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Training Programme:

Energy consumption and savings in households

Topic I

Co-funded by
the European Union

Energy consumption

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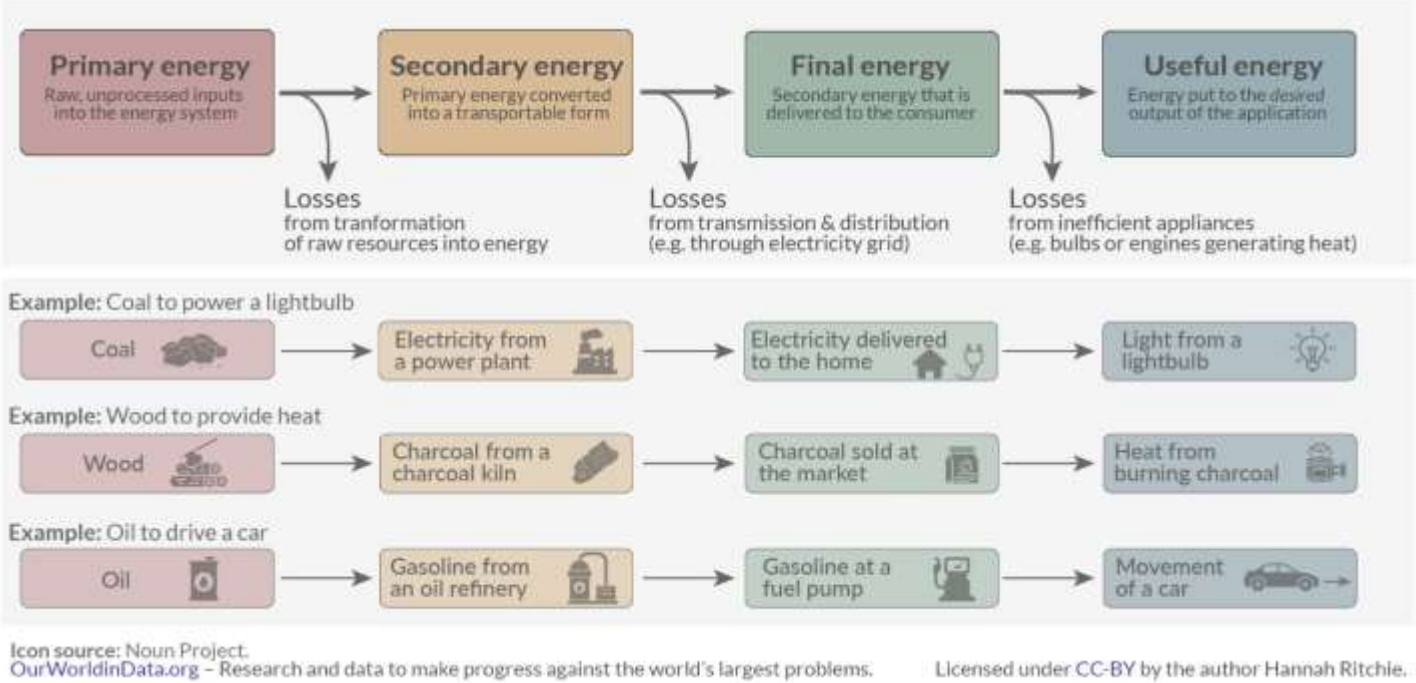
Fundamental concepts

Primary energy

It is any energy that exists "naturally" and has not been modified into another form by humans. Examples include both Renewable Energy Sources (RES) and fossil fuels.

Primary energy consumption

This is energy that includes the use and losses incurred during transformation into final energy.



(Source: OurWorldinData.org)

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Fundamental concepts

Examples

Primary energy

Final energy

Useful energy

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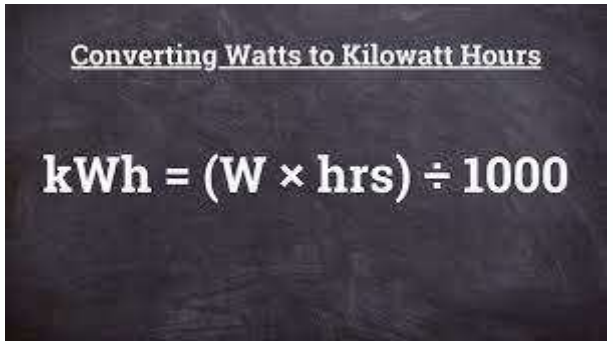
Unit of energy measurement

The kilowatt hour (kWh) is a unit of energy measurement. A kilowatt-hour is defined as the energy produced or consumed in one hour at a constant power of one kilowatt.

Example

If we have a 2-kilowatt (KW) air heater and run it for half an hour, then we will have consumed 2 KW * 0.5 h = 1 kWh (kilowatt hour)



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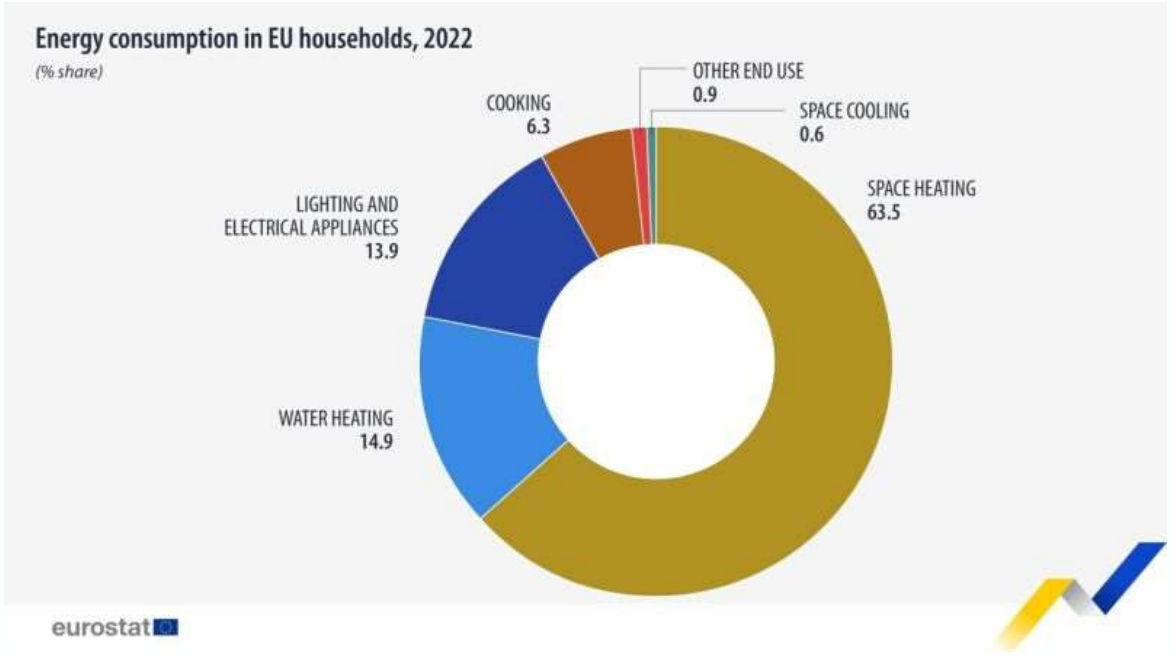
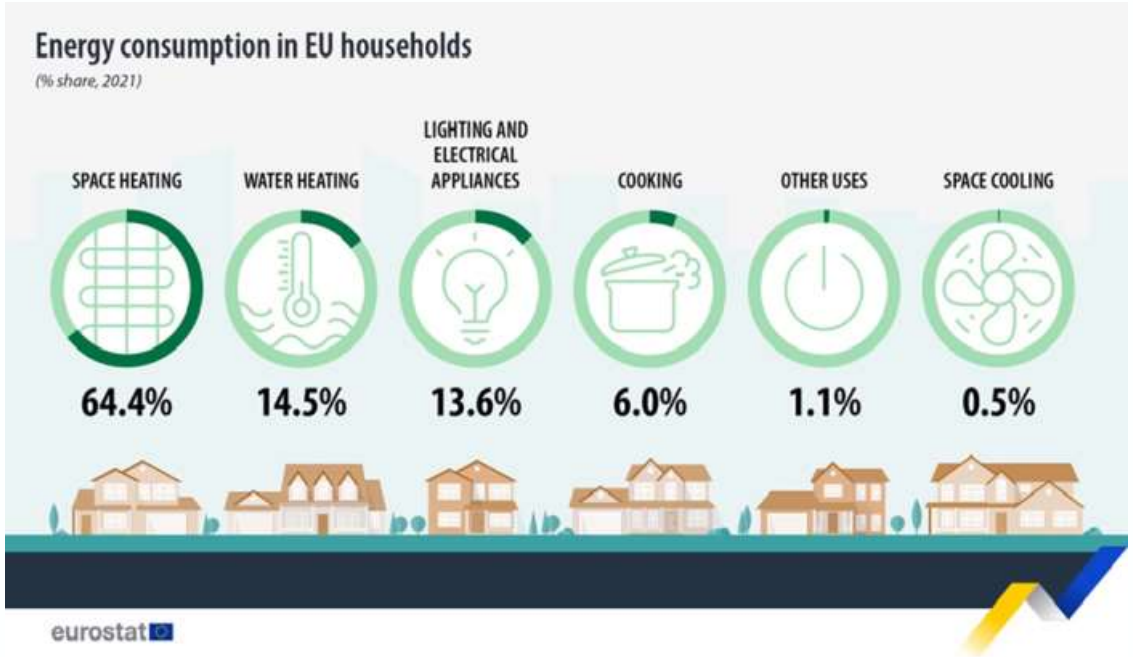
Household energy consumption in EU Member States



(Source: Eurostat 2024)



(Source: Eurostat 2021)

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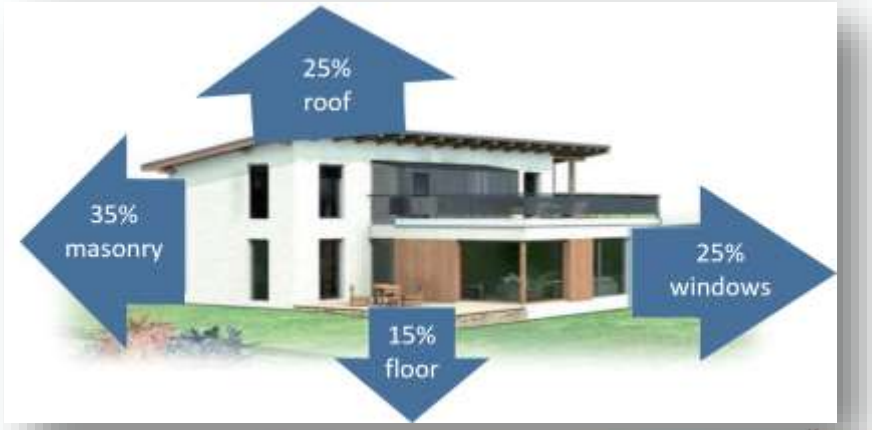
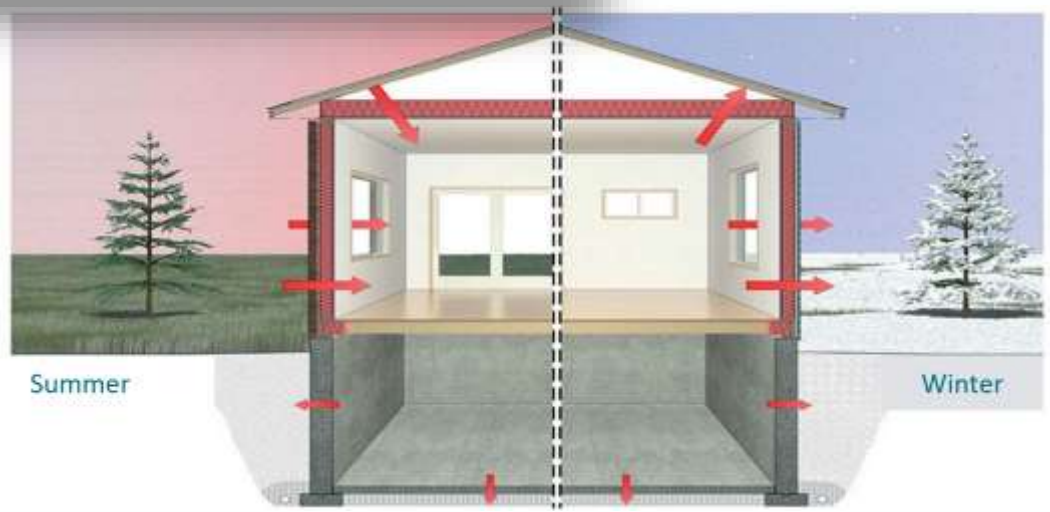
Building envelope & Heat losses

The purpose of the shell is to create a comfortable and pleasant indoor climate for the residents in all seasons of the year. Therefore, it must be constructed in such a way as to minimise heat transfer from the interior to the exterior and vice versa.

Thermal losses of the building envelope:



In the case of buildings, heat flows naturally from a warm space to a cooler one.



Through thermography, it can be seen that heat is lost in winter and cooling is required in summer, resulting in high costs for heating and cooling the building, respectively.

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Shell thermal insulation

The primary objective of these insulating materials is to reduce heat transfer through the masonry, thus reducing heat loss and consequently reducing energy demand for heating & cooling.

Table 1. Various thermal insulation materials

Materials	Density ρ (kg/m3)	Range of thermal conductivity coefficient λ (W/m^2K)	Use
Phenolic resin foam	30	0,30 – 0,45	Walls, roofs/ceilings
	35		Walls, roofs/ceilings, floors, masonry
Expanded polystyrene	15	0,4	Walls, roofs/ceilings
	20		Walls, roofs/ceilings, floors, masonry
	30		Walls, roofs/ceilings
Extruded polystyrene	25	0,3	Walls, roofs/ceilings, floors, masonry
	30		Walls, roofs/ceilings, floors, masonry
Hard polyurethane sheets	30/35	0,25 – 0,30	Walls, roofs/ceilings, floors, masonry
Fibrous materials: Fibreboard, Rockwool	-	0,35 – 0,50	Walls, roofs, floors, walls for external thermal insulation
Foam glass	100 - 150	0,45 – 0,5	Walls, roofs/ceilings, floors, walls for parking areas, and heavy vehicle parking

(Source: Eurostat 2021)

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$$Q = \frac{1}{\frac{1}{a_i} + \frac{d_1}{\lambda_1} + \cdots + \frac{d_v}{\lambda_v} + \frac{1}{a_a} + \frac{1}{a_e}} S(\theta_1 - \theta_2)$$

Where:

S in m^2: surface area of the wall.

θ_1 in °C: indoor temperature.

θ_2 in °C: outdoor temperature.

Q in W or kcal/h: amount of heat passing through the wall.

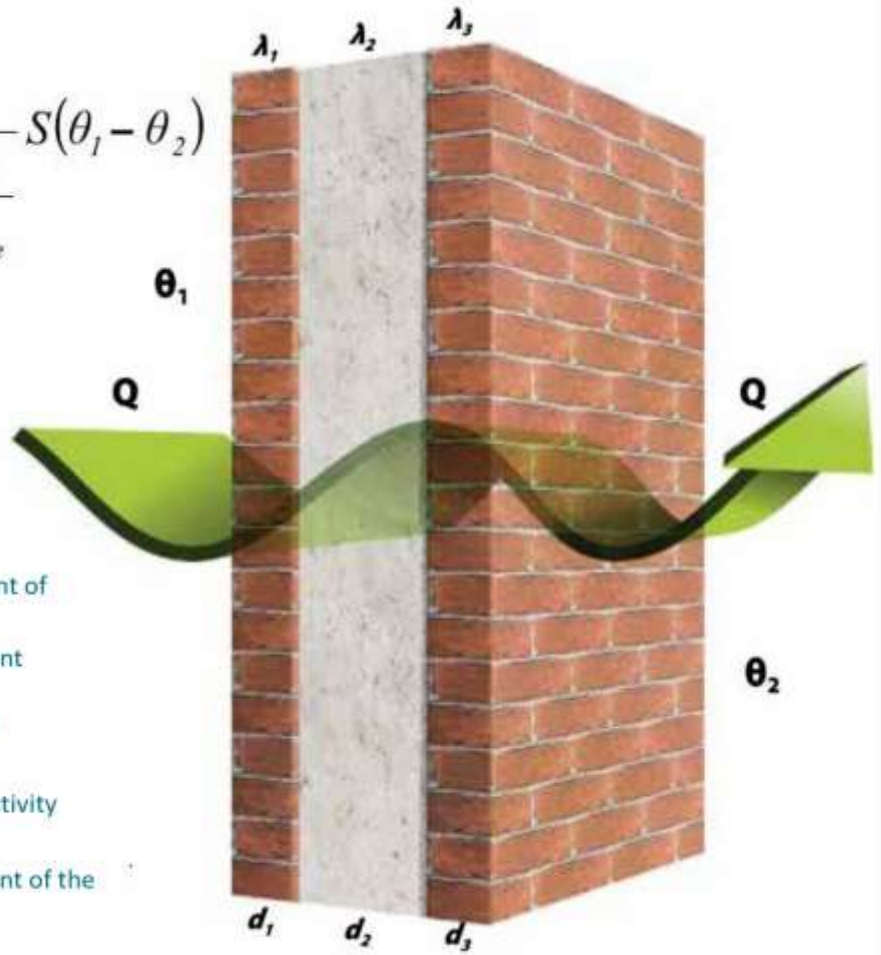
a_i in W/m^2K or $kcal/hm^2°C$: heat transfer coefficient of the internal fluid.

a_p in W/m^2K or $kcal/hm^2°C$: heat transfer coefficient of the external fluid.

d_1, d_2, d_3... in m: thickness of the various layers of the composite wall.

λ_1, λ_2, λ_3... in W/mK or kcal/hm°C: thermal conductivity coefficients of the layers' materials.

a_a in W/m^2K or $kcal/hm^2°C$: heat transfer coefficient of the air gap layer inside the composite wall.



Thermal transmittance (U -W/m^2K): Describes the amount of heat that flows through 1 m^2 of a building element when the temperature difference between the interior and exterior surfaces is 1K.

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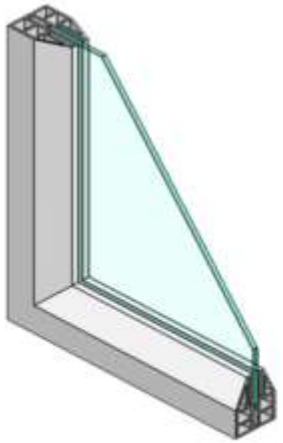
Glass panes - Windows

The openings (mainly windows) of buildings contribute to a large percentage of energy consumption for heating and cooling of the rooms, because a large amount of energy is transferred through them.

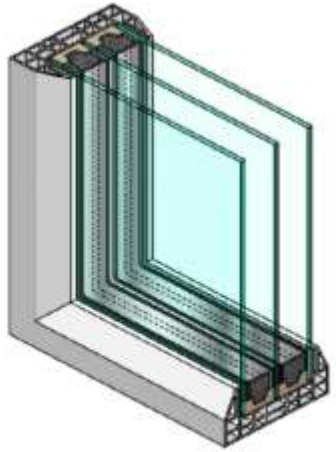
Types of glazing:

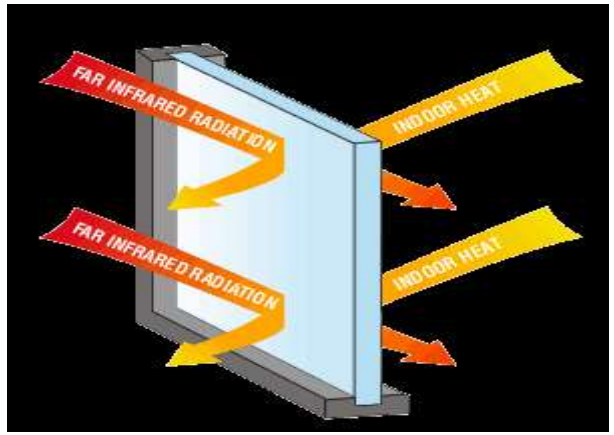
Single glazing



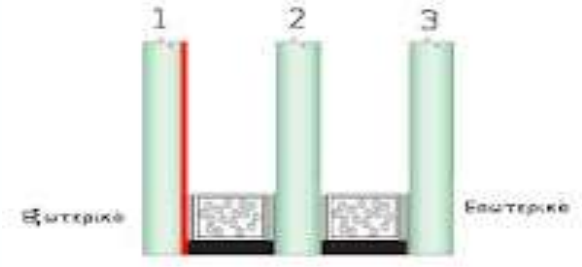
Double glazing

Triple glazing





Energy efficient (Low - e) - through special processing a special film is applied to increase thermal insulation - energy saving.



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Control of energy panels

Check of Low-e energy-efficient glass

Check of regular double-glazed glass

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Installation of systems for heating buildings

It is used for the production and distribution of thermal energy within the building.

Examples of equipment

Boiler-burner system with chimney: thermal energy production unit.

Circulator & piping network: distribution equipment.

Heaters: heat transmission system.

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Main generation systems for heating buildings

Heat pumps (heating/cooling)

LPG or gas boilers

Oil boilers.

Electric or oil-fired heaters

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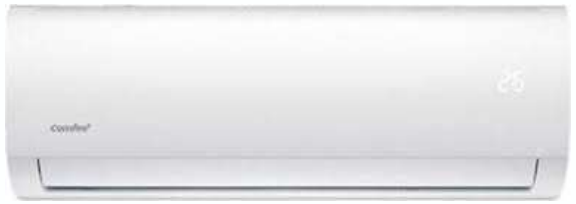
Installation of systems for air conditioning in buildings

Used for the air conditioning of rooms within the building.

Examples of equipment

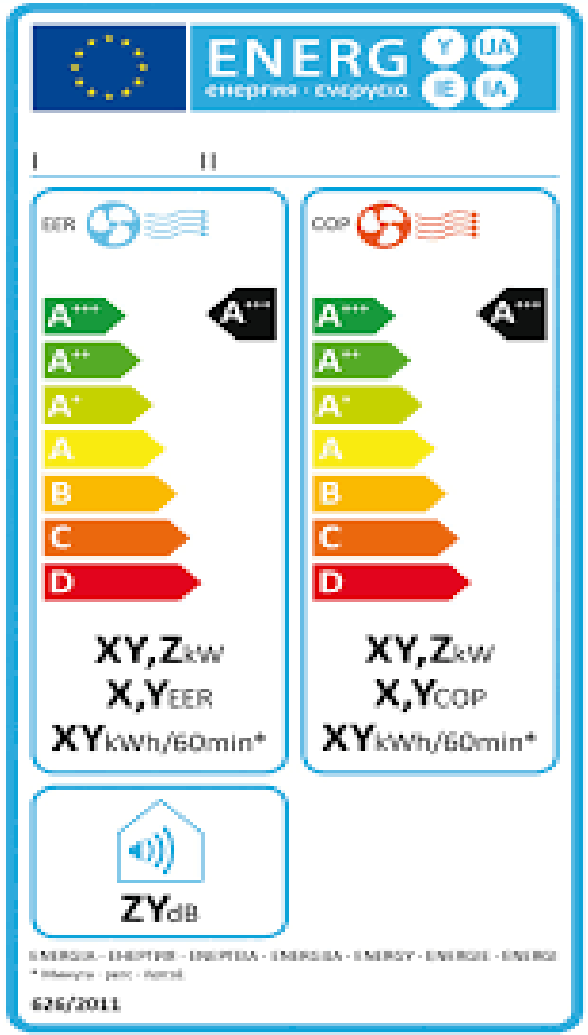
Wall air-conditioners.



Floor air-conditioners.

Portable air-conditioners.

Outdoor unit.



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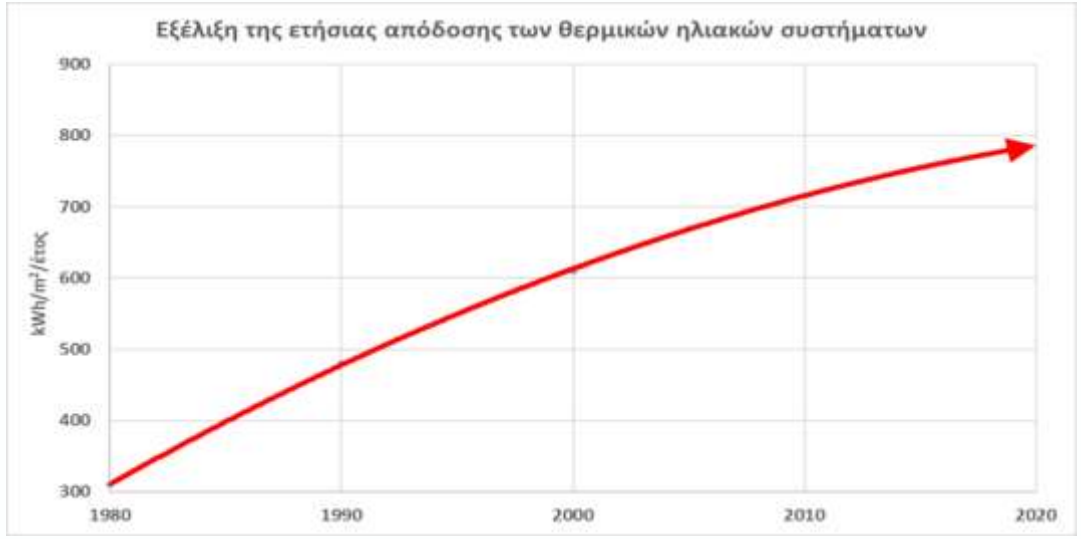
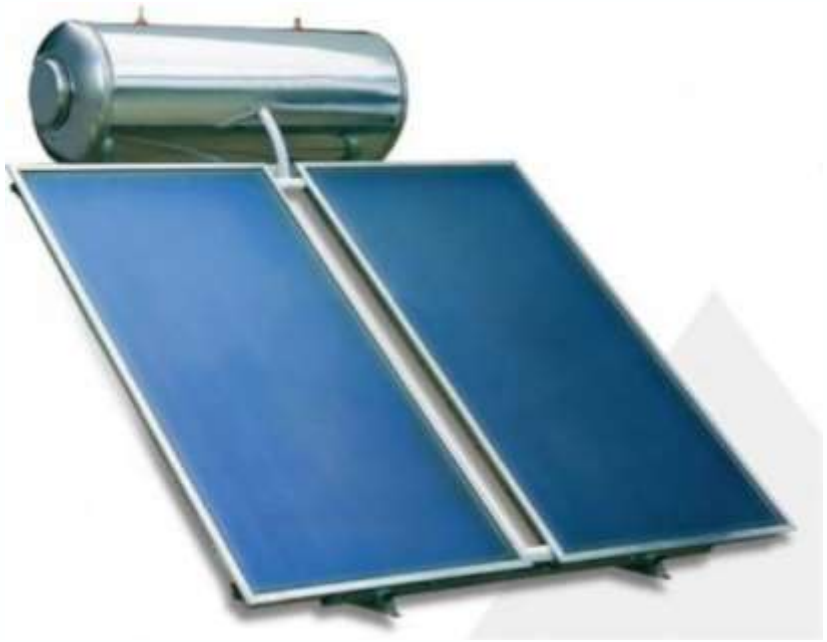
Renewable energy use in households

The aim is to accelerate the decoupling from fossil fuels for climate and economic reasons:

- Fuel savings
- Quick return of investment
- Reduced maintenance
- Reduced emissions





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Key parts of thermal solar systems for DHW

- Solar collectors.
- Hot water storage tank.
- Types of solar thermal collectors
  - Non-selective collectors.
  - Selective collectors with maximum solar absorption of 96%.
  - Vacuum collectors, zero losses, and suitable for areas with a cold climate and low sunshine.
- Solar thermal systems do not replace the heating produced by using other fuels, but they work as a supplementary contribution to the existing heating.

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PV Systems for electricity generation

They are systems that convert solar energy into electricity using cells (crystalline or polycrystalline silicon).

Basic Parts of Photovoltaic Systems

- Photovoltaic panels convert solar energy into electricity;
- Power regulation unit: inverters and charge controllers;
- Storage system - battery (optional): for storing excess electricity;
- Wiring: connection to PV and storage system;
- Monitoring system: PV system performance measurement equipment;
- Safety equipment: fuses, circuit breakers for safe operation.

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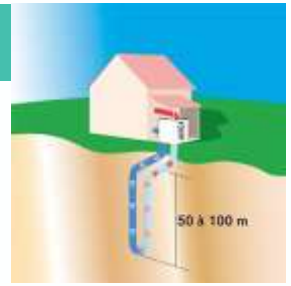
Geothermal energy - Geothermal heat pumps

- Used for heating, cooling, and DHW.
- It is the Earth's natural thermal energy that leaks from the subsoil to the surface.

Horizontal geo-exchangers

- Placed at a depth of more than 1,50 m.
- Ideal southern orientation (for heating).
- Large free surface area required

Vertical geo-exchangers



- Depth 60-110 m.
- Small required free surface.
- Increased efficiency.
- High initial cost.

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Energy-saving measures

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Energy saving

It is energy that is not wasted, not consumed, and therefore does not need to be produced. By saving energy, **we do not waste or suspend energy needs.** Saving energy **improves**, **not reduces**, the standard of living.

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Thermal comfort

It is the state in which a person does not want any thermal change of the internal environment.

Factors affecting thermal comfort

- temperature of gases and surfaces in the room;
- air humidity in the room;
- ventilation and freshness of the air in the room.

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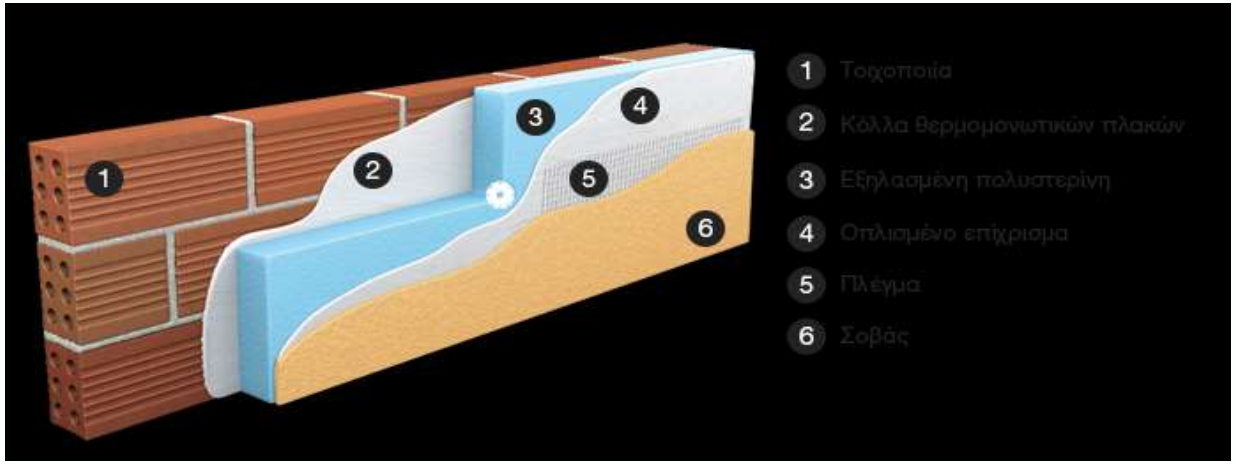
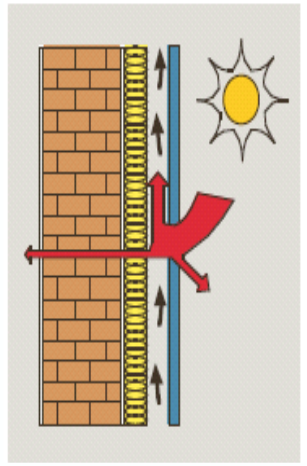
High & medium cost housing upgrading measures

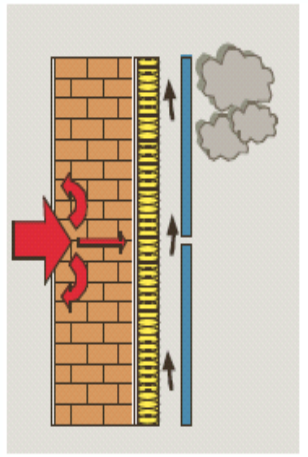
External thermal insulation

It is the optimal solution for limiting heat losses, since it utilizes the heat storage capacity of the walls.

By installing external thermal insulation, we can achieve energy savings of up to 60%.







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High & medium cost housing upgrading measures

External thermal insulation

It is a lower-cost solution compared to the external thermal facade and does not affect the external appearance of our house.

Its installation requires the commitment of usable space.

During the heating season, there is a significant risk of condensation of water vapour, so the installation of internal insulation should be combined with appropriate protection measures.

By installing internal insulation, we can achieve energy savings of up to 40%.

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High & medium cost housing upgrading measures

Ceiling/roof thermal insulation

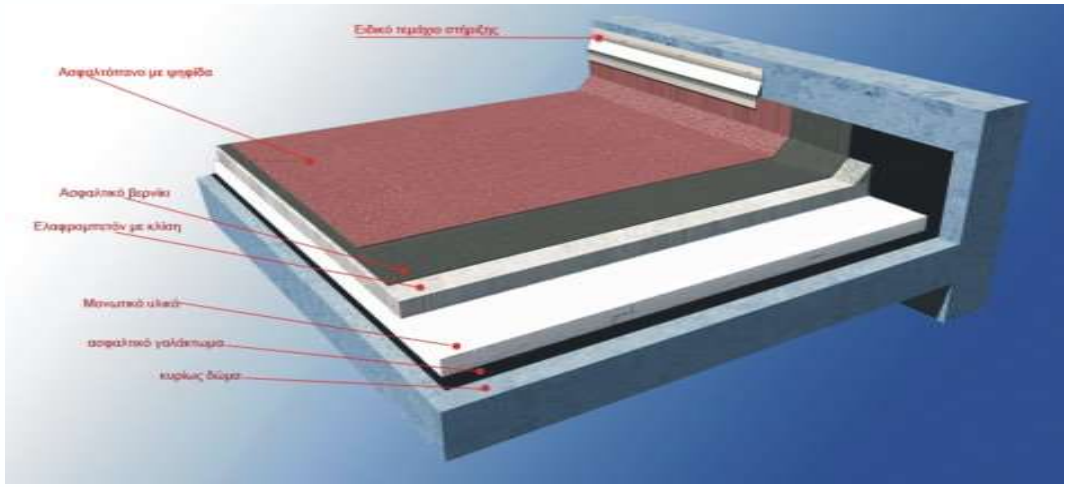
The roof is the most vulnerable structural element in a building.

The advantage of internal thermal insulation of a pitched roof is that the solution and re-installation of the tiles is not required, but also that the work (installation) does not depend on the weather conditions.

They relieve residents from overheating in summer and low temperatures in winter.

Protect the roof slab from corrosion and weather changes that gradually degrade it.

By insulating the roof, we can achieve energy savings of up to 30%. The average cost of such an intervention ranges from €30 to €40 per square metre.



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High & medium cost housing upgrading measures

Pilotis thermal insulation

The house pilotis is not directly stressed by the weather conditions, due to the fact that it is protected; however, its lack of insulation results in quite large energy losses, thus reducing the thermal comfort of the occupants.

Unpleasant sensations on the feet and condensation of water vapour are often observed in and on cold floors during the winter.

In winter, in an uninsulated apartment floor above a pilot, the heated indoor air, although at man's height (1.70 m), has a satisfactory temperature of 20-21°C, the flat has only 16-17 °C.

With the pilotis thermal insulation, we can achieve energy savings of up to 30%. The average cost of such an intervention ranges from 30 € to 40 € per square meter.

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High & medium cost housing upgrading measures

Replacement of glass panes/frames

Frames play an important role in energy consumption for heating and cooling rooms because a large amount of energy is transferred through them.

Metal frames should have a thermal break, i.e., a thermal insulating addition of polymer material between the outer and inner sides of the frame. By replacing the frames and glazing, we can achieve energy savings of up to 25%.

The average cost of such an intervention is estimated at:

- €250 to €300 per square metre for aluminium frames and double glazing.
- €200 to €250 per square metre for frames with a synthetic frame and double glazing.
- €350 per square metre for frames with a wooden frame and double glazing.

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High

Heating systems upgrade

Good thermal insulation of the boiler and pipe network - fuel savings of 4-6%

Replacement of an old burner with a new dual fuel (oil/gas) technology - fuel savings of 5-7%. From 2025, the sale and installation of heating oil burners will be prohibited. Five years later, i.e., from 2030, the use of heating oil, which will be mixed with biofuels at a rate of 30%, becomes mandatory (Climate Law - 4936/2022).

Replacement of an old boiler with a high efficiency boiler (>90%) - fuel savings of up to 15%.

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High & medium cost housing upgrading measures

Heating systems upgrade

- Use of heat pump, up to 50% energy improvement of the residence.
- The average cost of installing a new boiler ranges from €3,000 up to €8,000 in the case of installing a heat pump.
- Heating system maintenance (boiler/burner).
- Issuance of a maintenance sheet for the boiler/burner installation by a licensed technician (cost €100) – fuel savings up to 10%.

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Low and/or zero-cost housing upgrading measures

Heating – Behavioral measures (indicative)

- We set thermostats to the correct temperature. The ideal temperature for winter is 19–20°C. The air conditioner temperature for cooling should be 25–26°C. In general, prefer using the "auto" mode on air conditioners.
- We periodically bleed the radiators.
- We avoid covering the radiators or placing furniture in front of them.
- We regularly and carefully check for possible heat leaks. Improving airtightness can be done relatively easily by placing self-adhesive sealing tape around window frames. Door bottoms can be fitted with draft stoppers in contact with the floor.
- Energy savings in consumption from 10% to 15%.

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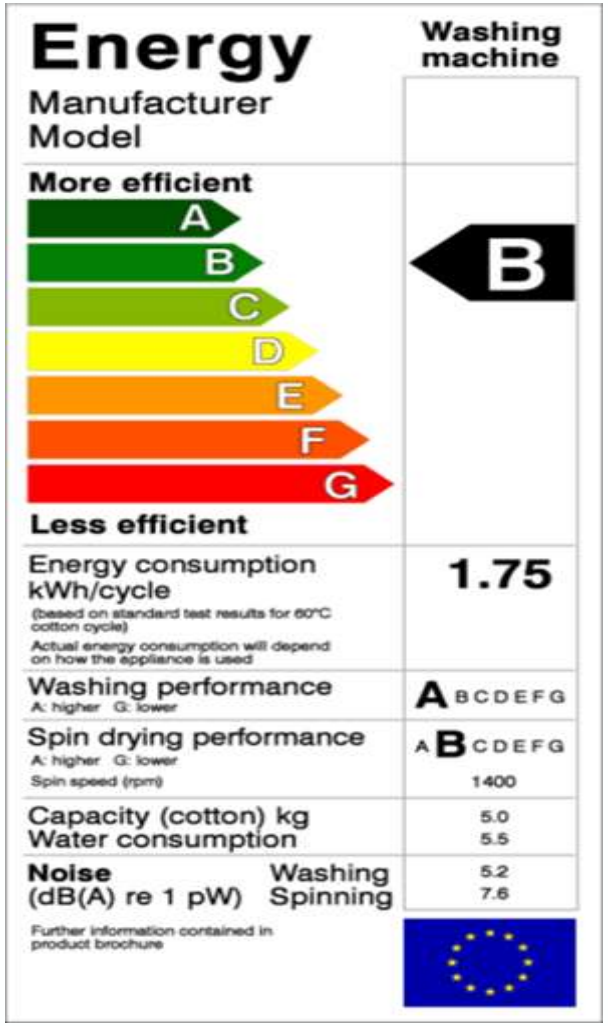
Low and/or zero-cost housing upgrading measures

Lighting/White appliances

We replace ordinary light bulbs with new, energy-efficient ones, a 50% reduction in energy. An average Greek household spends 6.5% or 40€ of its total annual electricity consumption on lighting.

Energy labelling of appliances. The label generally includes seven (7) energy efficiency classes, ranging from G (red colour indicating a low efficiency product) to A (dark green colour indicating a highly efficient product), depending on the type of product.



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High & medium cost housing upgrading measures

Electricity

- We install a solar water heater - a typical home installation for a family of four costs no more than 1,000 € and saves up to 1,400 kWh per year - about 600 euros at today's prices.
- Replacing an energy class C washing machine with an energy class A+ or A++ washing machine leads to energy savings of 40%, around €25/year.
- € Replacing an energy class B refrigerator with an energy class A+ refrigerator results in energy savings of 41%, around 35 €/year.
- Replacing an electric cooker with a medium-capacity stove of energy class C with an energy class A stove results in energy savings of 27%, about 65 €/year.
- We install motion sensors and/or timers in areas where permanent lighting is not needed and for external lighting.

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Low and/or zero-cost housing upgrading measures

Electricity (indicative)

- Avoid placing the refrigerator near heaters or exposing it to sunlight. Keep the refrigerator's storage area at 4-5°C and the freezer at -16°C.
- Use the washing machine when it is full without overloading it, and wash at low temperatures.
- We disconnect various electrical appliances from the mains because they still consume energy even when they are switched off.
- We make the most of the domestic night-time tariff.
- We set the thermostat of the electric water heater at 45-50°C, turn on the electric water heater as needed, and do not leave it on unnecessarily.

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Thank you!

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