ENERGY EFFICIENCY AND RENEWABLES FOR HEATING AND COOLING HOSPITALS

SMART HEALTHCARE ENGINEERING

Intensive Summer Programme

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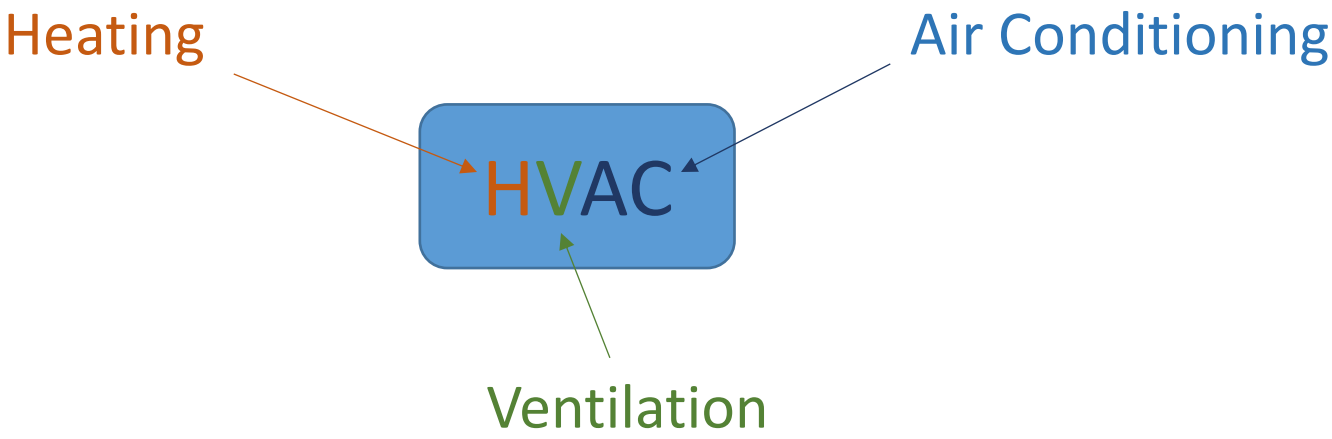
- HVAC systems in buildings
- Energy demand vs energy consumption
- What is energy efficiency?
- Renewable and residual energy use
- HVAC System Design
- Heat pumps and their performance
- Geothermal HVAC Systems
- Successful Case Studies

HVAC Systems

What are they?



What is their purpose?

- Systems designed to cover a building's heating and cooling *demands.*

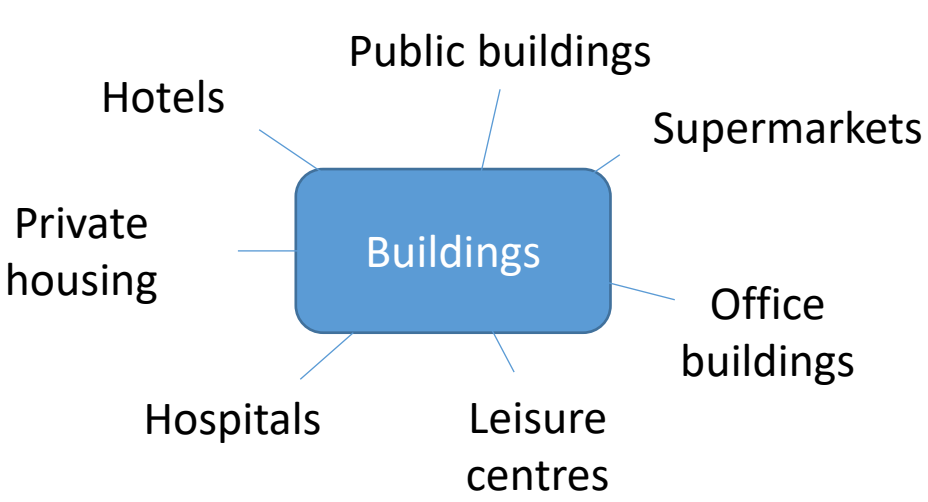
HVAC Systems

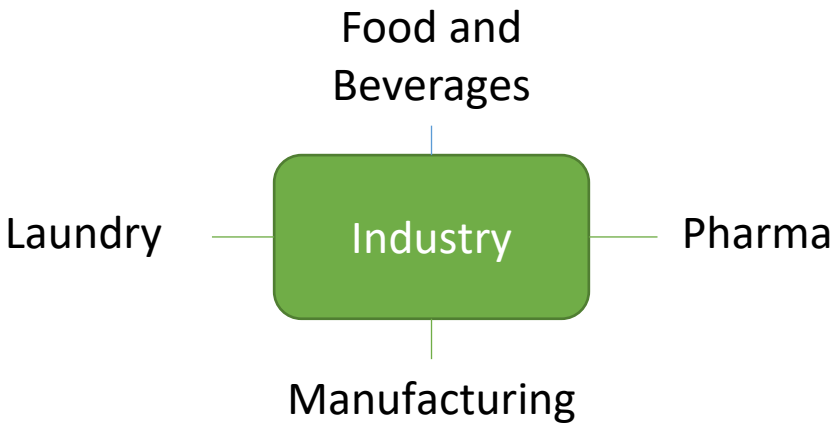
Why are they so important?

- Thermal **comfort** & patient **well-being** 🌡️
  - A stable indoor temperature supports recovery
  - Critical for vulnerable patients (infants, elderly, ICU)
- Support for **Medical Equipment** & Processes ⚙️
  - Many medical devices require precise temperature control
  - Thermal systems ensure hot water for disinfection
- Indoor **Air Quality** 🦠
  - Proper ventilation reduces airborne pathogen levels.

HVAC Systems

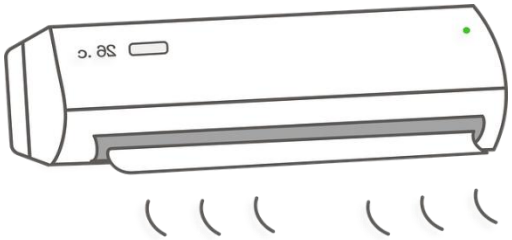
Where can we find them?

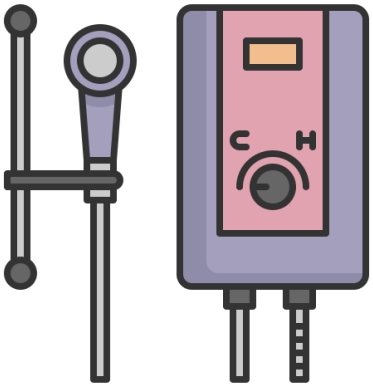


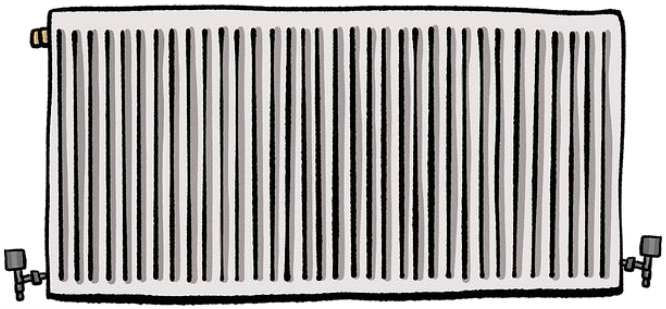


HVAC Systems in our environment

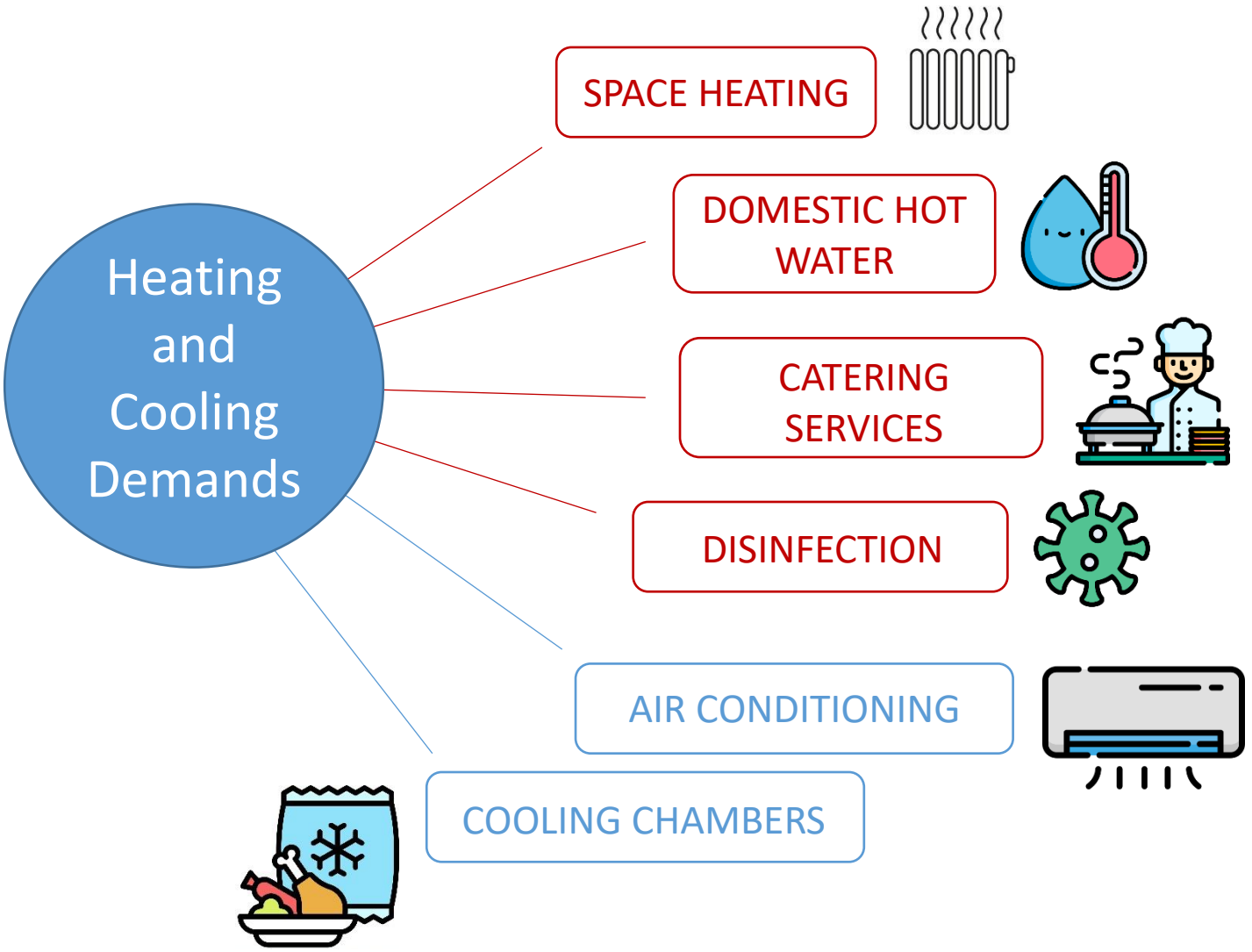
Examples of HVAC systems in our close environment







HVAC Systems in Hospitals



Energy Demand and Consumption

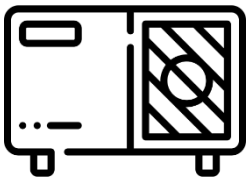
Energy **supplied** by the system to the facility

COMFORT

COOLING

HEATING

DEMAND



Energy **consumed** by the system

CONSUMPTION

ELECTRICITY

FOSSIL FUELS

RENEWABLE ENERGY

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HVAC Systems: **Main aims**

The main aim when designing HVAC systems is:

> To supply the building's heating and cooling demand with the **lowest possible energy consumption**

How is energy consumption reduced?

1. Increasing the building's **energy efficiency**
2. Introducing **renewable energy** and making use of **residual energy**

Energy Efficiency in HVAC Systems

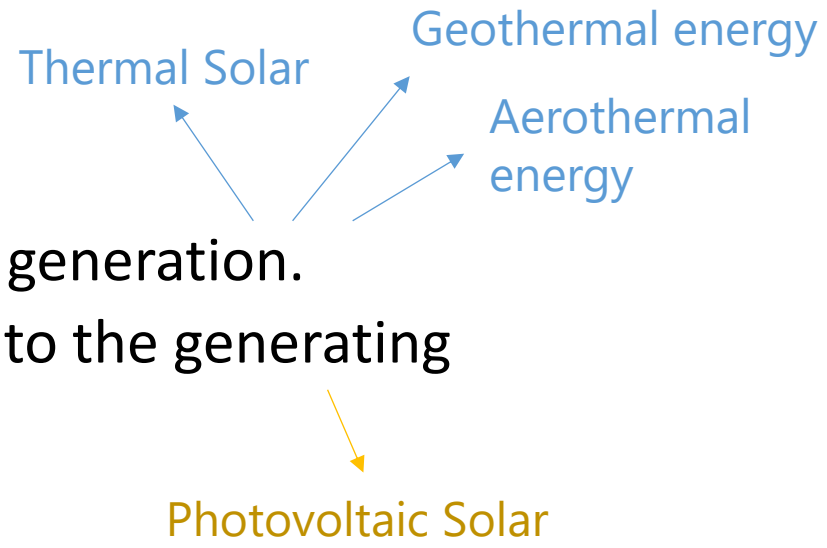
Energy Efficiency → Providing specific **performance** levels with **optimal energy consumption**

How is this achieved?

- *Design* – Demand minimization.
- *Construction* – Use high-quality equipment.
- *Maintenance* – Ensure the proper functioning of the system.
- *Monitoring* – Track the performance and development of the installation.

Renewable Energy in HVAC Systems

Once the energy efficiency of the generating equipment is maximized, **renewable energy** sources help reduce the final energy **consumption** of the installation.



How do they do it?

- By supporting thermal energy generation.
- By supplying electrical energy to the generating equipment.

Thermal energy generation technologies

Thermal Solar Panels

- Free energy
- Long-lasting
- Intermittent

Biomass

- Dispatchable
- Variable pricing
- Smoke emission

Aerothermal Energy

- Low-cost technology
- Low energy performance
- Weather dependent

Geothermal Energy

- Dispatchable
- High energy performance
- Weather independent

Electricity generation technologies

Photovoltaic

- Free energy
- Space-demanding (m^2)
- Multi-purpose

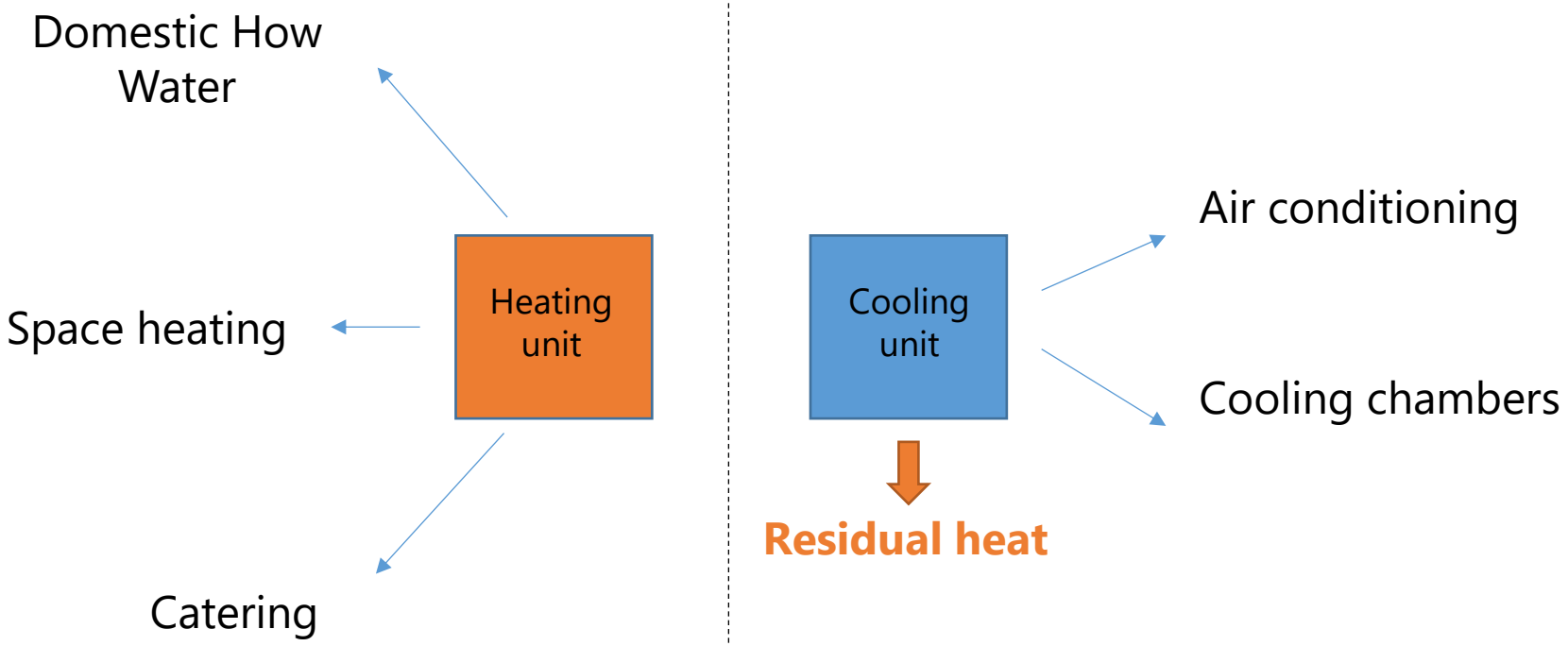
Wind energy

- Not suitable for hospitals

HVAC System Design

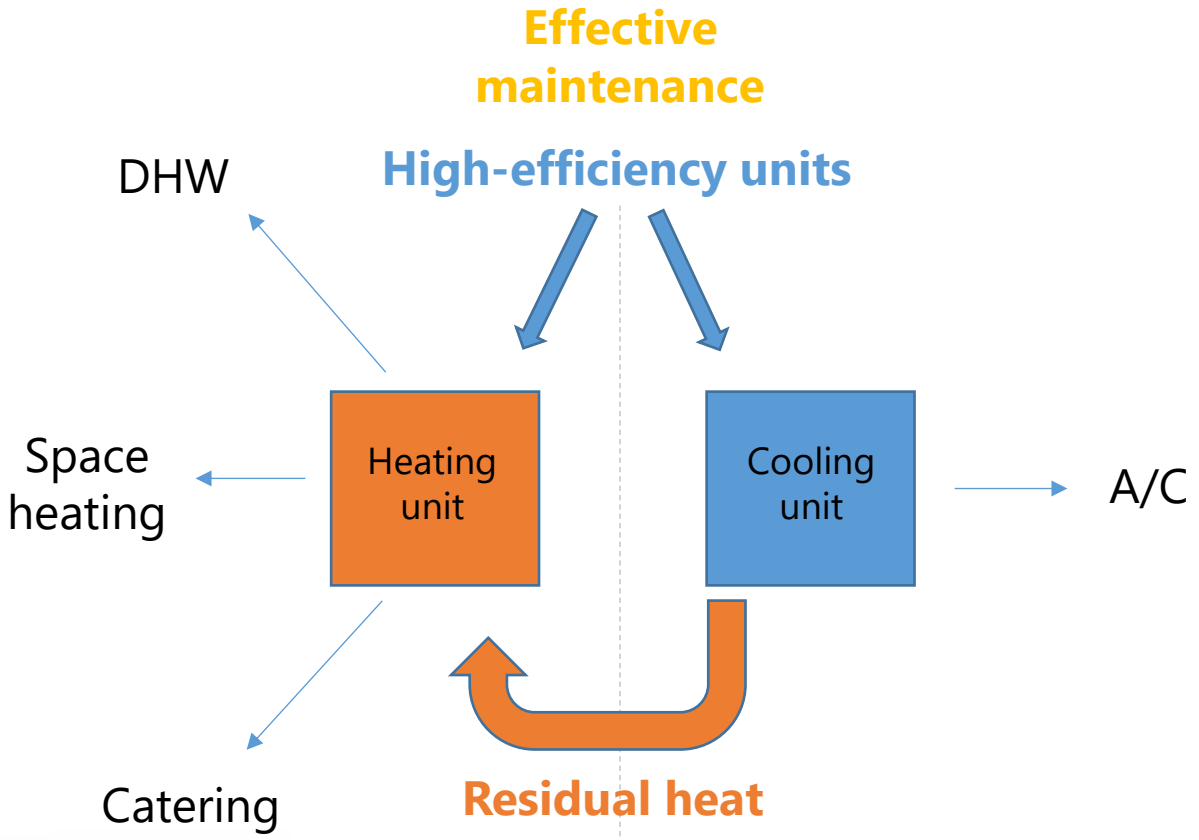
A typical HVAC system setup

- Two independent generation units



HVAC System Design: Energy Efficiency

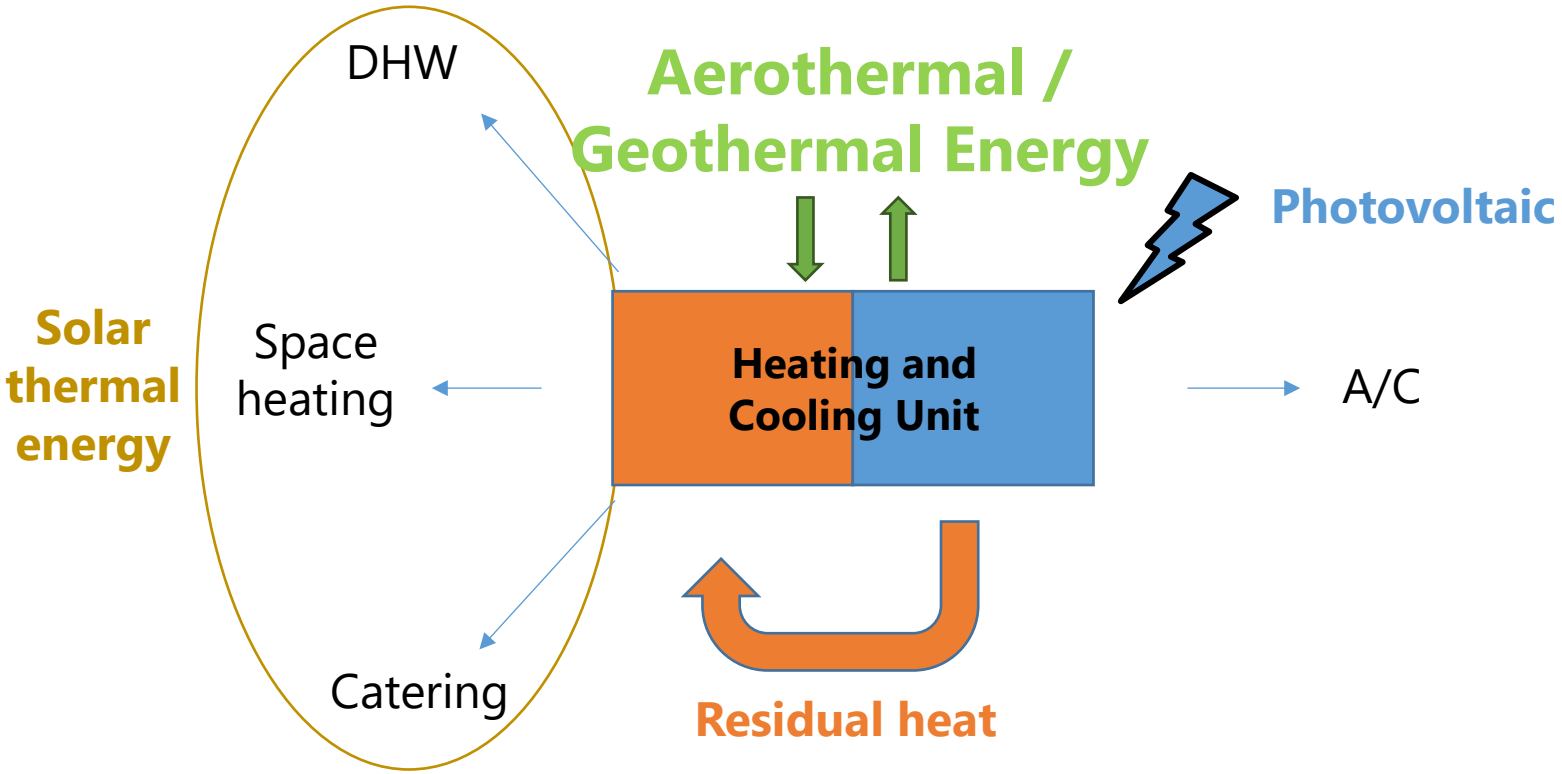
How can we increase its **energy efficiency**?



- **Equipment supervision**
- **Consumption monitoring**
- **Continuous management of the installation**

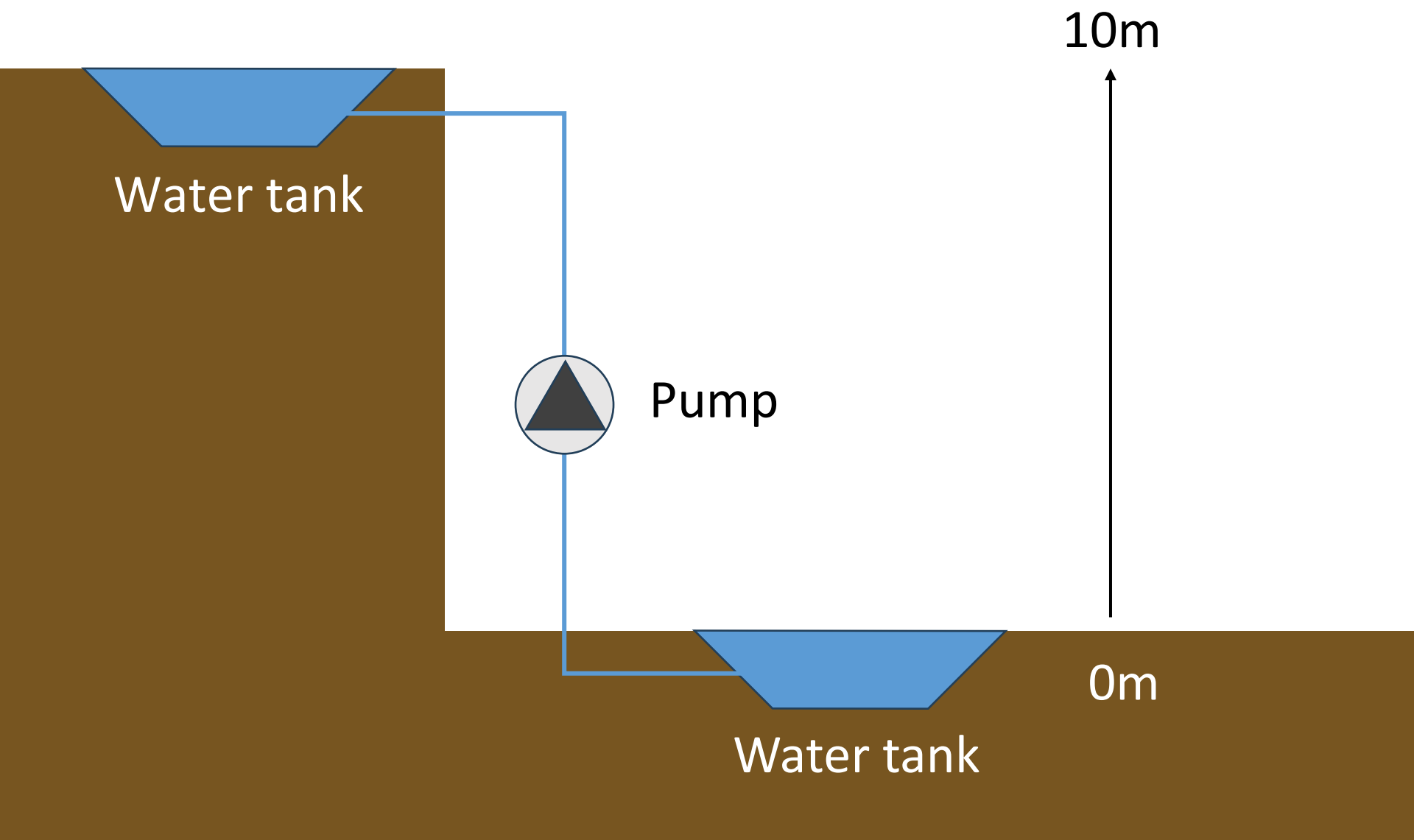
HVAC System Design: Renewable energy

Integrating **renewable energy** systems



The Heat Pump

What is a pump?



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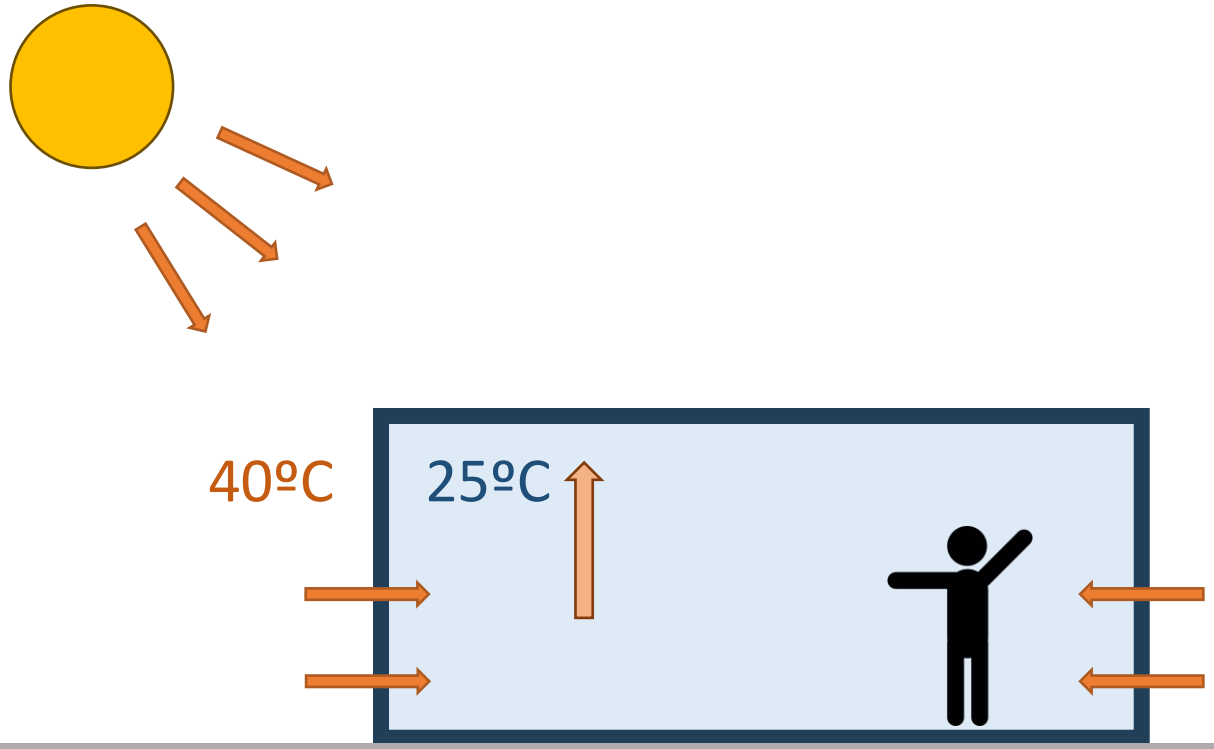
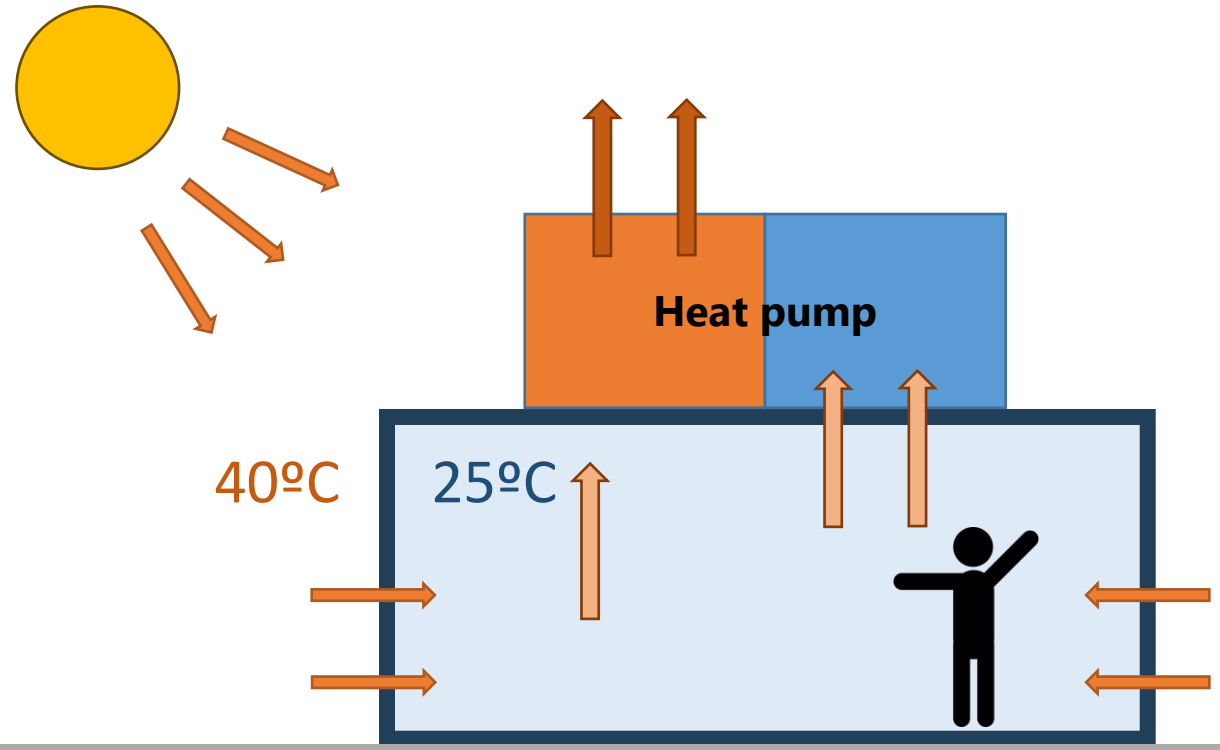
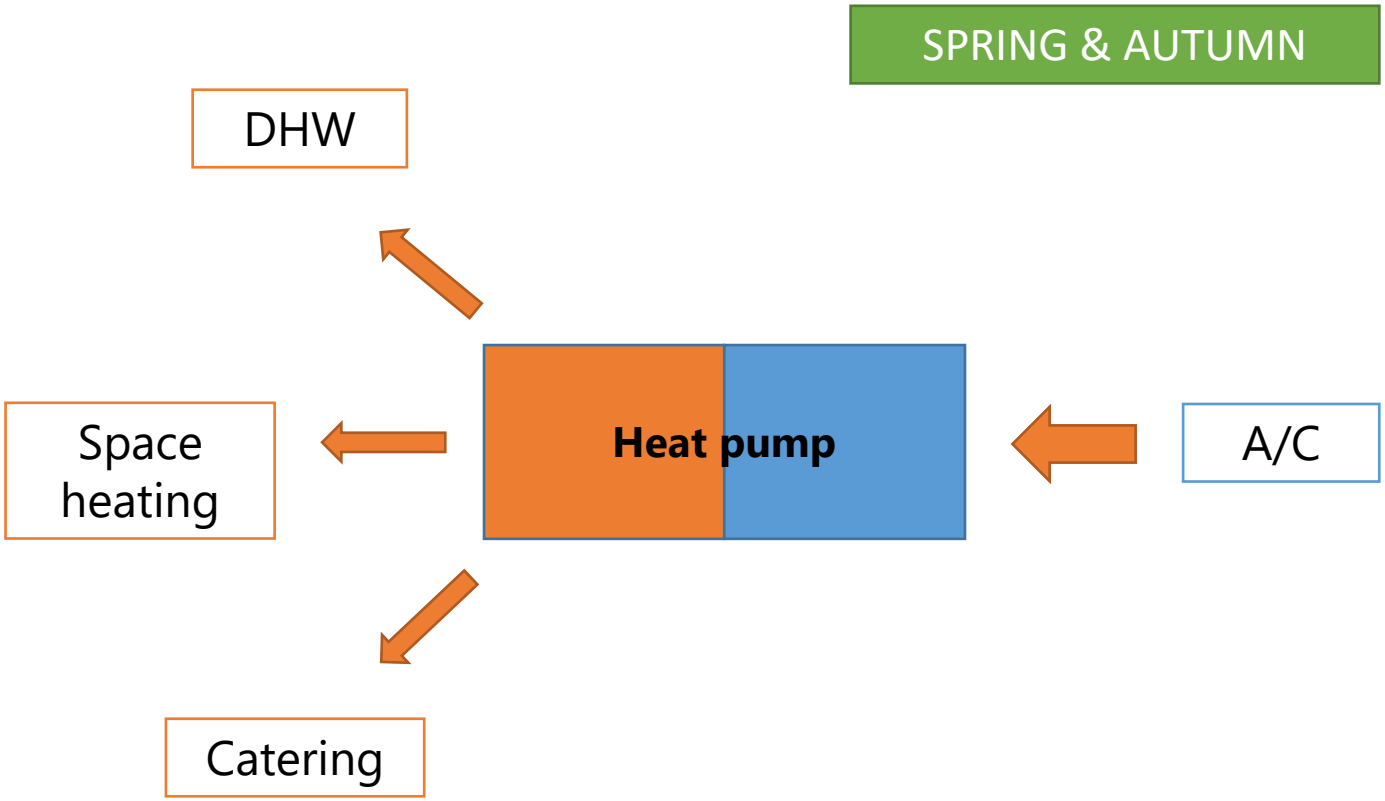


The Heat Pump



Heating and Cooling with Heat Pumps



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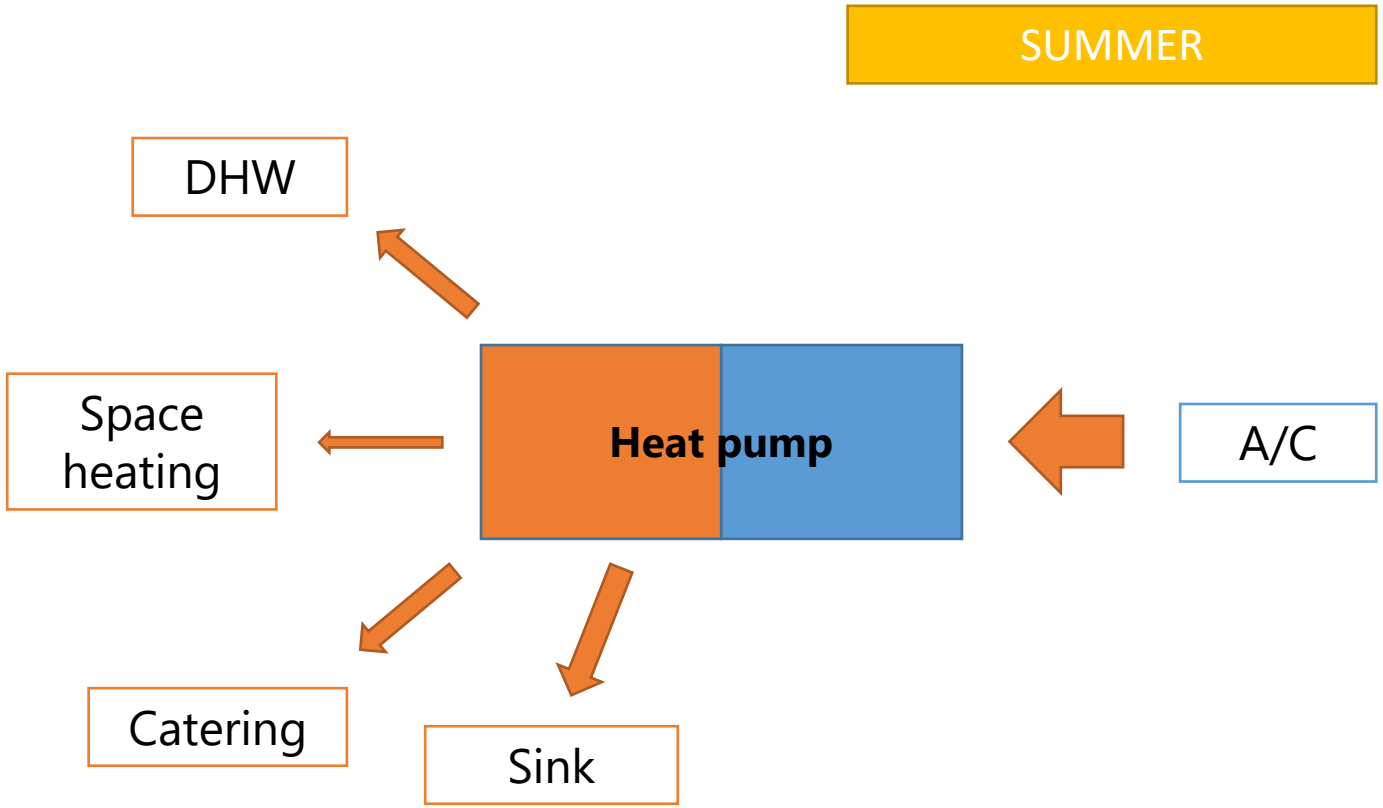
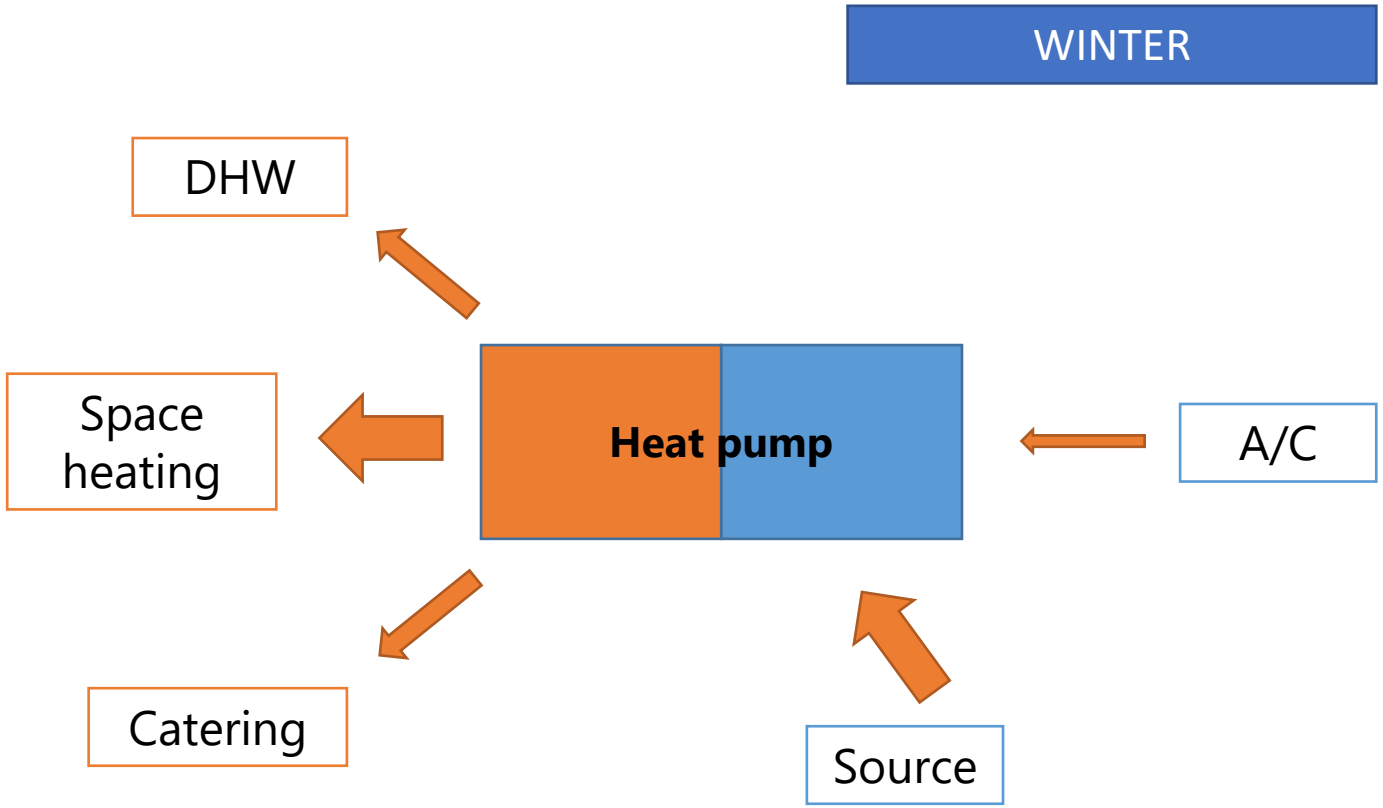
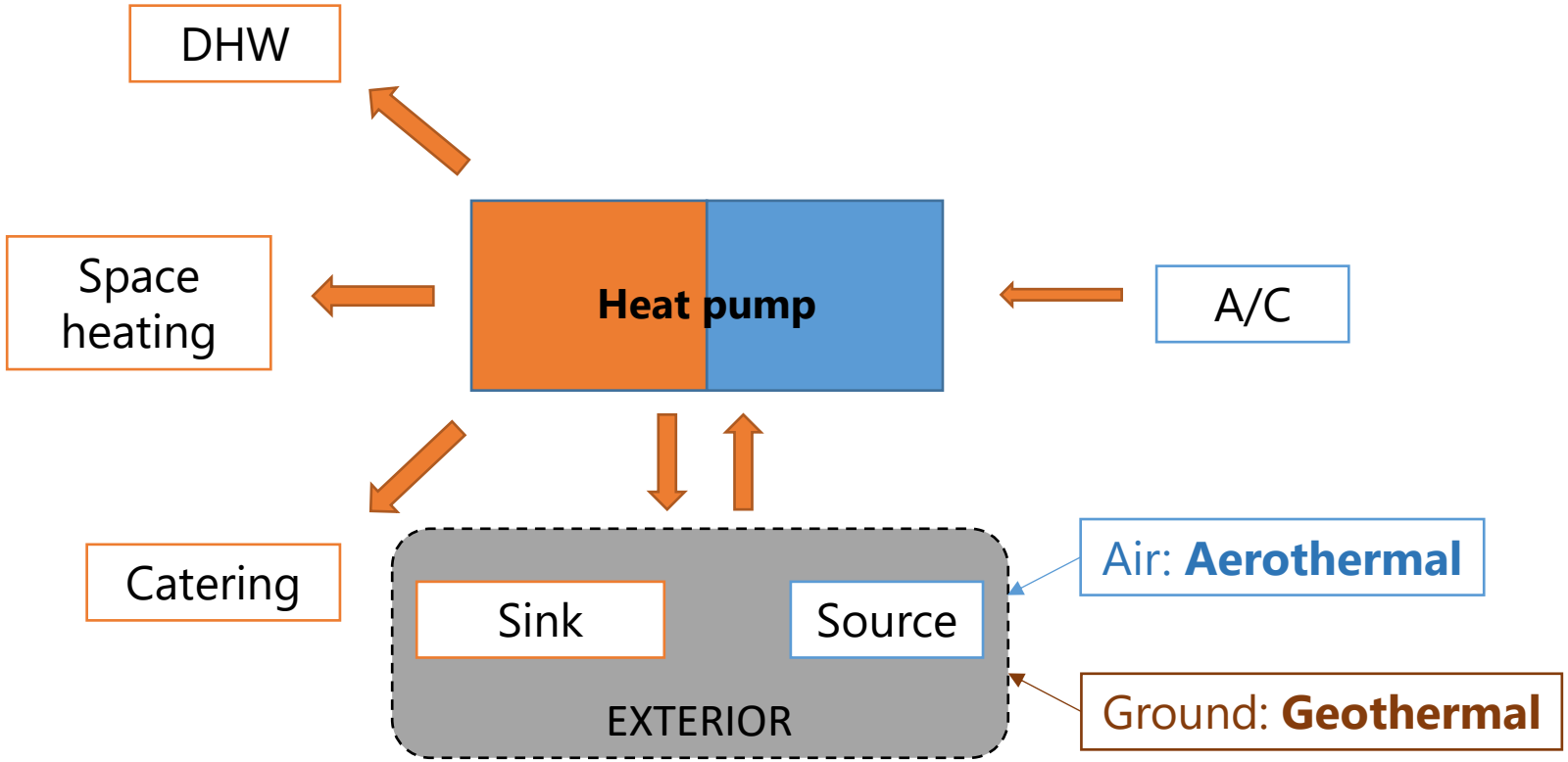


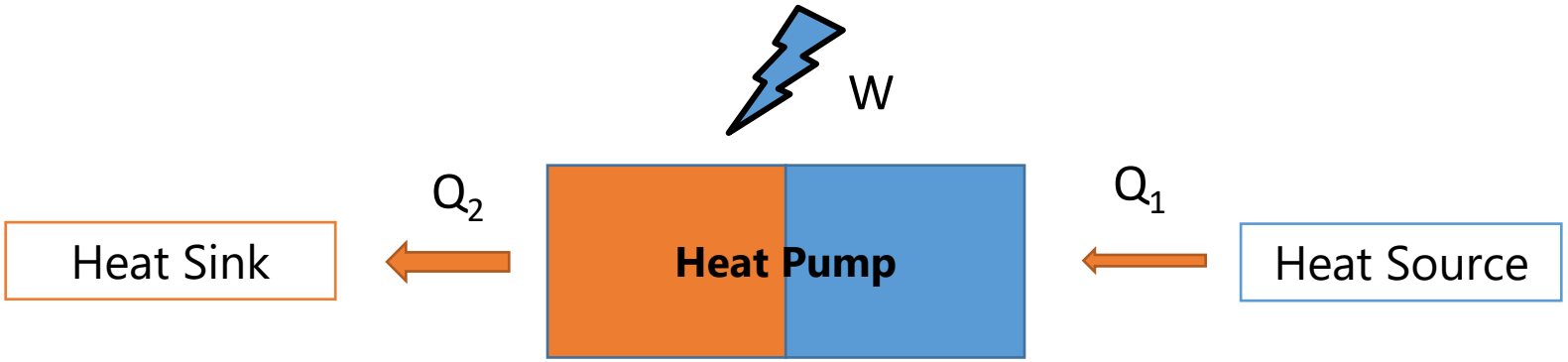
Heating and Cooling with Heat Pumps



Heating and Cooling with Heat Pumps



Heat Pump Performance: COP and EER



$$Q_2 = W + Q_1$$

Heating

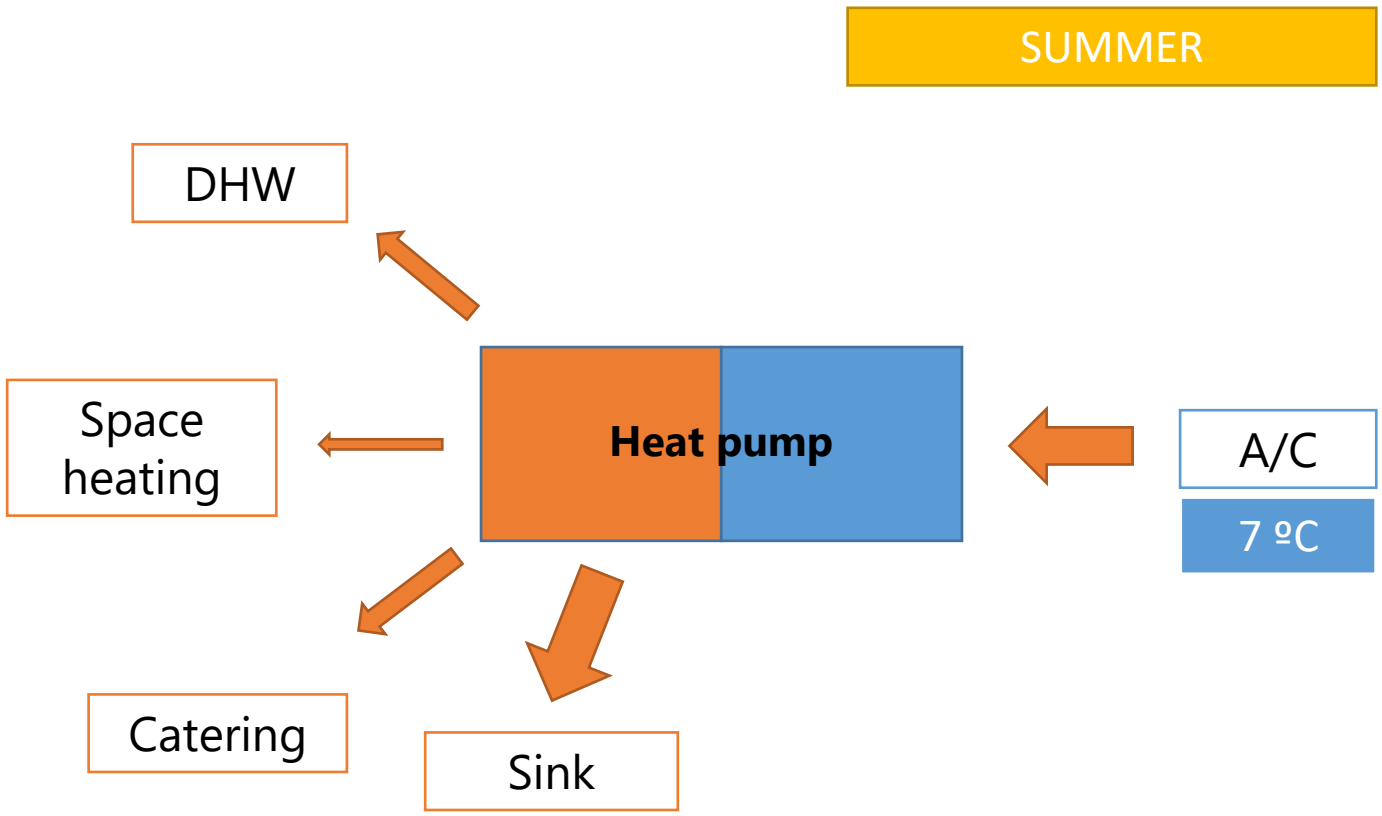
$$COP = \frac{Q_2}{W}$$

Cooling

$$EER = \frac{Q_1}{W}$$

Temperature difference between heat **source** and **sink**

HVAC System Performance



Aerothermal : Tª ext. 40ºC **EER = 2,5** → **η = 250%**

Geothermal : Tª ext. 20ºC **EER = 5** → **η = 500%**

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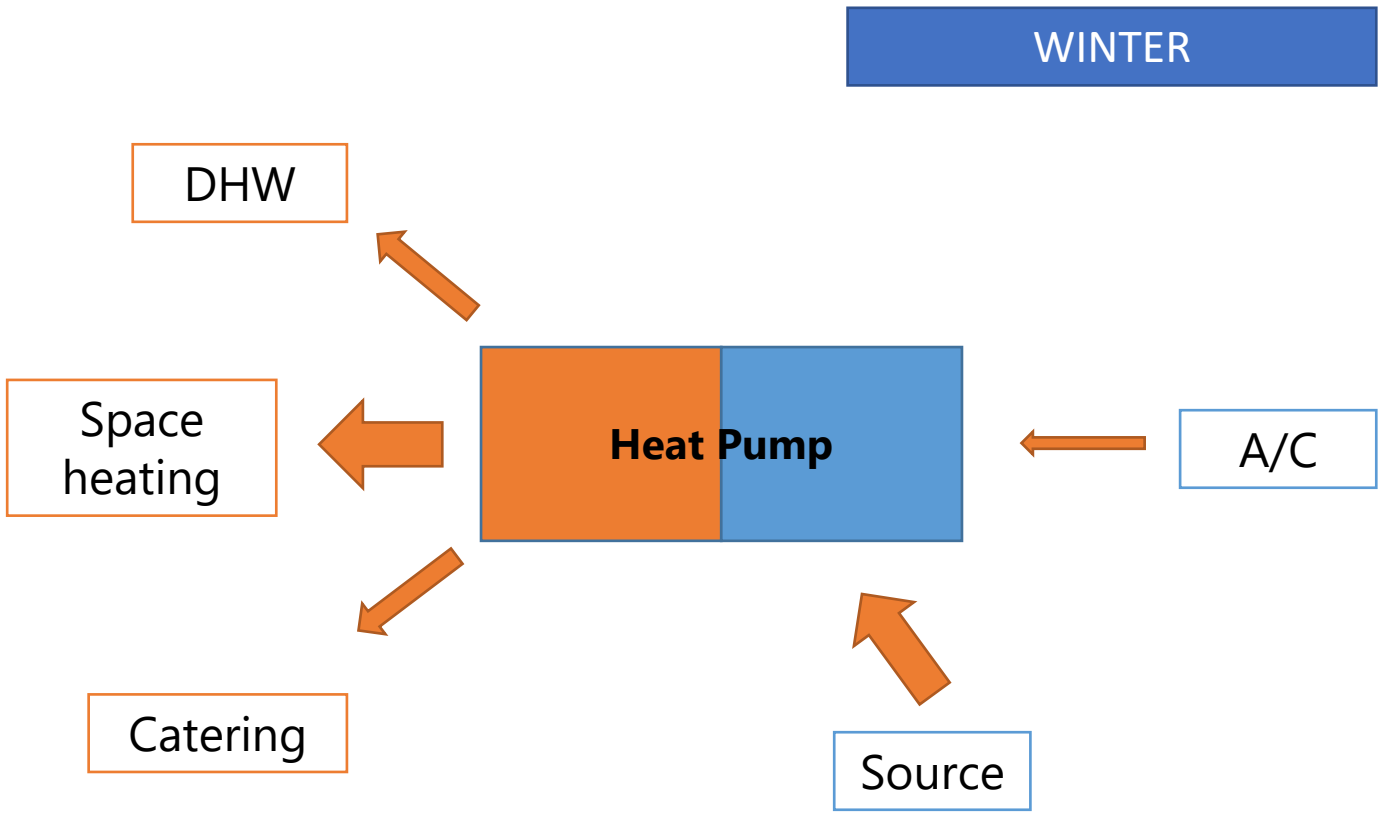
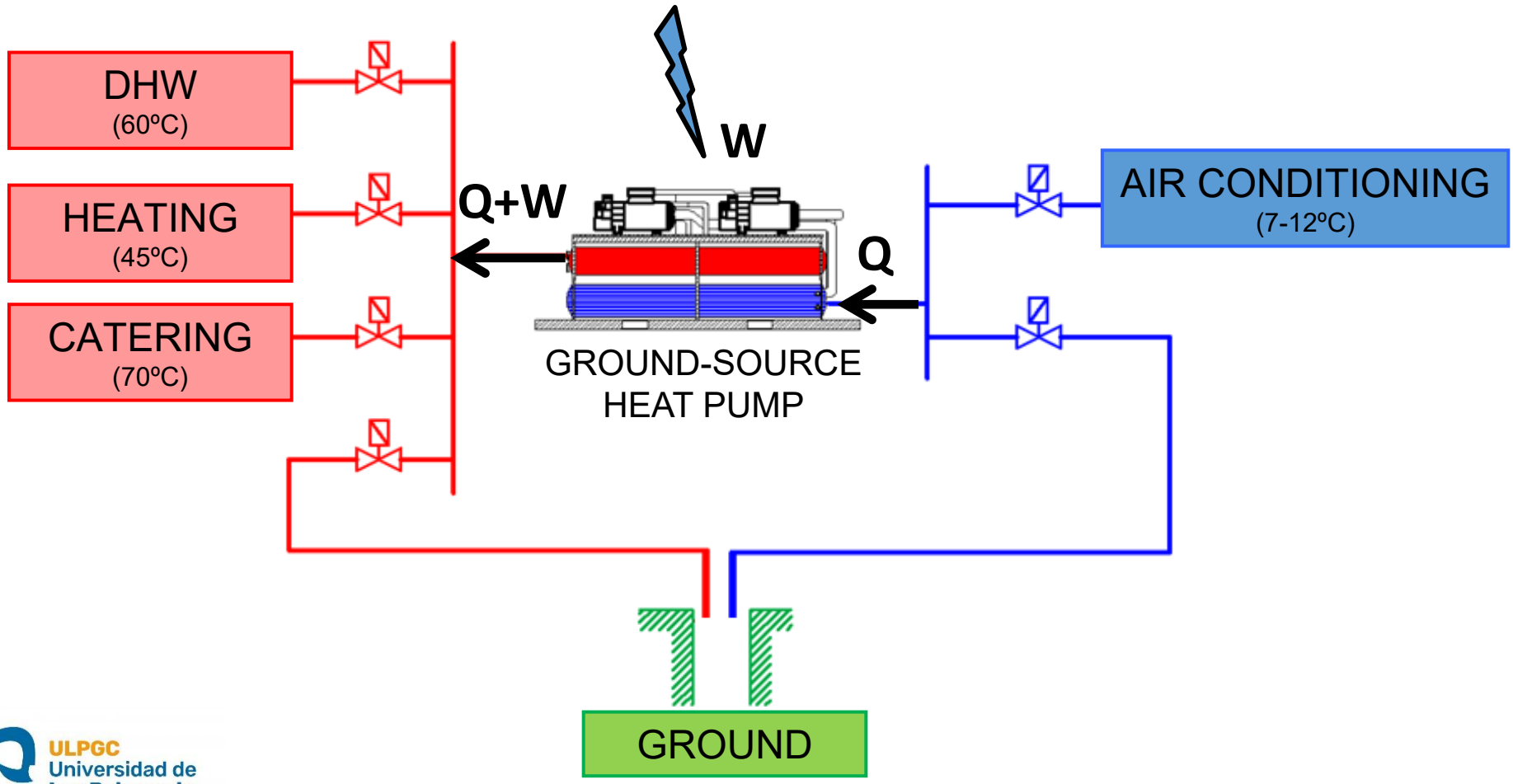
HVAC System Performance



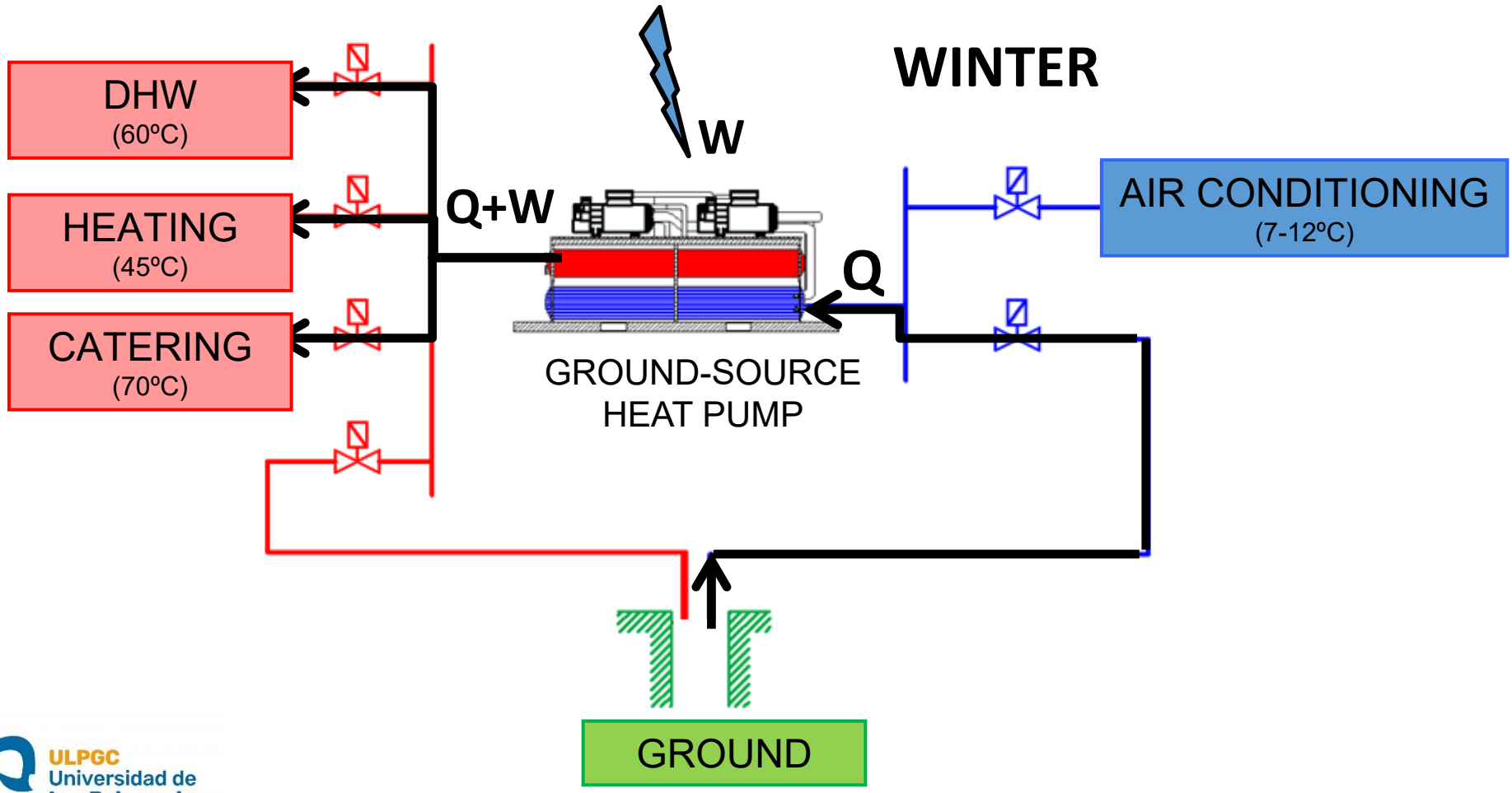
Aerothermal: Ext. T 0ºC **COP = 4** → **η = 400%**

Geothermal: Ext. T 20ºC **COP = 7** → **η = 700%**

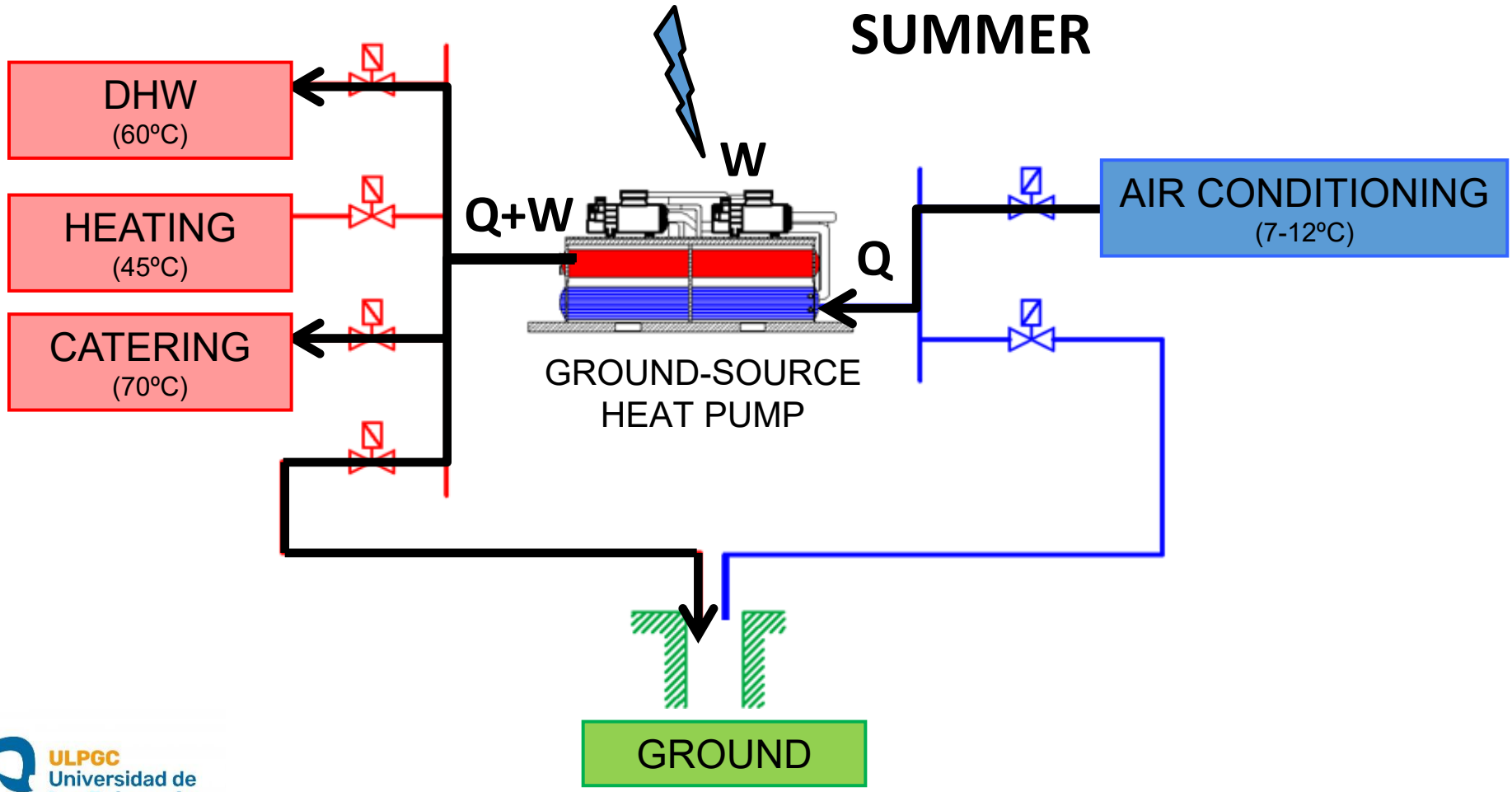
Geothermal HVAC System



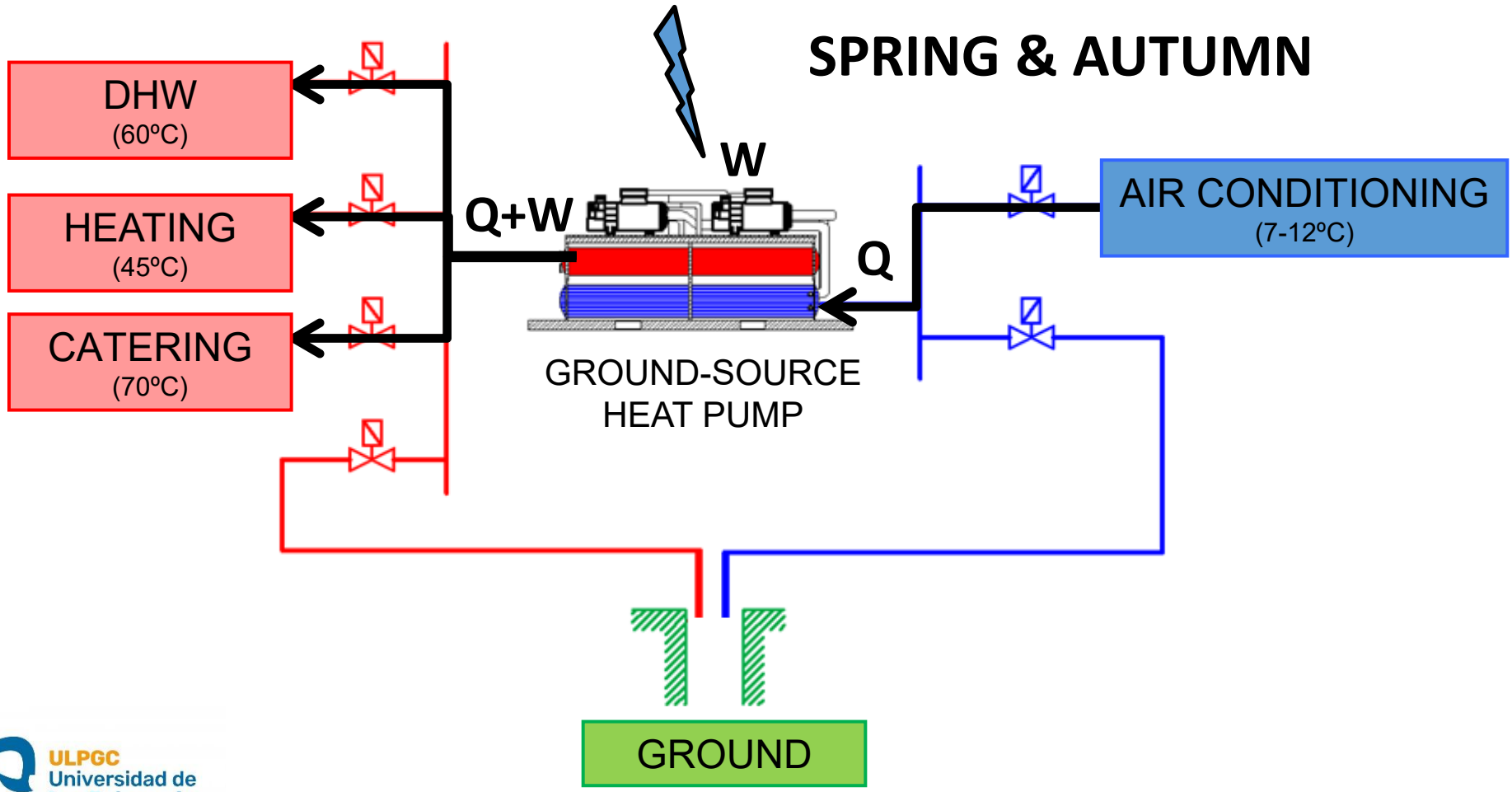
Geothermal HVAC System



Geothermal HVAC System

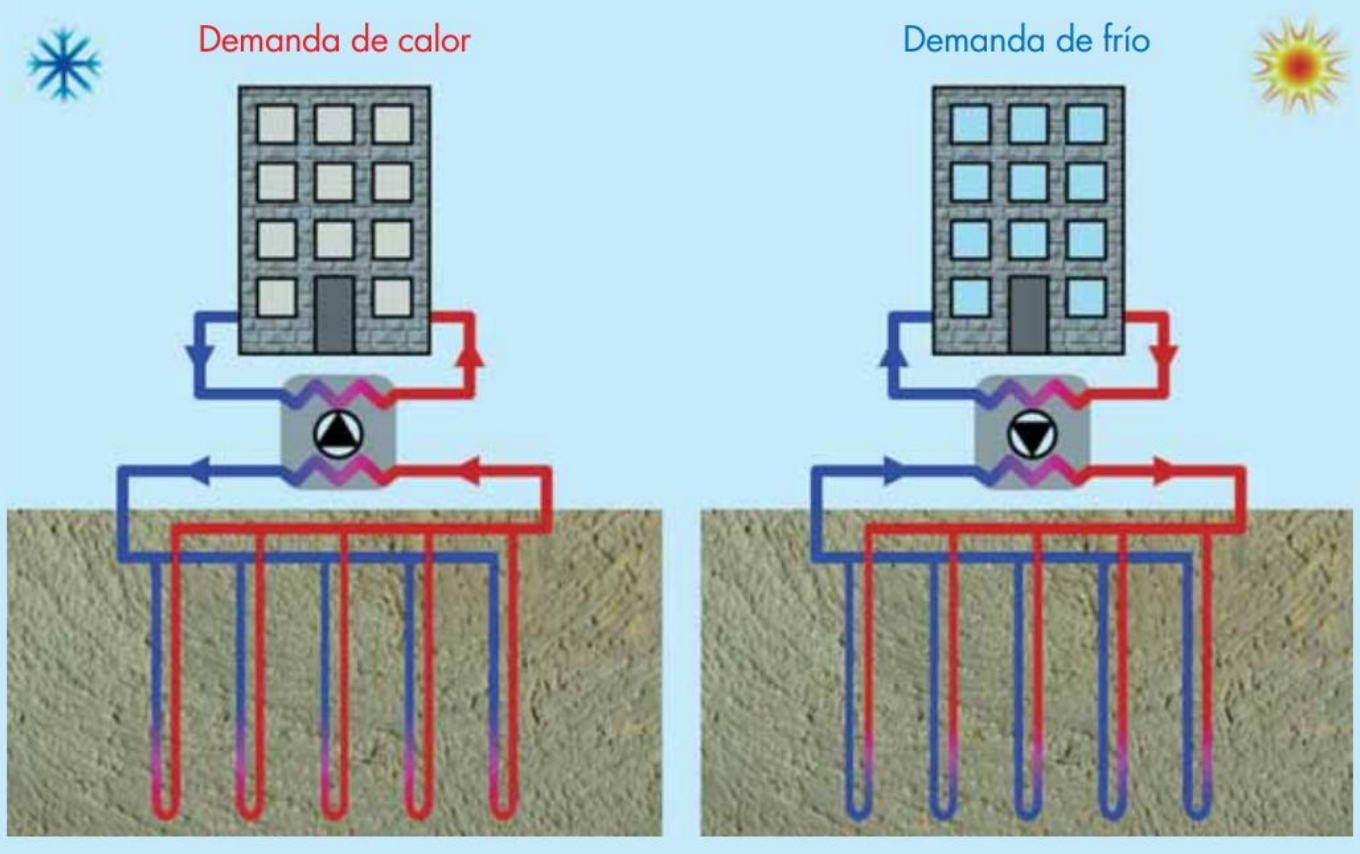


Geothermal HVAC System



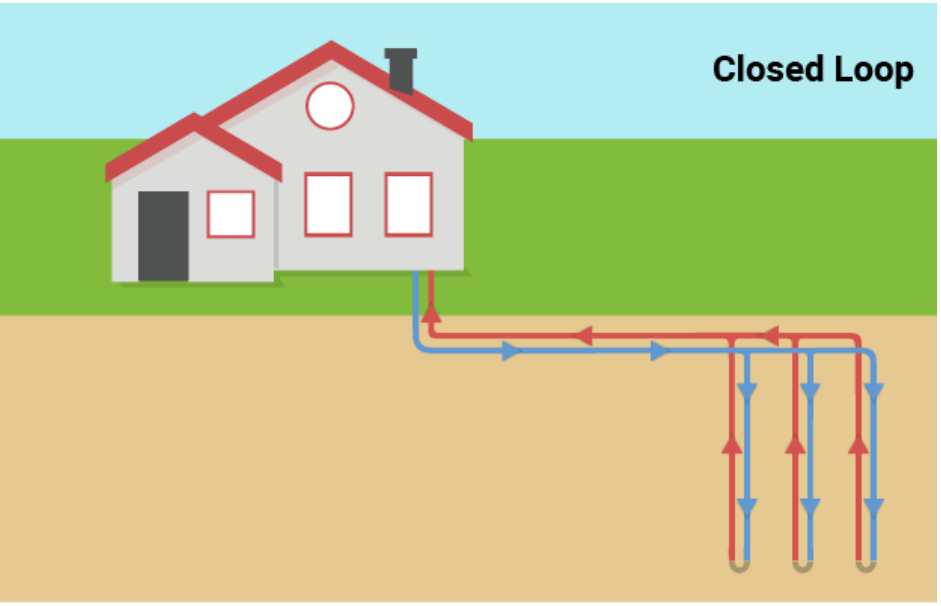
Ground Source Heat Pumps

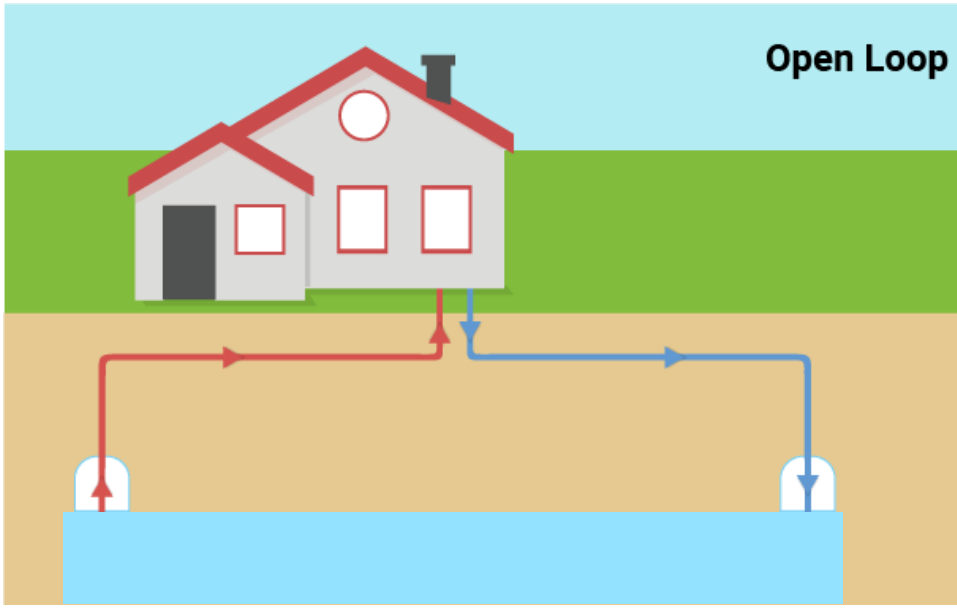
Working principle



Ground Heat Exchanging

There are two methods for ground heat exchanging





Open-loop Heat Exchange

Bore-hole drilling process

Closed-loop Heat Exchange

Underground piping distribution

Geothermal Case Studies

62% H&C Energy Cost
65% H&C Consumption
50% CO_2 Emission

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Geothermal Case Studies:

- Hospital de Mollet del Vallés (Barcelona, 2009)
- Medical Center Leeuwarden (Netherlands, 2022)
- Reha-Klinik Nayreuth (Germany, est. 2027)
- Kantonsspital (Switzerland, 2022)
- Ospedali di Padiva Sud (Italy, 2016)
- Hôpital Saint-Jean-de-Diue (France, 2021)
- Klinik Ottakring (Austria, est. 2027)