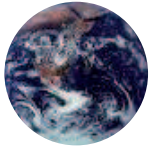


Understanding and controlling the energy in a building



Focus on the energy consumption of a building

Energy consumption of a building

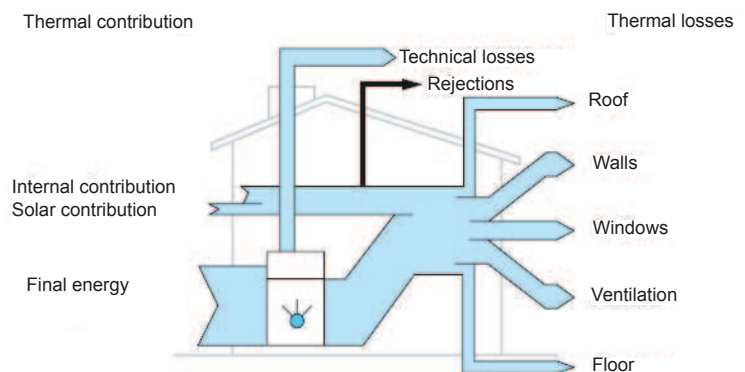
Where does the energy go inside a building?

Energy can be used for:

- **Creating a comfortable atmosphere** (temperature, light, fresh air)
- **Providing the necessary utilities** for the activities of the occupants (mostly electricity and domestic hot water).

Measuring and analysing this consumption is a necessary step but a difficult one considering the variety of buildings, their uses as well as the interaction of different components within a building.

Main energy flows



The following values are expressed in primary energy and taking into account that heating is produced by combustion or a heat pump.

Heating (average French climate)

15 → 400

15 kWhpe/m²/year
very efficient envelope
very efficient installation
moderate use
400 kWhpe/m²/year
weak insulation
old equipment
poorly managed use

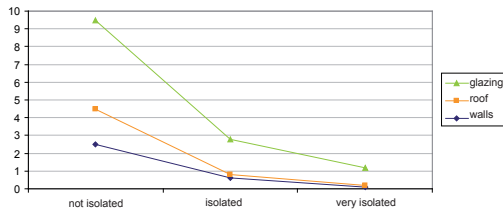
Heating consumption

The amount of energy required for heating can vary between 15 & 400 kWhpe/m²/year for a typical French climate.

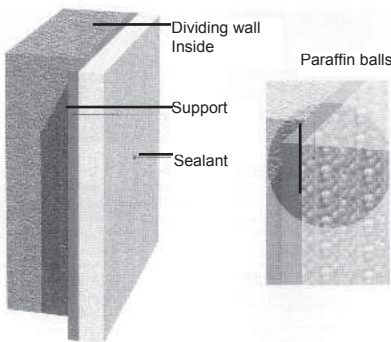
It depends on the envelope, the performance of the heating system (efficiency of the generator, the distribution network & and the heating equipment), the ventilation and uses.

Energy consumption of a building

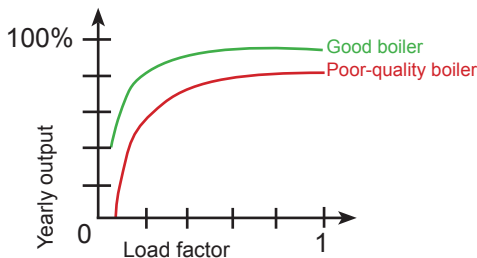
>>Where does the energy go inside a building?



Progress of insulation: evolution of the U parameter for gauging thermal transfers (W/m2.K)

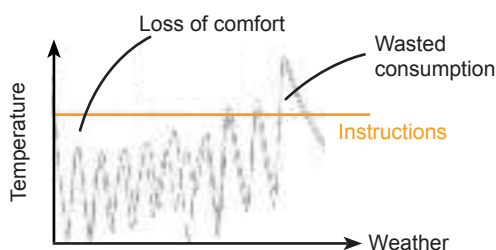


New materials (phase change)



Example of annual output depending on load factor.

(N.B.: the annual output also depends on the oversizing rate)



Temperature regulation rate: a discrepancy in temperature with the instructions reduces comfort and distributes 'wasted' energy

■ The influence of the envelope

It is characterised by the insulation, the inertia (and to a lesser degree by the permeability).

Insulation: reduces thermal exchanges between the outside and the inside. Progress in the insulation of wall, roofs, and windows, on the most thoroughly insulated buildings, makes thermal bridges a priority.

Inertia: characterises the ability of a building to accumulate and to conduct heat. It depends, in simple terms, on the mass of the walls, and therefore a priori on their thickness. However, we must note the appearance of new so-called "phase changing" materials which enable to achieve a high level of inertia with thin walls.

The inertia changes particularly depending on how intermittences are managed:

- Low thermal inertia makes it possible to heat/cool rapidly.
- High inertia makes it possible to store heat and particularly to use passive solar energy.

■ Influence of the heating system

A heating system comprises:

- One or more "source" appliances or more precisely energy transformers (heating oil, gas, electricity, wood, coal): boiler, electric resistance, heat pump, solar collector,
- A distribution network,
- Heat distribution devices
- And possibly a thermal accumulator.

The overall output of the system is calculated by the ratio of useful heat generated/primary energy consumed. It depends:

- on the nominal yield of the source appliance, but also the load factor of the appliance and the variation in output (depending on the dimensions)
- on thermal losses in the distribution network that can only be partially recovered
- on the consumption of the pumps and ventilators
- on the type of energy used: making the distinction between final costs and the energy efficiency of the source
- on the use of "free" energy (solar collectors, fuel cells)
- on the efficiency of the heating devices: performance of heat exchangers and controls

Energy consumption of a building

>>Where does the energy go inside a building?

Cooling

0 → 400

0 KWhpe/m²/year
no active cooling system
favourable climate
low level of demand
400 KWhpe/m²/year
premises with high internal input
unfavourable climate
no bio-climatic design

■ Influence of ventilation

The heating of fresh air produced by ventilation represents:

- 30 to 40 % of the needs of a building for housing and offices
- 45% to 80 % of heating needs for densely-occupied premises (schools, community centres, etc.).

■ Influence of temperature setting

A one degree difference in temperature setting causes an increase in heating consumption of 5 to 10%.

Cooling consumption

Consumption for cooling premises varies a great deal. It depends on the envelope, the climate, the performance of the appliances and systems, demand in terms of air conditioning and, to a lesser degree, on internal factors.

■ Influence of the envelope

As for heating, the performance of insulation is a key element. The envelope is also a means of controlling direct input of solar energy by covering windows and/or by using shades.

■ Influence of the cooling system

There are two types of system:

- individual units for each part of the building,
- a central system that includes a battery of cooling units and a distribution circuit that uses air or water.

In both cases, the basic principle is the same: a refrigerated circuit equipped with a compressor absorbs the heat in the air inside the building and releases it outside.

However, cooling systems can have highly uneven levels of performance due to the intrinsic quality of cold air production (design of the exchangers & monitoring, performance of the compressor), but also depending on its maintenance (cooling fluid leaks, frosting, compressor wear and tear, etc.).

Example of performance for various types of appliance.

Energy Efficiency = ratio of useful refrigerating energy over electrical energy used (COP).

Equipment type	Condensation	Energy Efficiency
Production group of piston-driven chilled water	Air	2,8
	Water	3,6
Production group of screw-driven chilled water	Air	3,5
	Water	4,6
Production group of centrifuge chilled water	Air	3,0
	Water	4,2

Energy consumption of a building

>>Where does the energy go inside a building?

Residential ECS

15 → **50**

15 KWhpe/m²/year

50 KWhpe/m²/year

Residential ventilation
"traditional" mechanical system

5 → **15**

5 KWhpe/m²/year

15 KWhpe/m²/year

Residential lighting

5 → **15**

5 KWhpe/m²/year

15 KWhpe/m²/year

Tertiary office lighting

20 → **60**

20 KWhpe/m²/year

60 KWhpe/m²/year

Domestic hot water consumption

The production of hot water depends on water needs and the temperature required (which can vary depending on use).

Ventilation consumption

Here, this corresponds to the consumption of the ventilators. The energy costs for heating (or cooling) fresh air are taken into account in the section "consumption for heating" (or cooling).





It depends mainly on the dimensioning in power of the ventilators, the operation time and the energy efficiency of the motor control.

Lighting consumption

It is highly variable according to the type of occupation (residential, offices, shops, etc.), the availability of natural light and the efficiency of the lighting system (which in turn depends on the type of lamp, its control and also the premises itself, in particular the colour of the walls)

■ Influence of the efficiency of lamps

Light efficiency (lm/W) depending on type of lamp

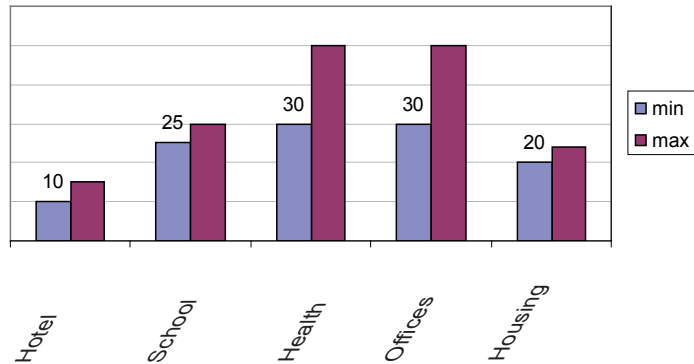
	Light efficiency (lm/W)	Average performance time (h)
 Standard incandescent lamp (40w)	14	1000
 Tungsten halogen lamp (60-500)	14	2000
 Standard florescent tubes (18-58 W)	58	8000
High-output florescent tubes	75	8000
 Compact lamps (electronic integrated power source(5-32W)	60	8000

Energy consumption of a building

>>Where does the energy go inside a building?

■ Influence of the type of occupancy

Some consumption ratios for lighting by use of the premises:



Electricity consumption (other than lighting)

Consumption is of course linked to the type of activities taking place in the buildings.

For domestic activities we make the distinction between large appliances (washing machines, refrigerators and freezers, ovens) and small appliances (occasional use, various large appliances and a wide variety of types of appliances)

As an example, the following chart provides some average consumption figures (in electrical KWh/year)

Residential uses

20 → **60**

20 KWhpe/m²/year
60 KWhpe/m²/year

Tertiary uses
vary a great deal

Indicative types of domestic-use electricity consumption

Equipment	2 to 3 people (KWh/year)	5 to 6 people (KWh/year)
Refrigerator	200 à 300	300 à 400
Freezor	250 à 350	360 à 550
Small household appliances	250 à 500	400 à 600
Cooking	700 à 1 000	1 300 à 1 500
Washing machines ..	500 à 700	800 à 1 200

It is important to note the consumption in standby mode:

For 'brown' goods (televisions, hi-fis, cassette players, computers, etc.), switching off these appliances can save 70% on energy consumption.

How can the energy consumption of buildings be reduced?

>> In summary, the key points

■ By reducing the basic requirements of buildings

- by controlling thermal losses:
 - quality of insulation and windows
 - optimisation of ventilation (controlling ventilation outputs, recovering the energy in the extracted air)

>> impact on consumption for heating and cooling

- by harnessing solar energy:
 - design of the building (orientation, inertia)
 - solar protection and blinds

>> main impact on consumption for lighting and cooling

■ By using energy more efficiently

- by using the right amount of heating, cooling, ventilation and lighting where and when it is needed
- by reducing losses linked to distribution (fluids, electricity) and the production of thermal and luminous energy

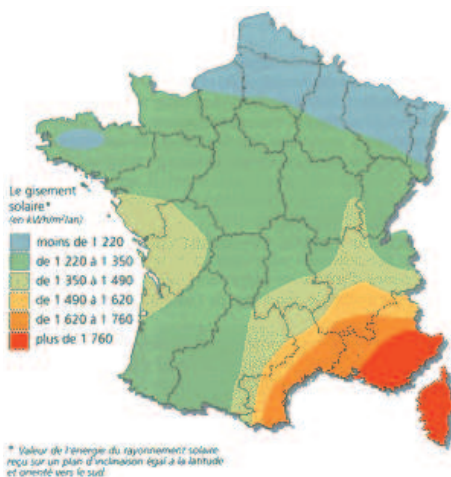
>> impact on total consumption

■ By using environmental resources

The environment is a major source of energy.

These sources include the sun (for energy and light), air (temperature and humidity), water (water table, rivers, etc.), the earth's heat (geothermal), wind, and biomass.

the time lag between the availability of the source and the energy needs of buildings is a major difficulty. A combination of energy sources and/or storing energy should be envisaged.



French map of incidental solar energy (varies between 1000 and 1500kWh/year/m²: around 10 times the primary energy consumption of current buildings.

Conducting the improvement process

In France, new and recent buildings have reached performance levels of **150 KWhpe/m²/year**

The remaining real estate (**70% of buildings**) has an average performance of **400 KWhpe/m²/year**

To improve this average over the coming decades, we will need to:

- Improve the envelope and equipment of all the old buildings,
- Dramatically improve the performances of new buildings:
 - Take care of thermal bridges
 - Repair leaks in the envelope
 - Adapt heating systems to limited but highly variable needs in heating
 - Reduce consumption for domestic hot water and other uses (which is now higher than consumption for heating)
 - Deal with the problem of summer and mid-season comfort
 - Exploit the potential of renewable energies (as the energy needs of buildings have decreased thanks to the various efficiency improvements, the potential of renewable energies becomes higher than consumption).

Improvement in performance in the residential sector

Source: CSTB

