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European Regional Development Fund

INTEGRATION OF COMBINED COOLING, HEATING AND POWER MICROGRIDS IN ZERO-ENERGY PUBLIC BUILDINGS UNDER HIGH POWER QUALITY AND CONTINUITY REQUIREMENTS

IMPROVEMENT Spanish Pilot Plant

28th-29th November 2022

Centro Nacional del Hidrógeno
UCLM Universidad de Castilla-La Mancha
ISAE ENSMA
TÉCNICO LISBOA
LNEG
Junta de Andalucía
Universidad de Córdoba
Junta de Andalucía Consejería de la Presidencia, Administración Pública e Interior Consejería de Hacienda y Financiación Europea Agencia Andaluza de la Energía
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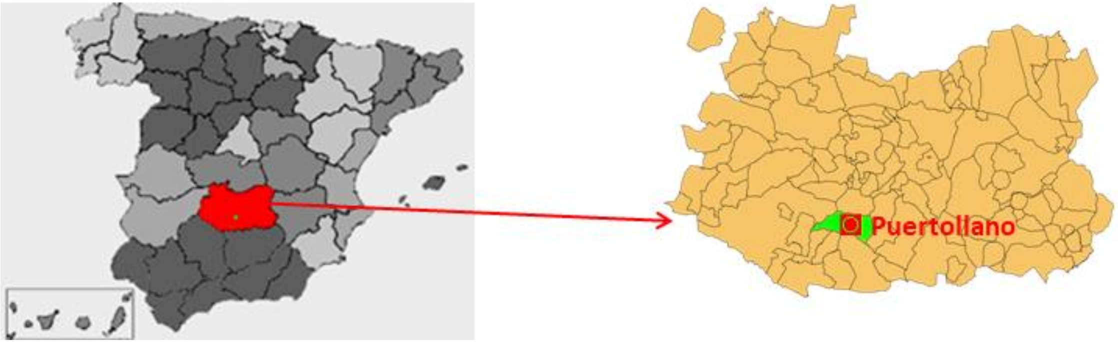
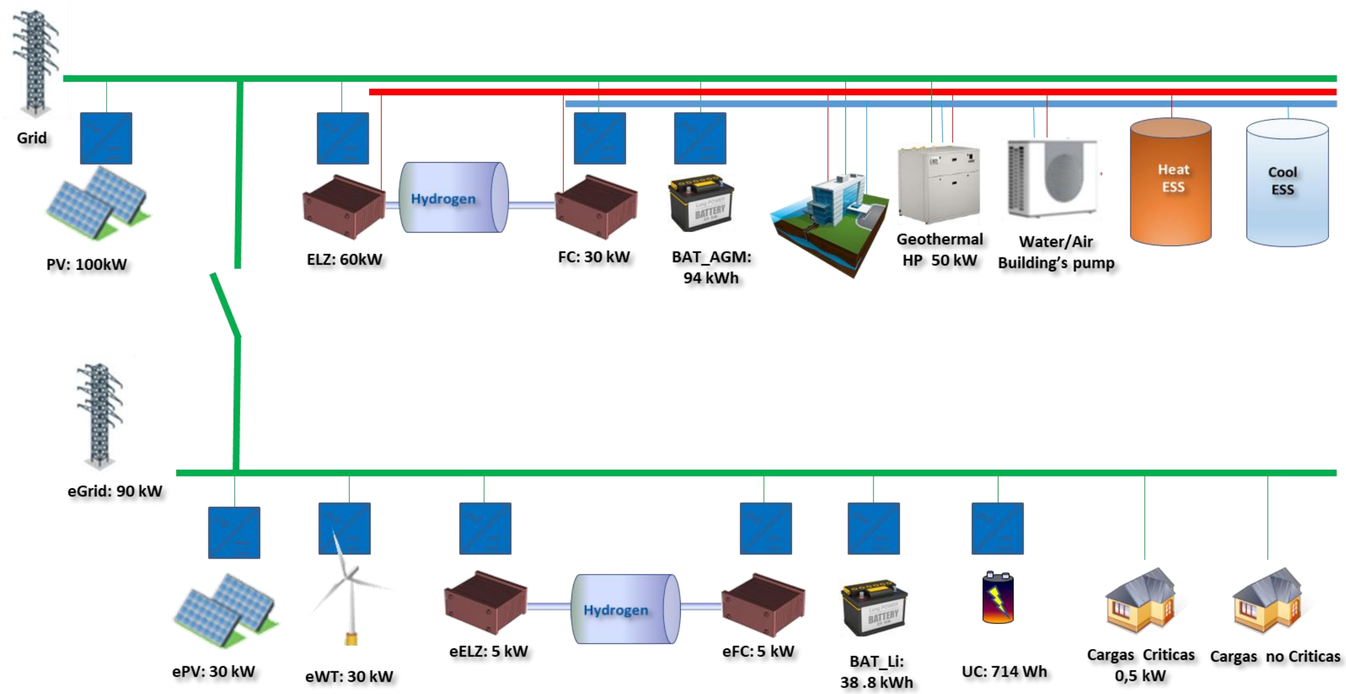
Planta Piloto Española



Centro Nacional del Hidrógeno

Planta Piloto Española



1. Microrred Eléctrica

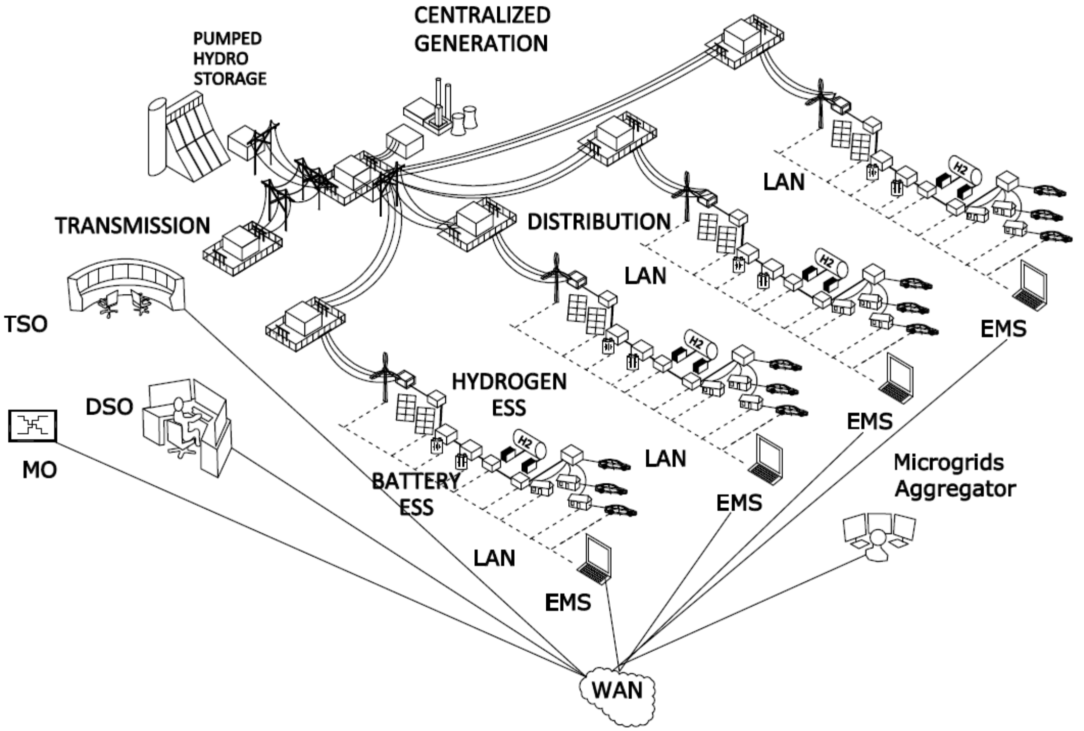
Objetivos Específicos

- Desarrollo de un sistema de **control de potencia resistente a fallos** para microrredes bajo criterios de diseño de alta calidad y continuidad de suministro

- Desarrollo de un **sistema de gestión de energía** para **microrredes** de generación renovable con **sistema hibrido de almacenamiento de energía** bajo criterios de degradación mínima, máxima eficiencia y prioridad en el uso de energías renovables.

1. Microrred Eléctrica

- Resiliencia frente a fallos en la red eléctrica general
- Flexibilidad
- Optimización económica del precio de la energía
- Problemas de congestión en la red
- Calidad de suministro



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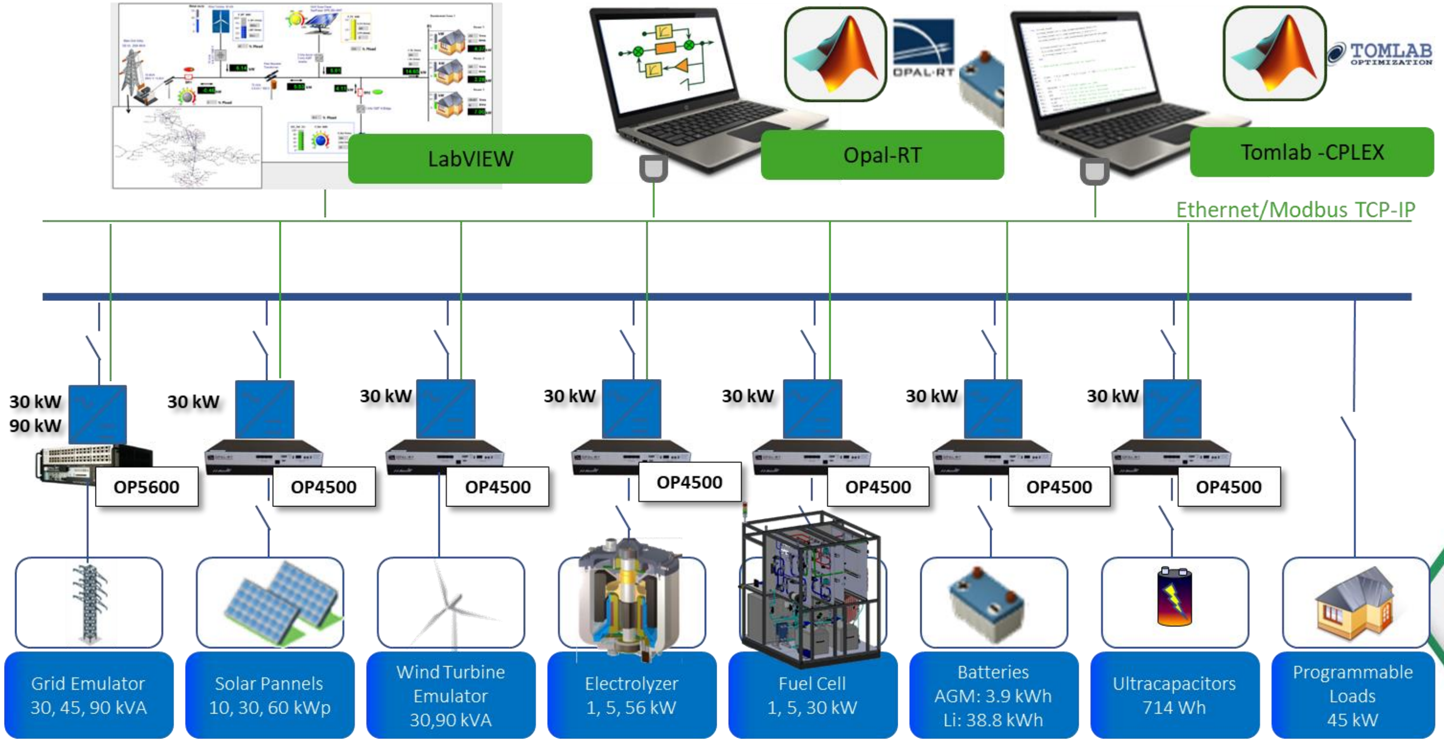

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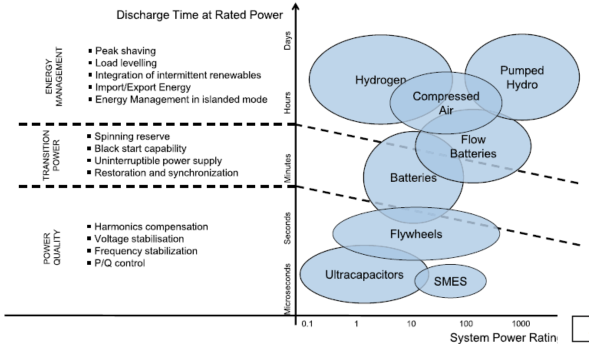
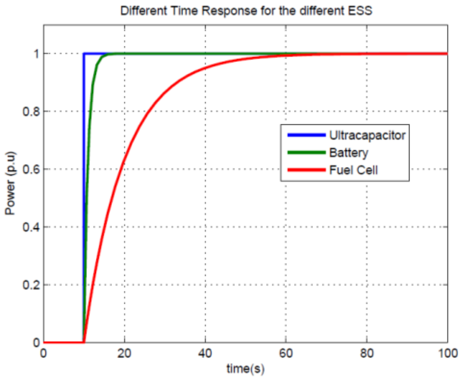
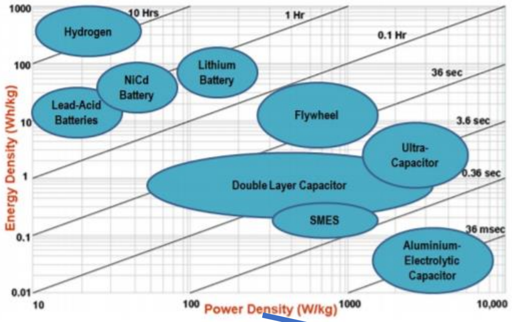
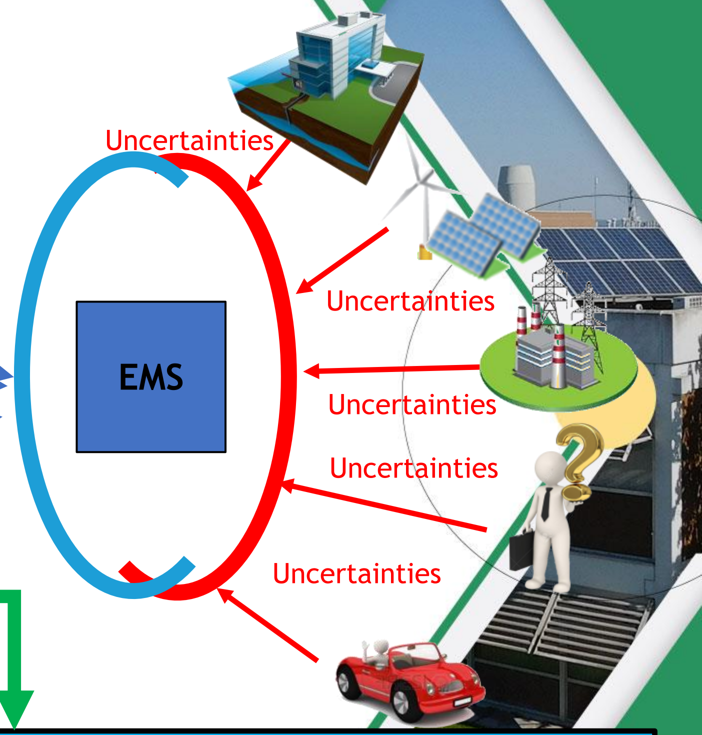






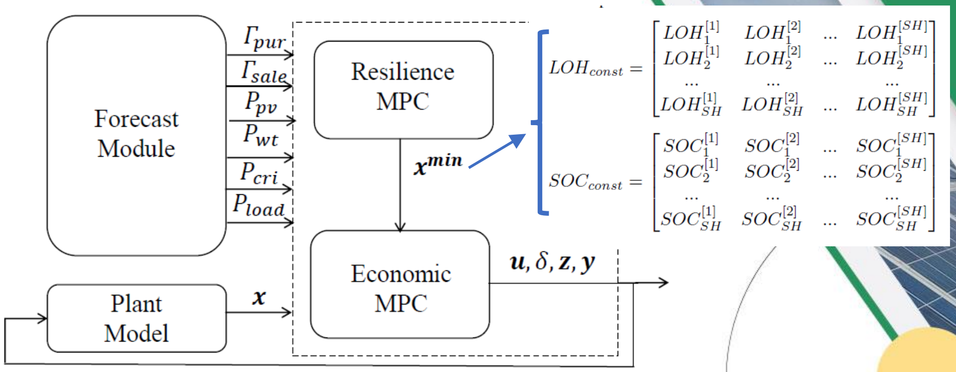
Energy Storage System	Degradation Issues
Ultracapacitors	Overcharge, Undercharge
Batteries **Lifetime:** Cycles	Overcharge, Undercharge High stress current ratio AC Current Ripple
Electrolyzer **Lifetime:** Hours	Fluctuations of current Start/Stop Cycles
Fuel Cell **Lifetime:** Hours	Fluctuations of current Start/Stop Cycles

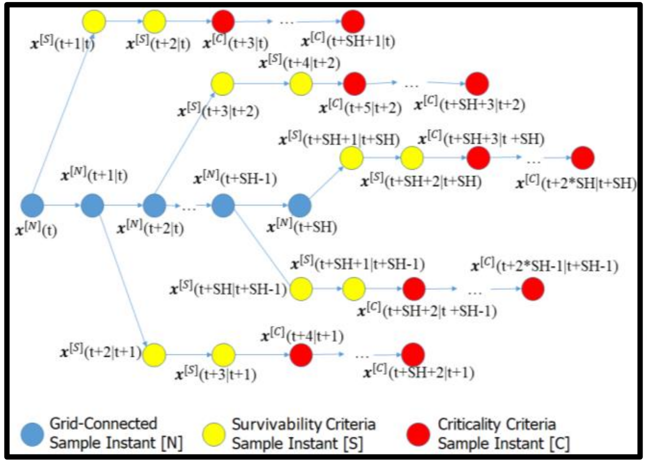


The use of storage systems is not free to meet service life costs. If the degradation criteria are not met, this useful life may be lower and detract from economic competitiveness. Battery-hydrogen degradation has complementary behavior

1. Microrred Eléctrica

- Criterio Económico
- Criterio de Resiliencia
  - Criterio de Supervivencia
  - Criterio de Criticidad
- Criterio de Energía Renovable
- Criterio de mínima degradación de los equipos





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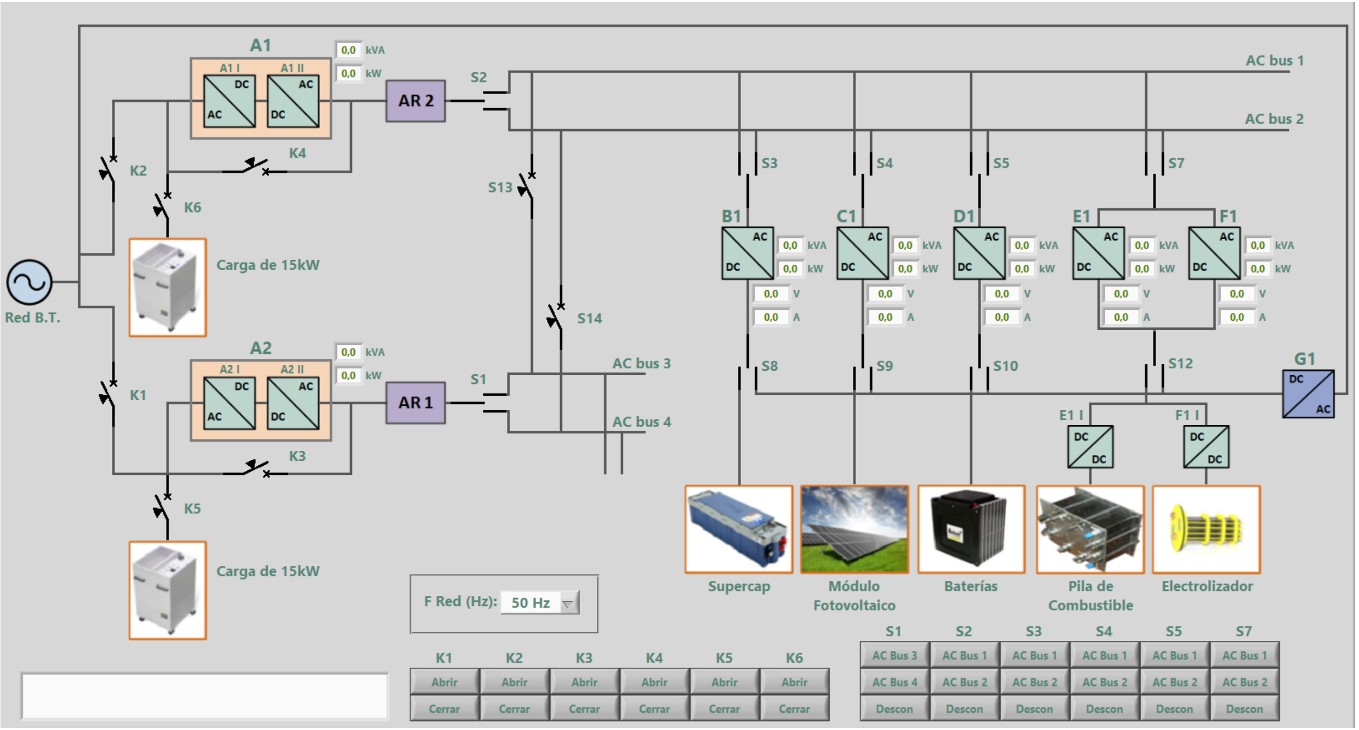
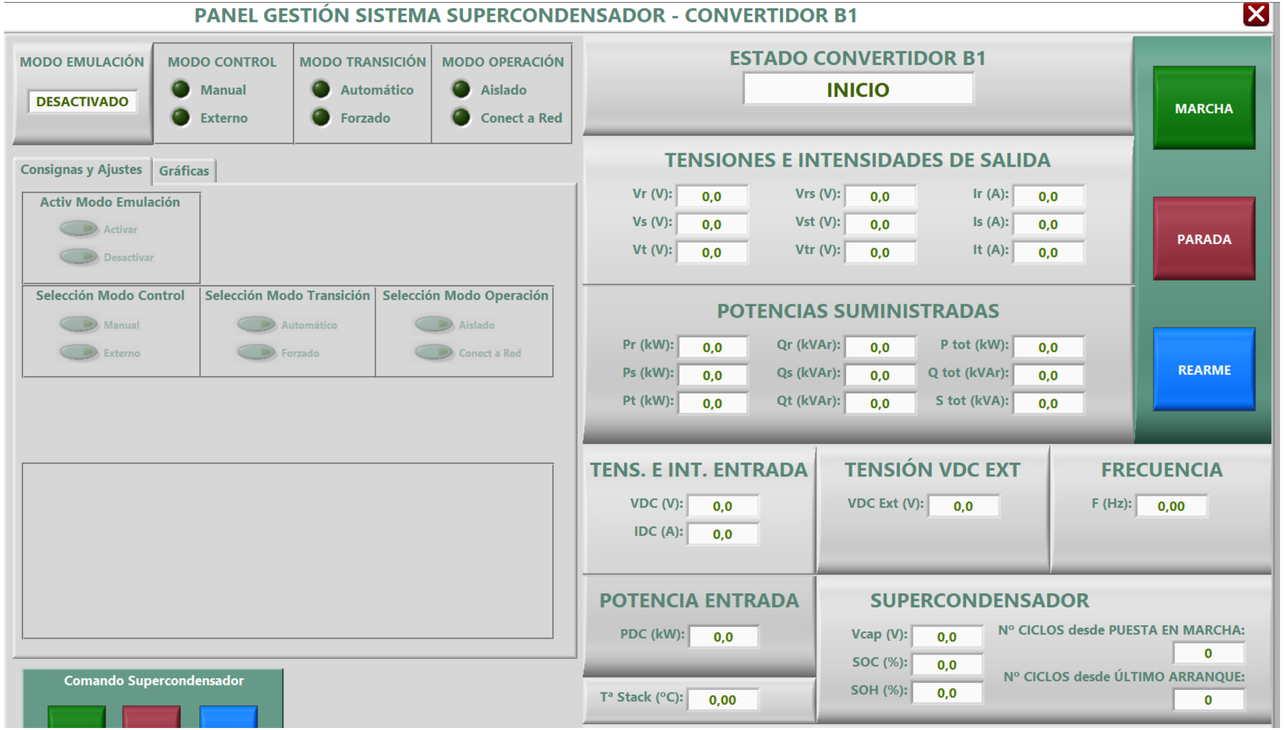
1. Microrred Eléctrica



1. Microrred Eléctrica



2. Thermal Recovery System (CNH2)

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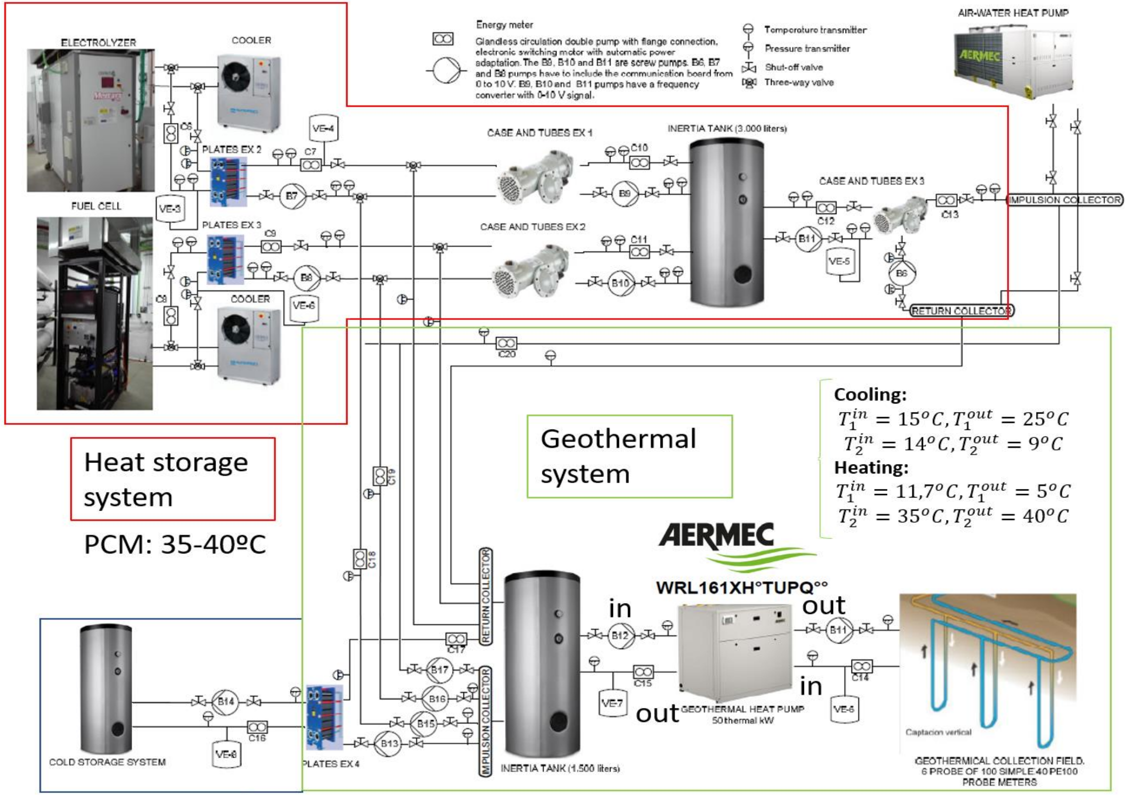
3 main parts:

- CESS
- HESS
- GRS

Capable of injecting recover heat to air conditioner system of the building

Reduce electrical consumption

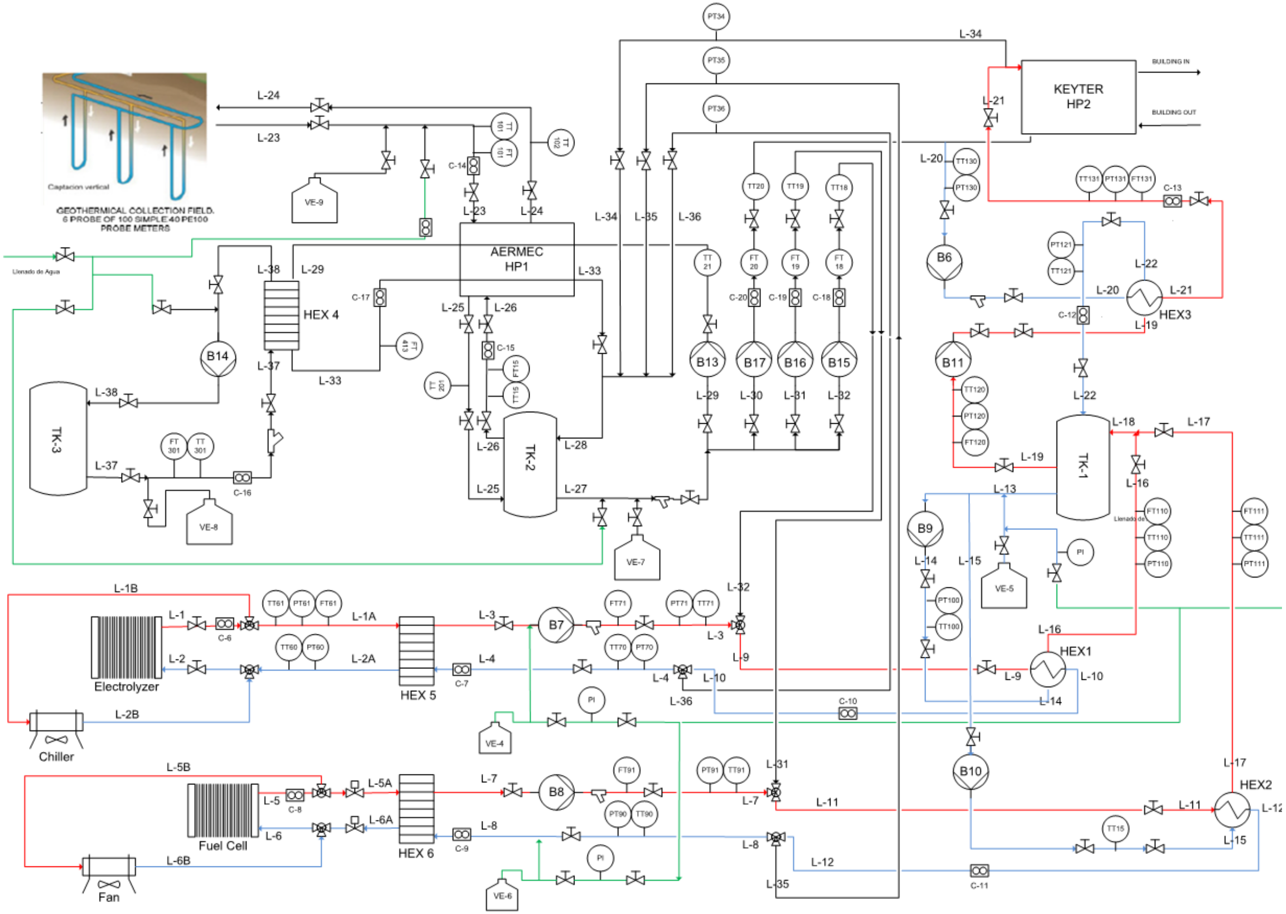


Cold storage system

PCM: 10-14ºC

2. Thermal Recovery System (CNH2)

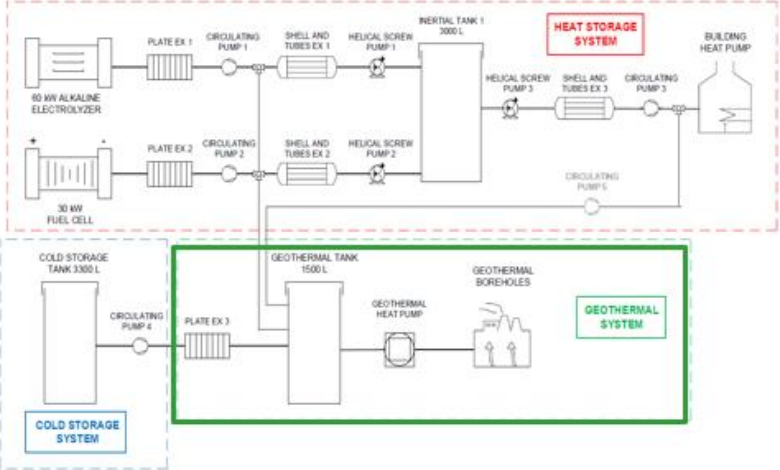
PID



2.1. Geothermal Recovery System (GRS)

GEOTHERMAL RECOVERY SYSTEM

- **OBJECTIVE:** Take advantage of the **heat / cool** from the subsoil to **reduce the building's energy consumption**
  - **6 U-shaped boreholes of 100 meters in deep** were carried out
  - Boreholes are connected to a **50 kW geothermal heat pump**
  - Downstream of the geothermal, is integrated a **1500 L inertial tank**
  - The **geothermal recovery system** is connected to:
    - **Heat storage system**
    - **General building air-conditioning pump**



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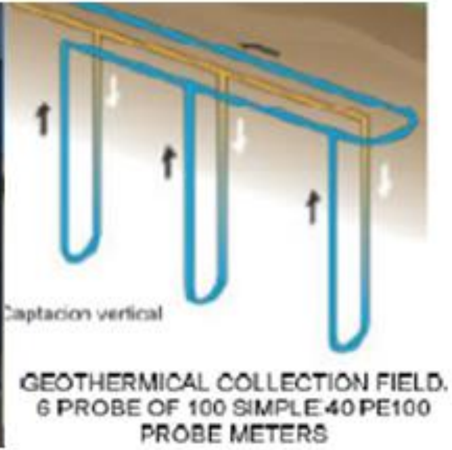
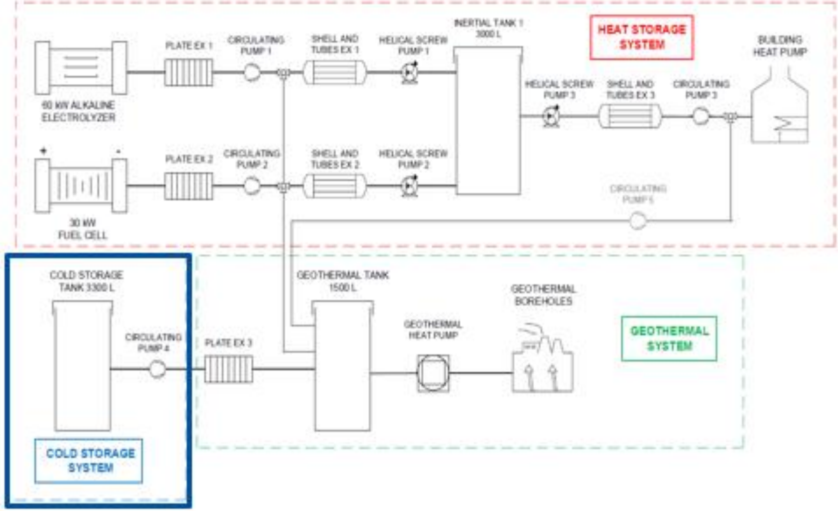


6 U boreholes of 100m in deep

2.2. Cold Energy Storage System (CESS)

COLD ENERGY STORAGE SYSTEM

- **OBJECTIVE: Storing** the **cool from the subsoil**
  - **100 kW macroencapsulated PCM** are placed inside **the 3300 L storage tank**
  - **PCM are immobile inside the tank**
  - **6 U-shaped boreholes of 100 meters in deep** were carried out
  - The **cold storage tank** is connected to:
    - **Geothermal inertia tank** through a plate heat exchanger



2.2. Cold Energy Storage System (CESS)

PCM of CESS (fix and inorganic)

2.3. Heat Energy Storage System (HESS)

HEAT STORAGE SYSTEM

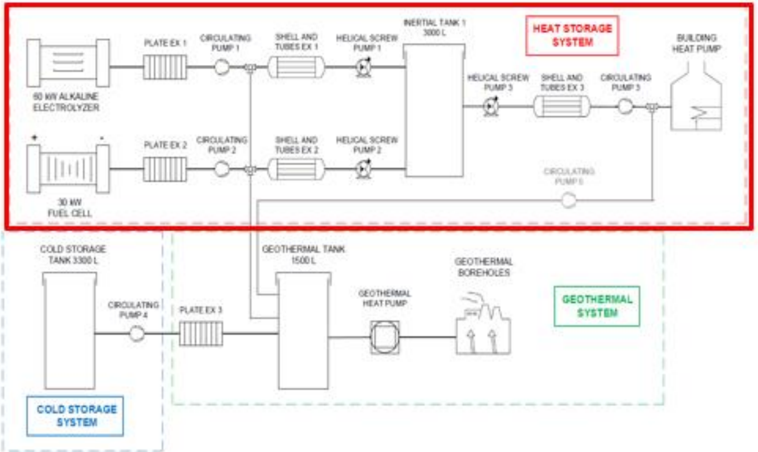
- **OBJECTIVE:** Take advantage of the **waste heat** generated from the **electrolyzer** and the **fuel cell** to **reduce the building's energy consumption**
  - **Waste heat** is recovered though different **heat exchangers**
  - The recovered heat is stored in **an inertial tank (3000 L)** which contains **100 kW slurry microencapsulated PCM**
  - The outlet of the inertial tank is injected in the general building air-conditioner

Alkaline electrolyzer

- Electric power: 60 kW
- Thermal power: 60 kW
- Operating temp: 60 – 75°C
- H_2 production: 10,66 Nm^3/h
- H_2 pressure: 10 bar

PEM Fuel Cell

- Electric power: 30 kW
- Thermal power: 30 kW
- H_2 consumption: ≤ 500 L/min
- Air consumption: ≤ 2500 L/min



2.3. Heat Energy Storage System (HESS)

Hydrogen Cycle

Heat

Alkaline Electrolyzer

H2 Storage Park (10 bar) and (200 bar)

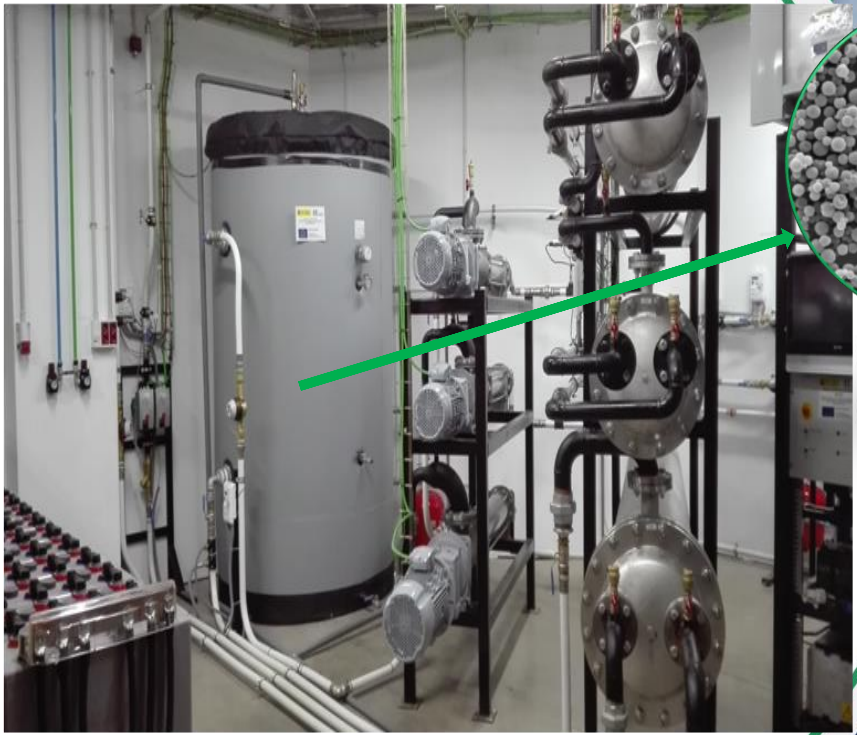
Heat

PEM FC

2.3. Heat Energy Storage System (HESS)

Generated Heat

Plates Exchangers



Shell/Tubes Exchanger Water + PCM Slurry Circuit

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2.3. Heat Energy Storage System (HESS)

Connection between GRS and HESS
through 4 motorized 3-way valves

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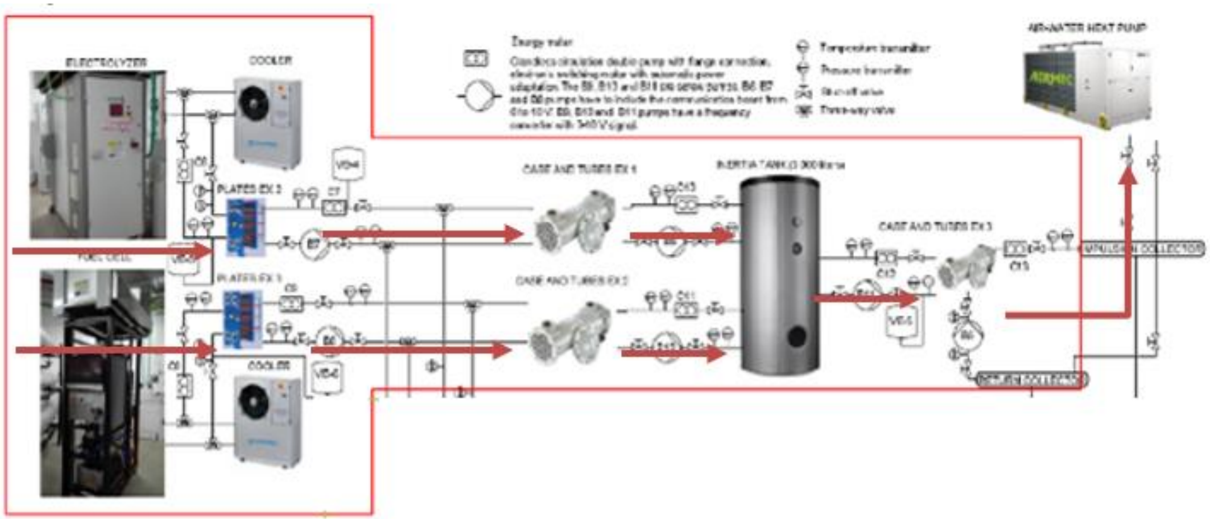
2.4.Operation Modes

Operation Modes

- WINTER MODE (HEATING)
  - 1.) Hydrogen + HESS + Injection (PLAN WINTER 22/23)
  - 2.) GRS + HESS + Injection (PLAN WINTER 22/23)
- SUMMER MODE (COOLING)
  - 3.) GRS + Injection (DONE)
  - 4.) GRS + CESS + Injection (DONE)

2.4.Operation Modes

Mode 1: Hydrogen + HESS + Injection



Heat storage system

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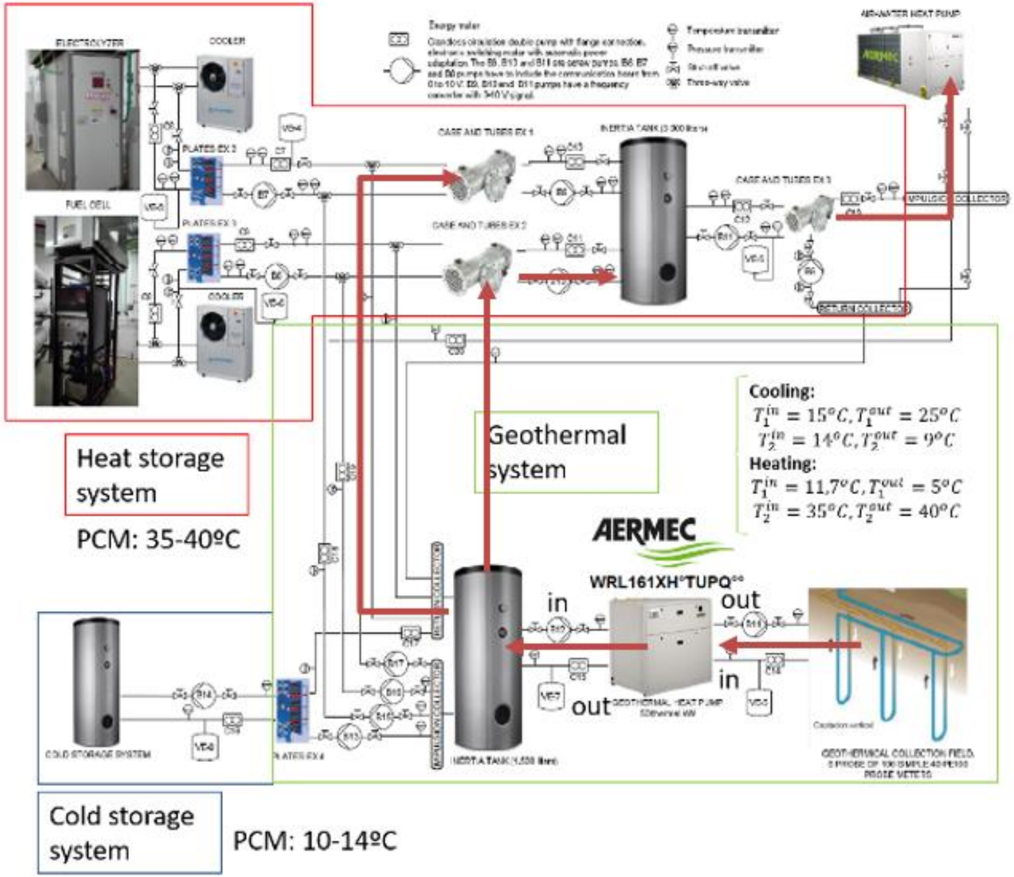
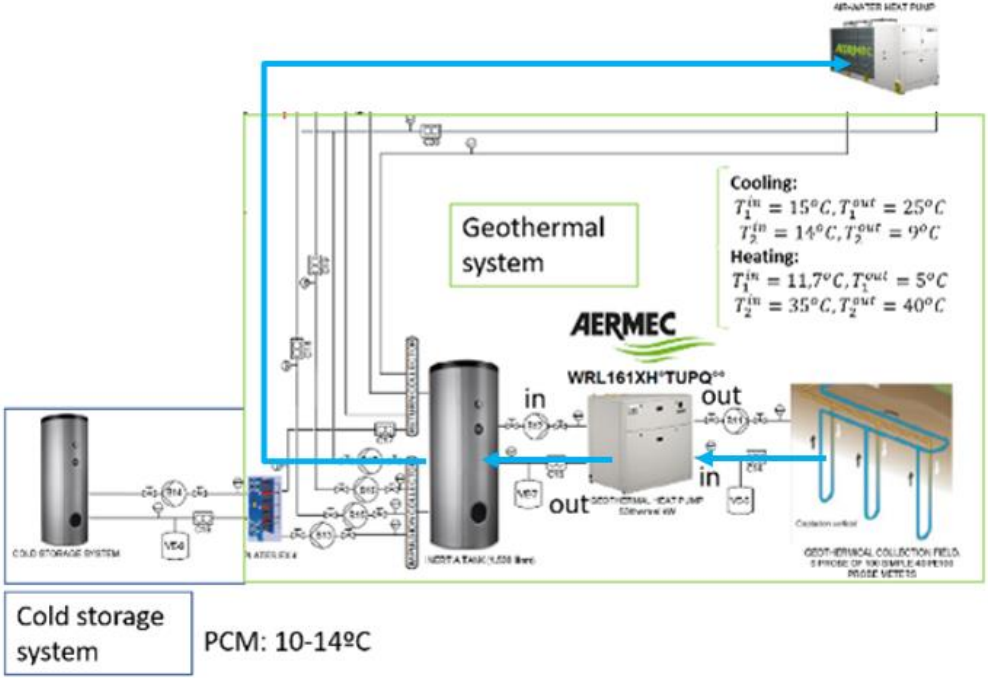
2.4.Operation Modes

Mode 2: GRS + HESS + Injection



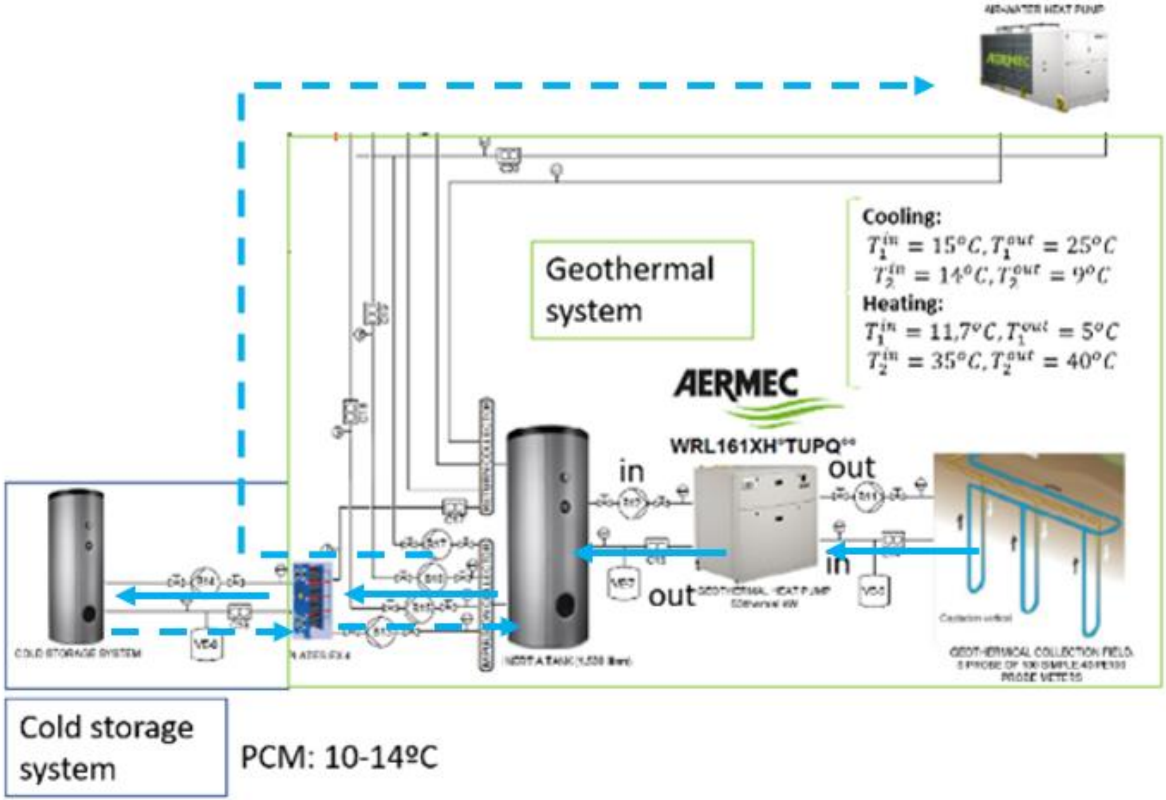
2.4.Operation Modes

Mode 3: GRS + Injection



2.4.Operation Modes

Mode 4: GRS + CESS + Injection



THANK YOU!

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