

Embodied energy in façade retrofit systems with different thermal insulation materials

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Introduction/Background

In the European Union (EU), the building sector accounts for more than 40% of the energy consumption and environmental impacts [1]. Existing policies promote energy efficiency and renewable energy use in buildings in order to reduce the operating energy.

In this sense, the retrofitting of the aged building stock is an opportunity to implement such reduction. But these activities suppose an increase of the total life cycle energy of the building, since the energy stored in the building materials during their life cycle, the embodied energy, has to be taken into account.

Goal & Scope

The aim of the study is calculate the energy incorporated to the building due to the retrofitting of 1m² of façade by means of LCA methodology with a cradle to site approach (Figure 1). In addition, the combination of different types of insulation material is assessed in order to compare the influence of them in the global impacts.



Figure 1. Diagram of the façade life cycle and system boundaries

Materials & Methods

Two façade-systems for retrofitting are analysed (Figure 2):

- ETICS (External Thermal Insulation Composite Systems)
- Ventilated façade

Moreover, due to the relevance of the thermal insulation materials in the energy performance, 5 different insulation types have been analysed for each system:

- Expanded polystyrene (EPS)
- Stone wool (SW)
- Extruded polystyrene (XPS)
- Glass wool (GW).
- Polyurethane (PU)

Simapro 7.3 software and ecoinvent 3.1 database have been used to calculate the environmental information related to the processes involved with materials [3,4]. The embodied energy has been calculated according the Cumulative Energy Demand method.

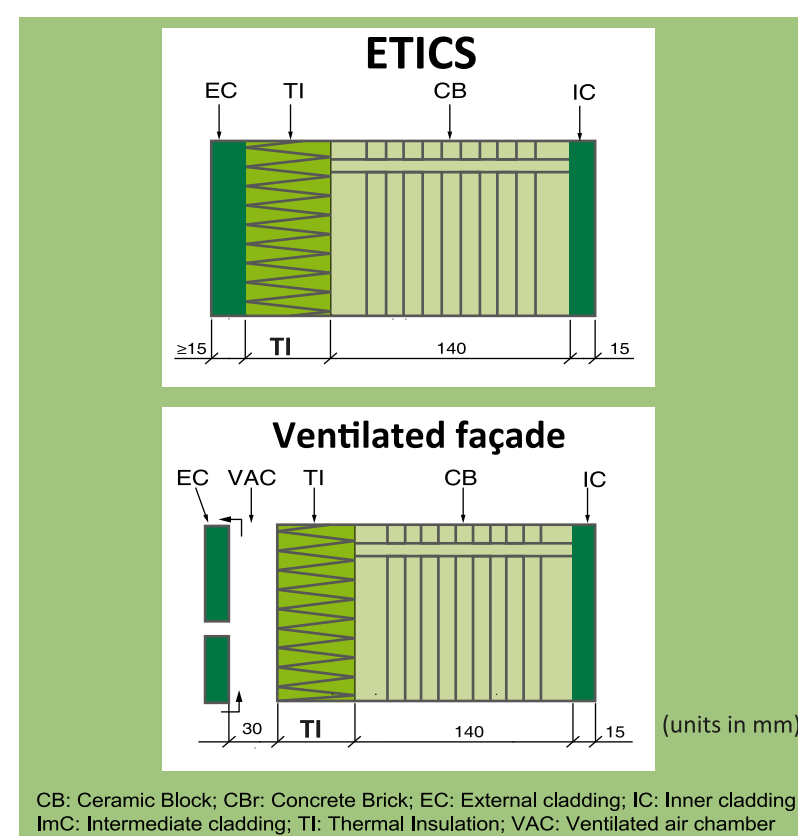


Figure 2. Constructive details of the studied façade systems [5]

The Declared Unit is the production, transport and installation of the necessary quantity of materials to construct 1m² of two selected façade-systems (Table 1). It has been established according to a "D" climate zone according to the Spanish Technical Building Code [5].

		XPS	EPS	PU	SW	GW
Thermal conductivity (λ) (W/m K)		0.032	0.035	0.023	0.039	0.036
Density (kg/m ³)		20	35	31	130	21.8
ETICS	Thickness (m)	0.10	0.11	0.07	0.13	0.12
	Weight (Kg)	2.06	3.95	2.30	16.35	2.53
Ventilated façade	Thickness (m)	0.10	0.11	0.07	0.12	0.11
	Weight (Kg)	2.0	3.8	2.2	15.8	2.5

Table 1. Declared unit (kg) required of insulation per façade solution

Results & Discussion

In general, the combination of ETICS with GW are the most advisable option, 4 times better than the worst combination: Ventilated façade with stone wool.

The Ventilated façade presents the highest embodied due to being a complex construction system. However, its structure provides a better energy performance in certain climatic conditions (Figure 3).

GW is the most advisable insulation material and its embodied energy represents 7% for Ventilated façade and 16% for ETICS

The insulation material has a significant weight in the total results for all retrofit options, especially for ETICS, in which most of insulation materials represent more than 40% of total embodied energy (Figure 4).

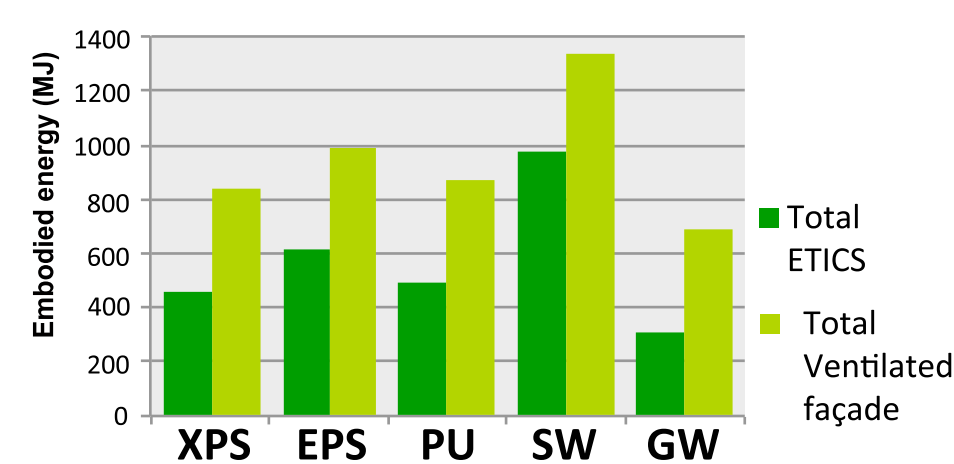


Figure 3. Embodied energy for the combination between façade-systems and different insulation materials

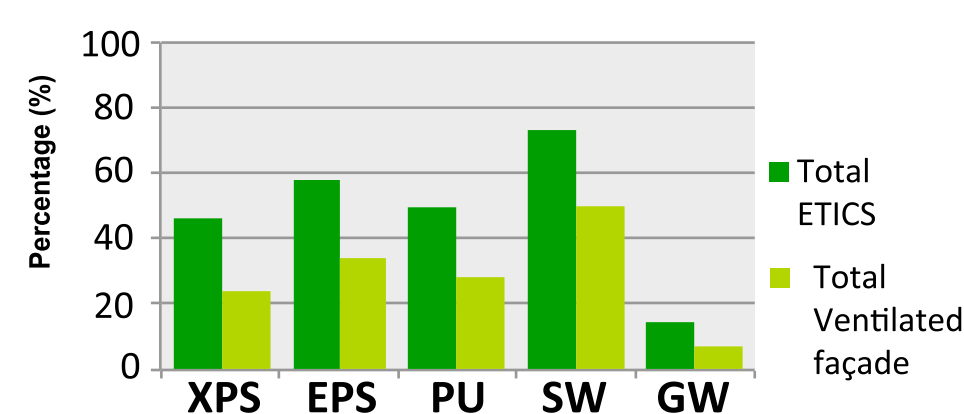


Figure 4. Percentage of embodied energy of insulation materials respect to total results by façade-system

Conclusions

The choice of system in the façade retrofit are very influential in the resulting environmental implications. Moreover, it can be noted the relevance of the insulation material in the final results for all the façade-systems.

Hence, when designing façade retrofits, decision-makers should not only consider the technical and economic factors, but also environmental impacts associated with each design, especially in the choice of the insulation material.

In further studies, the implication of a façade retrofit in the total life cycle of energy should be analysed deeply to make sure if the improvements in the energy efficiency during use balance with the embodied energy in the installed materials in the façade.

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