LOCAL GoGREEN

# ENERGY EFFICIENCY OF BUILDINGS

Co-funded by
the European Union

# AGENDA

- Introduction to LOCAL GoGREEN
- EU political and legal framework
- National political and legal framework
- Energy demanding parts and systems of a building.
  - Envelope. Improvements
  - Thermal energy generation and sources. Efficient systems
  - Other saving devices and practice.
- Case studies

# About the LOCAL GoGREEN project

## Clean Energy Transition process in 6 small European municipalities

8 partners from 7 European countries leading the capacity building, participatory decision-making and collaborative actions for the design and implementation of integrated climate and energy plans.

Aims:

- Provide **technical assistance** to local pilots in a comparable transnational framework
- Improve **synergies among public & private stakeholders** in implementing ICEPs
- **Facilitate the deployment of targeted investments** provided by the European Funds for improved ICEP planning
- Replicate & upscale the integrated measures for CET through **transnational municipal cooperation**
- Enable green & circular climate & inclusive decarbonisation **plans that support sustainable development**

**300** stakeholders with increased skills in the area of Clean Energy Transition

**90** local and regional authorities committed to accelerate the implementation of ICEPs

**5GWh/year** of renewable energy generation

**1,600tCO2/year** CO2 reduction in the 3-year period & 4,500 tCO2/year in the period 5 years after the project

**2.94GWh/year** of energy savings in the 3-year period & 8.4 GWh/year in the period 5 years after the project

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# LEARNING OBJECTIVES OF THE TRAINING

**After this training you will be able to:**

➔ Understand the importance of energy efficiency in buildings

➔ Be aware of:

- EU and national objectives in the medium and long term
- Both energy-related and non-energy-related benefits, resulting from efficient buildings and retrofitting projects
- The relevance of different parts and equipment of a building on its energy demand and consumption

➔ Distinguish and engage in discussions on:

- Efficient systems and equipment to reduce and satisfy energy demand of buildings
- Building retrofitting main technologies
- Electrification (decarbonising) of heat production

# EU POLITICAL AND LEGAL FRAMEWORK

# KEY FACTS ON ENERGY AND EU BUILDINGS

## GOAL

Net zero GHG emissions EU Cities by 2050

**Around 40%**
of energy consumed in the EU is used in buildings

**Over 1/3**
of the EU's energy-related emissions come from buildings

**+/- 80%**
of energy use in EU homes is for heating, cooling and hot water

(1) Eurostat energy balances and EEA Greenhouse Gas Inventory, 2023

- 85% of EU buildings were built before 2000
- Amongst those, 75% have a poor energy performance.
- Acting on the energy efficiency of buildings is **key** to:
  - saving energy
  - reducing bills for citizens and SMEs enterprises
  - achieving a zero-emission and fully decarbonised building stock by 2050.

# Key facts on energy and EU buildings

## Legislative route

**28 May 2024** — Revised Energy Performance of Buildings Directive (EPBD) entered into force

**8 May 2024** — The revised Directive was published in the Official Journal of the EU

**April 2024** — Formal adoption of the EPBD

**December 2023** — Provisional agreement between the co-legislators on the EPBD revision

**March 2023** — European Parliament's position on the EPBD revision

**October 2022** — Council General Approach on the EPBD revision

**May 2022** — REPowerEU Plan, including the EU 'Save Energy' Communication

**December 2021** — Commission proposal of a revised directive

**July 2021** — Delivering the European Green Deal ("Fit for 55" package)

**October 2020** — EU Renovation Wave strategy

**June 2019** — Commission Recommendation on building modernisation (EU/2019/1019)

**May 2019** — Commission Recommendation on building renovation (EU/2019/786)

**May 2018** — Amending Directive 2018/844

**May 2010** — Energy Performance of Buildings Directive (2010/31/EU)

# Benefits of renovating buildings in the EU

- Boosting buildings energy efficiency would:
  - reduce emissions;
  - tackle energy poverty;
  - lower vulnerability to energy price fluctuations;
  - support economic recovery and job creation;
  - enhance citizens' health and well-being by modernizing living standards for everyone.
- Investing in energy efficiency:
  - stimulates local economies;
  - supports EU industrial sectors;
  - creates more green jobs.
- The EU construction industry:
  - contributes approximately 9.6% to the EU's value added;
  - employs nearly 25 million people across 5.3 million firms;
  - SMEs in particular benefit from a boosted renovations market, as they make up 99% of EU construction companies and 90% of the employment in the sector.

# Revised energy performance of buildings directive

- It also **supports:**
  - better indoor air quality
  - digitalisation of buildings' energy systems (including the development of a Smart Readiness Indicator - SRI)
  - creation an infrastructure for sustainable mobility

- **Recognises** differences across EU countries in factors such as the existing building stock, geography and climate

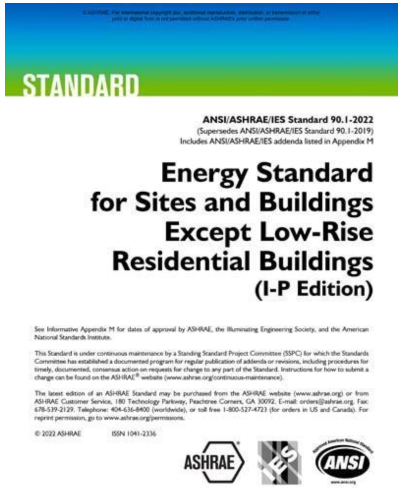
- **Allows** governments to decide on the renovation measures best-suited to their specific national context.

- Countries **can also exempt** various categories of buildings from the rules including historical buildings and holiday homes.

# APPROACHING ENERGY EFFICIENCY IN NEW BUILDINGS

New buildings are supposed to be designed and built according the national code, which is being reviewed periodically in order to achieve NET ZERO emissions in the short term.

- Every country has a building **code** in force, which includes energy efficiency requirements. All new building must comply with the code.
- Furthermore, there are building **standards** (Passivehuose, ASHRAE 90.1,…) that goes further on what refers to efficiency requirement levels.
- Almost all codes and standards allows to follow two different ways to comply with:
    - Prescriptive and mandatory provisions for every building aspect: envelope, HVAC system, lighting, electrical power, water heating, other equipment,…
    - Performance option that allows “trade-offs” to satisfy the facility owner’s requests as well as obtain compliance (so called energy cost budget method). A building complies if the annual energy consumption estimated for the proposed design does not exceed the annual energy consumption of a base design that fulfills the prescriptive requirements.
    - Whatever the way taken to show compliance, domestic appliances are not subject to the building codes and standards.

# Approaching energy efficiency in existing buildings

- The EU defined the retrofitting of existing public and private buildings as a strong priority in the European **Green Deal**. Energy efficiency retrofitting involves replacing obsolete systems with updated and more efficient technologies and features.
- Almost all EU members have a building renovation targets, a strategy and action plans to promote renovations, including grants and financial schemes.

Existing buildings are **the target** of the EU and member states efforts.

The strategy focus on

- Tackling energy poverty and worst performing buildings,
- Public buildings renovation,
- Decarbonization of heating and cooling

# ENERGY DEMANDING PARTS AND SYSTEMS OF A BUILDING

# TECHNICAL APPROACH TO ENERGY EFFICIENCY IN BUILDINGS

Where to start from? Steps in EE decarbonization of buildings must follow a one-direction path

1. Design according local code, climate conditions, orientation,…(new buildings)
2. Use of low carbon building materials and smart building methods (for new buildings and retrofitting)
3. High performance envelope to reduce heat transmission but keeping necessary infiltration level (not too tight) to ensure indoor air quality (or providing mechanical ventilation systems)
4. High performance HVAC and DHW generation systems (including renewable on-site generation and storage systems)
5. User friendly control and regulation systems.

# ENVELOPE

Why we care about the building envelope:

- The condition of the building envelope impacts HVAC system operating costs, as well as the occupants' comfort, health, and overall well-being.
- Retrofitting the building envelope can be challenging: existing systems often "work," but upgrades are costly and may cause disruptions.

The building envelope typically includes:

- External walls
- Roof and foundation
- Windows, doors, and other openings

The building envelope plays a critical role in energy efficiency by controlling heat gains and losses within the building.

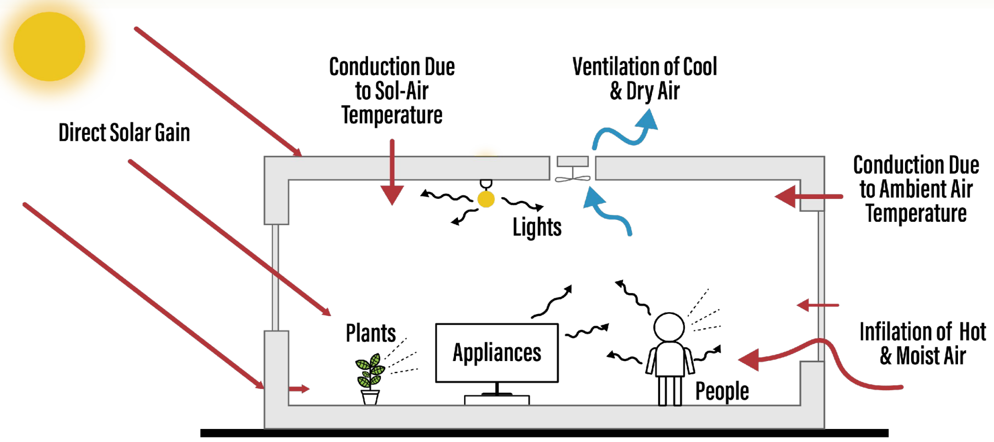
# Envelope

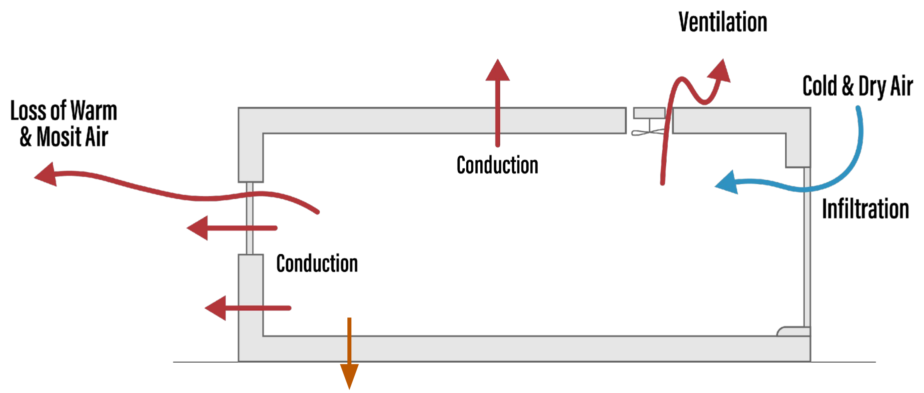
## Sources of heat gain:

1. Infiltration/Ventilation
2. Conduction
3. Solar Gain (radiation)
4. Internal Loads (appliances, lighting, people)

## Sources of heat loss:

1. Infiltration/Ventilation
2. Conduction




Source: Certified Energy Manager training course. Association of Energy Engineers

# Envelope. Insulation materials

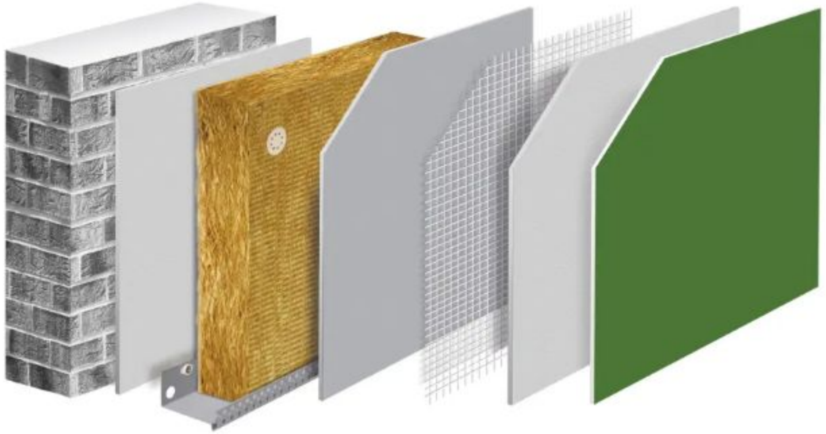
## Reduce the heat flux through walls, roofs, and foundations

Rock wool

Glass or wood fibers

Elastomeric polymers

…



External insulation latyers beissier.es

Indoor insulation Source: ralphplastering.co.uk

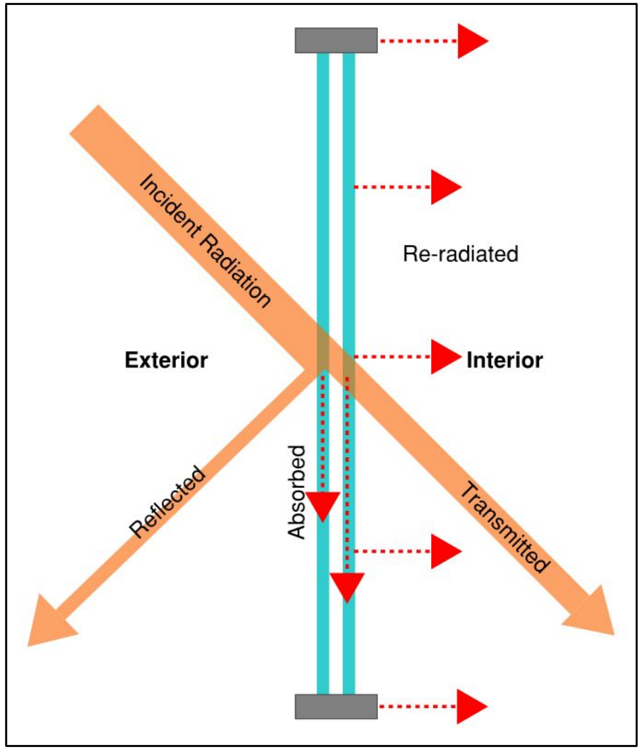
# ENVELOPE. WINDOWS

## Solar heat gain through windows depends on

- solar radiation intensity;
- time of day;
- orientation;
- availability of shading;
- type of glassing.

## Other factors affecting window energy performance include

- Frame material and airtightness
- Thermal bridge prevention




Source: Certified Energy Manager training course. Association of Energy Engineers

# Envelope retrofitting

Envelope retrofitting minimizes heat transmission, reducing heating and cooling demand.

Depending on the initial condition, heating and cooling savings can reach up to 80%.

Internal insulation:

- space-consuming;
- more affordable but does not improve the building's thermal mass;
- limits indoor space and impedes normal use of workspace.

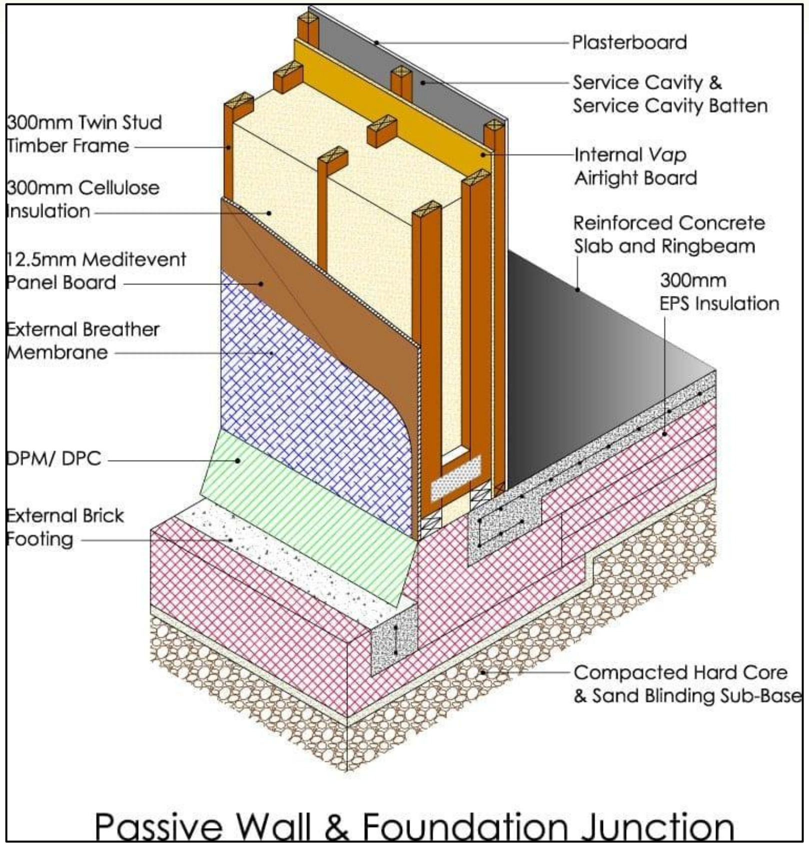
External insulation:

- Significantly more effective; reduces thermal bridges and enhances the building's thermal mass.
- Generally more expensive and particularly challenging and costly for floors and roofs.

# ENVELOPE

External insulation is an excellent solution for:

- older buildings lacking an air gap between internal and external walls;
- facades in deteriorated or poor condition;
- preventing water infiltration.




Source: mbctimberframe.co.uk

# Heating, ventilation and air conditioning (HVAC)

## HVAC function:

- Regulates heat and moisture to maintain the desired indoor environmental conditions.
- Provides ventilation and air circulation, even in the absence of heating or cooling demand.

## HVAC components:

- motors, pumps, pipes, ducts, fans, controls, and heat exchange units which distribute heated or cooled air or water throughout the building;
- heating and cooling generators.

Source: www.freepick.com

# DISTRICT HEATING AND COOLING NETWORKS (DHCs)

DHCs distribute heated and cooled water to groups of buildings or entire districts.

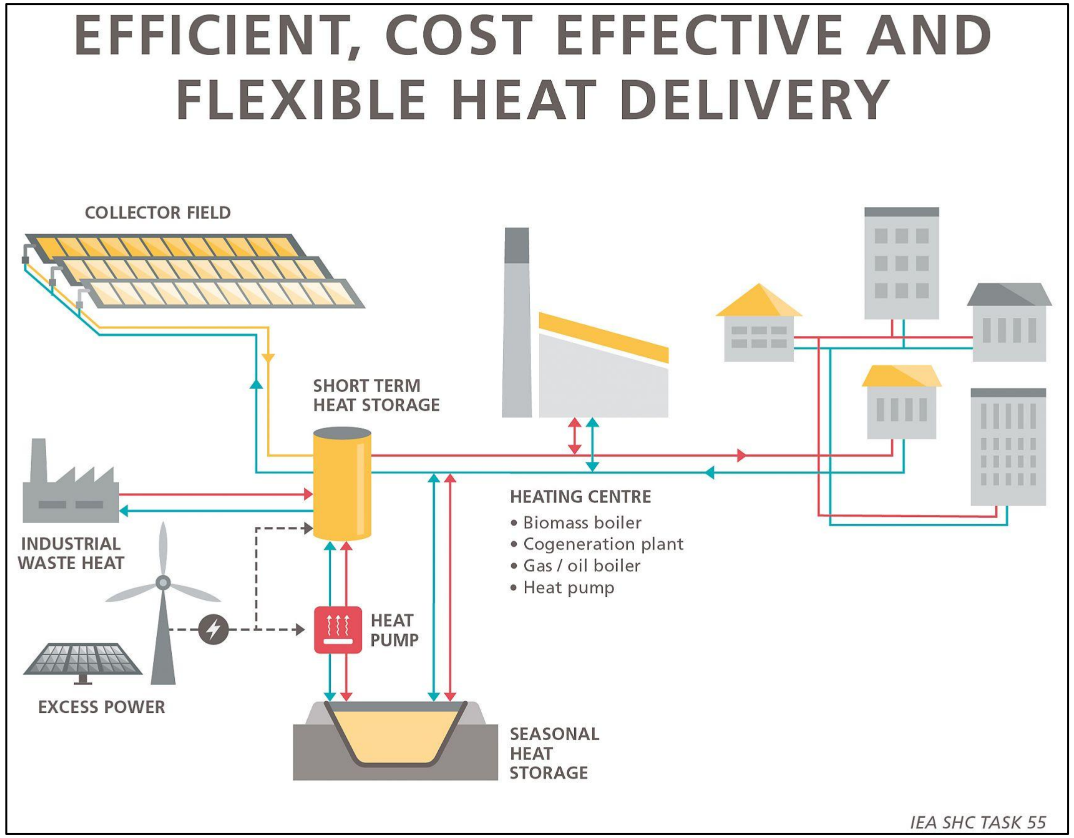
Heat and cooling generation may be centralized or decentralized.

4$^{th}$ and 5$^{th}$ generation DHCs have the capability to recover waste heat and utilize renewable heat sources from various locations, including:

- commercial buildings, data centers, supermarket refrigeration systems;
- manufacturing facilities;
- urban infrastructure (subway, sewage systems, storm drains);
- shallow geothermal and solar thermal sources.

4$^{th}$ and 5$^{th}$ generation DHCs match very good with radiant floor emission systems.

# DISTRICT HEATING AND COOLING NETWORKS (DHCS)

# Heating and cooling sources (collective or individual systems)

## Heat production:

- **Boilers:** combustion of fuels generates heat, which is transferred to water. Heated water is distributed to final emitters such as radiators, radiant floors, fan coils, and air handling units.
- **Heat pumps (electrically powered):** extract low-temperature heat from external sources (ground, water, air) and transfer it to air or water, which is then supplied to final emitters.

## Cooling may be produced by:

- Chillers and reversible heat pumps (mechanical compression - power acted): transfer the low temperature heat outside (ground, water, air) into air or water that is distributed to final emitters.
- Not very popular: there are heat acted chillers (absorption and adsorption cycle). They are very useful to use waste heat and solar thermal heat.

# Biomass, biogas, biomethane boilers (see also Waste to energy training module)

Commercial boiler units are available for both solid biofuels and renewable gases.

Gas boilers designed for natural gas or LPG (liquefied petroleum gas) can be easily modified to operate with biogas or biomethane. However, pipes and valves need to be replaced for compatibility.

The use of biofuels, particularly those produced locally, supports regional economies and fosters job creation.

Examples of local biofuel sources:

- **Solid biofuels:** Wood processing residues (cleaning and cutting), the cellulose and paper industries, timber and furniture production, pruning waste from fruit trees, agricultural by-products, as well as pellets and briquettes.
- **Biogas and biomethane:** Sewage and municipal industrial waste treatment plants, and livestock manure treatment facilities.

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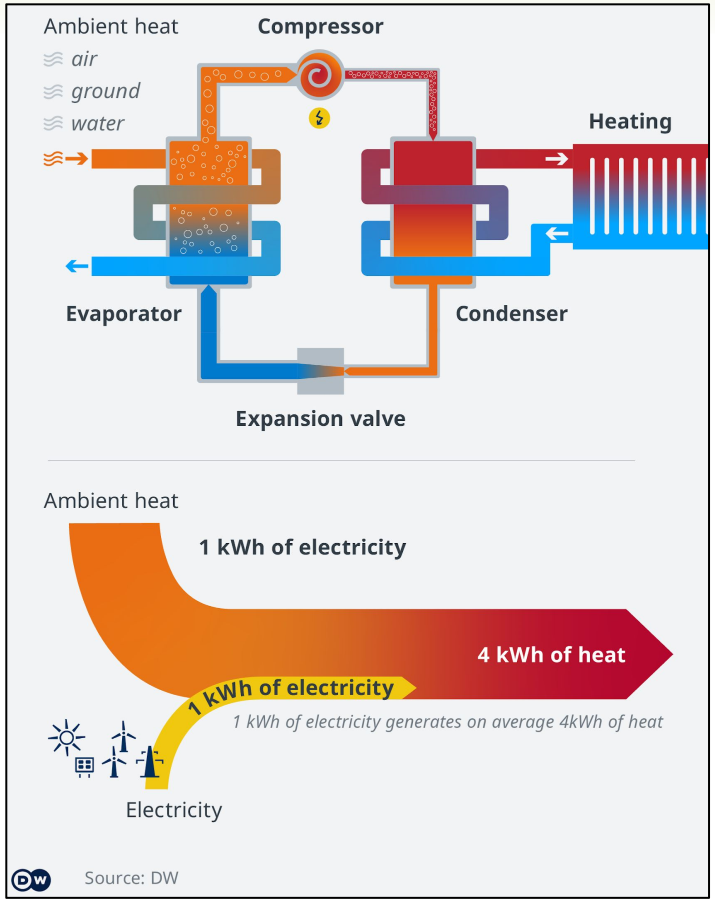
# Heat pumps. How do they work?

- In winter: Extracts heat from a low-temperature outdoor source and transfers it to indoor air or water. The heated air or water is then circulated through indoor emitters to provide warmth.
- In summer (like a refrigerator): Removes heat from the building and expels it to the outdoor environment.
- Uses electricity to power the compressor.
- Efficiency depends on the type of heat source and the temperature difference between indoor and outdoor environments.



# HEAT PUMPS VS BOILERS: KEY BENEFITS

**Electrification of heat demand:** Heat pumps reduce reliance on fossil fuels, significantly lowering greenhouse gas (GHG) emissions.

**Cleaner air in cities:** By eliminating combustion, heat pumps produce no NOx, SOx, VOCs, or particulate matter.

**Greater efficiency**: Heat pumps are 2.5–5 times more efficient than boilers:

- Boilers consume approximately 1.1 kWh of fuel to produce 1 kWh of heat.
- Heat pumps consume only 0.17–0.4 kWh of electricity for the same output.
- With renewable electricity, GHG emissions from heat pumps are near zero.

**Wide market availability:** Heat pumps are available in various types, with diverse heat sources and thermal capacities.

**Regulatory compliance:** Heat pumps comply with the EU energy labeling scheme, ensuring transparency and efficiency standards.

# Heat pumps coupled with conventional radiators

- Replacing conventional radiators with radiant panels or underfloor heating can be costly and disruptive for tenants.
- Heat pumps can be integrated with existing conventional radiators, but the temperature set point must be raised by 2 to 3 degrees to maintain the same level of thermal comfort in rooms.
- Combining radiant and convection heating effects allows the set point to be 2–3 degrees lower compared to using convection alone.
- Therefore, heat pumps and conventional radiators can work together effectively. However, energy consumption increases by approximately 6% for each degree the set point is raised.

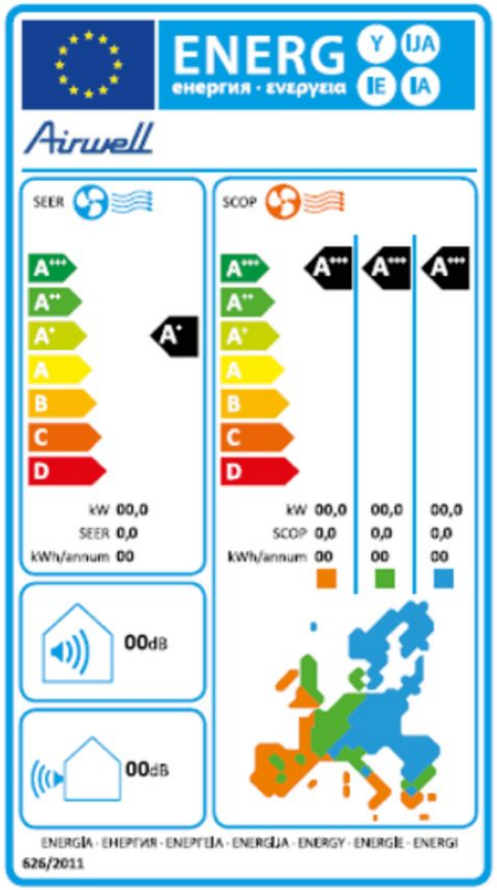
# Heat pumps efficiency

For a given HP, the shorter is the temperature jump, the higher the efficiency is.

Ground-to-water heat pumps are the most efficient type of HP system.

Water-to-water and air-to-water heat pumps also demonstrate good efficiency.

Air to air HPs efficiency is 2 – 4 COP




| Class | SEER (Cooling mode) | SCOP (Heating mode) |
|---|---|---|
| A+++ | SEER ≥ 8,50 | SCOP ≥ 5,10 |
| A++ | 6,10 ≤ SEER < 8,50 | 4,60 ≤ SCOP < 5,10 |
| A+ | 5,60 ≤ SEER < 6,10 | 4,00 ≤ SCOP < 4,60 |
| A | 5,10 ≤ SEER < 5,60 | 3,40 ≤ SCOP < 4,00 |
| B | 4,60 ≤ SEER < 5,10 | 3,10 ≤ SCOP < 3,40 |
| C | 4,10 ≤ SEER < 4,60 | 2,80 ≤ SCOP < 3,10 |
| D | 3,60 ≤ SEER < 4,10 | 2,50 ≤ SCOP < 2,80 |
| E | 3,10 ≤ SEER < 3,60 | 2,20 ≤ SCOP < 2,50 |
| F | 2,60 ≤ SEER < 3,10 | 1,90 ≤ SCOP < 2,20 |
| G | SEER < 2,60 | SCOP < 1,90 |

Source: airwellbaltic.lt

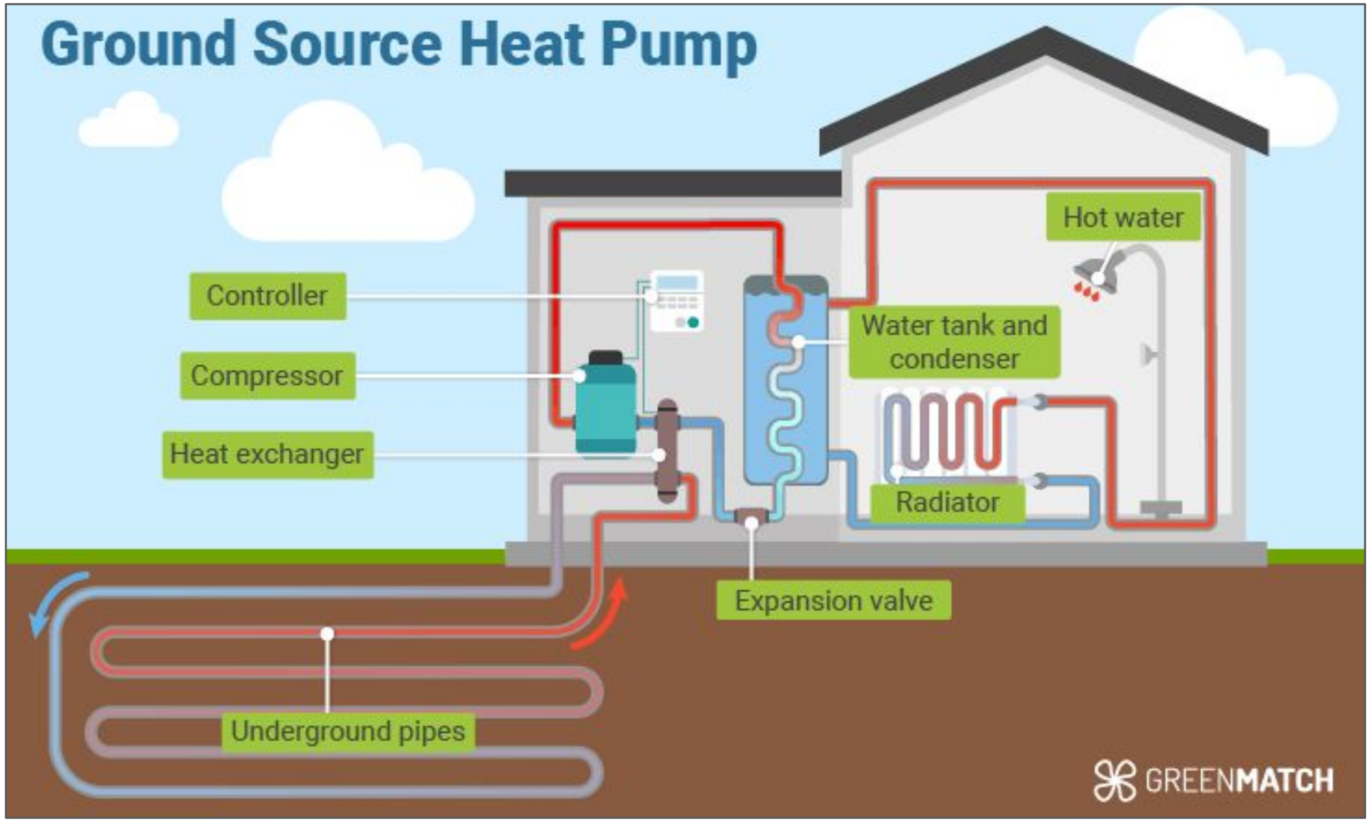
# GROUND-COUPLED HEAT PUMPS

The ground acts as a heat source during winter and as a heat landfill during summer.

During summer, the ground is replenished with heat from cooling processes, serving as a warm reservoir.

Free cooling is achievable in summer through direct heat exchange between the ground water loop and the cooling water loop.

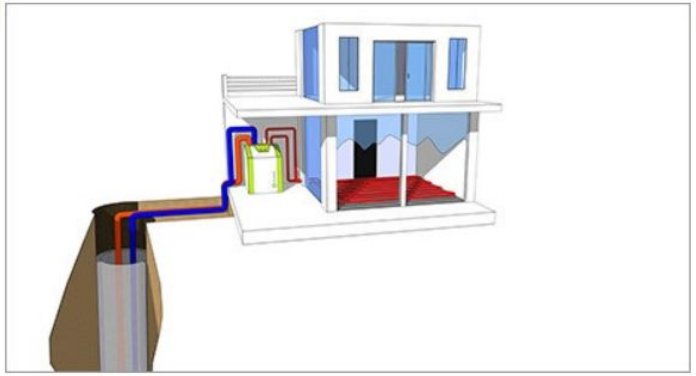
While it has the highest investment cost per kW, it is also the most efficient system.



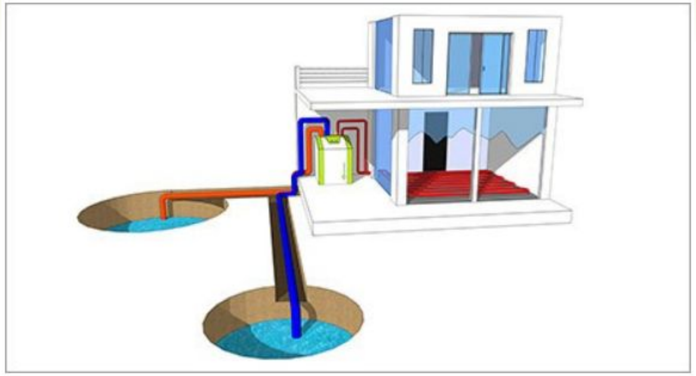

Source: www. www.greenmatch.co.uk

# Energy capture systems for geothermal heat pumps

Drilling works for a vertical borehole

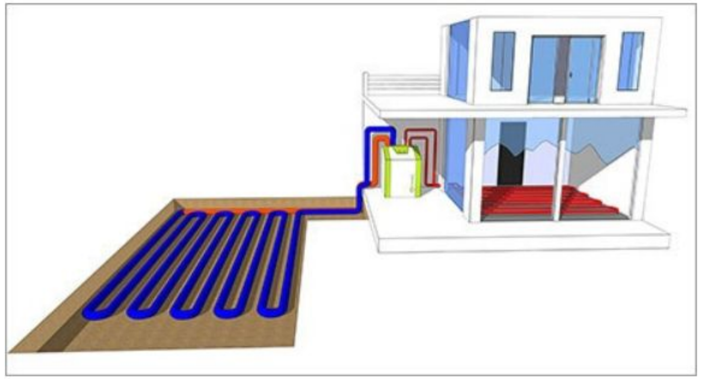


Closed loop in vertical boreholes (till 150m Depth)



Open loop water wells (high phreatic level requiredфреатичност)

Pipes integrated into basements pillards



Closed loop in horizontal grid

All pictures courtesy of GEOTER. https://geoter.es/

# Water-to-water heat pumps

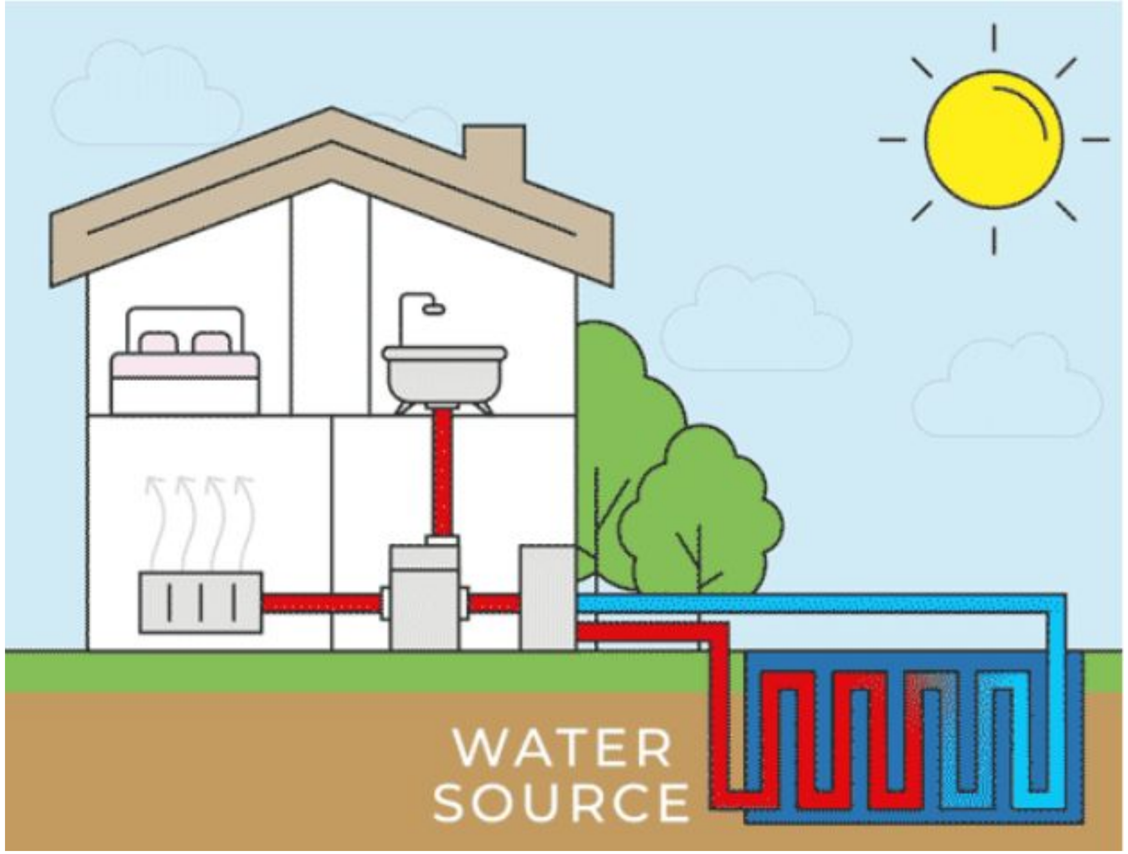
Require a water source such as a lake, river, which serve as the heat source or landfill.

Highly efficient heat exchange process.

Best applications:

- Warm climates
- Waste heat recovery (industrial processes, data centers, sewers)

Highly recommended for low-temperature district heating and cooling networks.




Source: www.thermalearth.co.uk

# Air-to-water heat pumps

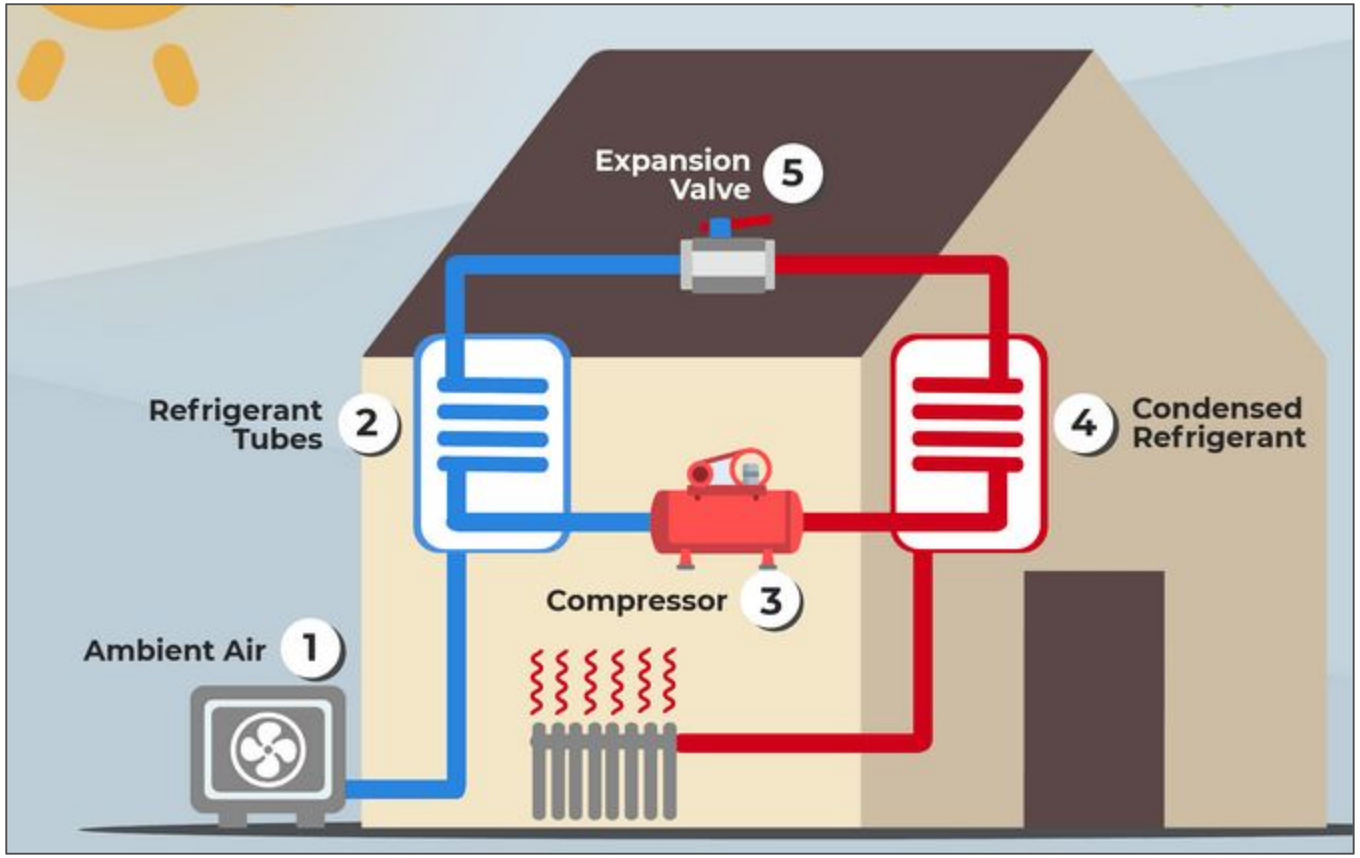
Air is the heat source and landfill.

Does not require connection to water or ground. Easy to install it almost everywhere.

The most common system in new or refurbished HVAC systems.

Available in models designed for installation on the ground, terraces, flat roofs, or mounted on walls (facades, though less aesthetically pleasing).

**Needs free air circulation**




Source: derekharrington.ie

# AIR-TO-AIR HEAT PUMPS

Air is the heat source and landfill

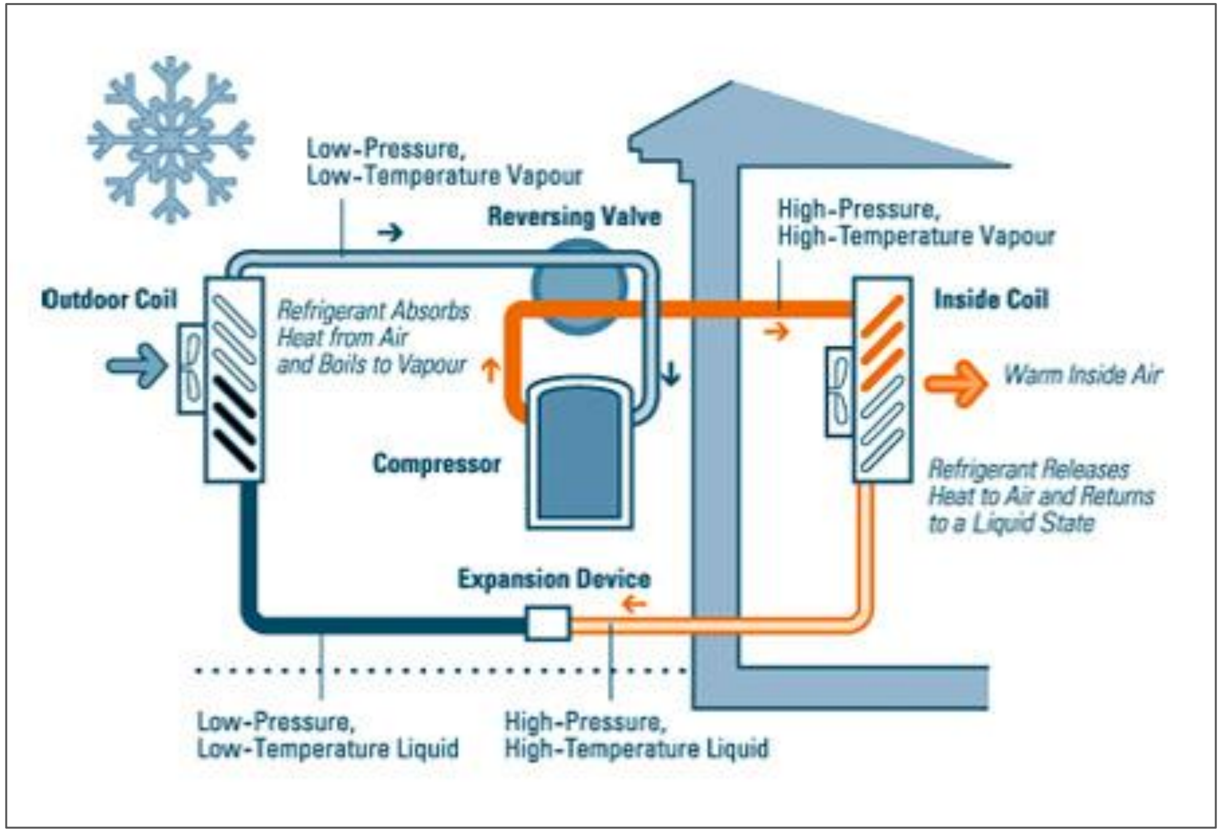
The easiest installation everywhere.

Recommended for small heat / cooling loads, warm climates.

Models adapted to be placed on the ground / terraces, on flat roofs, or hung on a wall (facades – less aesthetically pleasing)

The most cost-effective HP technology

**Needs free air circulation**

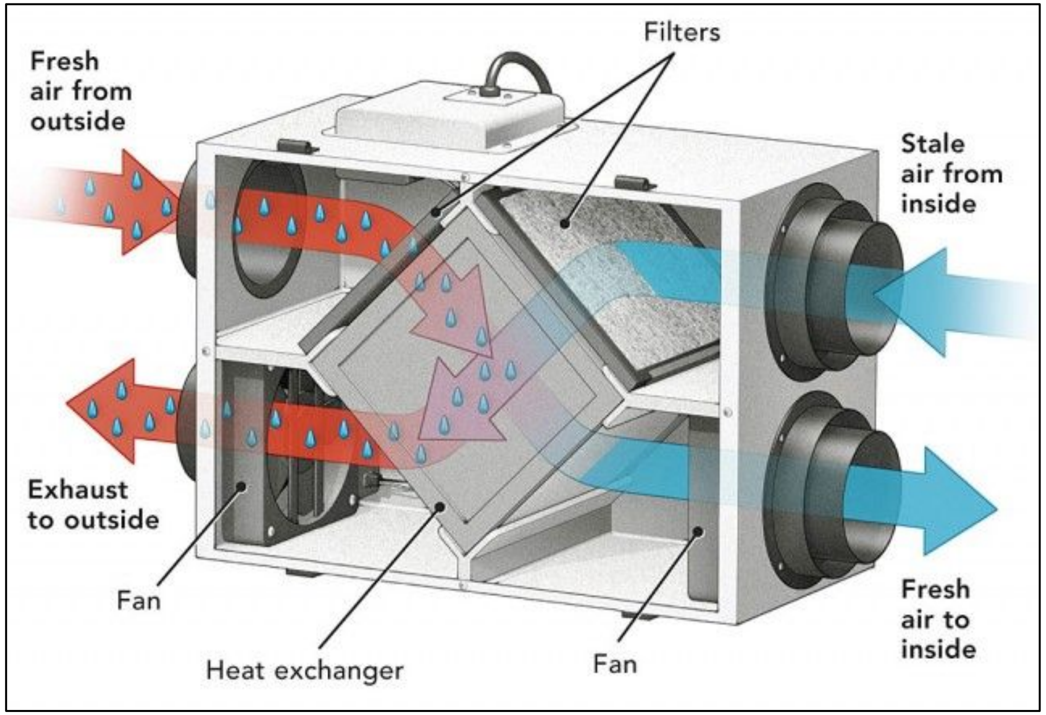



Source: communicty.bettercentury.org

# Other energy saving devices

**Heat recovery**: The energy from stale air in ventilation systems can be recovered and used to preheat or precool fresh air drawn from outside before it is expelled.

**Demand controlled ventilation:** Ventilation is regulated based on factors such as $CO_2$ concentration to ensure air quality meets the minimum standards outlined in local or national codes. Over-ventilation provides no added benefit and increases the energy required to heat or cool the fresh outdoor air.




Source: Certified Energy Manager training course. Association of Energy Engineers

# Other energy saving devices / practices

- **Variable speed drives (VSDs):** Regulate air and water flow in HVAC systems to minimize electricity use, often close to the theoretical minimum.
- **Free cooling:** Use naturally cool outdoor air during spring, autumn, and summer nights to reduce or eliminate chiller operation, saving energy.
- **Recommissioning:** Optimize set points, equipment performance, and schedules to align with building needs, often uncovering major energy savings through better operation.

LOCAL GoGREEN

# Case studies

# CASE STUDY 1. GIJÓN, ASTURIAS (SPAIN).
## PARTIAL RENOVATION OF A HISTORIC-PROTECTED BUILDING

<u>Initial situation</u>

- Built in 1914 (eclectic-modernist). Abandoned for 20 years. Energy label F
- Heating demand 119,9 kWh/sqm-yr. Energy consumption 222,2 kWh/sqm-yr
- $CO_2$ emissions 197 t/yr

<u>Achievements</u>

- Heating demand reduced by 82%. Total energy consumption reduction 87%
- Energy label A.

<u>How did they do it</u>

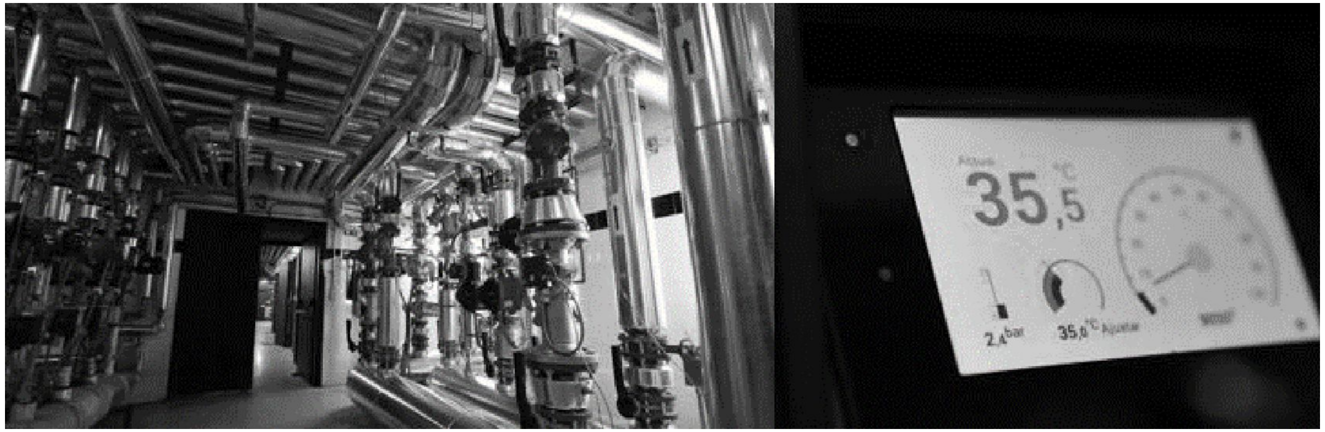
- Wall and roof indoor insulation (respecting facades). Minimizing thermal bridges.
- Windows substitution (timber and HQ glazing) keeping aesthetics
- New heating boiler and radiant floor. Heat pump for DHW

Source: Plan de climatización de municipios de más de 45.000 habitantes. Fundación Renovables

# CASE STUDY 2. IURRETA, BASQUE COUNTRY (SPAIN). ULTRA LOW TEMPERATURE DH&C NETWORK

## Initial situation

- Regional Basque police quarters: 14 buildings
- District heating: 2 diesel oil boilers (650 kW), distribution at 80/60ºC. Some buildings did have a connection to the DH
- Cooling: chillers / fancoils




Source: Plan de climatización de municipios de más de 45.000 habitantes. Fundación Renovables

## Achievements

- GHG emissions reduction 35%
- Renewable energy use increase in a 350%

## How did they do it

- DH converted into ULT DHC network: 40-45ºC. Buildings requiring higher temp. are fed by means of water to water HP to achieve 50-55ºC
- DHC extended to connect reaming isolated buildings.
- Building integrated low temperature thermal systems: use of solar thermal energy and waste heat for swimming pool heating.
- Adaptation of control strategies to ensure maximum use of BILST and Heat pump capacity.

# Thank you!

Website

Linkedin

X (Twitter)

YouTube

Instagram

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