Graphenano
nanotechnologies

Comparative study of the heating power and the energy and environmental savings obtained by using the Floor Graphene® product in the construction of houses in Madrid

HEAT POWER (W)[1] = A · B · C · D · 85

A. Area to be heated.

The area in m^2 of the room to be heated. It is important to note that the height should not exceed 2.5 m.

B. Orientation.

The orientation of a house depends to a greater or lesser extent on where it receives the most or least sunlight.

- North: (Value= 1.12)
- South: (Value=0.92)
- East: (Value=1)
- West: (Value = 1)

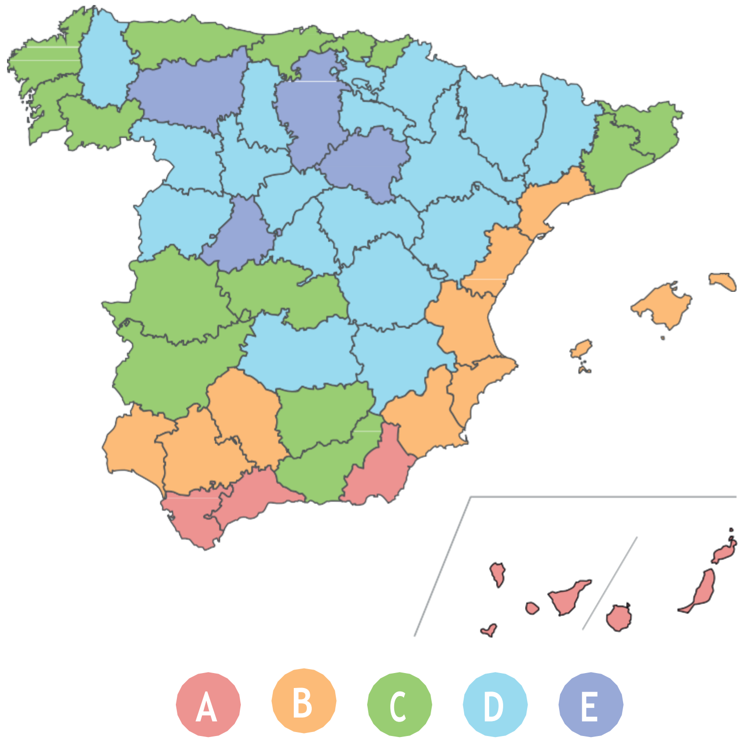
C.Insulation

The insulation of the dwelling will determine the energy efficiency of the room.

- Good insulation. Double window and partition (Value = 0.93)
- Single insulation: Single window and double partition or double window and single partition (Value = 1)
- No insulation: Single window and single partition (Value = 1.10).

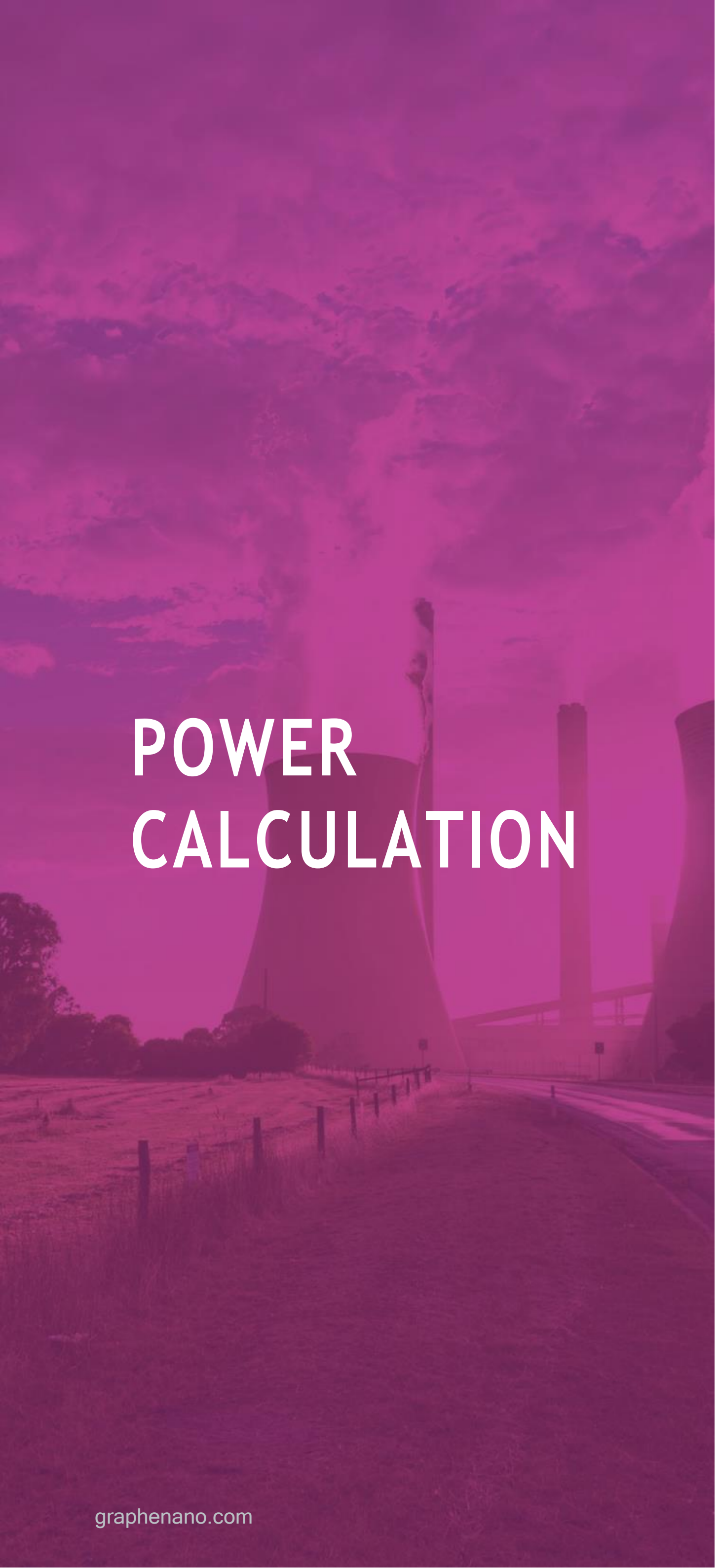
D. Climatic zone

Depending on the location of the dwelling, climates can be more extreme and require more heating capacity. This territorial division was established by: "Código Técnico de la Edificación"[2].



- Zone A:(Value = 0.88)
- Zone B:(Value = 0.95)
- Zone C:(Value = 1.04)
- Zone D:(Value = 1.12)
- Zone E:(Value = 1.19)

[1] https://www.gasfriocalor.com/blog/calefaccion/calculo-de-potencia-calorifica-para-tu-casa/
[2] https://www.codigotecnico.org/DocumentosCTE/AhorroEnergia.html



POWER CALCULATION

The study is based on the assumption of a room of 125 m^2 and 2.5 metres in height facing west, located in the southern part of the Pyrenees. We will assume conventional insulation with a single partition wall and double glazing constructed with conventional cement mortar.

HEAT POWER (W) = A · B · C · D · 85 = 125 · 1 · 1 · 1.12 · 85

HEAT POWER (W)* = 11900 W = 11.9 KW

Data.

- A = 125 m^2
- B = West = 1
- C = Insulation = 1
- D = Climatic zone = 1.12

*There can be a variation of between 64 W/m^2 to 125 W/m^2.

ELECTRICITY COSTS AND CARBON FOOTPRINT

For the calculation of the energy cost, an annual scenario will be established in which the thermal installation is kept on for 10 hours every day during the 6 months of autumn and winter (~1800 hours). It should be noted that the efficiency of aerothermal plants is around 300%, i.e. each kW of electricity is equivalent to 3kW of thermal energy (COP=3). The average cost per kWh in Spain in 2022 will be 0.205 €/kWh1**.**

ANNUAL COST (€) = Heat power (kW)/COP · Consumption time (h) · Electricity cost (€/kWh) =11.9 kW/3 · 1800 h · 0.205 €/kWh

ANNUAL COST (€) = 1.463,70 €

Electricity consumption leads to the emission of carbon dioxide into the atmosphere. The calculation of CO2 emissions takes into account the emissions generated by each of the energy sources used in the electricity mix. In the year 2022, the average emissions were 0.390 kg CO2/kWh2**.**

EMISSIONS (kg CO_2) = Heat power (kW)/COP · Consumption time (h) · Mixed electricity emissions (kg CO_2/kWh) = 10,1 kW/3 · 1800 h · 0.390 kg CO_2/kWh

CO_2 EMISSIONS (KG CO_2) = 2.784,60 KG CO_2

[1] https://es.statista.com/estadisticas/993787/precio-medio-final-de-la-electricidad-en-espana
[2] https://energia.gob.es/desarrollo/EficienciaEnergetica/RITE/Reconocidos/Reconocidos/Otros%20documentos/Factores_emision_CO2.pdf

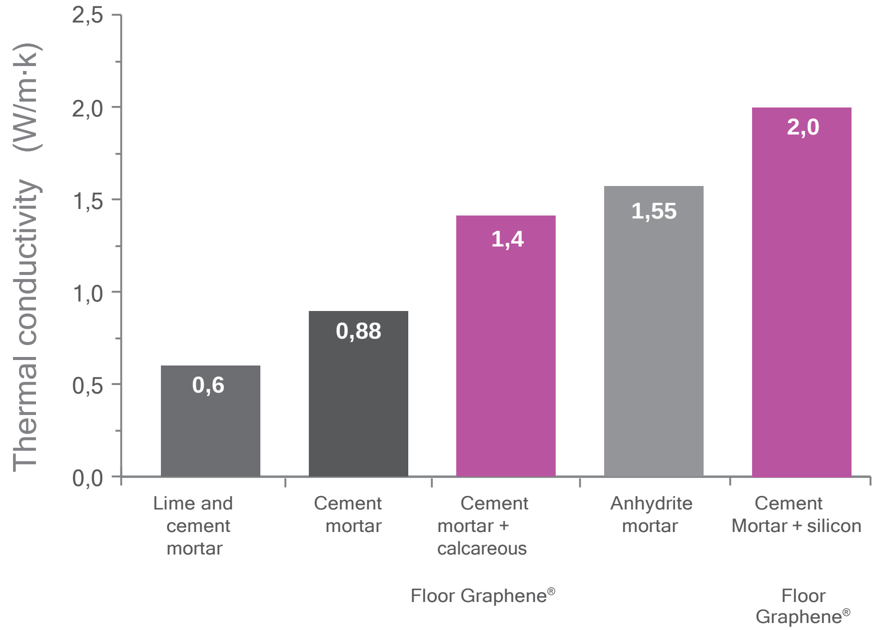
COMPARISON OF MATERIALS

One of the most important variables for studying heat output is the thermal conductivity (k) of materials. The higher the thermal conductivity, the better heat conductor it is and the more thermal energy it is able to radiate.

$$Q = A \cdot K \cdot \Delta T/$$

Thermal conductivity values of different materials:

- Lime mortar[1] = 0.6
- Cement mortar[1] = 0,88
- Cement mortar + calcareous aggregate + FloorGraphene® = 1,4
- Anhydrite mortar[1] = 1.55
- Cement mortar + silicon aggregate + FloorGraphene® = 2



$$\text{ENERGY SAVINGS} = \left(\frac{\text{THERMAL COND.}_{\text{previous material}}}{\text{THERMAL COND.}_{\text{current material}}} - 1\right) \cdot \text{HEATING POWER (KWH)}$$

COMPARISON OF MATERIALS

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Material	k (W/m·k)	Heat power (Wh)	Energy Efficiency
Lime and Cement Mortar	0,6	17.453	- 31,8 %
Cement mortar	0,88	11.900	0,0
Cement mortar + calcareous aggregate + Floor Graphene	1,4	7.480	**+ 59,1 %**
Anhydrite mortar	1,55	6.756	+ 76,1 %
Cement mortar+silica mortar + Floor Graphene	2	5.236	**+127,3%**

* Note: In order to analyse the data analytically and objectively, the data provided by the cement mortar is taken as a reference, as it is the most widespread and common in applications.

ECONOMIC AND ENVIRONMENTAL SAVINGS

ANNUAL COST (€) = Heat power (kW)/COP · Consumption time (h) · Electricity cost (€/kWh)

CO_2 EMISSIONS (KG) = Heat power (kW)/COP · Consumption time (h) · Mixed electricity emissions (kg CO_2/kWh)

Material	Cost (€/year)	Economical savings (€/year)	CO_2 Emissions (kg/year)	Environmental savings (kg CO_2/year)
Lime and Cement Mortar	+2.146,76€/year	+683,06€/year	4.084,08	+1.299,48kg CO_2/year
Cement mortar	1.463,70€/year	0,0	2.784,60	0,0
Cement mortar + calcareous aggregate + Floor Graphene	920,04€/year	-543,66€/year	1.750,32	-1.034,28kg CO_2/year
Anhydrite mortar	831,00€/year	-632,70€/year	1.580,93	-1.203,67kg CO_2/year
Cement mortar + silica mortar + Floor Graphene	644,03€/year	-819,67€/year	1.225,22	1.559,38kg CO_2/year

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