The role of the fuctional equivalence in LCA of buildings and building products

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objective of the presentation

Comparative LCA of buildings products or technical systems

Functional unit / Functional equivalence

(what kind of performances? It depends from the building)

Comparative LCA of buildings

Normalisation of results assuming a Reference unit

(what kind of unit? surface, volume, durability …)

Change of functional unit or reference unit = change of LCA results

LCA comparison of building’s products

Comparative study and functional equivalence

Reference flows . functional equivalent . same level of service

What kind of performance?

Uncertainty of reference flow

Uncertainty of LCA comparison

The functional equivalent in a LCA-based comparison of products

functional equivalent = performance more relevant

Example

Product: insulation materials

Relevant performance: heat insulation

And the other performances?

Sound insulation

Durability

Fire resistance

Structural stability

Flexibility of use

Thermal inertia

Breathability

Water resistance

…

The functional equivalent in a LCA-based comparison of products

There aren't eco-friendly products in an absolute sense,

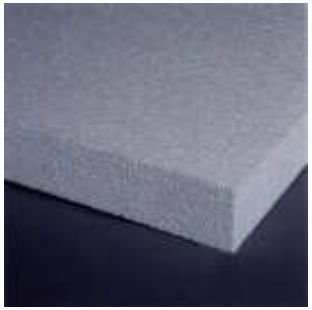
but a product can be defined ecological only in relation with

the performance required in a specific building

Requirement: flexibility, …

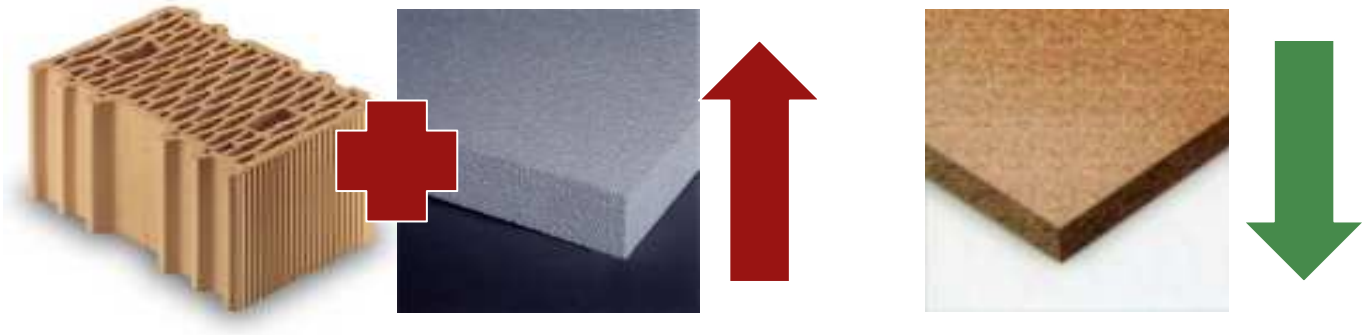
Requirement: durability, …

Functional unit: thermal insulation



requirement: thermal insulation		
functional unit: thermal transmittance of 0.34 W/m^{2}K (limit value according to italian Legislative Decree no. 311/06 climatic zone E) of 1 m^2 of opaque vertical closure		
	expanded polystyrene (EPS)	**wood wool**
thermal conductivity λ (W/mK)	0,035	0,049
specific heat (J/kgK)	1450	2100
thickness (m)	0,10	0,15
thermal transmittance	0,33	0,31
periodic thermal trasmittance	0,33	0,12
volume (m^3)	0,10	0,15
density ρ (kg/m^3)	19	250
weight (kg)	1,9	37,5
embodied energy of the material (MJ/kg)	130	20
embodied energy in 1 m^2 (MJ)	**247**	**750**

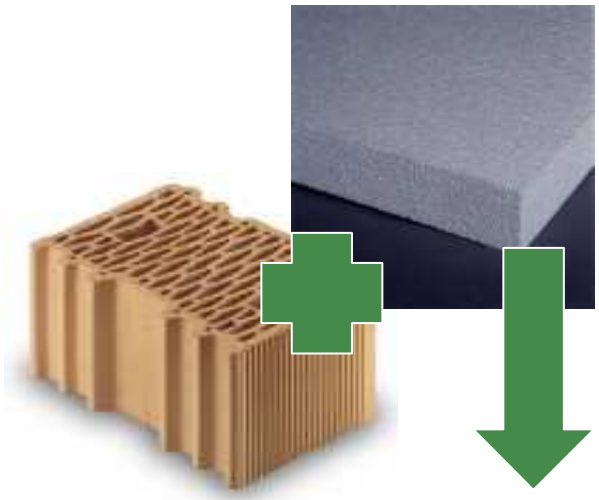
Functional unit: thermal insulation + thermal inertia

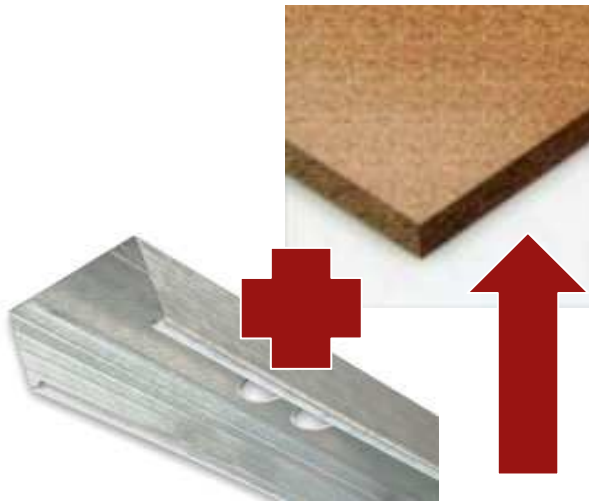


requirement: thermal insulation + thermal inertia		
functional unit: thermal transmittance of 0,34 W/m^{2}K and periodic thermal trasmittance of 0,12 (limit value according to italian Legislative Decree no. 311/06) of 1 m^2 of opaque vertical closure		
	EPS + brick blocks	**wood wool**
thermal conductivity λ (W/mK)	0,035 / 0,93	0,049
specific heat (J/kgK)	1450 / 840	2100
thickness (m)	0,10 + 0,25	0,15
thermal transmittance	0,30	0,31
periodic thermal trasmittance	0,12	0,12
volume (m^3)	0,10 + 0,25	0,15
density ρ (kg/m^3)	19 / 720	250
weight (kg)	1,9 + 180	37,5
embodied energy of the material (MJ/kg)	130 / 3	20
embodied energy in 1 m^2 (MJ)	**247+540 = 787**	**750**

Example of comparative LCA: from products to system

Functional unit: thermal insulation + thermal inertia + mechanical resistance



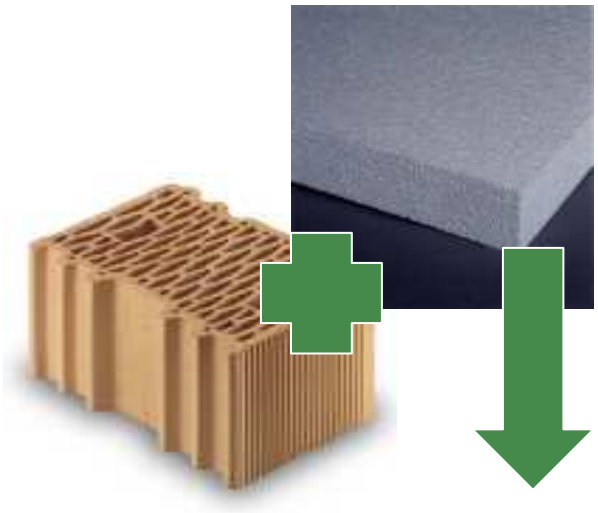


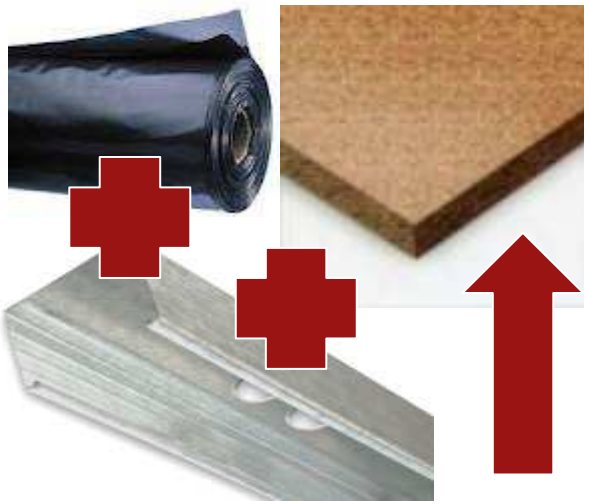
requirement: thermal insulation + thermal inertia + mechanical resistance		
functional unit: thermal transmittance of 0,34 W/m^{2}K and periodic thermal transmittance of 0,12 of 1 m^2 of opaque vertical closure self-sustaining		
	EPS + brick bloc	**wood wool + steel frame (0,0008x0,25x1 m x 2 elements)**
volume (m^3)	0,10 + 0,25	0,15 + 0,0004
density ρ (kg/m^3)	19 / 720	250 / 7800
weight (kg)	1,9 + 180	37,5 + 3,12
embodied energy of the material (MJ/kg)	130 / 3	20 / 35
embodied energy in 1 m^2 (MJ)	**247+540 = 787**	**750+110 = 860**

Example of comparative LCA: from products to system

Functional unit: thermal insulation + thermal inertia + mechanical resistance

+ vapor barrier

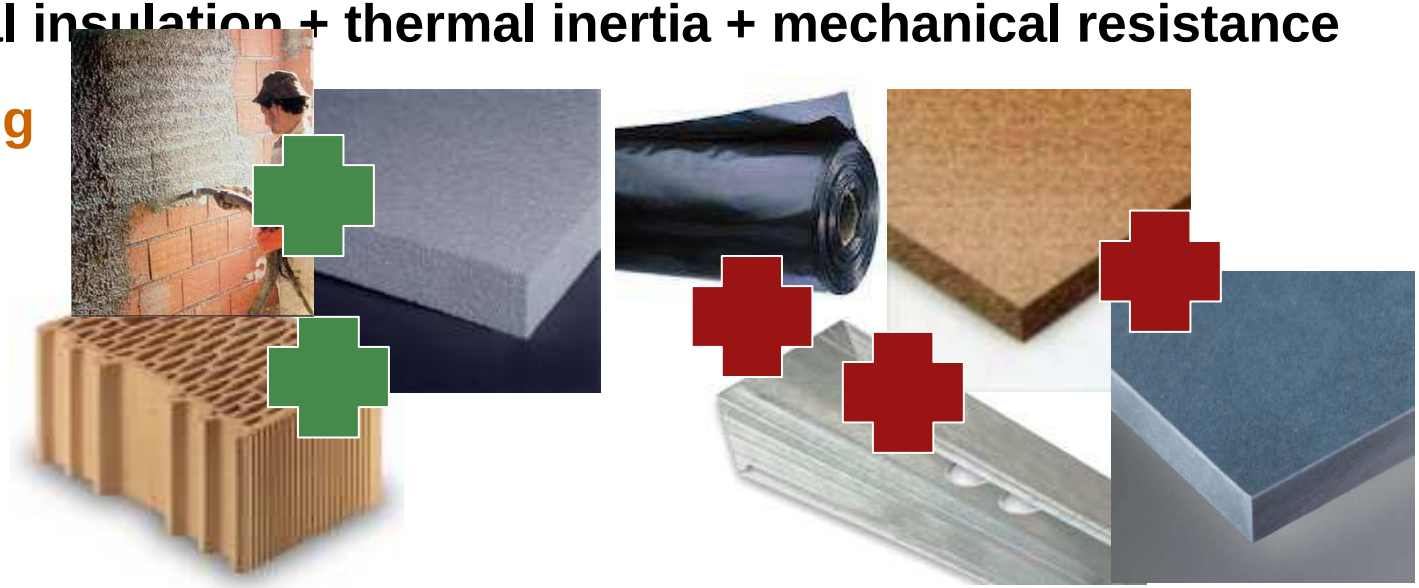




requirement: thermal insulation + thermal inertia + mechanical resistance + vapor barrier		
functional unit : thermal transmittance of 0,34 W/m^{2}K and periodic thermal transmittance of 0,12 of 1 m^2 of opaque vertical closure self-supporting and vapor impermeable		
	EPS + brick blocks	**wood wool + steel frame + vapor barrier in polyethylene**
volume (m^3)	0,10 + 0,25	0,15 + 0,0004 + 0,0008
density ρ (kg/m^3)	19 / 720	250 / 7800 / 920
weight (kg)	1,9 + 180	37,5 + 3,12 + 0,74
embodied energy of the material (MJ/kg)	130 / 3	20 / 35 / 90
embodied energy in 1 m^2 (MJ)	**247+540 = 787**	**750+110+66 = 926**

Example of comparative LCA: from products to system

Functional unit: thermal insulation + thermal inertia + mechanical resistance + vapor barrier + coating

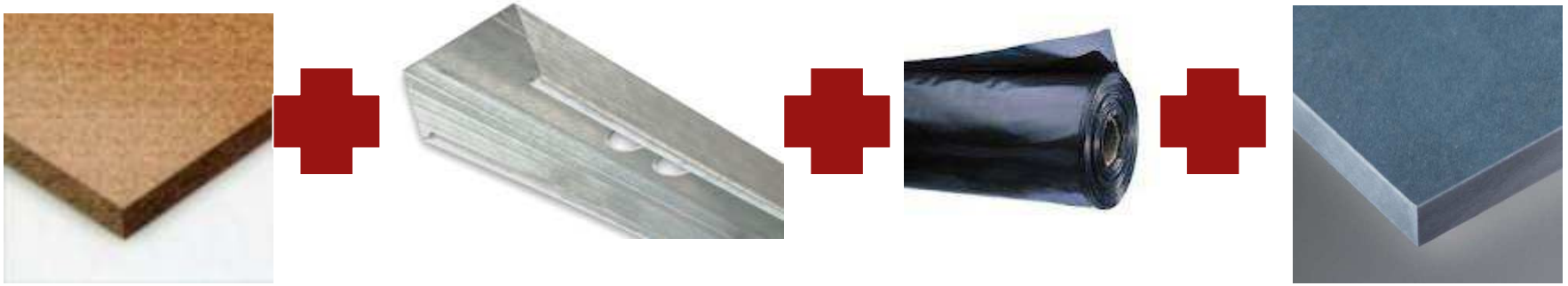


requirement: therma insulation + thermal inertia + mechanical resistance + vapor barrier + coating		
functional unit: thermal transmittance of 0,34 W/m^{2}K and periodic thermal transmittance of 0,12 of 1 m^2 of opaque vertical closure self-sustaining, vapor impermeable and protected by internal external coatings		
	external plaster + EPS + brick bloc + internal plaster	**external fibercement + wood wool + steel frame + vapor barrier in polyethylene + internal plasterboard**
volume (m^3)	0,10 + 0,25 + 0,015	0,015 + 0,15 + 0,0004 + 0,0008 + 0,030
density ρ (kg/m^3)	19 / 720 / 1150	1500 / 250 / 7800 / 920 / 900
weight (kg)	1,9 + 180 + 18	22,5 + 37,5 + 3,12 + 0,74 + 27
embodied energy of the material (MJ/kg)	130 / 3 / 1,8	10 / 20 / 35 / 90 / 7
embodied energy in 1 m^2 (MJ)	**247+540+ 33 = 820**	**225+750+110+66+ 189 = 1.350**

Example of comparative LCA: from products to system

Solution 1

Solution 2



	requirement	material of solution 1	material of solution 2
opaque vertical closure	thermal insulation	EPS	wood wool
	thermal inertia	+ brick	
	mechanical resistance		+ steel frame
	vapor impermeable		+ vapor barrier (polyethylene)
	coating	+ internal & external plaster	+ fibercement + plasterboard

LCA comparison of buildings

The functional equivalent in a LCA-based comparison of buildings

FprEN 15978:2011

The functional equivalent of a building shall include:

- ✓**building type (e.g. office, factory etc.);**
- ✓**relevant technical and functional requirements;**
- ✓**pattern of use (e.g. occupancy);**
- ✓**required service life**

“The assessment results of the buildings that have different functional equivalents can also be compared based on a common unit of reference.”

“A reference unit may be dimensionless or qualified with a dimension (e.g. per m², per year, per employee, per room, …).”

The reference unit of results of LCA of buildings

3.900 GJ ? **4.500 GJ**

Normalisation

/m²

Internal surface area

Normalisation

/m²

Internal surface area

2.6 GJ/m² **2.3 GJ/m²**

The reference unit of results of LCA of buildings

3.900 GJ ? **4.500 GJ**

Normalisation

/m²

3 GJ/m²

/m³

1 GJ/m³

or

Normalisation

/m²

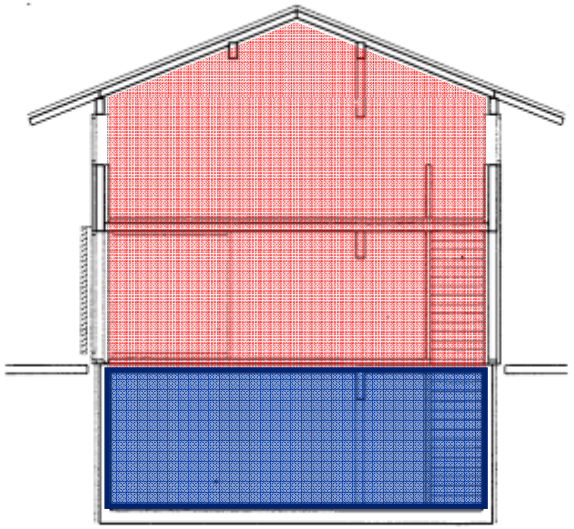
2.6 GJ/m²

/m³

1.2 GJ/m³

The reference unit of results of LCA of buildings

Internal surface or volume = heated spaces?



How to consider unheated spaces (ex. garages)?

Considering the high impacts caused by underground construction …

How to consider accessories spaces?

stairs

balconies

Conclusions

The functional equivalent of a building product in LCA comparison must be choosen in a “building systems” context

No eco-friendly products in an absolute sense, but only related to the specific building

The reference unit of a building is really difficult to define univocally

It is necessary that the normalisation approach is clearly defined into standardisation documents

for more information

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