº	REV.
		ABG11890-C-01-EN 1 / 1	0

CHP APPLICATION AT HOTEL IN PALMA



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COMPROBADO		SEP-21
APROBADO		SEP-21
G. DE CALIDAD		SEP-21

SEGULA TECHNOLOGIES

PROYECTO:

ESCALA (S): S/E

PFD SYSTEM LAYOUT

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GREEN HYSLAND PROJECT:
CHP APPLICANTION AT HOTEL IN PALMA

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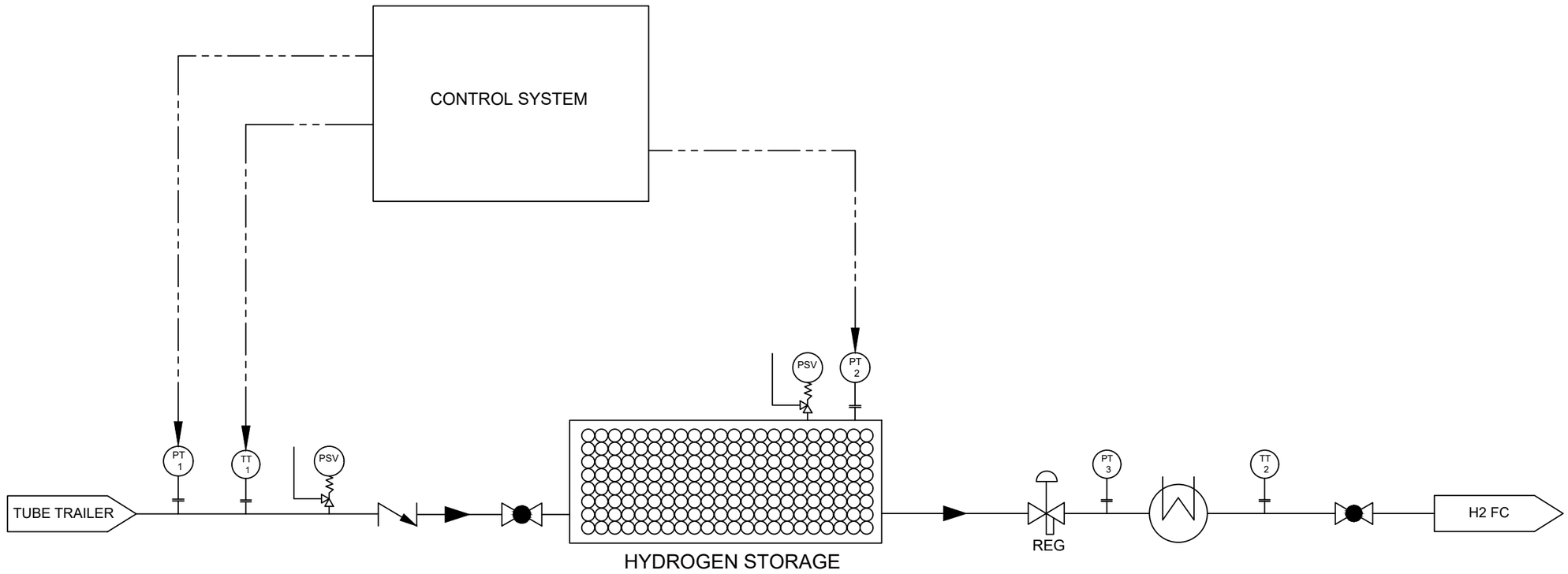

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APROBADO		SEP-21
G. DE CALIDAD		SEP-21

SEGULA TECHNOLOGIES

PROYECTO:

ESCALA (S): S/E

P&I HYDROGEN STORAGE SYSTEM

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GREEN HYSLAND PROJECT:
CHP APPLICANTION AT HOTEL IN PALMA

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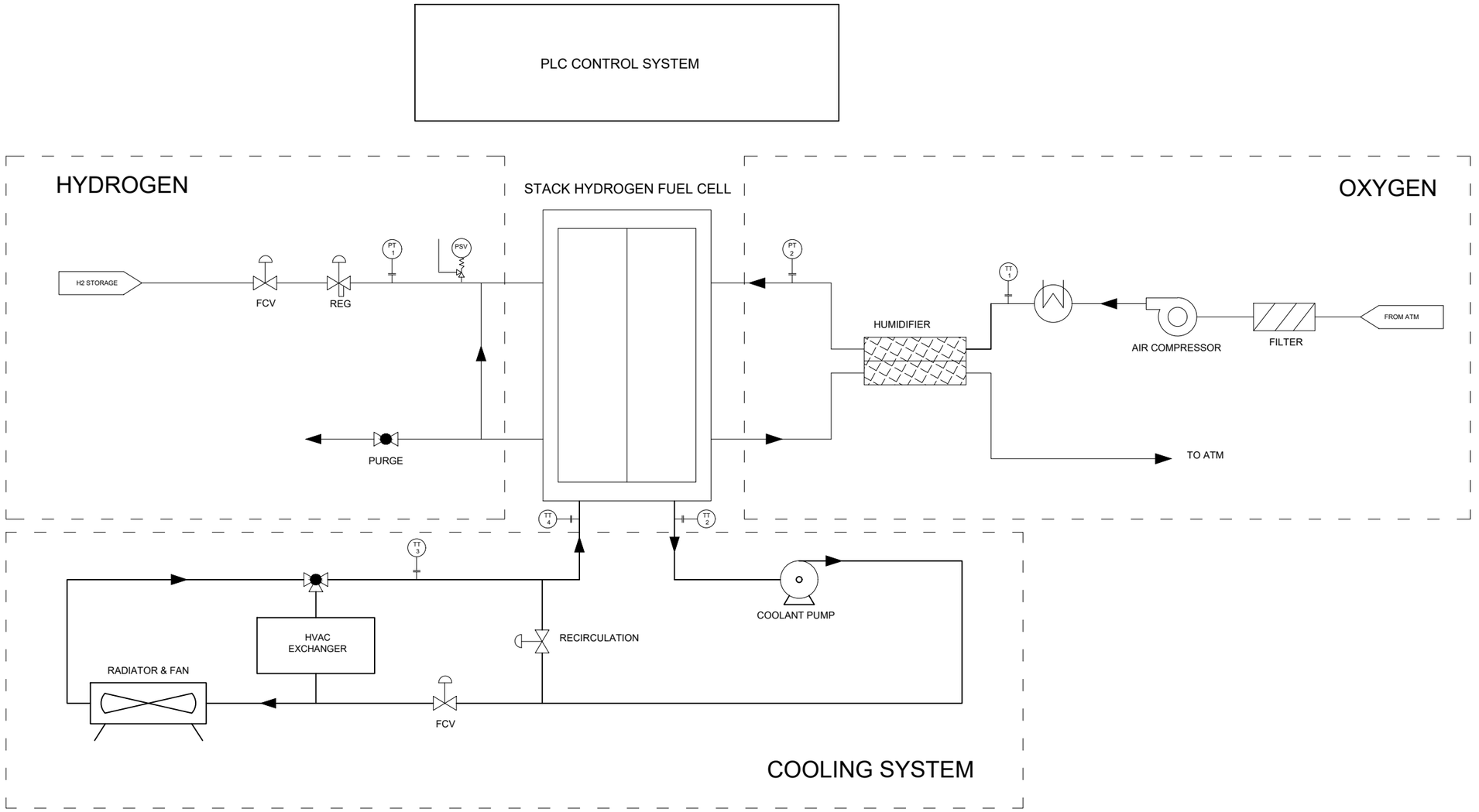

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GREEN HYSLAND PROJECT:
CHP APPLICANTION AT HOTEL IN PALMA

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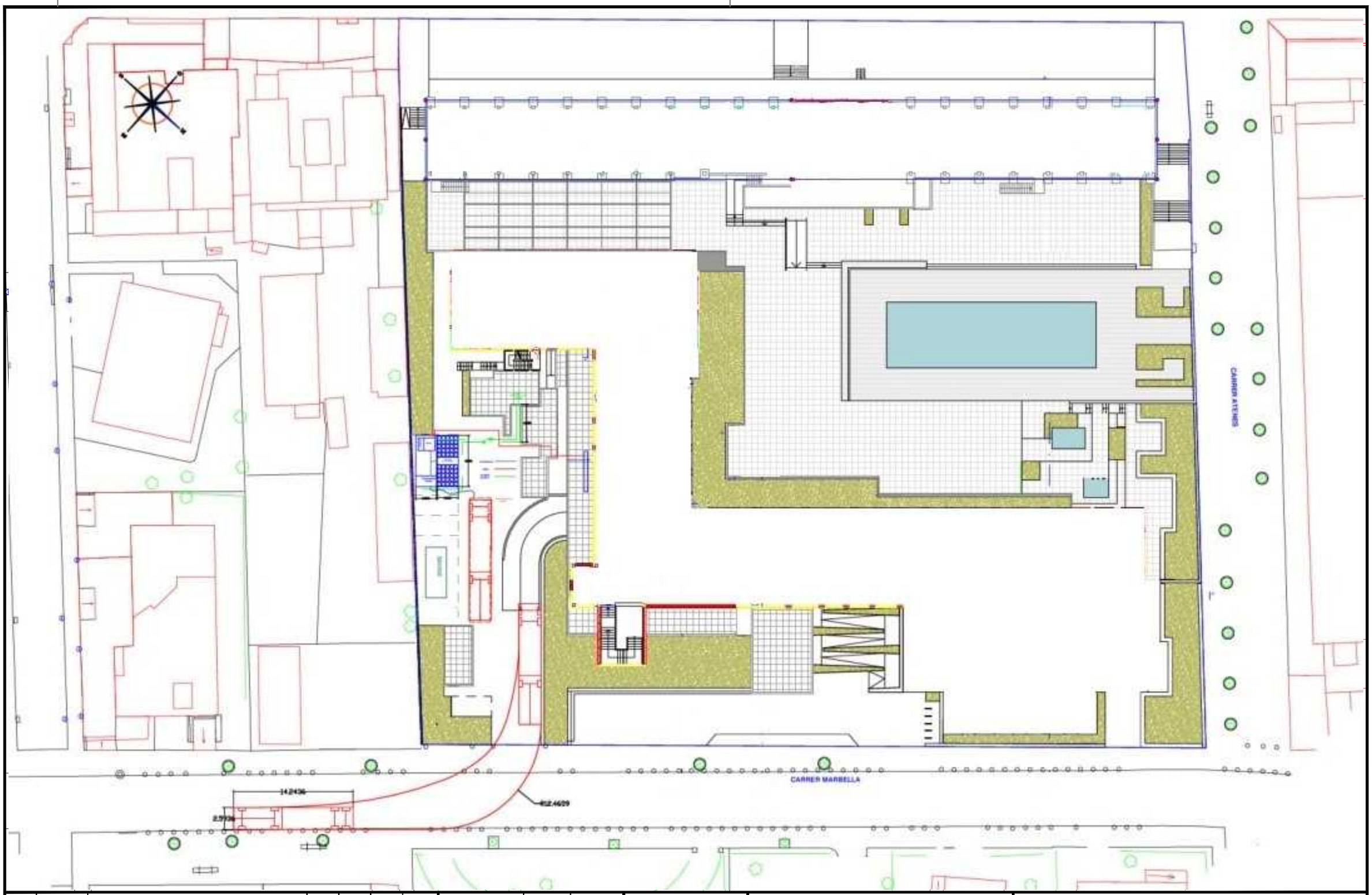

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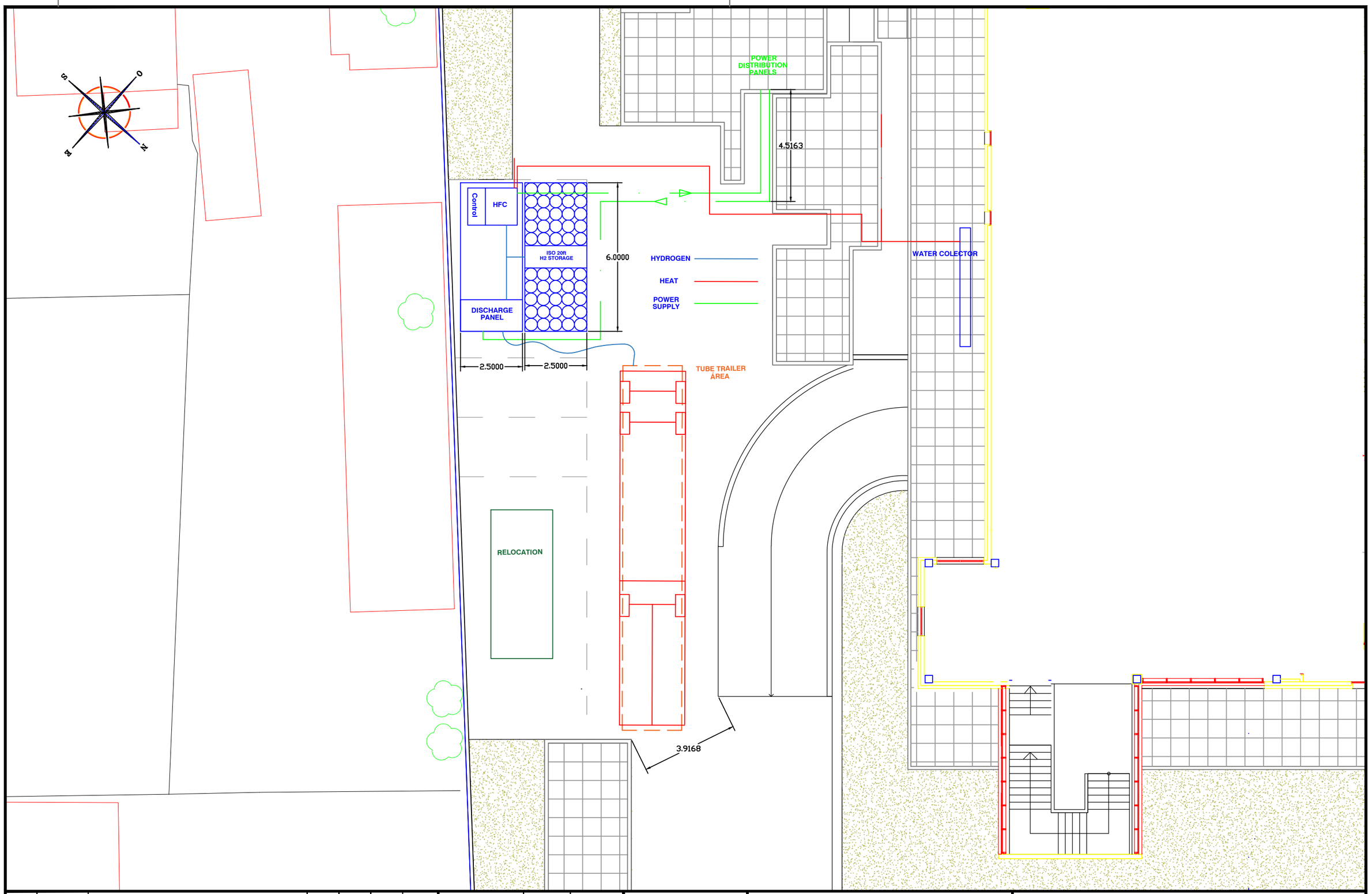
GREEN HYSLAND PROJECT:
CHP APPLICANTION AT HOTEL IN PALMA

ANEXO	ESP.	PLANO Nº	REV.
		ABG11890-C-05-EN 1 / 2	0



								FIRMA	FECHA
							REALIZADO		SEP-21
							COMPROBADO		SEP-21
0	SEP-21	PARA INFORMACIÓN Y/O COMENTARIOS					APROBADO		SEP-21
REV.	*FECHA*	*DESCRIPCION*	*REALIZ.*	*COMP.*	*APROB.*	*Gª. Cª.*	G. DE CALIDAD		SEP-21

SEGULA TECHNOLOGIES

PROYECTO: 25070

ESCALA (S): S/E

LAYOUT SCHEME
IBEROSTAR BAHIA

Redexis

GREEN HYSLAND PROJECT:
CHP APPLICANTION AT HOTEL IN PALMA

ANEXO	ESP.	PLANO Nº	REV.
		ABG11890-C-05-EN 2 / 2	0

GREEN HYSLAND

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Clean Hydrogen Partnership

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