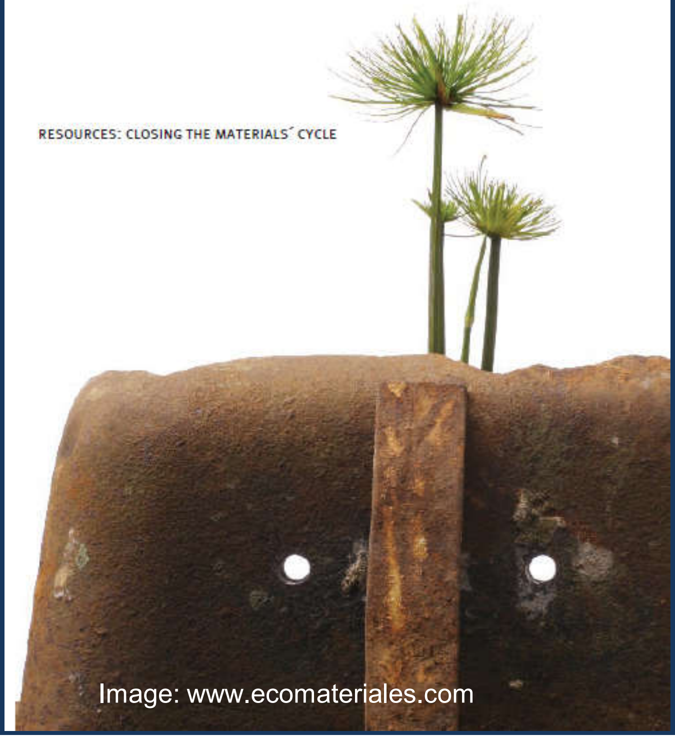
Sustainable materials & resources

GREEN BUILDING PROFESSIONAL Series



An education initiative supported by

WORLD GREEN BUILDING COUNCIL

Europe Regional Network

COPYRIGHT

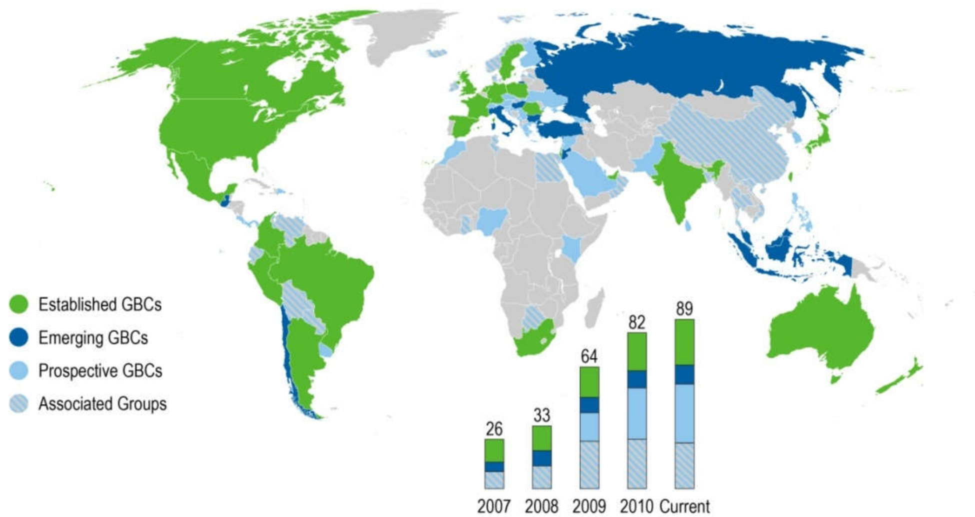
About the GBC network

World Green Building Council

The World Green Building Council (WorldGBC) is a coalition of national Green Building Council (GBCs) with the collective mission to facilitate the global transformation of the building industry towards sustainability through market driven mechanisms.

With presence in over 90 countries, WorldGBC is the largest international organization influencing the green building market place.

To find out more visit www.worldgbc.org.



Green building council españa

GBCe (Green Building Council España) is an autonomous organization, member of the World Green Building Council, WGBC. GBC España has currently been recognized as an Established Council of this organization. The process was led by the United States Green Building Council, USGBC.

GBC España also Works alongside the "International Initiative for a Sustainable Built Environment" Association, iiSBE, based in Ottawa, (Canada), representing the Spanish Area.

The non-profit organization "GREEN BUILDING COUNCIL - ESPAÑA", is an association with offices nationwide, and redirects all its income and investments, whichever their origin, to the achievement of its objectives and goals.

Find out more at www.gbce.es/

Why Green Building?

Globally the built environment accounts for:

17% of fresh water consumption
25% of wood harvest
33% of CO^2 emissions
30-40% of energy use
40-50% of raw materials used

The building sector also has the highest potential to cost effectively mitigate GHG emissions, it holds huge opportunities to stimulating economic growth and has a direct impact on our health and wellbeing.

This is why Green Building Councils all around the world are tapping into the potential of the built environment to drive sustainability.

Learning Objectives

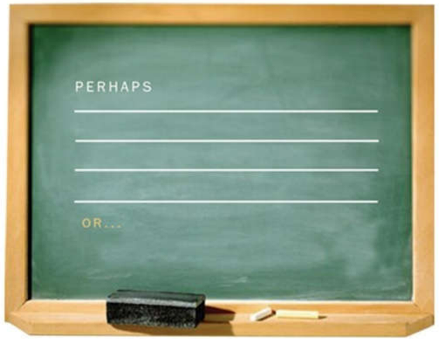
1 – Establish the relationship between the demands of sustainability and the resources used in construction.

2 – Understand the environmental impact of materials used in construction

3 – Critical reflection of the typical way of designing, using and managing resources throughout the lifecycle of buildings

4 – Propose an evaluation methodology and suggestions for improving the materials used in construction, maintenance and refurbishment of buildings.

5 - Share the knowledge brought from different professional backgrounds and determine the active roles for reducing the environmental impact of materials.



CourseAgenda

First part (morning, 3h)

1.1 Overview (90’)
Sustainability and materials (30’)
Environmental impact / open materials cycle (30’)
Environmental strategies / closed materials cycle (30’)

1.2 Sustainable materials and building ratings tools (70’)
Requirements (10’)
Assessment and comparison (40’)
Demonstration and certification (20’)

1.3 Discussion (20’)
Questions, comments, debate (20’)

Second part (afternoon, 3h)

2.1 Showcase of sustainable materials and resources (60’)
Closing the material cycle (12’)
Nature based materials (16’)
Industrial based materials (32’)

2.2 Case studies (60’)
Case study 1 residential (30’)
Case study 2 workplace (30’)

2.3 Workshop (60’)
Introduction (10’)
Work in groups (30’)
Sharing knowledge (20’)

1.1 Overview: Sustainability and materials

First part (morning, 3h)

1.1 Overview (90’)
Sustainability and materials (30’)
Environmental impact / open materials cycle (30’)
Environmental strategies / closed materials cycle (30’)

1.2 Sustainable materials and building ratings tools (70’)
Requirements (10’)
Assessment and comparison (40’)
Demonstration and certification (20’)

1.3 Discussion (20’)
Questions, comments, debate (20’)

Our common future: sustainability

Our Common Future (also known as Brundtland report):

“Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”

The current development model

Any human activity demands the use of materials. Our Western model of development is based on a constant increase of new and more demanding needs that, in turn, require more and more use of materials in order to be satisfied.

This model currently serves as a reference for a constantly growing human population, and is the backbone of an economy spread all over the planet.

Problems of the current model

Materials are extracted from nature causing environmental impacts associated with this extraction and diminishes their reserves.

Once the use of the products has been exhausted, the materials return to the environment as waste, often causing serious contamination problems.

This procedure works against a long-term development model. Therefore, it is necessary to create a model that is sustainable.

The challenge of sustainability

The current production model is a process of converting resources into high entropy waste which destroy the natural capital.

Taking on the challenge of sustainability implies doing the opposite: conserving the natural capital so that future generations can have the same possibilities at their disposal as the present.

The environmental aspect of building

Global resources used in buildings

Resource	Building use (%)
Energy	50
Water	50
Materials (by bulk)	50
Agricultural land loss	80
Coral reef destruction	50 (indirect)

Global pollution

Pollution	Building related (%)
Air quality (cities)	24
Global warming gases	50
Drinking water pollution	40
Landfill waste	20
CFCs/HCFCs	50

Source: The rough guide to sustainability, Royal Institute of British Architects.

One of the sectors which uses materials most intensively is the construction industry.

Our buildings are made of materials of diverse origin and function, and whose extraction, transformation and disposal back into the environment at the end of their lifespan accounts for a large part of the global environmental impact by our society.

Consumption of materials

Image: Marble quarry

The building industry consumes 25% of raw materials extracted from the lithosphere.

Each square meter which is built represents 2 tons of direct material, affecting between 6 to 7 tons of resources (abiotic and biotic) and 20 tons if water is included in production.

Source: World Watch Institute and Wuppertal Institute.

Generating waste

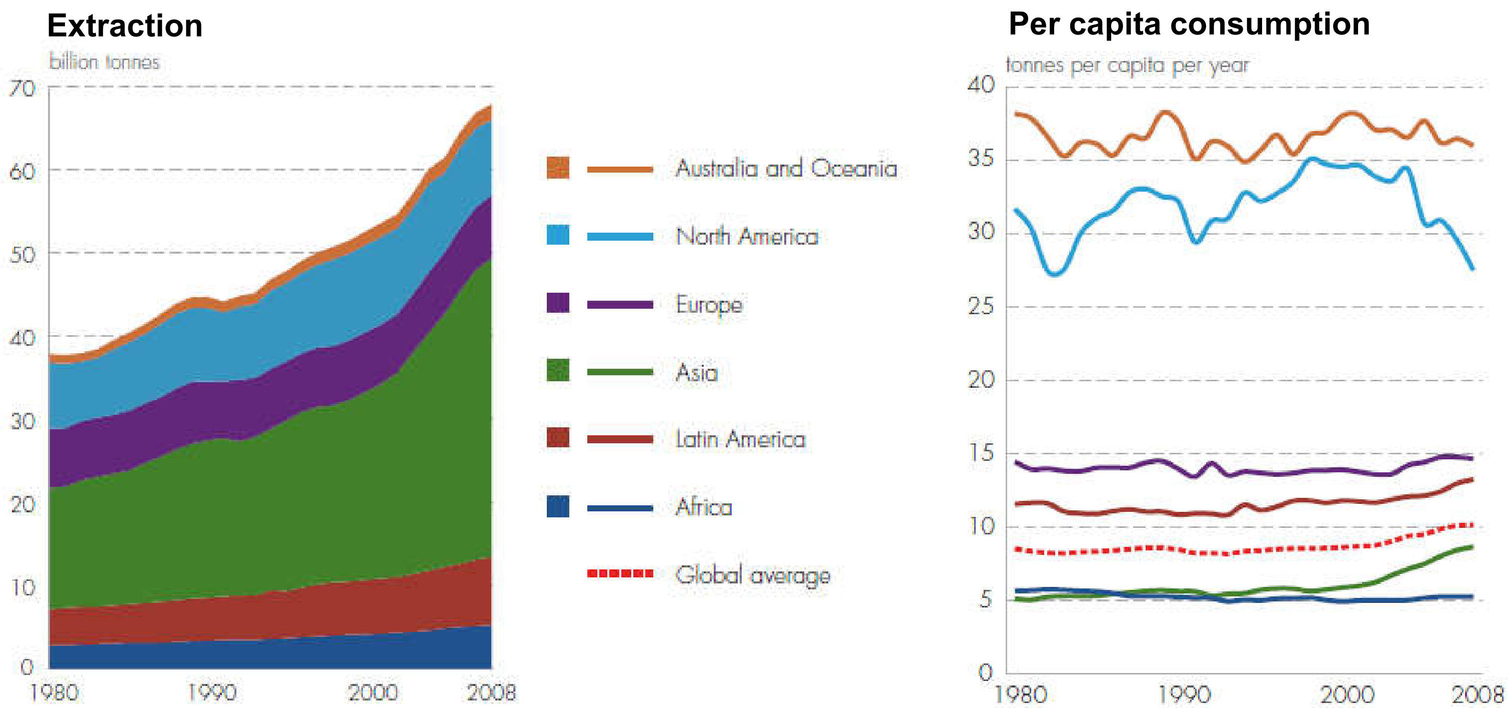
Image: landfill

Construction waste usually makes up 33% of the total sum generated by society (5,2 tonnes per person per year) and domestic waste up to 8,5% (1,3 tonnes per person per year).

On average, 60% of construction waste is recycled compared to 20% of domestic waste.

Source:: Eurostat, 2008/2009

Indicators: consumption of resources

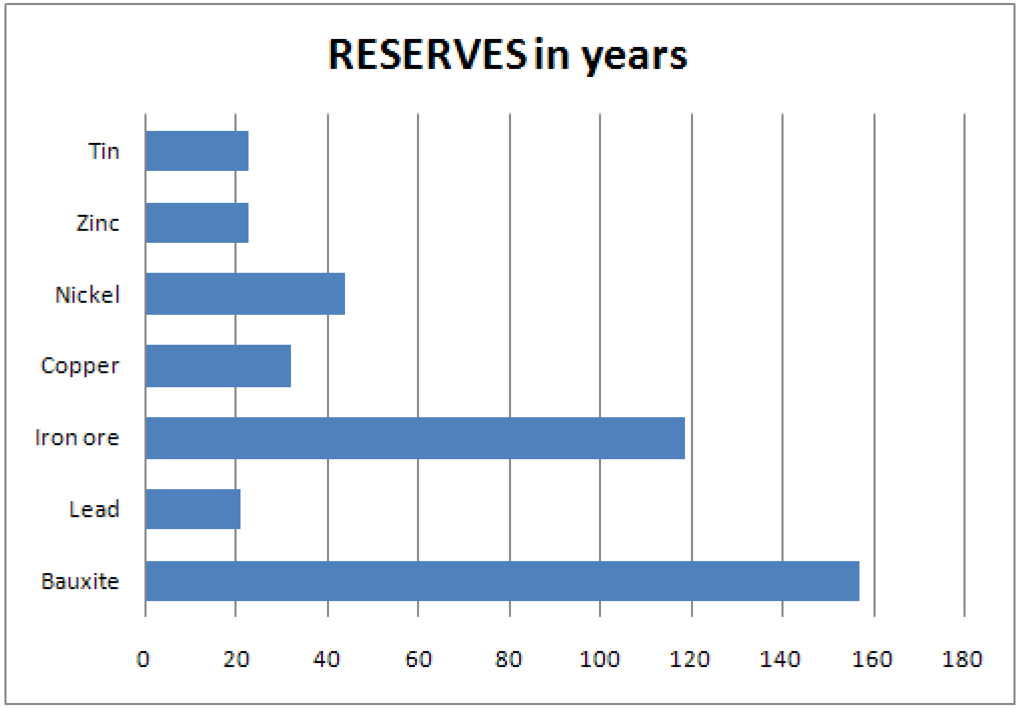


Source: Green economies Around the world? M. Dittrich, S. Giljum, S. Lutter and C. Polzin

Global consumption of raw materials has doubled since the 1960s. The difference in the level of consumption per capita between countries can be three or four times in proportion. Furthermore, rich countries import most of their raw materials from poor countries, where a large part of the environmental impact is left behind.

Indicators: availability of resources

Estimated available reserves of metals

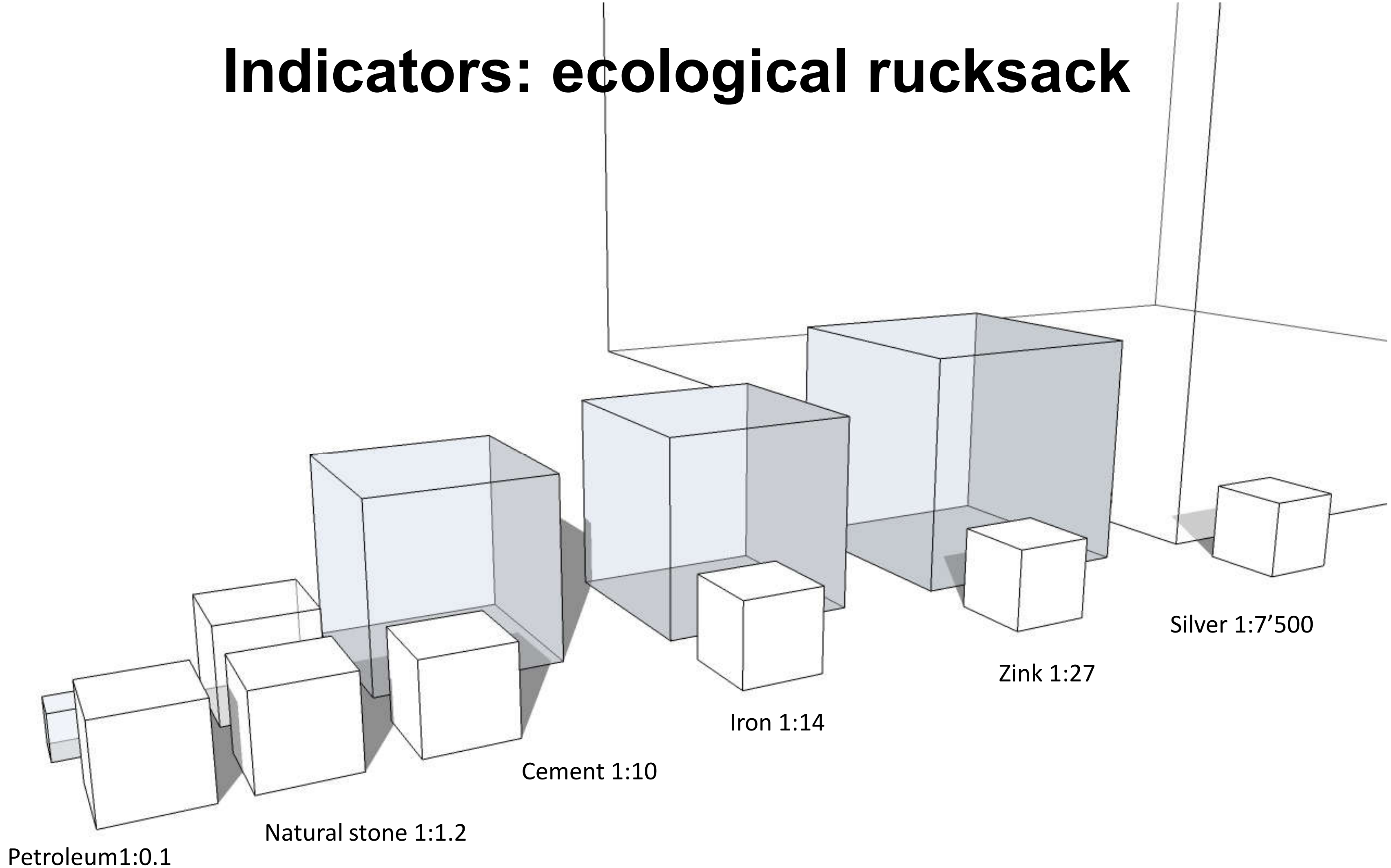


Source: USGS

Raw material reserves pose limitations to the use of materials and the quanitites which can be utilized.

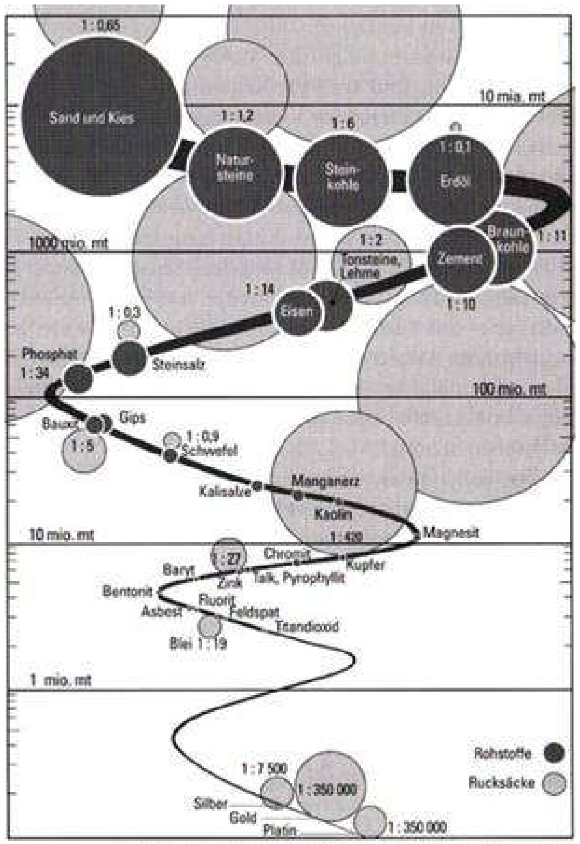
The consumption of raw materials in terms of environmental balance should not exceed the rate of its' natural renewal.

Indicators: ecological rucksack



Source: Societat Organica

Indicators: ecological rucksack



Source: Schmidt-Bleck

The ecological rucksack represents the raw materials necessary to manufacture a certain amount of material or product.

A mobile phone weighing 150 g can have an ecological rucksack of up to 75 kg and a 6 kg computer that of 1500 kg.

Aluminum 1:6

Steel 1:15

Copper 1:420

Gold 1:350,000

Indicators: toxicity

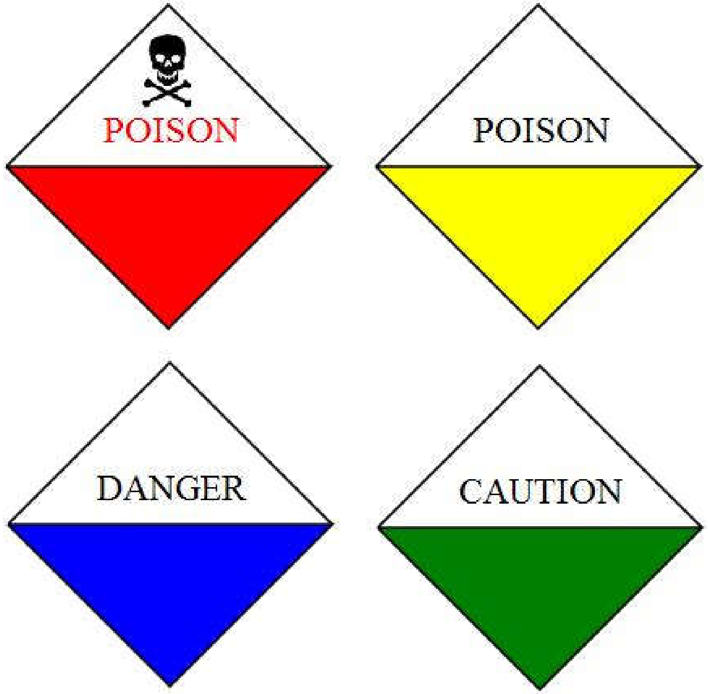


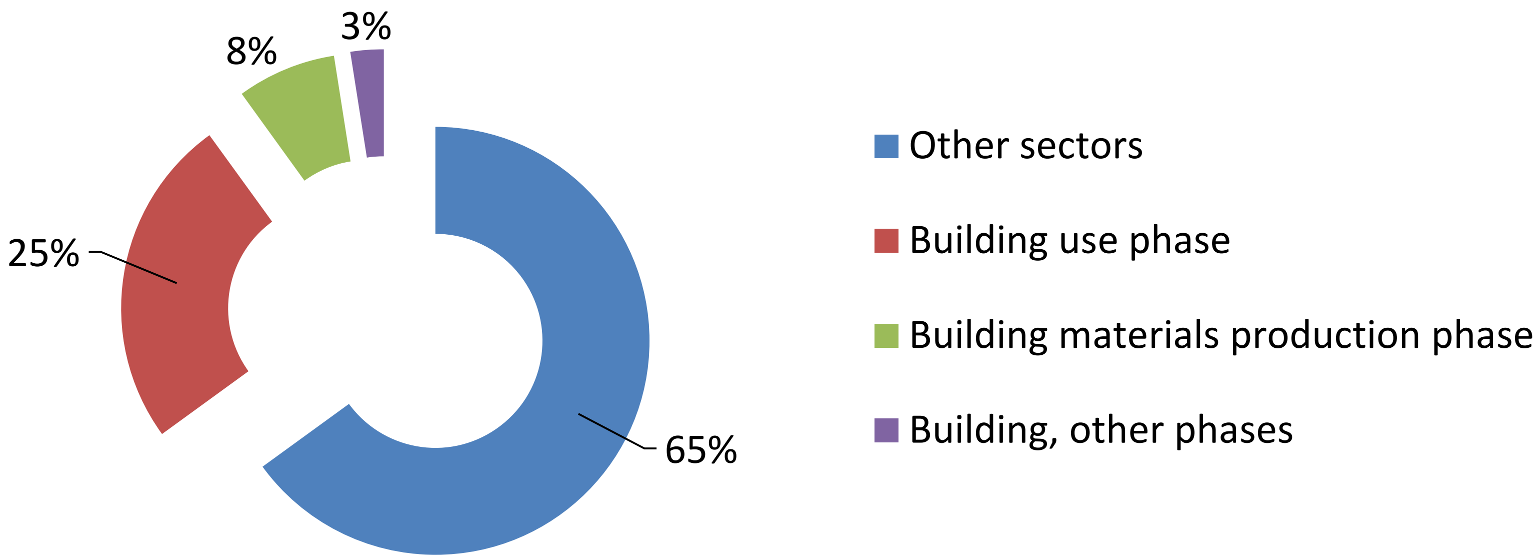
Image: Toxicity labels, Wikipedia

The term toxicity encompasses all harmful environmental effects generated through solid, liquid and gaseous waste that enter the air, water and ground.
It informs the ways in which nature and humans are affected by emissions resulting in the production of materials, construction, maintenance and waste management.

Indicators: VOCs, SOX, NOX, radioactivity, ionisation, electric and electrostatic charge.

Indicators: CO_2 emissions

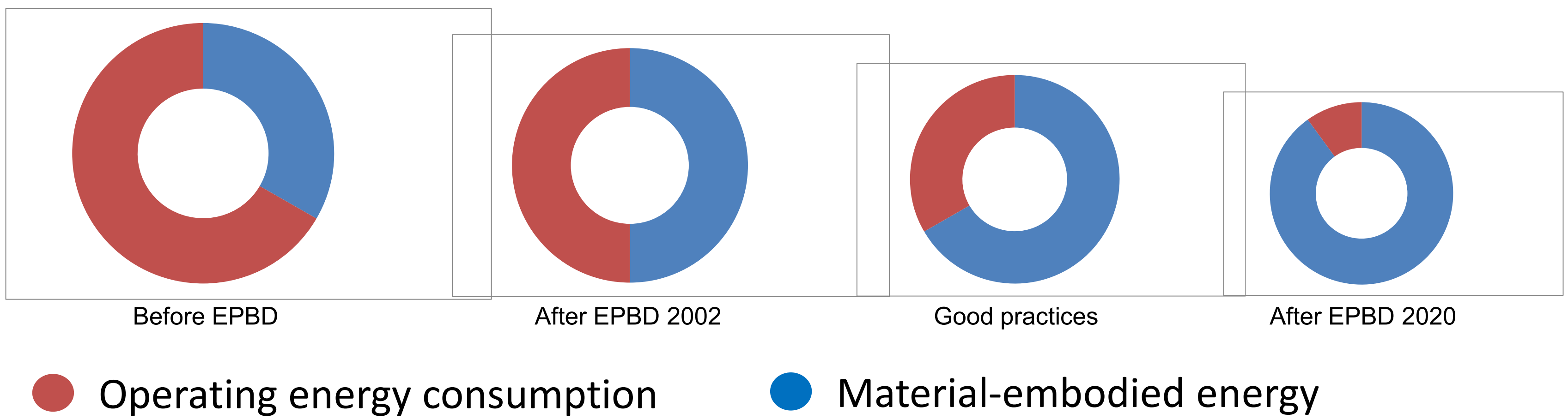
The approximate averages of CO_2 emissions between different sectors of the economy



Source: average based on different EU national statistics

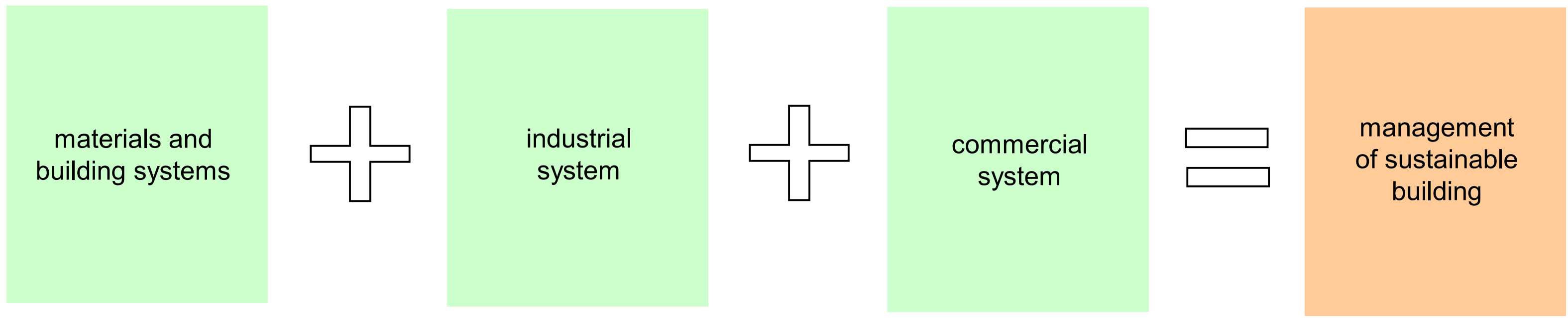
CO2 emissions are global indicators: they refer to the consumption of energy, climate change, cleanliness of the source and the associated contamination. There is no solution to the problem of climate change if there is no intervention in the building industry. This refers to the use of buildings as well as building materials.

Future tendencies (energy and CO_2)



The changes in regulations on energy and CO2 emissions in the use of buildings (derived from EPBD, EU Energy Performance Buildings Directive) reduces them. Currently there are no restrictions made in the material production phase. Furthermore, making buildings that are more energy efficient implies a higher consumption of materials. The result is a reduction of the environmental impact at the scale of a building´s life cycle, but has a larger repercussion on material use.

System concept, holistic vision



Material redesign

Minimise quantities

Low impact solutions

Dry and retrievable joints

Recycled / renewable options

Industry redesign

Zero waste

Post consumption recycling

Renewable energy

Efficient transport

Commerce redesign

Demanding environmental quality

Transform products into services

Natural capital maintenance costs

Promoting environmental efficiency

1.1 Overview: Sustainability and materials

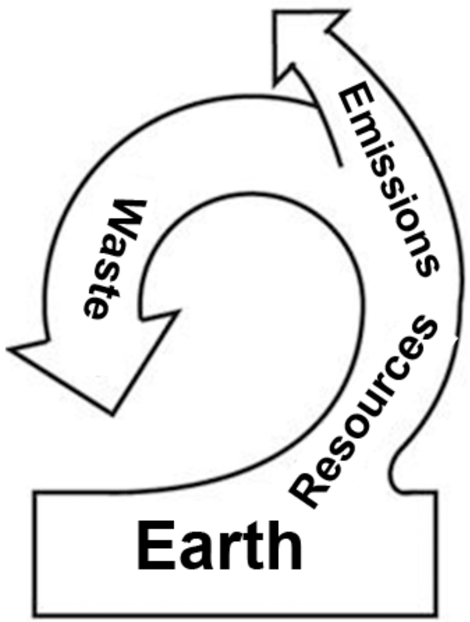
Conclusions

-The challenge of sustainability assumes that future generations should have the same resources available to them, equal in quality and quantity, as the current one. The current development model is not sustainable.

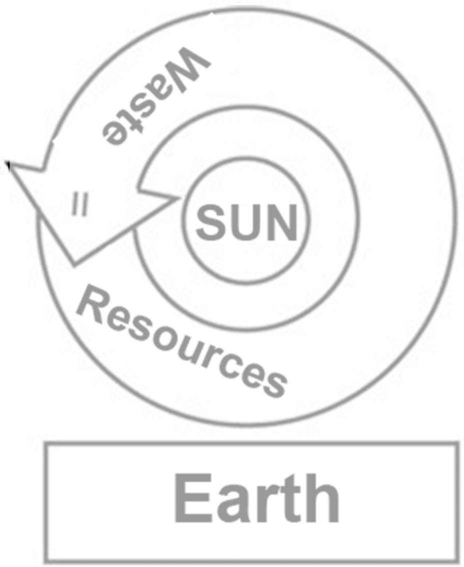
-The consumption of materials and generating waste causes multiple environmental impacts: energy consumption, toxic emissions, greenhouse effect, etc.

- The building industry has a large impact on the extraction of materials, as well as generating waste (between 1/4 and 1/3 of society´s total). Acting on this is essential.

XX and XXI century industry models



XX Century:
open materials cycles



XXI Century:
closed materials cycles

the dominant production model can be summarised in a linear sequence
extraction>manufacturing>use>waste

industrial ecology, inspired by the great biospheric recycling machine, proposes the cycle
recycling-manufacturing-use-recycling

Environmental impacts of buildings

Data: 1 Wuppertal Institute, 2 and 4 Eurostat, 3 Spanish statistics

and…

- acidification
- biodiversity
- ozone layer
- greenhouse effect
- erosion
- eutrophy
- acid rain
- heavy metals
- non biotic resources
- biotic resources
- winter smog
- summer smog
- land occupancy
- environmental toxicity
- human toxicity

Inputs and outputs of the building cycle

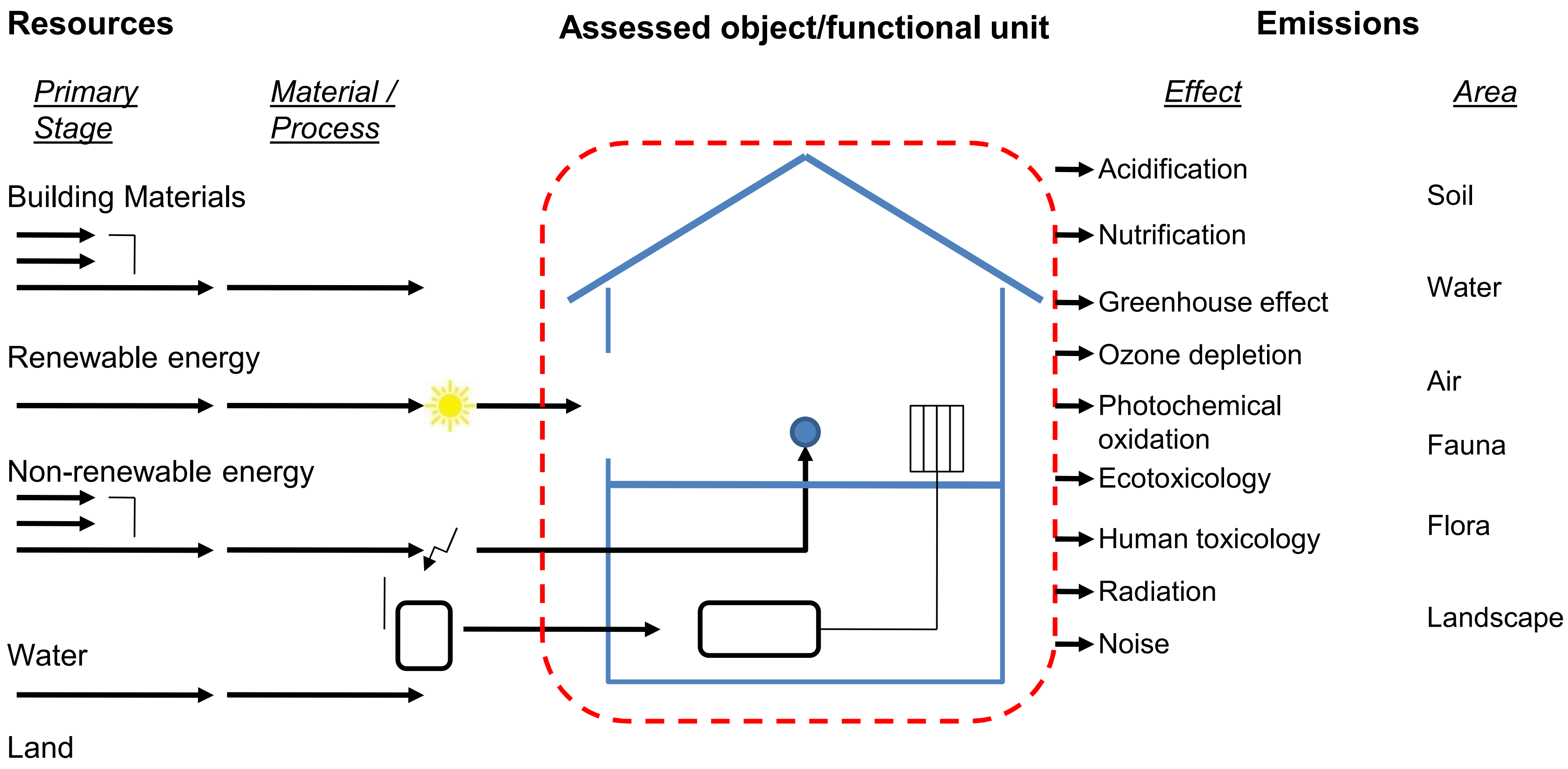


Image: Societat Organica

The environmental quality of a building is the relationship between the living conditions and the resources consumed and waste generated.

Life cycle analysis, concept

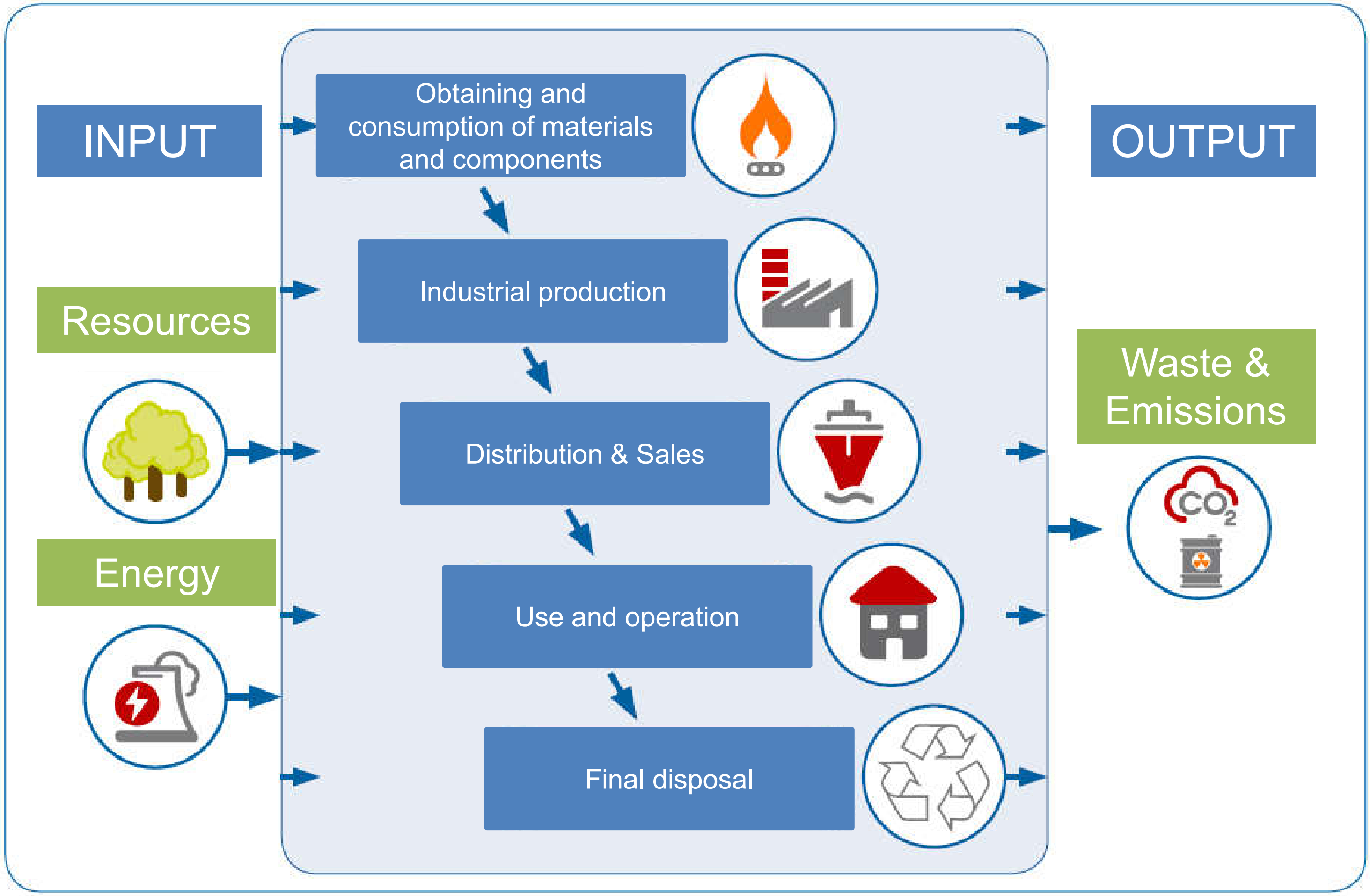


Image: IHOBE

Life cycle analysis, limits

Image: IHOBE

Life cycle analysis, process and utilities

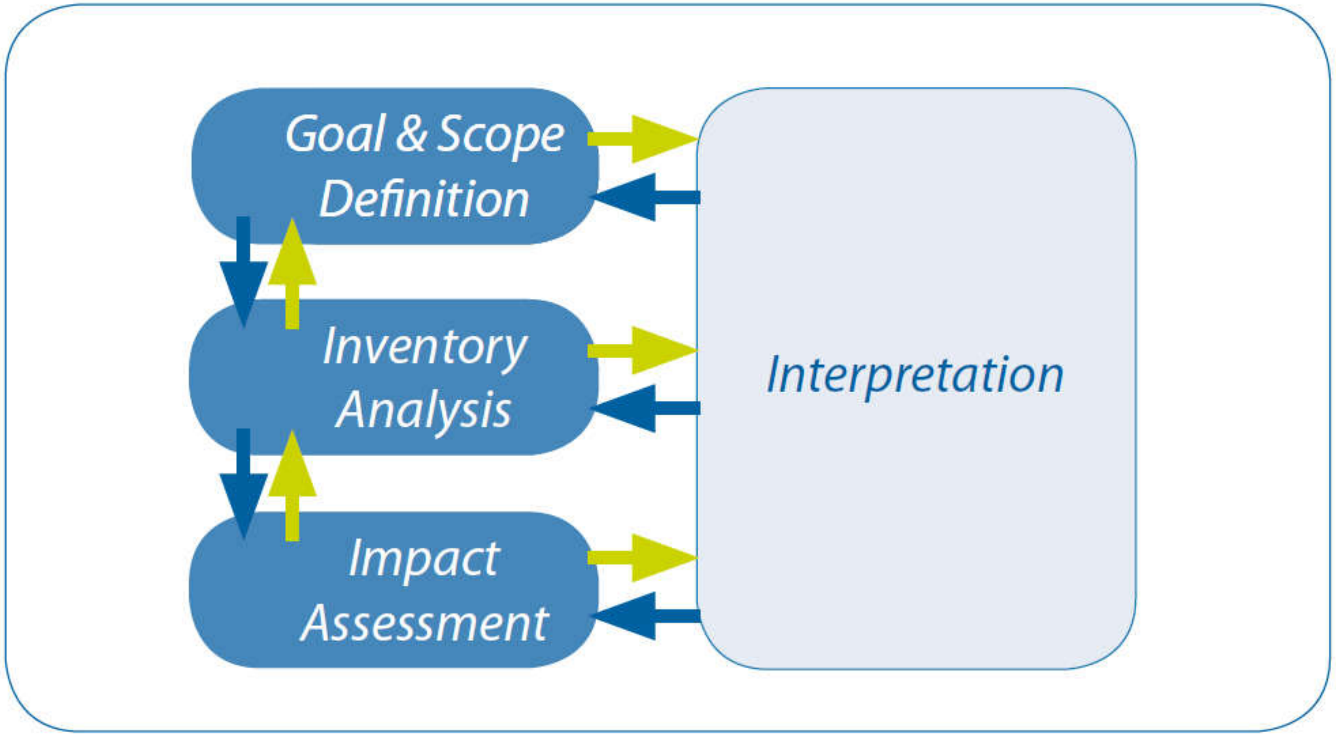


Image: IHOBE

In order to compare the results of two or more life cycles, the objectives, definitions, environmental inventories, the phases considered, limits of the system, functional units, etc. must be the same.

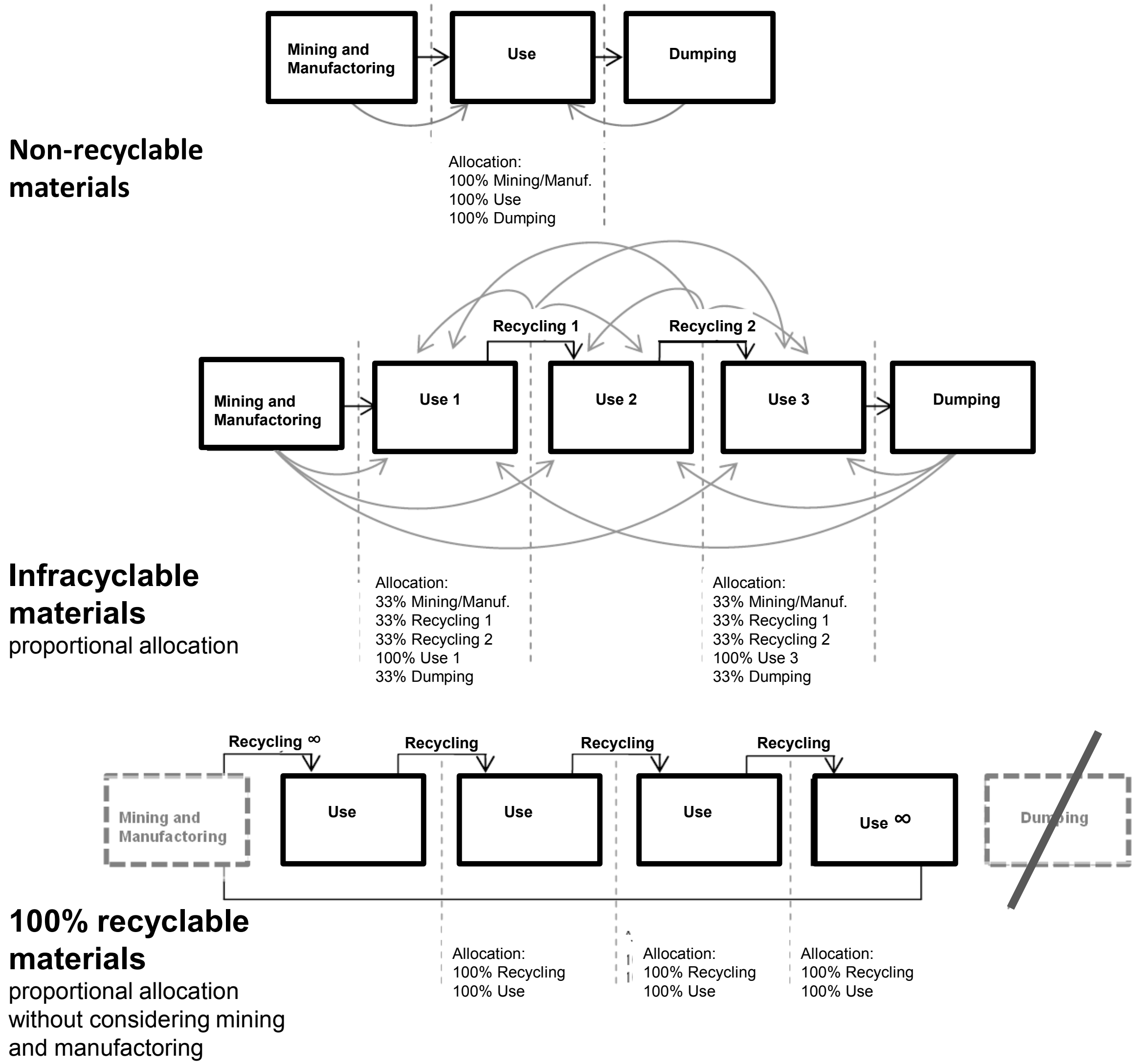
Environmental impacts of a building life cycle

	Materials production	Transport	Construction	Use (50 years)	Maintenance (50 years)	Demolition, waste management	
Energy	26,0%	0,9%	1,7%	66,9%	2,0%	2,5%	20.720 MJ/m^2
CO_2	38,6%	1,0%	2,8%	51,3%	3,3%	2,5%	1.554 $KgCO_2/m^2$
Solid waste	74,1%	irrelevante	2,1%	irrelevante	1,1%	22,7%	5.462 Kg/m^2
Toxicity	75,3%	0,8%	1,8%	18,3%	1,4%	2,4%	53.523 $ECAKg/m^2$

Source: La sostenibilidad en la arquitectura industrializada. La construcción modular ligera aplicada a la vivienda.
G. Wadel (PhD thesis). The study was focused on typycal multifamiliar residencial buildings of Spain.

The phases of material production, use, and the end of the life cycle are where most of the environmental impacts occur. The materials have a large repercussion in all of them.

Recyclable and non recyclable materials



The environmental impact of materials is greater the further they are from the condition of recyclability (industrial) or renewal (natural).

Thereby, non recyclable materials carry all their impacts in one cycle, the infra-cyclables in a few cycles and the recyclables in infinite cycles.

The repercussion of the impacts of infinite cycles and the disappearance of the phases of extraction and disposal make this option the most desirable one.

Material impacts: energy

Image: Wikipedia

Ceramic tiles

During the phase of extraction and manufacturing:

2,76 MJ/kg

The environmental impact of energy represents the consumption of non-renewable raw materials and contamination resulting from transformation processes.

The embodied energy of materials is one of the main indicators used in their environmental characterisation.

Sources: BEDEC, ITeC www.itec.cat

Material impacts: CO_2 emissions

Sources: Wikipedia

Ceramic tiles

During the phase of extraction and manufacturing:

0,22 $kgCO_2/kg$

The environmental impact of CO_2 emissions results from energy consumption and depends on the type of source that is used. It can be very high for fossil fuels and very low for renewable sources.

CO_2 associated with materials is one of the main indicators used in their environmental characterisation.

Sources: ICE, Bath University www.bath.ac.uk

Material impacts: solid waste

Ceramic tiles

During the phase of extraction and manufacturing:

2,11 kg/kg (minerals)

5,33 kg/kg (water)

The environmental impact of solid waste represents the consumed raw materials that do not make up the final product.

Solid waste or MIPS (material intensity per unit of service) is an indicator that is rarely used in environmental characterisation of materials.

Sources: Wuppertal Institute and Ecoinvent

Material impacts: toxicity

Image: Wikipedia

Ceramic tiles

During the phase of extraction and manufacturing of materials:

3,44 ECA Kg/Kg
(toxic emissions released into the air)

The environmental impact of toxicity represents the damage on biodiversity. According to the indicator, it evaluates the effects on the environment, human beings or both.

Sources: CIES based on Ecoinvent CML 1992

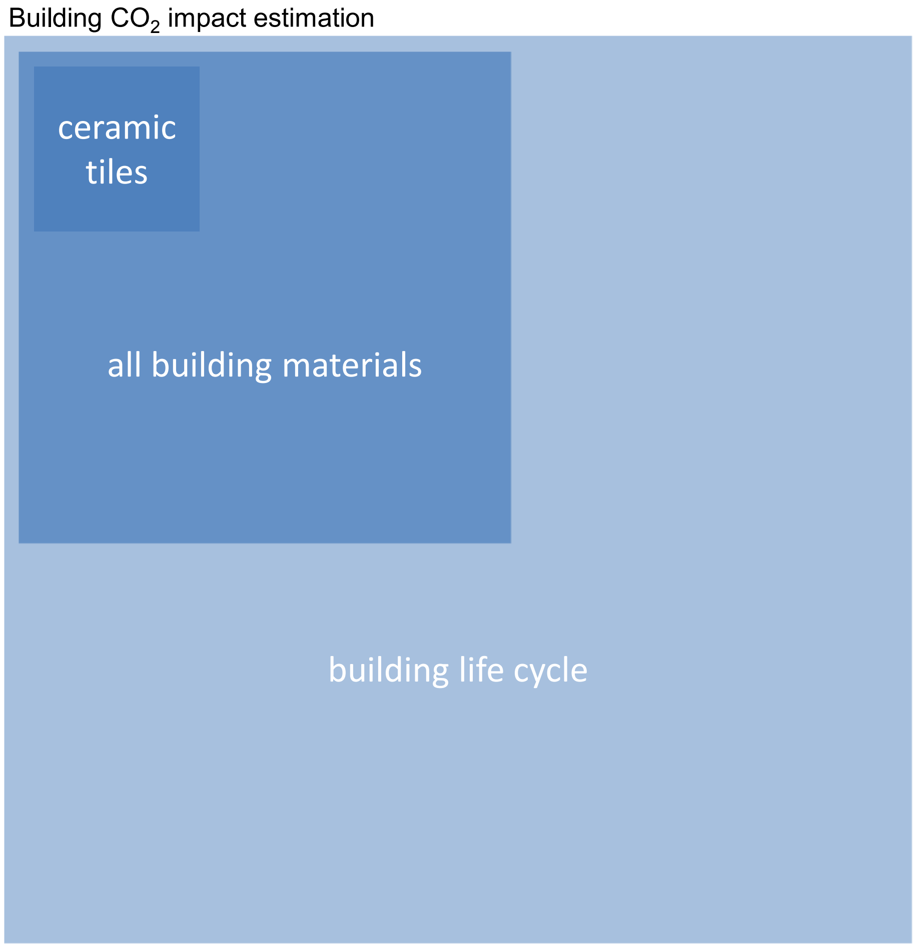
Material impacts: others

Ceramic tiles

Apart from the most important impacts (energy, CO_2, solid waste and toxicity), extraction and manufacturing of materials cause:

- water and earth acidification
- ozone layer depletion
- land erosion
- eutrophication
- acid rain
- heavy metals pollution
- land occupancy
- and more…

Material impacts: place and scale



The environmental impact of a specific material is closely linked to the rest of the building materials which, in turn, form an important part of impacts throughout a buildings' life cycle.

1.1 Overview: Environmental impact / open materials cycle

Conclusions

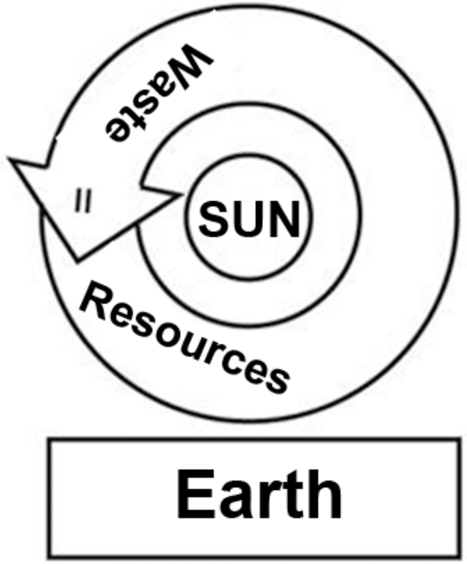
-Open materials cycles, the extraction of resources and generating waste are the causes of environmental impacts of building products.

-These impacts arise from the extraction of raw materials, industrial processes of transformation and manufacturing, transport, building maintenance and the disposal at the end of its lifespan.

-There are materials that are managed in an open cycle whose impacts can be smaller because they contain some environmental improvements. They are a palliative but not a solution. The underlying problem remains.

XX and XXI century industry models

XX Century:
open materials cycles



XXI Century:
closed materials cycles

the dominant production model can be summarised in a linear sequence
extraction>manufacturing>use>waste

industrial ecology, inspired by the great biospheric recycling machine, proposes the cycle
recycling-manufacturing-use-recycling

Five environmental strategies

1. **Demand reduction**
   optimise material use, reduce quantities per unit of service
2. **Increase efficiency**
   select materials with the same characteristics but lower impact
3. **Use of local resources**
   building by using or reusing local materials
4. **Recycling/renewal**
   use recycled (industrial) or renewable (natural) materials

5 **Impact neutralisation or compensation**
choose products that compensate their own impacts (carbon neutral)

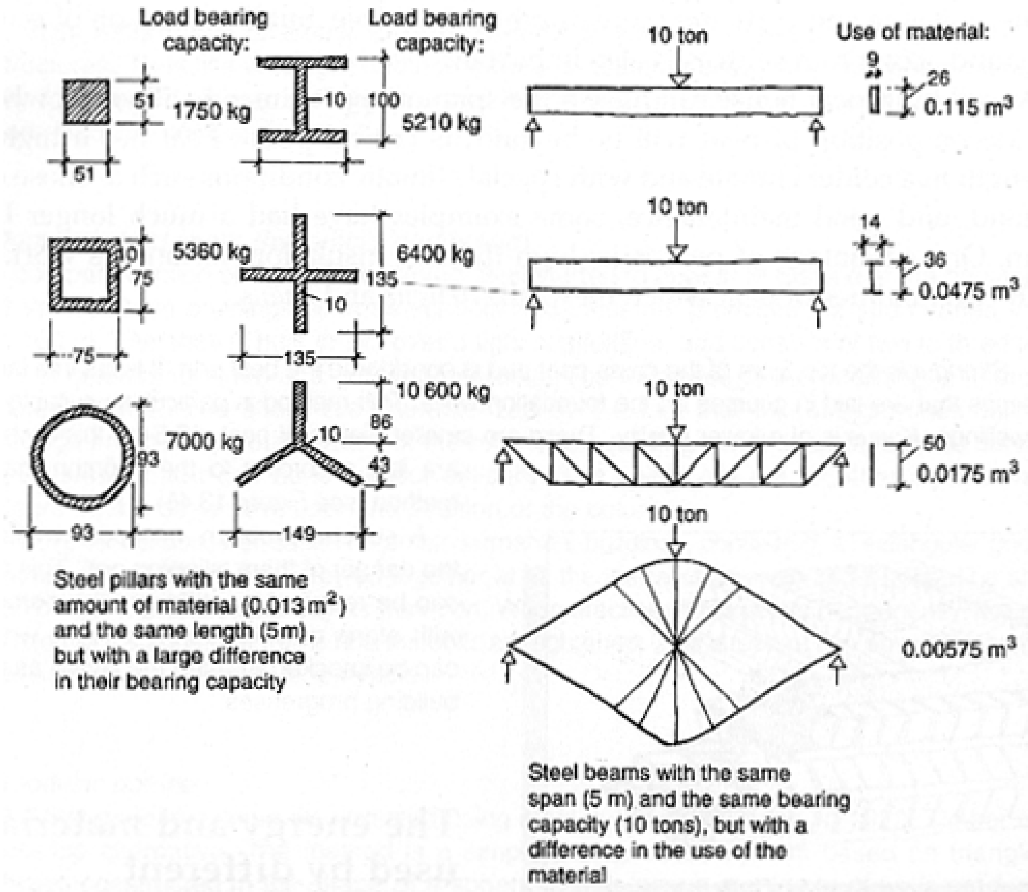
How much material does a building consume?

A lot. Only on site, it consumes 2.500 kg/m^2 which in reality is 7.500 kg/m^2, since producing 1 kg of material implies also generating an additional 2 kg of waste, including various associated environmental impacts.

However, by avoiding unnecessary consumption and by optimising the use of materials and recycling, it is possible to save on both materials and their related impacts.

Source: average of diverse studies of residential building materials, Spain.

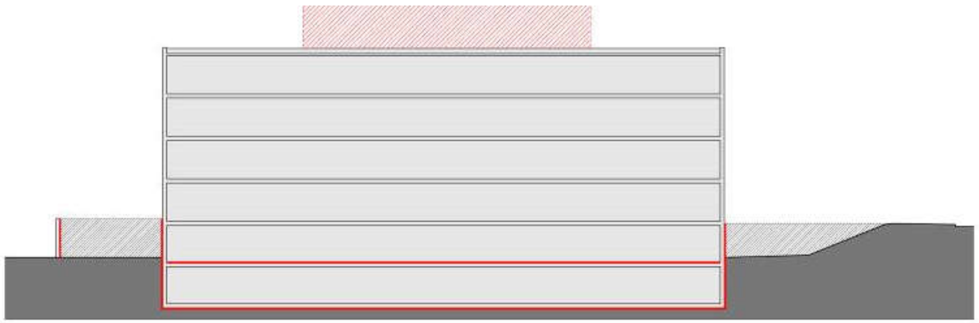
1. Demand reduction



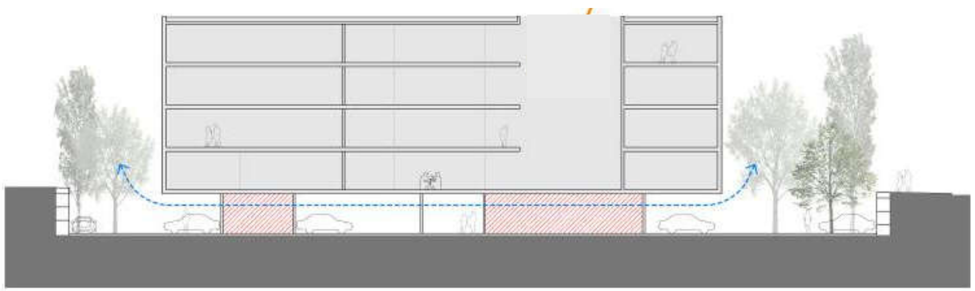
Material optimisation maintaining or increasing structural capacities.

Source: Structural alternatives to columns and beams, Reitzel and Mathiasen, 1975

1. Demand reduction



Conventional: retaining walls and floor slab in contact with the ground



Demand reduction: no retaining walls or floor slabs in contact with the ground

The reinterpretation of building codes and space allocation can reduce the quantity of resources needed to build an underground garage (excavations and retaining walls). This can result in additional benefits such as, in this case, natural ventilation and lighting.

2. Increasing efficiency

$94,17\ KgCO_2/m^2$

$65,56\ KgCO_2/m^2$

Two thermally equivalent facades with different environmental impacts

Source: Sabaté arquitectes Arquitectura i Sostenibilitat / Government of Catalonia

2. Increasing efficiency

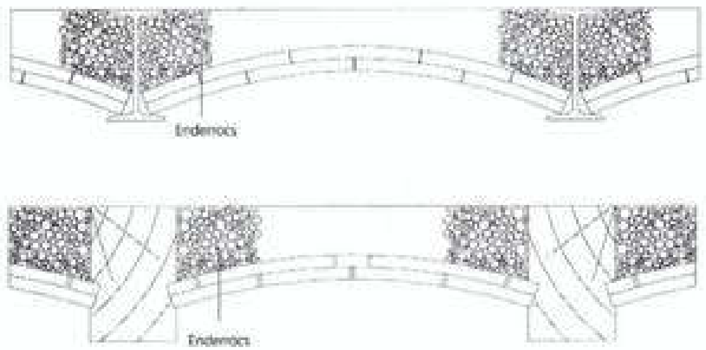
Cross Laminated Timber (CLT) structure

Concrete structure

Environmental comparison

timber		concrete
+ 16%	COST	√
√	WEIGHT	+ 350%
√	ENERGY	+170%
√	EMISSIONS	+220%

3. Use local resources



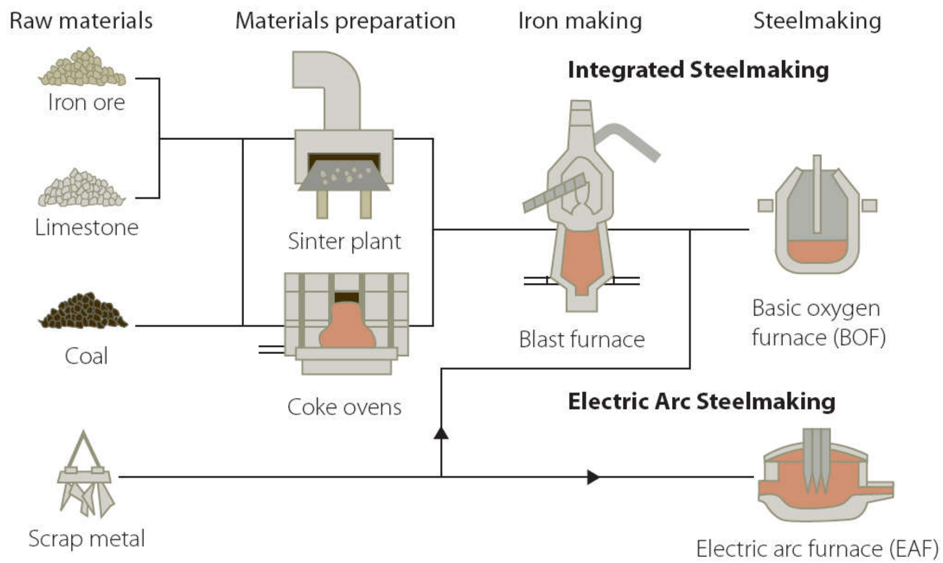
Left: Old buildings with reused materials. Right: Earth construction.

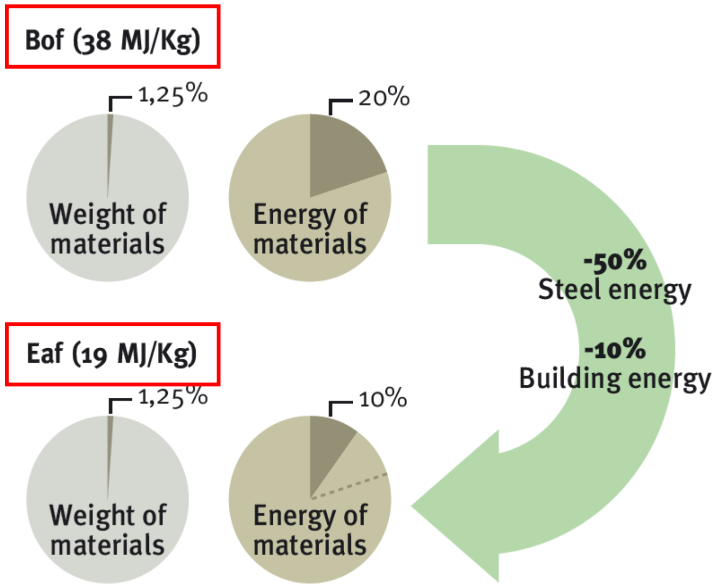
3. Use local resources

Museum of Science, Climate and Environment (Lérida, Spain).

The project involves the reuse of earth and stone materials from the excavation of this site. They are used in the development of the building and landscaping of the adjacent park. Thereby, the consumption of new materials and their transportation to the site is avoided.

4. Recycling/renewal





Basic oxygen (BOF) and electric arc furnace (EAF) energy consumption for steel production
Source: Ecomateriales, Societat Orgànica, 2010

4. Recycling/renewal

InfraRecycling
Used concrete transformed into aggregate for blocks

Ecoblock (www.xirgu.net)

Recycling
Used aluminium transformed into new aluminium for frames

Viessmann (www.viessmann.com)

5. Impact neutralisation or compensation

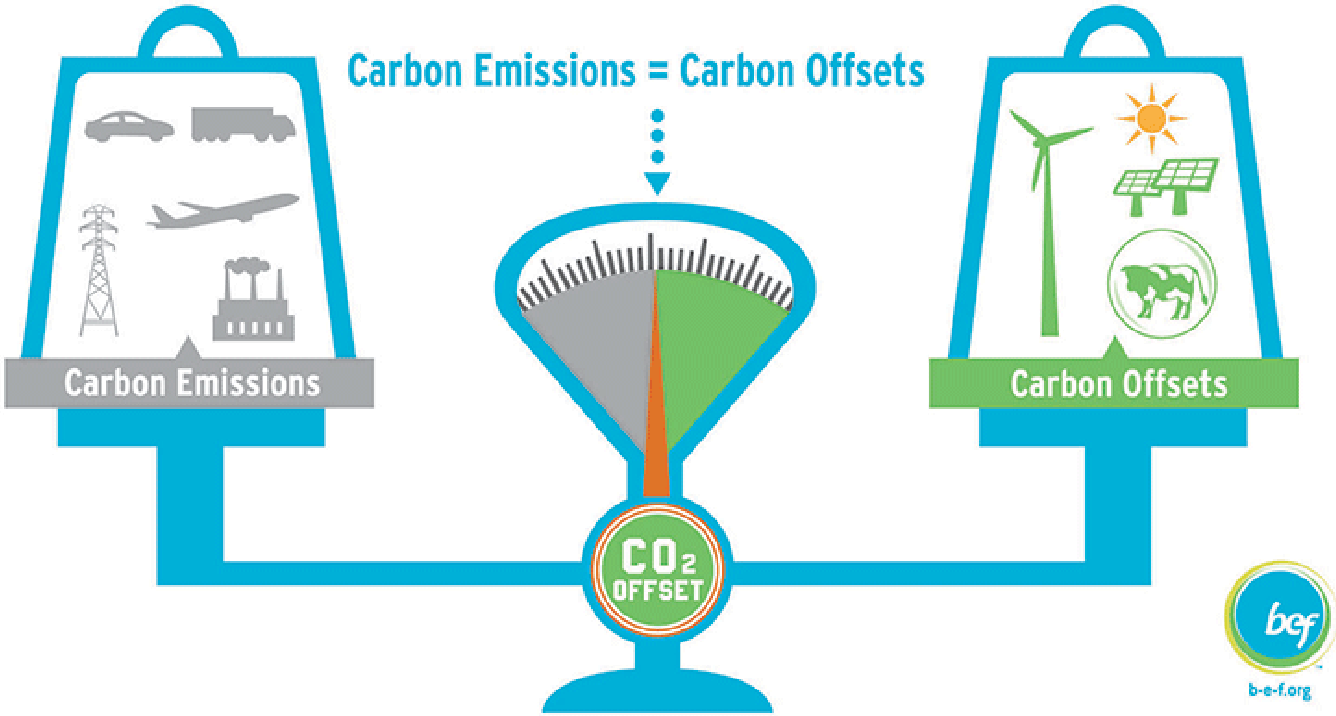


Image: Bonneville Environmental Foundation (www.b-e-f.org)

5. Impact neutralisation or compensation

Neutral carbon Cool Carpet programme from Interface™

Actions to minimise material impact

A – Decreasing the demand
1 Design of a building that decreases materials demand
2 Design of a building that decreases the generation of waste
3 Design of a building that can be deconstructed, reused and recycled
4 Efficient user manual of the building
5 Training plan for those responsible for maintenance

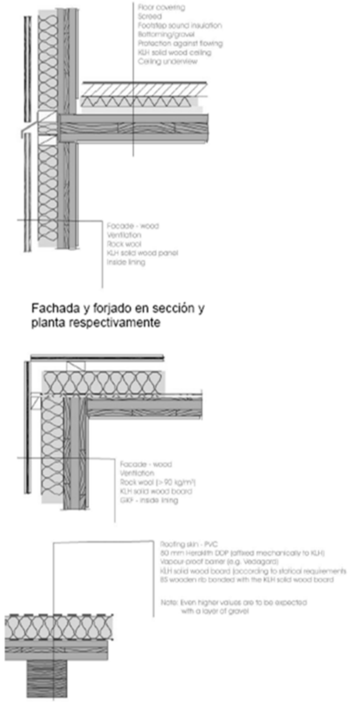
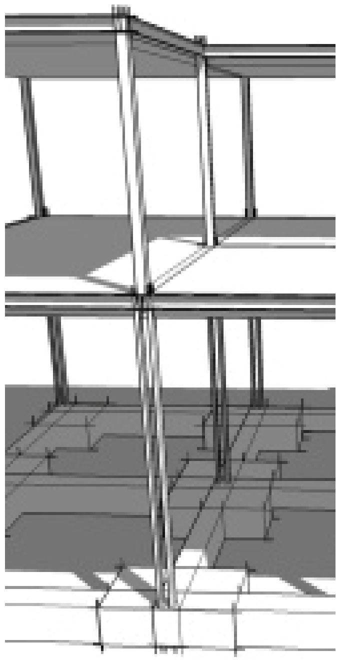
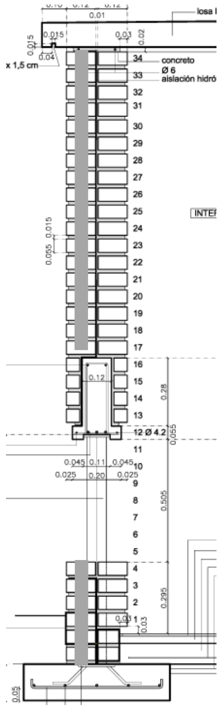
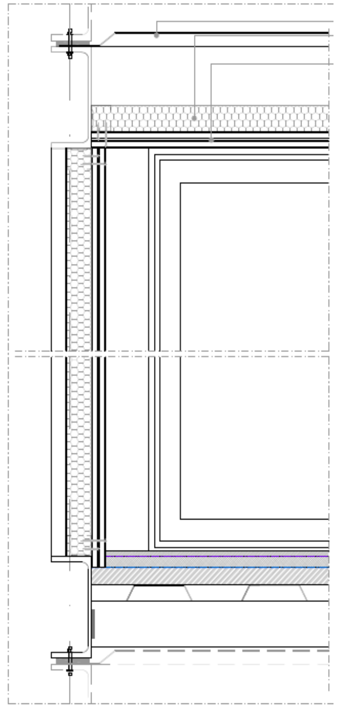
B – Increasing the efficiency of the construction system
6 Excavation and foundations
7 Horizontal and vertical structures
8 Facades and dividing wall
9 Roofs
10 Windows and solar protection
11 Horizontal and vertical interior partitions
12 Flooring and panelling
13 Thermal and acoustic insulation
14 Waterproofing
15 Paints and varnishes
16 HVAC

C – Taking advantage of the local resources
17 Ground
18 Rock and gravel
19 Pre-existing constructions

D – Recycling and reuse
20 Recycled materials
21 Reused materials

E – Compensation of the generated impact
22 Balance of resources tending towards zero
23 Materials that neutralise impacts
24 Study of minimisation and waste management (design phase)
25 Plan of waste minimisation and management (construction phase)

Low carbon construction systems (≤ 300 $KgCO_2/m^2$)

Timber	Industrially manufactured structure	Structural walls	Recycled steel
			
CO_2 absorption during the growth of wood.	Light structure + recycled or renewable materials.	Double functioning walls (structure and envelope) + recycled or renewable materials	Construction system made entirely of retrievable materials.

1.1 Overview: Environmental strategies / closed materials cycle

Conclusions

-Closing the materials cycle is the answer to the demands of physical and environmental sustainability. Doing this within the limits of the carrying capacity of the planet is the sufficiency condition.

-In the building industry, the key to closing the materials cycle isn´t found in specific materials, a construction system or a type of building, but in the management of resources in a life cycle.

-Depending on the scale of intervention, the systems that need to be managed can be buildings, neighbourhoods, cities or territories.

1.2 Sustainable materials and building ratings tools

First part (morning, 3h)

1.1 Overview (90')
Sustainability and materials (30')
Environmental impact / open materials cycle (30')
Environmental strategies / closed materials cycle (30')

1.2 Sustainable materials and building ratings tools (70')
Requirements (10')
Assessment and comparison (40')
Demonstration and certification (20')

1.3 Discussion (20')
Questions, comments, debate (20')

Check list of criteria for materials

Example criteria 2 and 3:
Wood-particles-board without formaldehyde

01 Low primary energy and emissions:
Natural production, recycled material.

02. Nonpolluting:
Without VOC's, radiation, etc.

03. Not hazardous to health:
Low or zero toxicity

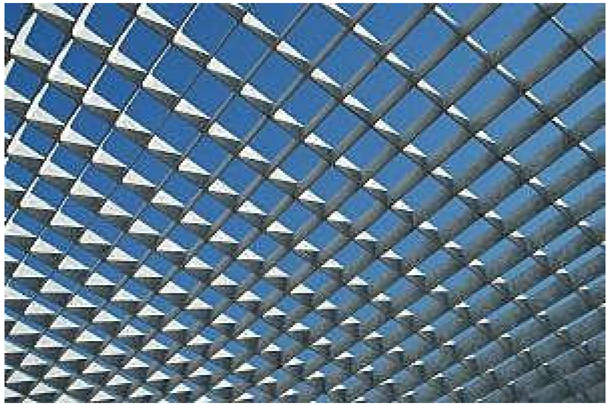
04. Seperable and recyclable waste:
Simple, non-composite materials

Check list of criteria for materials

Example criteria 5:
Paint with the EU certified label for low toxicity

05. With environmental certifications
    Ecolabel I to III
06. Removable joints, can be dismantled
    Dry assembly, can be deconstructed
07. Made with recycled materials
    Residue as raw material
08. Reusable
    Long lifespan, modular

Check list of criteria for materials



Example criteria 9:
Galvanised steel mesh , no maintenance required

09. Durable and low maintenance
    Without conservation treatments
10. Uses non-recyclable waste
    To extend its' lifespan
11. Saves energy
    Through inertia or thermal insulation
12. Saves water
    Collects rainwater

Types of ecolabels

Type I: environmental labeling

Type II: self-declaration claims

Type III: environmental declarations

Criteria Areas / Metrics:		Life Cycle Consideration:	
Type I	multiple	Type I	yes
Type II	single	Type II	no
Type III	multiple	Type III	yes
Selectivity:		**Third Party Verification/Certification:**	
Type I	yes	Type I	yes
Type II	no	Type II	preferred
Type III	no	Type III	yes

ISO Definitions (www.iso.org)

UE type I ecolabel

European Union
Eco-label

When developing EU Ecolabel criteria for products, the focus is on the stages where the product has the highest environmental impact, and this differs from product to product.

Taking a look at textiles, for instance, fabrics have strong environmental impacts when they are dyed, printed and bleached. For this reason, experts have come up with criteria for textiles in order to make sure that harm at the manufacturing stage is reduced as much as possible.

Source: http://ec.europa.eu/environment/ecolabel/

1.2 Sustainable materials and building ratings tools Requirements

Conclusions

-For each individual material, environmental requirements can be determined that ensure low environmental impact during manufacturing, but also throughout its' lifecycle.

-Establishing these requirements can not be done automatically. Its' application depends on the function of each material in the construction system and how it is managed.

-Ecolabels guarantee certain environmental characteristics of a material through an evaluation and certification system conducted by a third party.

First step: what to do

1.Initial characterisation of the material

Origin and type of raw materials, manufacturing process used, differences respect to the alternatives.

2.Defining an equivalent functional unit

Determining the surface area, building envelope, etc., with defined performance characteristics.

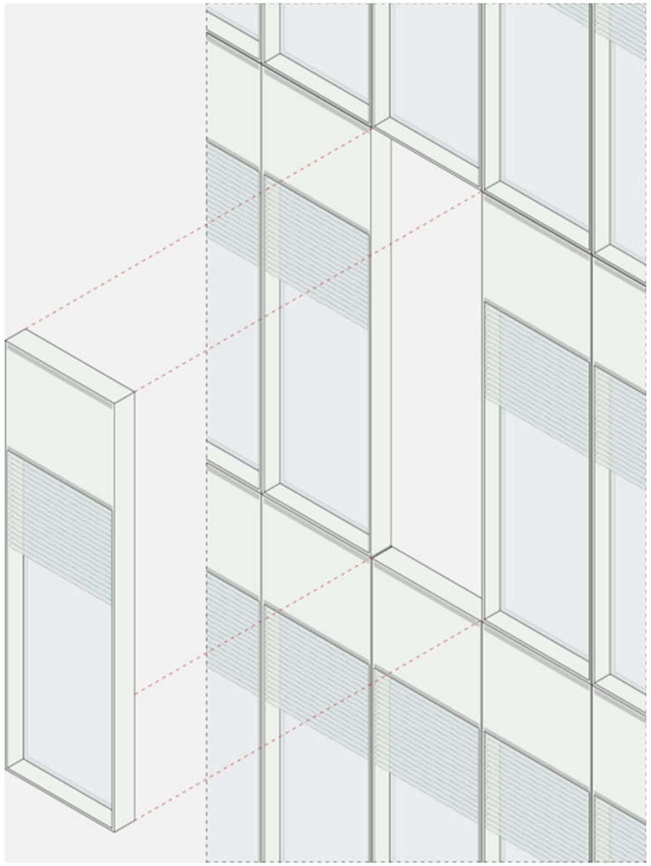
3.Evaluation through multiple impacts

Energy, CO_2 emissions, solid waste, toxicity, exhausting non-renewable resources, etc.

4.Vision of the complete life cycle

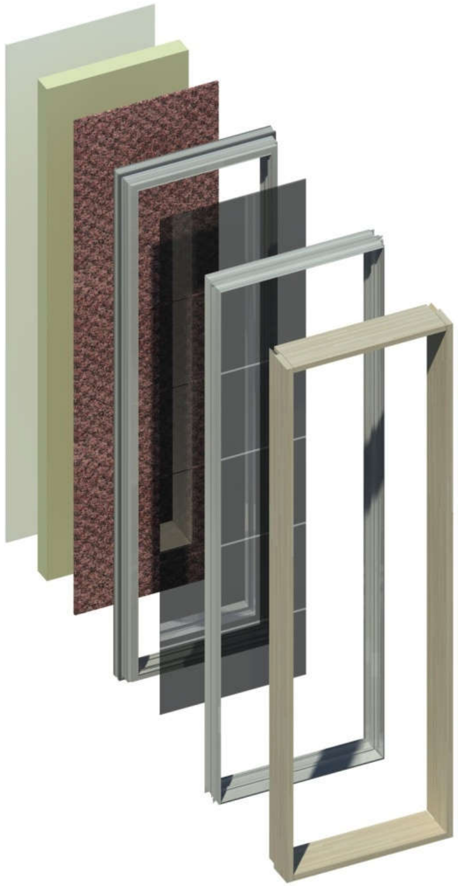
Examination of the different phases (manufacturing, transport, construction, end of the lifespan) and the interactions between them.

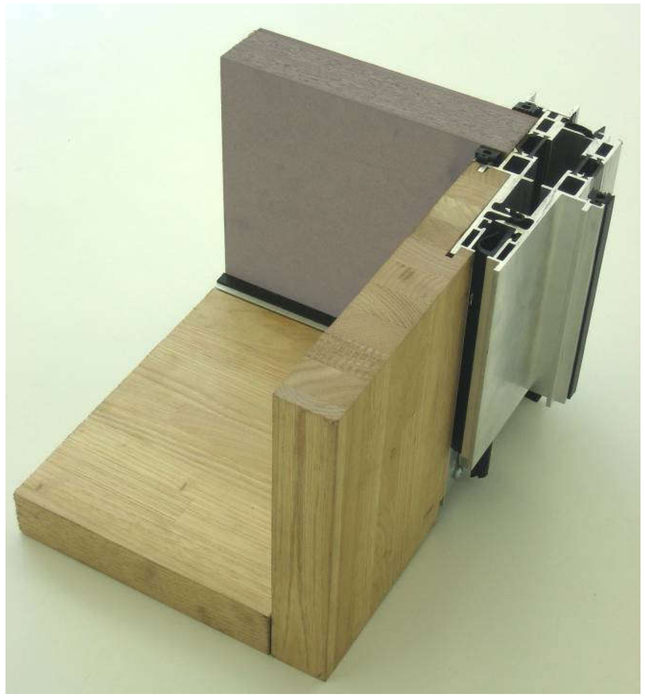
Example: FB720 modular curtain wall



Reference: Simplified LCA in skin design: the FB720 case. b720 Architects, Technical University of Catalonia, Societat Orgànica

Example: FB720 modular curtain wall





Reference: Simplified LCA in skin design: the FB720 case. b720 Architects, Technical University of Catalonia, Societat Orgànica

Context considerations

Facade analysis from the environmental point of view

Energy, CO_2 emissions, waste, toxicity, etc.

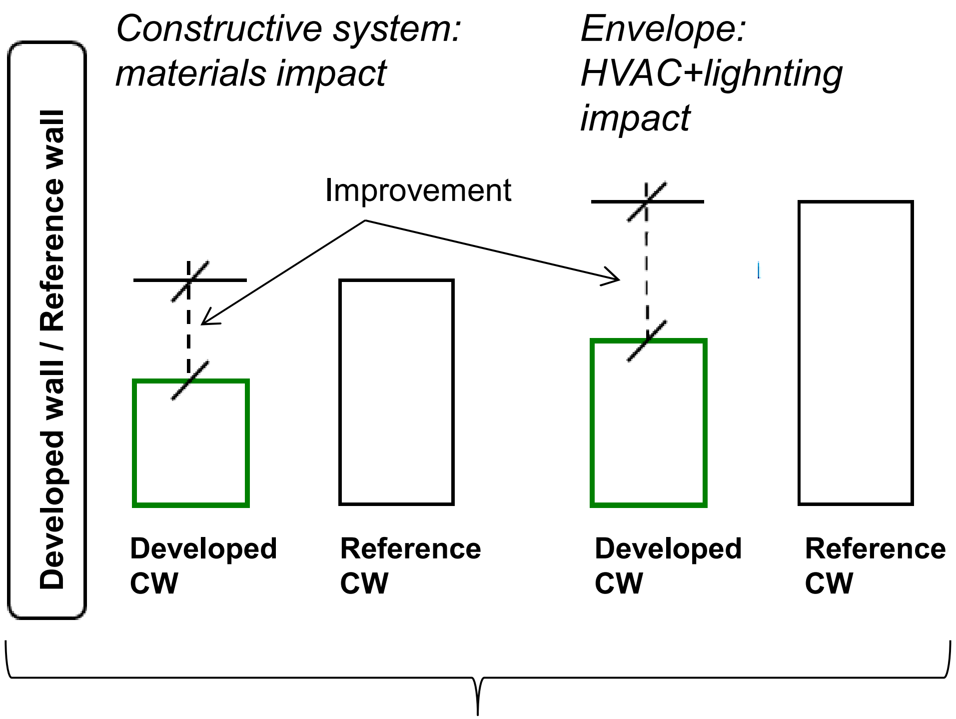
Energy, CO_2 emissions and toxicity.

How should a facade be composed?

How should a curtain wall facade be composed?

Reference: Simplified LCA in skin design: the FB720 case. b720 Architects, Technical University of Catalonia, Societat Orgànica

Comparison framework



Comparisons

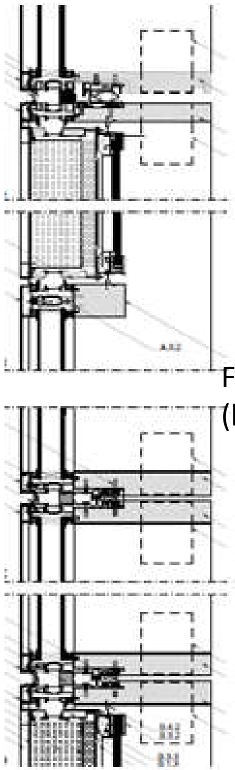
1) FB720 new curtain wall / MCW conventional curtain wall
2) FB720 new curtain wall / TF traditional facade

Reference: Simplified LCA in skin design: the FB720 case. b720 Architects, Technical University of Catalonia, Societat Orgànica

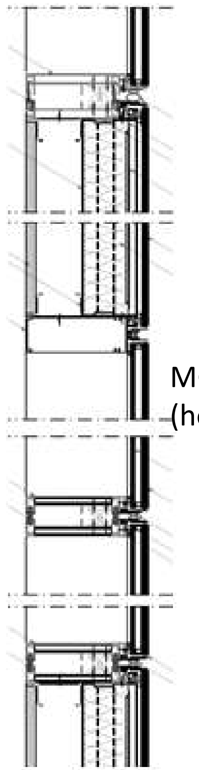
Comparison scenarios

1) New /existing curtain wall

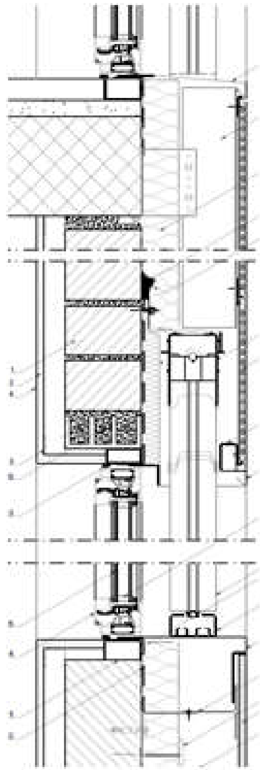
2) New curtain wall / masonry facade



FB720 new curtain wall
(horizontal section)



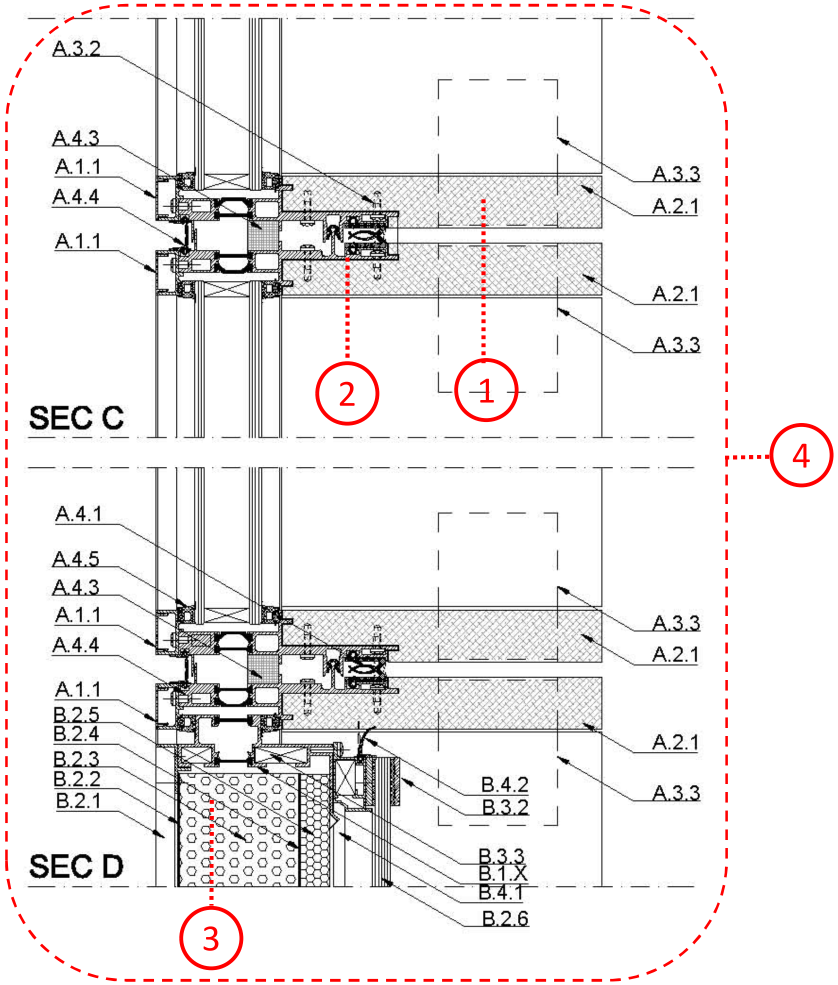
MCW existing curtain wall
(horizontal section)



TF traditional facade
(vertical section)

Reference: Simplified LCA in skin design: the FB720 case. b720 Architects, Technical University of Catalonia, Societat Orgànica

Environmental strategies

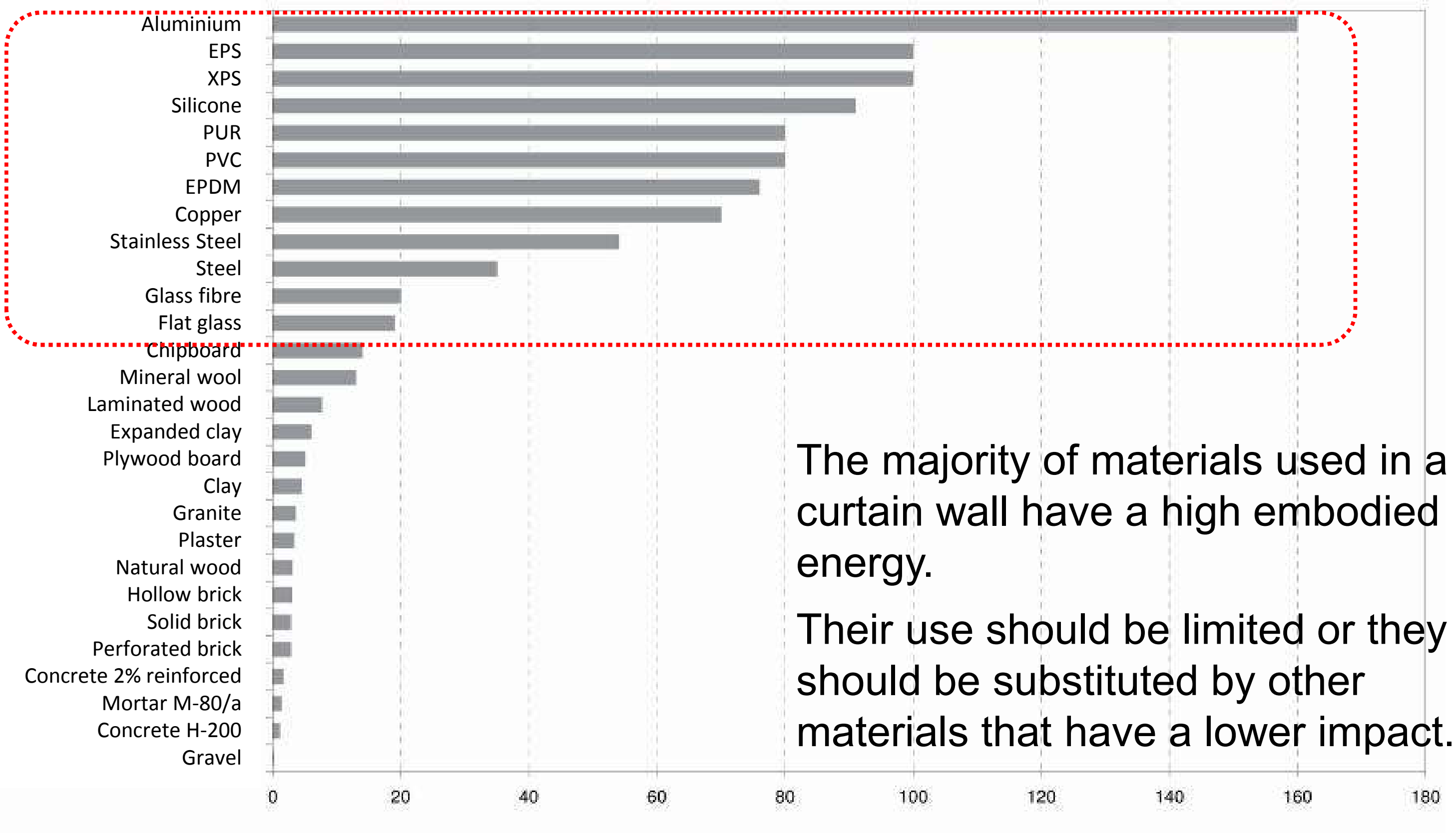


1. Reducing the proportion of aluminium used and using recycled aluminium.
2. Integrating renewable or recycled materials into the substructure.
3. Integrating renewable or recycled materials into the opaque panels.
4. Maximise the potential to separate, reuse or recycle the materials.

Reference: Simplified LCA in skin design: the FB720 case. b720 Architects, Technical University of Catalonia, Societat Orgànica

Impact of the traditional materials

Primary energy content (MJ/kg)



The majority of materials used in a curtain wall have a high embodied energy.

Their use should be limited or they should be substituted by other materials that have a lower impact.

Reference: Simplified LCA in skin design: the FB720 case. b720 Architects, Technical University of Catalonia, Societat Orgànica

Alternatives for material substitution


Aluminium 100% recycled


Plywood of local origin


Various recycled plastics


Wood-polyethylene composite


Concrete with fibreglass


Recycled and pressed carpet


Natural plaster / recycled cellulose


Chipboard with recycled wood


Natural sheep wool


Recycled textile fibres

Reference: Simplified LCA in skin design: the FB720 case. b720 Architects, Technical University of Catalonia, Societat Orgànica

Material accounting

Measuring materials for different versions of a $1m^2$ FB720 curtain wall

Element	Quantity		Materials			
	measurement	weight	Type A	Type B	Type C	Type D
Structure						
Primary profiles	m	kg	Aluminium	Aluminium	Aluminium	Aluminium
Reinforcement, primary profiles	m	kg	Timber	PVC r	Plastics r	Concrete
Fittings and fasteners	unit	kg	Steel	Steel	Steel	Steel
Sealing and joints	m	kg	EPDM r	EPDM r	EPDM	EPDM
Opaque enclosures						
Interior layer	m^2	kg	Wood board	Plasterboard	Wood board	Wood board
Thermal insultion	m^2	kg	Sheep wool	Fibres r	Sheep wool	Sheep wool
Waterproofing	m^2	kg	Kraft paper	EPDM r	Kraft paper	Kraft paper
Exterior insulation	m^2	kg	Aluminium	Aluminium	Aluminium	Aluminium
Fittings and fasteners	unit	kg	Steel	Steel	Steel	Steel
Sealing and joints	m	kg	EPDM r	EPDM r	EPDM	EPDM
Transparent enclosures						
Glass panel type I	m^2	kg	Double norm.	Double norm.	Double norm.	Double norm.
Glass panel type II	m^2	kg	Sun control	Sun control	Sun control	Sun control
Glass panel type III	m^2	kg	Metal s. cont.	Metal s. cont.	Metal s. cont.	Metal s. cont.

Reference: Simplified LCA in skin design: the FB720 case. b720 Architects, Technical University of Catalonia, Societat Orgànica

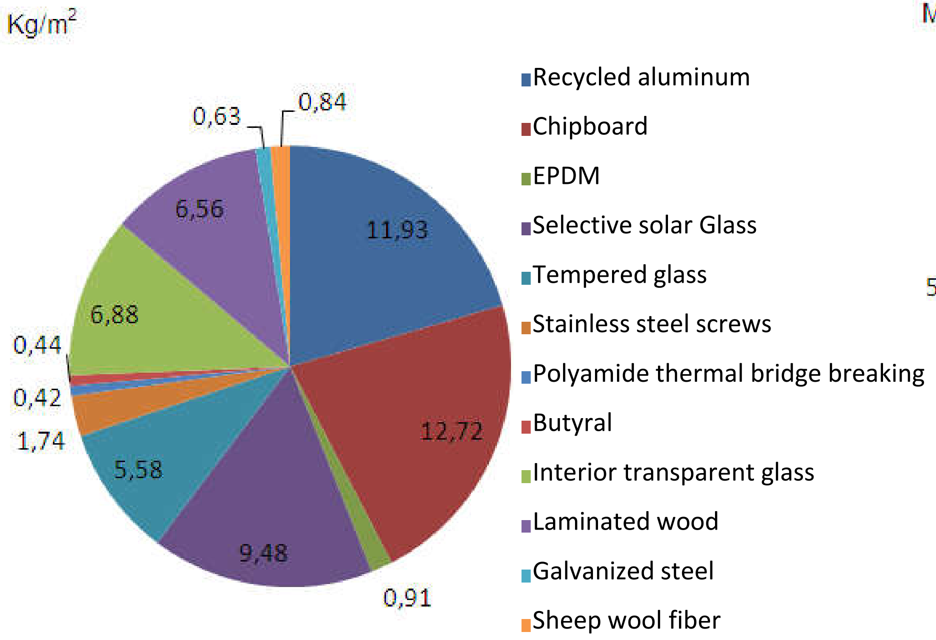
Environmental data for materials

MATERIAL	RECYCLED ALUMINUM 33%					
INFORMACIÓN TÉCNICA	UNIDAD	BASES DE DATOS				
		BEDEC	ICE	EMPA	ELCD	ECOINVENT/CML1992
COMPOSITION AND QUANTITIES						
weight	Kg	1			1	
voume	m3					
density	Kg/m3					
SOURCE / ORIGIN						
resources origin						
factory location						
stockist location						
transportation type						
ENVIRONMENTAL IMPACT INDICATORS: ALUMINUM						
energy	Mj/Kg	160,85	**154,00**	78,24	/	
solid waste	Kg					2,49
CO2 emission	KgCO2	9,25	**8,16**		/	
CO2 equivalent emissions				4,61		
recycled or renewable material at the beginning of life cycle	Kg/Kg					
recycled or compostable material at the end of the life cycle	Kg/Kg					
toxicity	ECA Kg/Kg					47600
ENVIRONMENTAL IMPACT INDICATORS: LACQUERED ALUMINUM						
energy	Mj/Kg		**211,07**			
solid waste	Kg					
CO2 emission	KgCO2		**30,91**			
CO2 equivalent emissions						
recycled or renewable material at the beginning of life cycle	Kg/Kg					
recycled or compostable material at the end of the life cycle	Kg/Kg					
toxicity	ECA Kg/Kg					

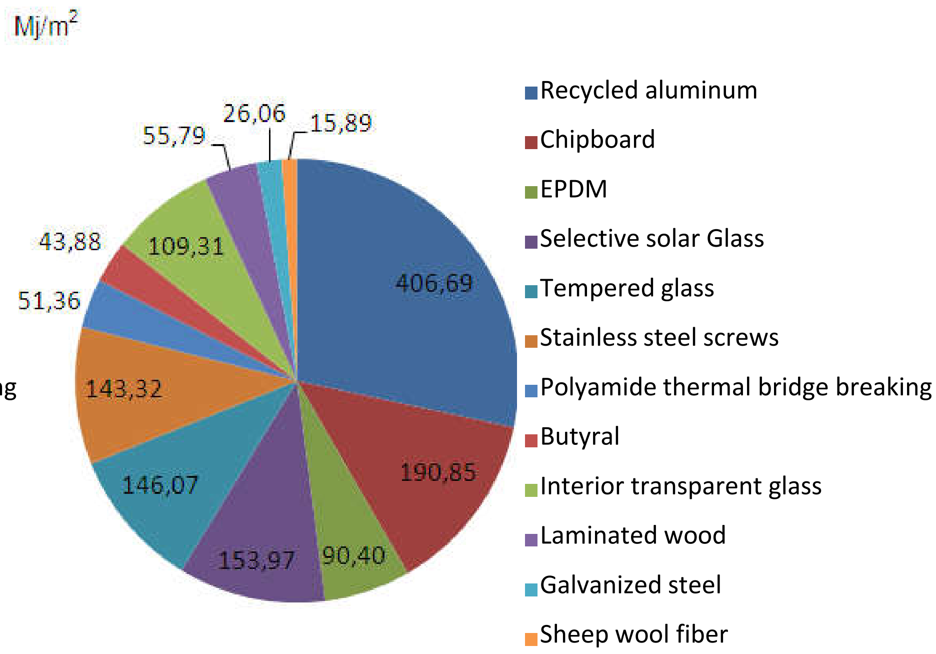
Reference: Simplified LCA in skin design: the FB720 case. b720 Architects, Technical University of Catalonia, Societat Orgànica

Production phase indicators

FB720 type A: Weight (amount)



FB720 type A: Energy (impact)



Reference: Simplified LCA in skin design: the FB720 case. b720 Architects, Technical University of Catalonia, Societat Orgànica

Results of the four FB720 types

Energy and CO_2 emissions, all life cycle phases

Fb720 (II/37/120)	Extraction + Manufacture		Transport		Construction		Maintenance		Dismantling		Total	
	(*)	(**)	(*)	(**)	(*)	(**)	(*)	(**)	(*)	(**)	(*)	(**)
Version A	1.447,50	107,41	102,71	8,19	11,99	0,75	699,89	61,11	10,99	1,18	2.273,08	178,64
Version B	1.486,15	125,38	134,97	11,18	11,99	0,75	699,89	61,11	10,99	1,18	2.343,99	199,60
Version C	1.756,12	114,71	105,50	8,41	11,99	0,75	699,89	61,11	10,99	1,18	2.584,49	186,16
Version D	1.615,61	136,31	108,56	8,65	11,99	0,75	699,89	61,11	10,99	1,18	2.447,04	208,00

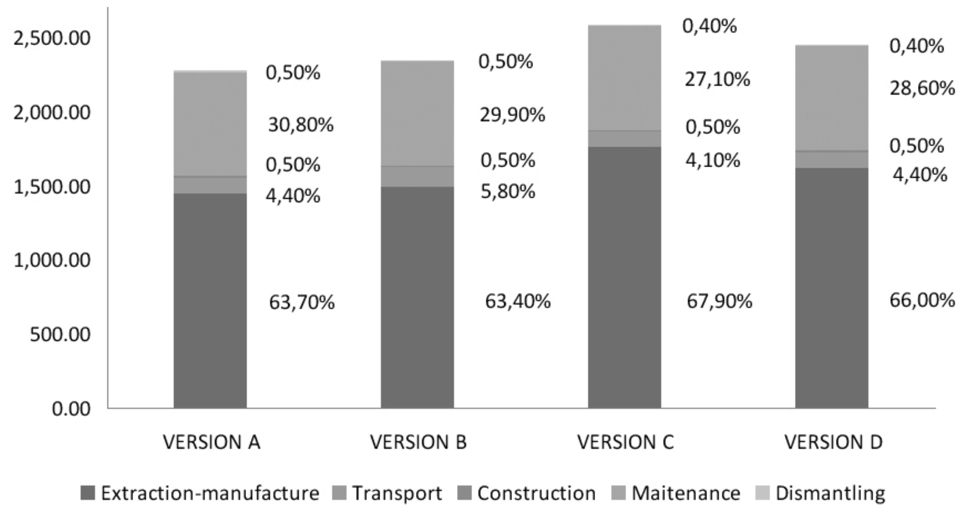
(*) Mj / m^2
(**) Kg CO_2 /m^2

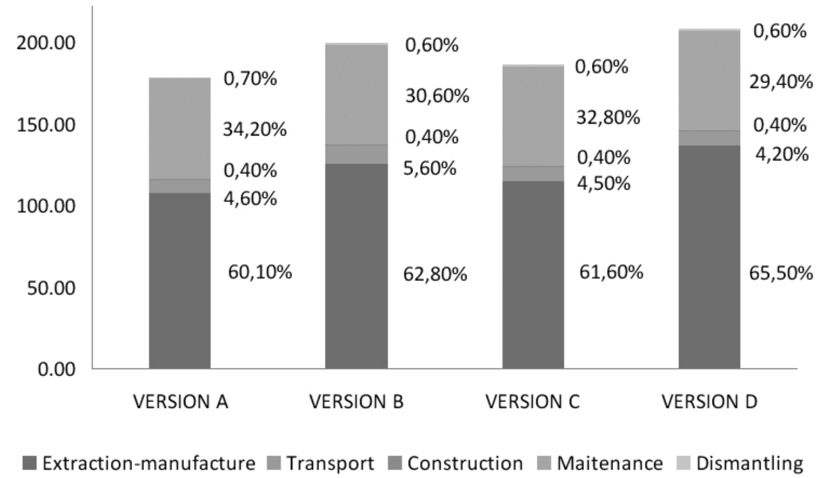
FB720 curtain wall types: A: renewable natural materials such as wood, sheep wool, and kraft paper. B: recyclable industrial materials such as recycled PVC, recovered cotton and recycled plasterboard. C: natural and industrial materials such as wood-polyethylene composite, sheep wool and kraft paper. D: fourth model with hybrid natural and industrial materials such as concrete, sheep wool and kraft paper. All these types include Type II glass (normal solar control), 37% transparent area and a 120 cm separation between vertical profiles.

Reference: Simplified LCA in skin design: the FB720 case. b720 Architects, Technical University of Catalonia, Societat Orgànica

Results of the four FB720 types

Energy (Mj/m²) **and CO_2 emissions** (kg/m²), **all life cycle phases**



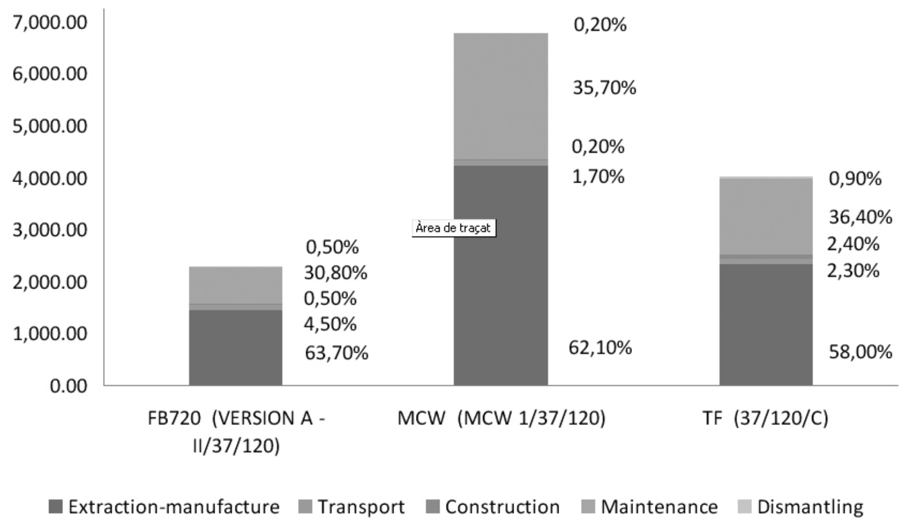


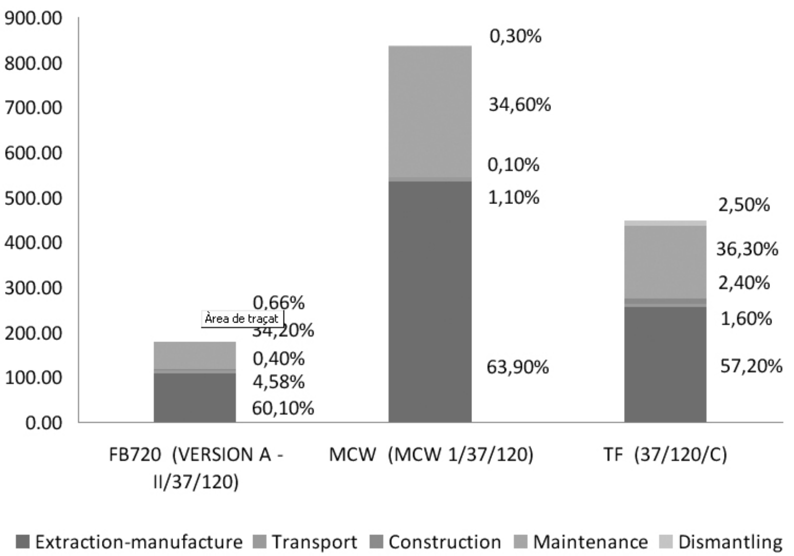
Version A/II/37/120, which is comprised mainly of renewable natural materials, has the best environmental behavior throughout its life cycle. Most of the environmental impact is concentrated in the production (ranges between 60,1% and 63,7%) and maintenance (ranges between 30,8% and 34,2%) phases.

Reference: Simplified LCA in skin design: the FB720 case. b720 Architects, Technical University of Catalonia, Societat Orgànica

A FB720, MCW and TF comparison

Energy (MJ/m^2) **and CO_2 emissions** (kg/m^2), **all life cycle phases**





The facade systems, both those that were prefabricated and those constructed in situ, were compared in energy and CO_2 emissions, where the main impacts occurred during the extraction and manufacturing phase and the maintenance phase.

Reference: Simplified LCA in skin design: the FB720 case. b720 Architects, Technical University of Catalonia, Societat Orgànica

Four FB720 types, MCW and TF comparison

Solid waste, all life cycle phases

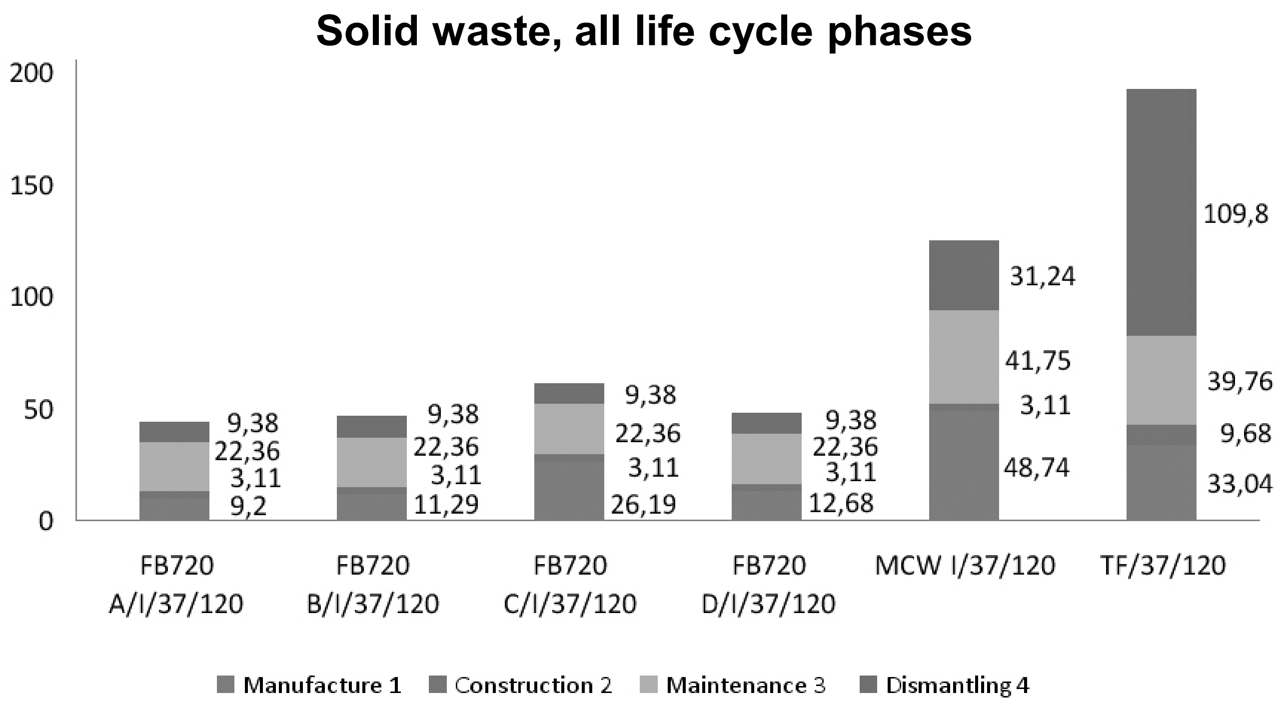
Façade	Manufacture [1]	Construction [2]	Maintenance [3]	Dismantling [4]	Total	%
FB720 A/I/37/120	9,2	3,11	22,36	9,38	44,05	100%
FB720 B/I/37/120	11,29	3,11	22,36	9,38	46,14	105%
FB720 C/I/37/120	26,19	3,11	22,36	9,38	61,04	139%
FB720 D/I/37/120	12,68	3,11	22,36	9,38	47,53	108%
MCW I/37/120	48,74	3,11	41,75	31,24	124,84	283%
TF/37/120	33,04	9,68	39,76	109,8	192,28	437%

Kg/m2 of (1) Waste from the manufacture of basic materials, (2) Waste from packaging (FB270, MCW and TF) and surplus construction material (TF), (3) Non-recyclable waste due to the partial replacement of the wall at 35 years, and (4) Non-recyclable waste due to the dismantling or demolition of the wall at 50 years.

The chart provides a clearer idea of the impact of each phase on the total waste in each case, as well as a relative comparison between the various façade systems. The lowest values, with a variation of up to 40%, due mainly to the manufacture phase, correspond to the different versions of the FB720 façade.

Reference: Simplified LCA in skin design: the FB720 case. b720 Architects, Technical University of Catalonia, Societat Orgànica

Four FB720 types, MCW and TF comparison



The MCW type of envelope is in an intermediate position, with double the impact of the FB720 façade that generates the most waste. The highest level of impact was caused by the TF façade, with four times the average impact of FB720 and a 50% greater impact than MCW.

Reference: Simplified LCA in skin design: the FB720 case. b720 Architects, Technical University of Catalonia, Societat Orgànica

FB720 A type, additional impact reduction

Combined positive impacts of the various possible improvements

Improvement measure	Savings (MJ/m²)	Percentage of total savings
1. Replacement of aluminium frames with wood	65.00	2.85
2. Façade workshop close to the building site (75 km)	71.40	3.13
3. Reusable packaging and recyclable materials	3.43	0.15
4. Useful life of the joints extended to 50 years	442.91	19.44
5. Glass panels that can be totally disassembled	204.90	8.99
Totals	787.64	34.57

Impact of the proposals to improve the life cycle: the table shows the combined positive impacts of the different additional proposals to improve environmental performance, in absolute and relative terms (taking into account total energy consumption for the FB720 façade of 2,278.08 MJ/m^2 throughout the entire life cycle).

Reference: Simplified LCA in skin design: the FB720 case. b720 Architects, Technical University of Catalonia, Societat Orgànica

1.2 Sustainable materials and building ratings tools Assessment and comparison

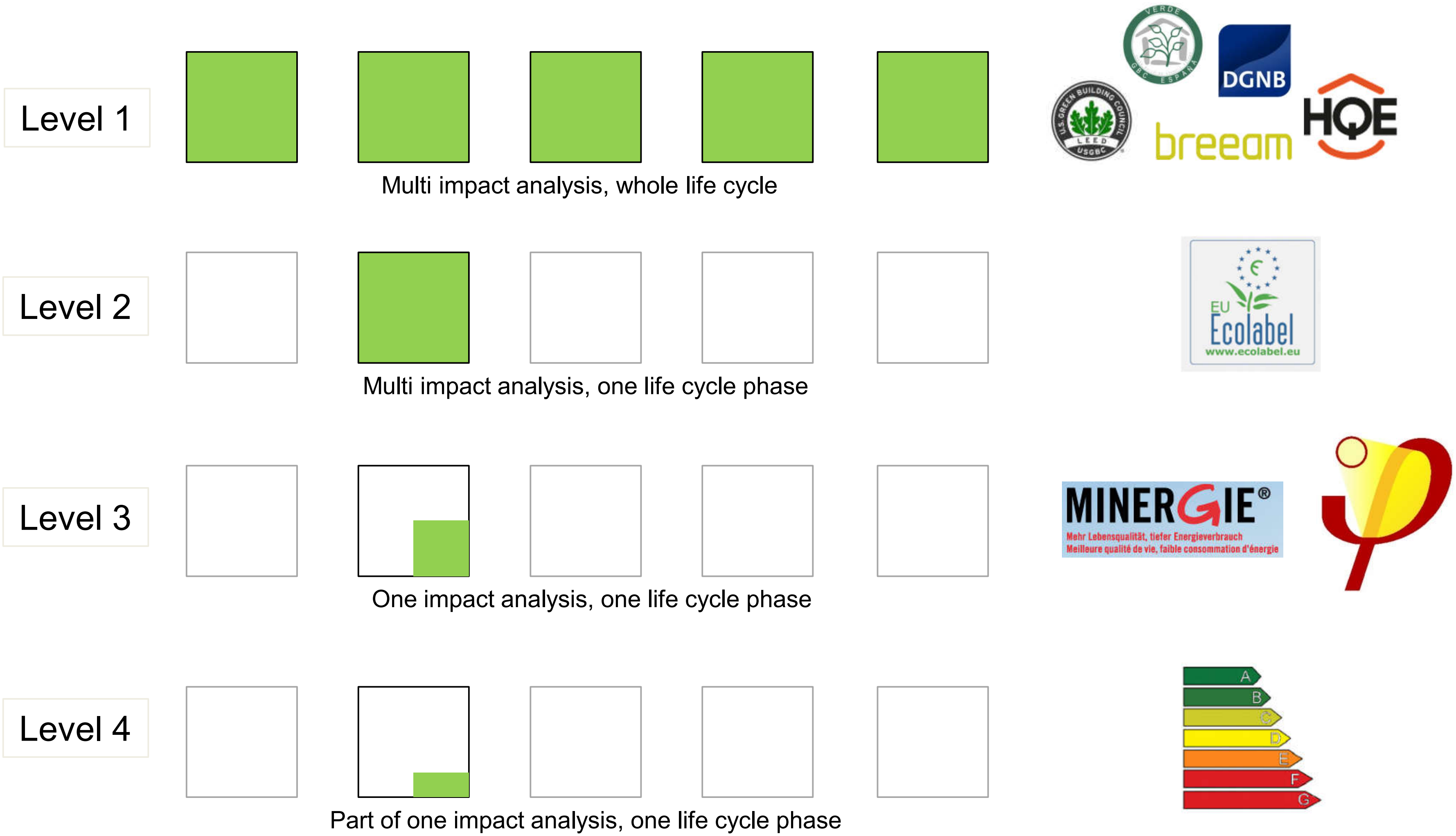
Conclusions

-In the phase prior to making design decisions, technical factors are crucial to the control of environmental impacts and do not depend directly on the materials that are used.

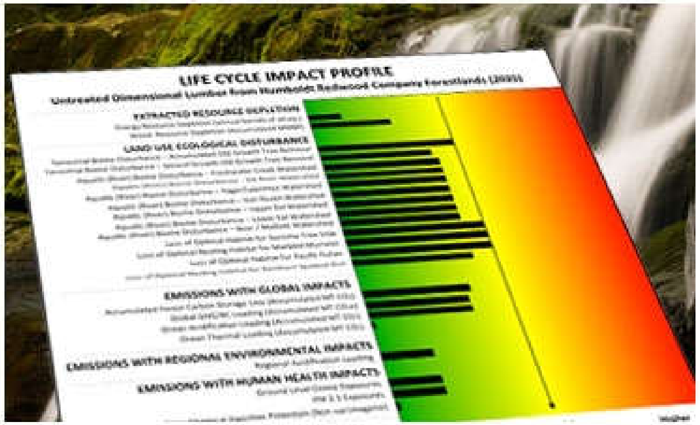
-The materials selection and optimisation, the geometric definition, the determination of joints and the management of the material resources up to the end of their cycle are the main keys to reducing impacts.

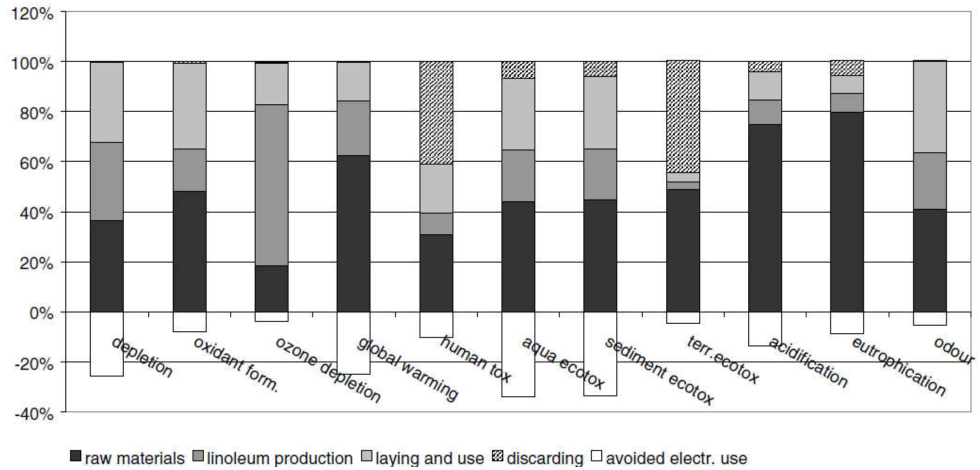
-Although the degree of difficulty in implementing the various proposed additional measures varies, there are sufficient opportunities to make improvements that have a positive impact.

Certification tools under the LCA vision



Environmental Product Declaration (EPD)





Source: LCA linoleum - Centre of Environmental Science (CML)

Main certification systems

Building certification types

First generation
(check-list format)

1. The project is evaluated by contrasting it to criteria of good practices.
2. Global points or ”ecopoints” are awarded that summarise different impacts.
3. The evaluation of specific impacts is not apparent to the user.
4. The system does not provide quantified data of the environmental impact.
5. The rating is done by scoring points, occasionally there are references.

Second generation
(summarised LCA format)

1. The project is evaluated through modeling its’ performance.
2. Impact indicators are used with objective magnitudes.
3. The evaluation of specific impacts is apparent to the user.
4. The system does provide quantified data of the environmental impact.
5. The rating is done by comparing impacts to a reference and through a point system.

LEED certification (USGBC)

Organisation: USGBC
Brought to market : 2000
Eval.√ **Qual.** √ **Cert.** √
Impact categories:
Site, Water, Energy and atmosphere, Materials and resources, Interior environmental quality, Design innovation, Regional priorities.
Phases:
Design, construction, renovation and management
Type: 1st generation. Check list of criteria(does not provide impact values).
Uses: residential, tertiary, interiors, distribution hub, neighborhoods, new buildings and renovations.
Regionally Adaptable: no

www.usgbc.org/LEED

Qualitative evaluation of materials (without quantities)
The impact on the total value is 13%

Criteria	Performance
Waste management	Seperation of the elements and delivery to recyclers.
Reuse of materials	Possible reuse of structural and envelope components.
Recycled content	Materials that impact the budget.
Regional origin	Factories at a distance to the site no farther than 800 km.
Quickly renewable	Wood and plant fibres in general.
Certified wood	Wood certifications FSC, PFEC and others

Research assistance provided by Eric Johnson and Tomáš Kurka

DGNB certification (DGNB)

Organisation: DGNB
Brought to market : 2008
Eval.√ **Qual.** √ **Cert.** √
Self-evaluation: no
Impact categories:
Site, Water, Energy and atmosphere, Materials and resources, Life cycle cost, Interior environmental quality, Design innovation, Regional priorities.
Phases: Design, construction, renovation and management.
Type: 2nd generation. Quantitative evaluation of criteria (includes impact values).
Uses: residential, tertiary, neighborhoods, new buildings and renovations, etc.
Regionally Adaptable: yes

www.dgnb-international.com

Quantitative evaluation of materials (with quantities)
The impact on the total value is relative

Criteria	Performance
LCA impacts (energy, CO_2,)	Low impact products (energy, CO_2, toxicity, etc.).
LCC life cycle costing	Building costs during the entire life cycle and value stability
Waste reduction	Separation of the elements at the end of life cycle
Maintenance	Simple maintenance and easy cleaning
Constructive efficiency	Efficiency of the constructive system (net area/built area)

HQE certification

Organisation : CERQUAL-QUALITEL (for Homes); Certivea (for Non-residential buildings.)

Brought to market: 2003

Eval. √ **Qual.** √ **Cert.** √

Self-evaluation: not for certification, but self assessment tools available

Impact categories: Construction, Site, Water, Energy, Waste, Materials ,Resources, Comfort, Indoor environmental quality, Adaptability, Maintenance performance

Phases: Design, Construction, Renovation , In-Use stages and management

Type:2nd generation certification (LCA and Performance Indicators considered).

Uses: Homes, non-residential, new, existing buildings and renovations.

Internationally adaptable: yes

www.qualite-logement.org

www.certivea.com

Quantitative evaluation of materials (with quantities)

The impact on the total value is relative

Criteria	Performance
LCA impacts of Products and Building	Favours low impact products (energy, CO_2, toxicity) and use of certified products, consideration of Impacts and EPDs from 50% up to 100% of products, global building impact calculation and assessment.
Waste	Waste management, reduction and reuse LCA considerations
Local production	Optimize transport of renewable materials.
Biosourced product	Minimum quantity biosourced materials
Certified wood	Wood certifications, Integration of a specific minimum volume of wood, implement materials and products enabling CO2 to be trapped (ex. wood).
Recyclability (end of cycle)	Removability/separability of the construction products and processes with a view to optimal environmental management of their end of life

Research assistance provided by Ana Cunha

BREEAM (Bre)

Organisation: BRE Trust
Brought to market : 1992
Eval.√ **Qual.** √ **Cert.** √
Impact categories:
Management, Health, Energy, Transport, Water, Materials, Waste, Land use, Pollution, Innovation
Phases:
Design, construction, renovation and management
Type: 1st generation. Check list of criteria(does not provide impact values).
Uses: residential, tertiary commercial, existing buildings, neighborhoods
Regionally Adaptable: yes

www.breeam.org

breeam

Qualitative evaluation of materials (without quantities)
The impact on the total value is 12,5%

Criteria	Performance
Low environmental impact	Encourages low environmental impact materials such as renewable ones.
Reuse in façade	Reuse of reclaimed material is not very common
Reuse in structures	Possible reutilization of structural recovered elements
Responsible materials	Labeled materials such as certified wood with FSC, PFEC etc.
Low impact insulation	Renewable materials are encouraged
Robust Design	High durability and low maintenance design and materials

VERDE certification (GBCe)

Organisation : GBCe
Brought to market : 2006
Eval.√ Qual.√ Cert.√
Self-evaluation: yes
Impact categories:
Site, Water, Energy and atmosphere, Materials and resources, Interior environmental quality, Design innovation, Regional priorities.
Phases: Design, construction, renovation and management.
Type: 2nd generation. Quantitative evaluation of criteria (provides impact values).
Uses: residential, offices, services, new buildings and renovations.
Regionally Adaptable: no

www.gbce.es

Quantitative evaluation of materials (with quantities)
The impact on the total value is relative

Criteria	Performance
LCA impacts (energy, CO_2,)	Low impact products (energy, CO_2, toxicity).
Waste reduction	Seperation of the elements and delivery to recyclers.
Local production	Factories at a distance to the site no farther than 800 km.
Reuse (beginning of cycle)	Possible reuse of structural and envelope components.
Reuse (end of cycle)	Standardised elements with removable joints (not attached)
Recyclability (end of cycle)	Large volumes with removable joints (not attached)

1.2 Sustainable materials and building ratings tools Demonstration and certification

Conclusions

-Environmental Product Declarations (EPD) describe the main environmental impacts of a product in a standardised way, but do not guarantee that this impact is low.

- The evaluation systems and environmental certifications of buildings analyse the lifecycle of a building in a simplified way. Multiple effects of the various phases are evaluated and an overall rating is provided.

-Second generation systems quantify environmental impacts in conventional units of measurement. Compared to a conventional system, they also inform about impacts that are avoided.

1.3 Discussion

First part (morning, 3h)

1.1 Overview (90')
Sustainability and materials (30')
Environmental impact / open materials cycle (30')
Environmental strategies / closed materials cycle (30')

1.2 Sustainable materials and building ratings tools (70')
Requirements (10')
Assessment and comparison (60')
Demonstration and certification (20')

1.3 Discussion (20')
Questions, comments, debate (20')

1.3 Discussion

Developers, designers, manufacturers, builders, managers and public administration, through their often disjointed actions and decisions, demand resources (materials, energy, water, etc..) and generate waste (construction, CO2 emissions, etc..).

They often require the optimization of the productivity benefits of the industrial system. Consequently environmental impacts deriving from the production of goods and services increase significantly.

1.3 Discussion

-Urban planner
Preserve the territory, reducing mobility and freezing the growth of the urban footprint.

-Developer
Develop alternatives that respond to the unmet housing without increasing building stock and consuming natural areas.

-Designer
Design processes capable of drastically reducing the consumption of energy, water and materials, as well as the generation of waste.

1.3 Discussion

- Manufacturer of materials
Offer products that close the material cycles

- Builder and other technicians
Structure and training tailored for the renovation of the building stock

- Public administration
Take actions for removing barriers and creating incentives for the implementation of the renovation sector. Create the market for green retrofitting

User and building manager
Management and control strategies to reduce energy consumption, water, impacts of maintenance materials, generation of household waste.

2.1 Showcase of sustainable materials and resources

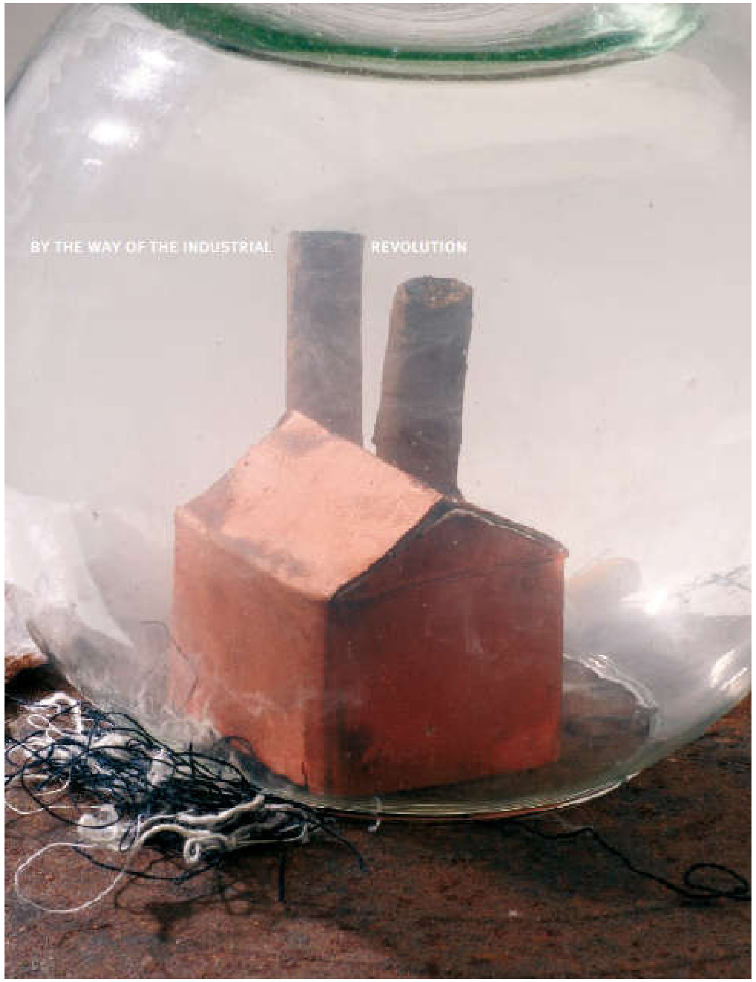
Second part (afternoon, 3h)

2.1 Showcase of sustainable materials and resources (60')
Closing the material cycle (12')
Nature based materials (16')
Industrial based materials (32')

2.2 Case studies (60')
Case study 1 residential (30')
Case study 2 workplace (30')

2.3 Workshop (60')
Introduction (10')
Work in groups (30')
Sharing knowledge (20')

The standard production model is a problem

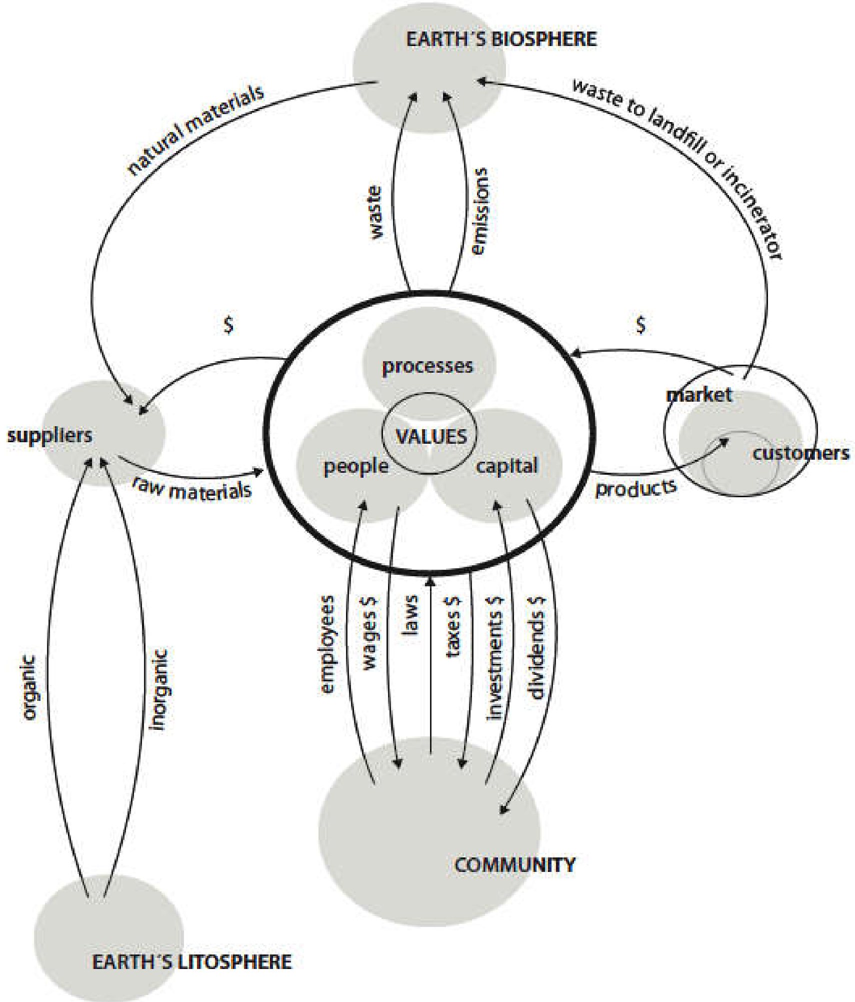


The manufacturing of almost all industrialized products, including the most innovative ones, follows a sophisticated linear production system based on the sequence: extraction>manufacturing>waste

From an environmental point of view, this model still has the same negative characteristics since its creation during the first industrial revolution.

Image source: www.ecomateriales.es

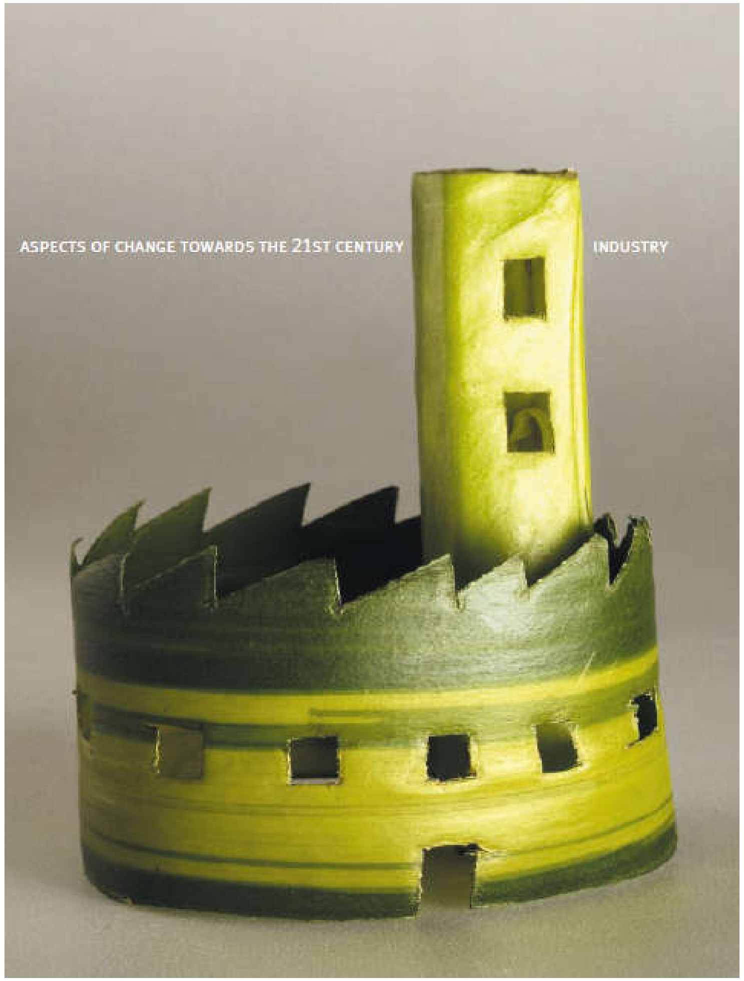
The standard production cycle is a problem



Production starts by extracting resources from the lithosphere and transforming them into industrial raw materials.
As a result, resources are exhausted and waste is generated.
Raw materials are transformed into products using energy and generating solid, liquid or gaseous waste. The product, at the end of its' lifespan, will also be disposed of as waste, and thus contaminate the biosphere.

Image source: Mid-course correction. Towards a sustainable enterprise, Ray Anderson.

The new production model is a solution



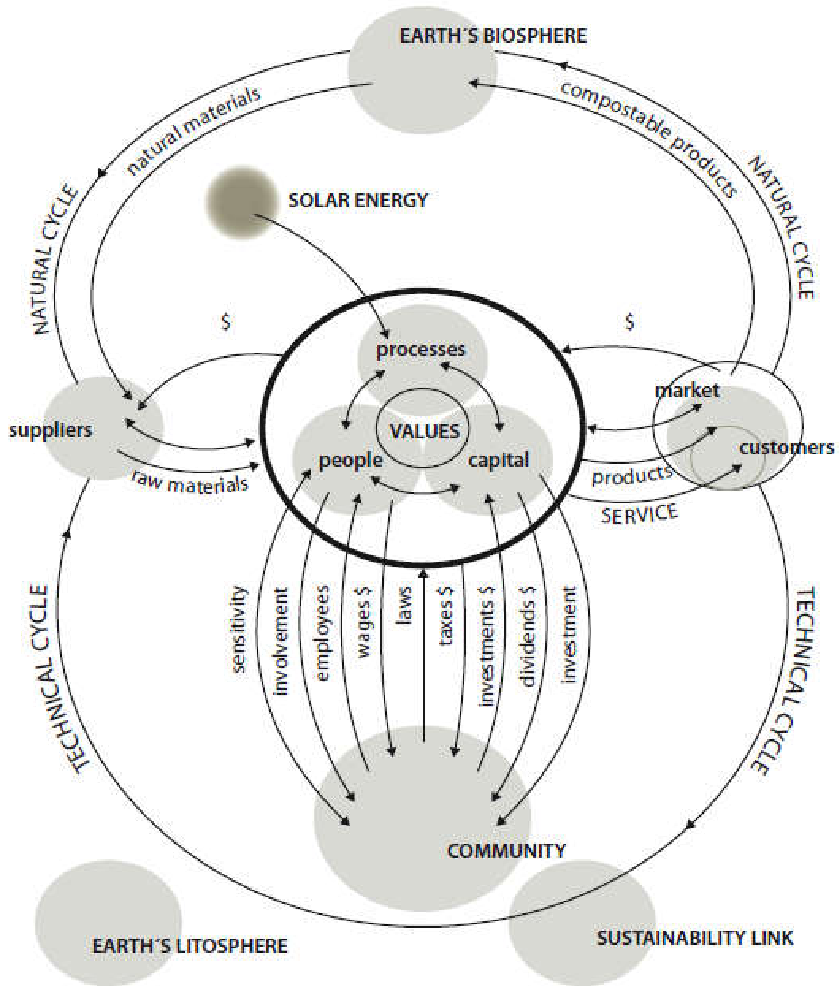
The closing of the materials cycle, and the re-conversion of waste back into resources, must be included in our industrial model to face the challenge of sustainability.

In order to do so, renewable material can be used (letting nature do the recycling) or the materials can be recycled industrially.

In both cases, the future strategies lie in finding which is the most adequate option, case by case.

Image source: www.ecomateriales.es

The new production cycle is a solution



Highlights of sustainable enterprises:

-Zero waste

-Non-contaminating emissions

-Renewable energy

-Closing the loop

-Efficient transportation

-Participation of all parties

-Redefining economic values

Source: Mid-course correction. Towards a sustainable enterprise, Ray Anderson.

Two ways to close the materials cycle

The first is to use the biosphere as the `great machine´ capable of gathering waste and turning it into resources by means of its own natural processes. This is the path of the renewable materials.

The second path to follow is to use the technical system, by organizing adequate waste management, designing the recycling processes and turning the waste again into resources. This is the path of the non-renewable materials.

Image source: www.ecomateriales.es

2.1 Closing the materials cycle

Conclusions

-There are no good or bad materials, sustainable or unsustainable materials.

-There are unsustainable ways of using them - like in most cases nowadays - and sustainable ways of using them.

-Each material offers possibilities to implement closing-the-loop strategies. These should be used in the development of new products.

Closing the cycle through the biosphere

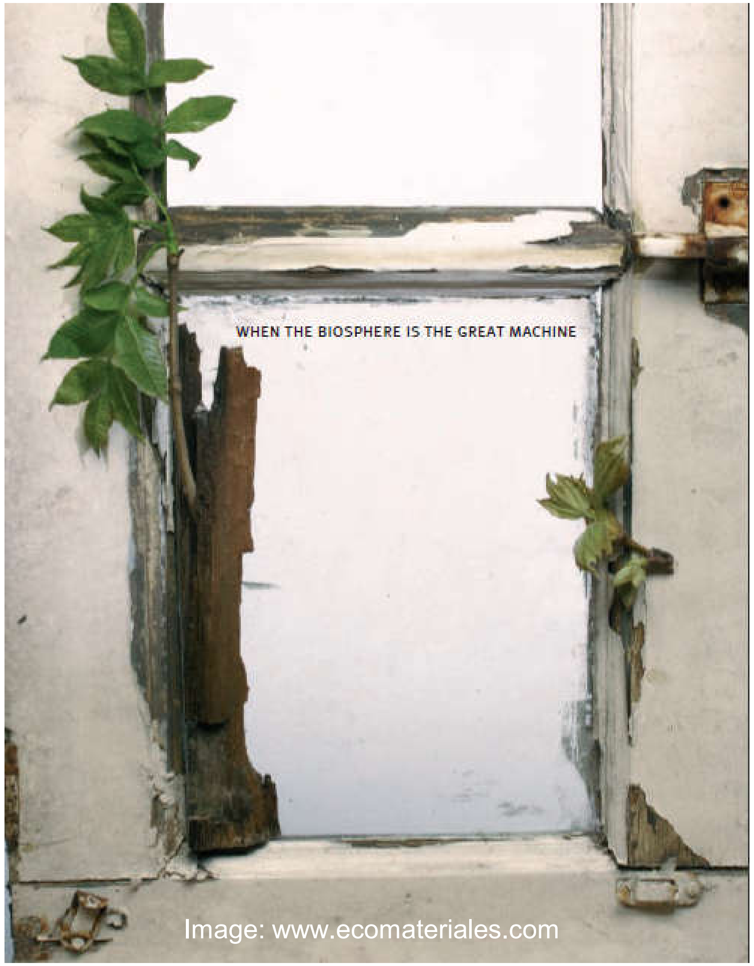
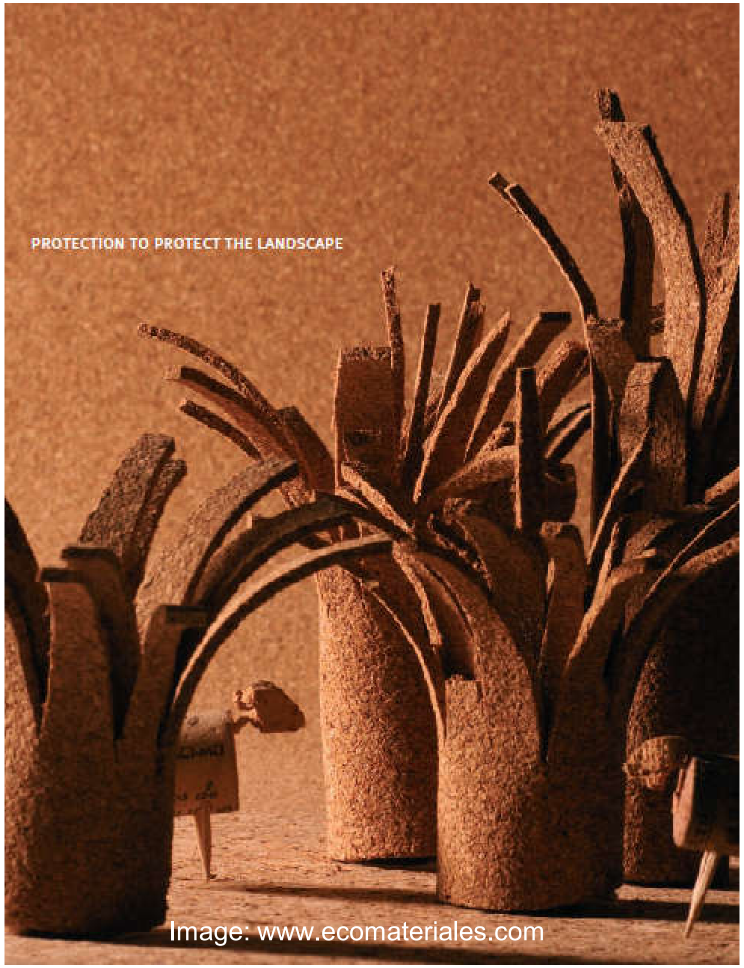


Image: www.ecomateriales.com

Timber, together with plant and animals fiber tissues, constituted the basic resources for most civilizations prior to the industrial revolution.

Such materials, when their use is depleted, can be returned into the natural environment that produced it and, after being naturally processed, be transformed again into the original resource.

Building landscapes



Cork can be extracted from the cork oak without putting its life at risk. This process starts 25 years after it is planted and can be repeated every 9-12 years.

A tree grown by traditional methods commonly reaches its productive life after two centuries, without any artificial irrigation, using neither herbicides nor fertilizers.

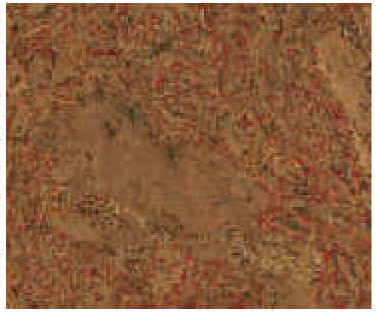
Currently, the planted cork oak takes up an area of 2.2 million hectares and it is mainly located in Spain and Portugal.

Building landscapes


Cork oak forests are raw materials while being natural landscape.


Cork can be extracted without risking the life of the tree.


This “factory” has been working for at least 200 years.


Natural materials design landscapes.

A cork oak forest is more than just a cork-harvesting field, since the natural activity of these trees becomes indispensable in maintaining the ecosystem balance of the arid place they inhabit.

By using cork for insulation or finishing, we are opting for a renewable and low-energy content material, and we are furthermore ensuring the continuity of its production and the subsequent natural landscape preservation.

Feeding the biosphere

Image: www.ecomateriales.com

Polishes and paints usually have negative impacts. These include: significant amounts of manufacturing energy, petrol-derived raw materials consumption, heavy metals incorporated as pigments and toxic emissions into the atmosphere during both its production and application processes due to the evaporation of organic solvent.

However, there is a new generation of products based on natural raw materials that has been developed for decades in Europe which avoids all the previously mentioned toxic effects.

Feeding the biosphere

Paints, solvents and polishes can also be obtained from nature.

This is not petrol but a natural solvent from raw material.

Do it yourself without any health risk.

This oil treatment keeps the timbers' natural condition (making it recyclable).

Natural polishes and paints are products whose finish and durability qualities are equal to those of synthetic origins. Their use drastically reduces the environmental impact since minimum amounts of energy are employed in its manufacturing process, compared to paints based on inorganic solvents. Raw materials derived from plants are used, which are consequently renewable and free of heavy metals (minerals and oxides from minerals are used as pigments). The release of VOCs into the air is smaller. All its' waste is biodegraded and returned to the natural environment to be composted.

Certifying the future

Image: www.ecomateriales.com

While deforestation is increasing at an annual rate of 1% in non-certified tropical rainforests, resources are continuously growing in controlled forests .

According to the wood importing associations from areas in central Europe, this is occurring thanks to the independent forestry certifications by organisations such as the Forest Stewardship Council (FSC), the Sustainable Forestry Initiative (SFI) and the voluntary forestry certification system (PEFC).

Certifying the future


This timber factory is a living factory.


Responsible management assures its survival.


Certification is the core of the system.


Timber: best if certified

Certified systems assess forestry practices in accordance to previously established regulations and make it possible for forest management to meet environmental, social and economic parameters ensuring a durable health and productivity of the forest.

Moreover, wildlife habitat, water quality and social benefits for the community, such as proper and regular work is ensured in these forests.

2.1 Nature based materials

Conclusions

-The biosphere has a limited capacity defined by the territory to which it is confined to and by the solar radiation affecting it, the latter being the main source of energy to feed it.

-Production must be carried out without diminishing its potential while at the same time extracting its resources for maximum use.

-The management of renewable materials demands consideration of the fact that resource extraction implies (apart from this isolated act) important environmental repercussions. We need to learn from the experience of the integrated biosphere management models.

Closing the cycle through technology

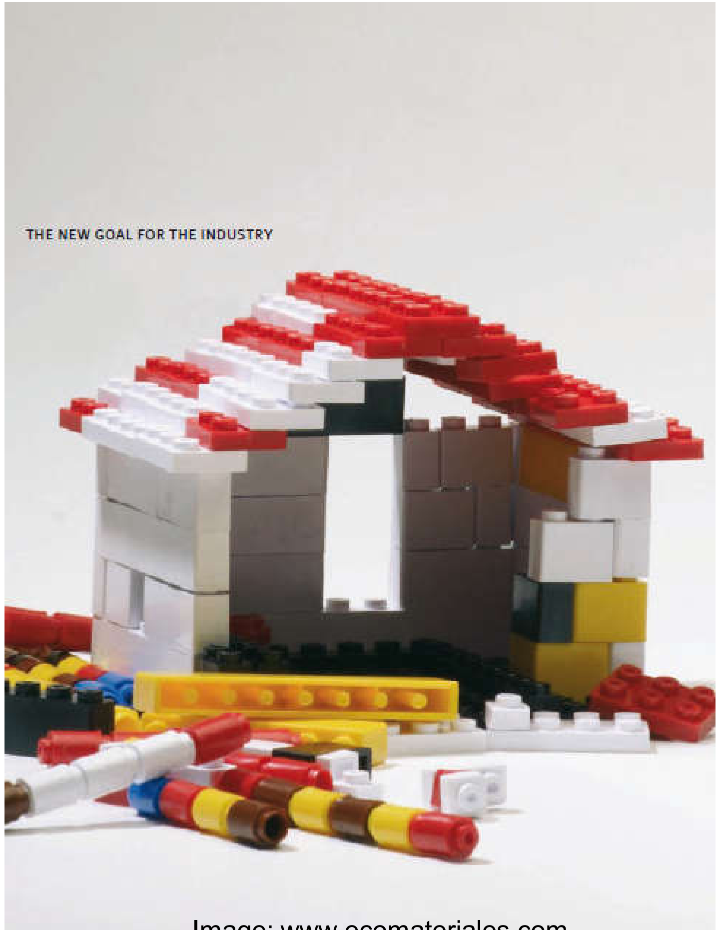


Image: www.ecomateriales.com

Closing the non-renewable materials cycle, that is to say their transformation from waste into resources, must be done through industrial processes.

Tackling these issues involves developing different strategies, designing new processes and products, and implementing alternative policy models.

The mission is to turn our industrial metabolism from a linear system that constantly consumes resources and expels waste, into a closed cycle system where residues do not exist.

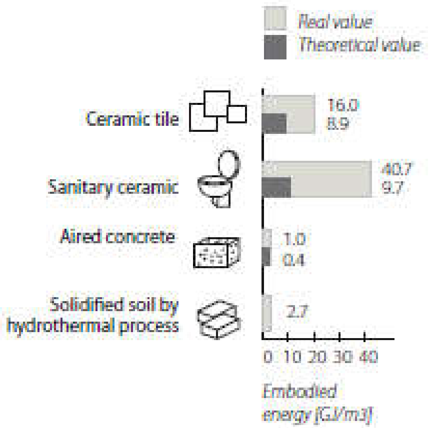
Doing only what is necessary

Image: www.ecomateriales.com

A great deal of the ceramics tiles we use frequently offer more technical features than those really needed for their use. This is either because its operational conditions are not as severe as they are designed for, or because in some cases the material is prematurely replaced due to changes in fashion or owners' aesthetic preferences.

Through correct design, excesses of raw materials and energy consumption during manufacture could be avoided.

Doing only what is necessary



Non profitable ceramics lifespan wastes a lot of energy.

Some ceramic tiles last at least 100 years.

Some ceramic tiles just last 5-10 years.

Ecocarat. There is no difference between ceramic adjusted to their us or conventional ones.

Emile Ishida, from INAX Corporation Japan wondered how to develop a ceramic product to use for housing facilities. He developed ceramics that are produced by hydrothermal solidification (hardening through controlled humidity and heat) under low temperatures, between 500 and 900ºC.

This is an important environmental advantage because flat ceramics usually are cooked at 1.100 – 1.800ºC corresponding to an energy consumption that is six times larger.

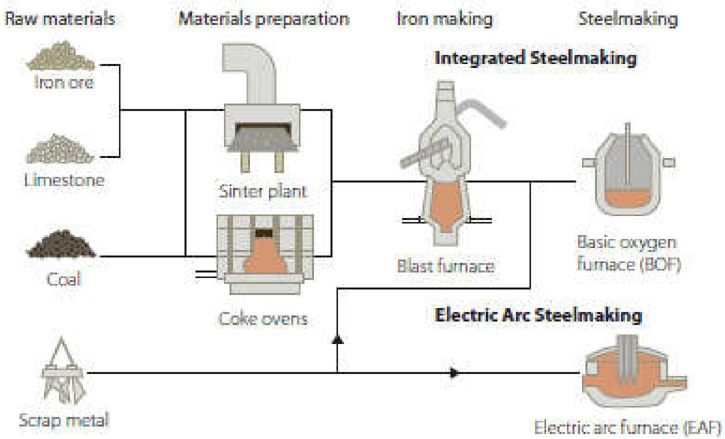
Exploiting new mines

Image: www.ecomateriales.com

Steel, like many other metals, has been recycled for decades. It is one of the few resources that regains its' value during the whole building deconstruction process by simply sorting it out selectively.

Fusion can take place an unlimited number of times without its quality being altered. In fact, production energy can be reduced by between 25% and 30% from the fourth recycling process onwards, compared to steel manufactured from iron, carbon, limestone and a low proportion of scrap.

Exploiting new mines



Steel can be continuously recycled without any loss in quality.

Both new and old steel mine types are currently coexisting.

Old or new steel? When recycled, its age does not matter.

Under certain building circumstances (dry construction with removable joints), 99 out of every 100 tons of the steel in a building is likely to be recovered, thus obtaining 95 tons of new steel by means of the re-fusion processes. This rate of recovery (95%) and the preservation of material quality are encouraging companies to change their forms of commercialisation.

The continuation of the recycling process can be ensured by means of steel supplies of construction systems that can be easily dismantled (rather than demolished) and long-term rental contracts instead of purchases

Doing it together


Image: www.ecomateriales.com

Approximately 1.2 million tonnes of glass waste is generated in Europe in the construction industry every year. It is mostly not recycled due to problems in the separation process and technical difficulties caused by other adhered materials.

On the other hand, 9.4 million tonnes of glass from bottles are collected by an immense network of municipal collection, all of which can be recycled.

Doing it together

9,4 million tonnes seperated in Europe every year.

1kg of bottles collected equals 1kg of new glass production.

Before it meant waste. Today this material can be reused.

A quarter of this glass panel is made from crushed bottles.

This system of municipal collection, reduces new production, a reintroduces the recycled glass into the manufacturing of float glass for 25% of the construction industry. The quantity produced could be larger but is limited by a degree of purity that is required in this type of glass.
The key to increasing glass recycling is waste management at the construction site -where a lot of material is available- and copying urban collection system by separating it from other materials and collecting it in large volumes.

Consuming the waste of others


Image: www.ecomateriales.com

In the production of plastic materials, petrol –a resource, which we must remember, is depleting - is doubly used in two ways, namely as a source of energy and as raw material.

The possibilities of reusing and recycling plastics depends on complex technical factors.

Most plastics can be recycled although two important obstacles must be avoided: low purity of the resource and availability of a sufficient amount of each type of compound.

Consuming the waste of others

Plastics can feed the biosphere through a biodegradation process that generates nutrients rather than waste. Ecoflex by Basf.

Milk feeds people. Milk plastic packages feed the building industry.

Jet polyurethane foam. It is difficult to recycle.

Recycled polyurethane foam panel. It is easy to recycle. Copopren.

The industry shows how good quality products can be made from plastic waste. A good example are panels and boards manufactured out of all sorts of plastics derived from municipal waste collection, ground and pressed, free of glue or adhesives and very resistant to changes in humidity. Another example is the acoustic board produced from the agglomeration of diverse polyurethane foam particles, a compound which has a really high acoustic absorption capacity for all sound frequencies.

In both cases, they are 100% recycled and can be used within and outside of the construction industry and can again afterwards be completely ground up and pressed again.

Consuming our own waste


Image: www.ecomateriales.com

.Approximately 60% of the weight of a concrete structure building is made up of crushed natural stone. These are fragments of natural stone extracted from quarries whose technical characteristics are very similar to the product obtained after grinding concrete itself.

Under certain technical and regulatory conditions, a large amount of this natural stone granules can be replaced by a new material, that until quite recently was regarded simply as waste.

Consuming our own waste

Crushing concrete to make It processable.

Concrete turning into crushed stone.

Building demolition site as an arid aggregate factory.

Recycled concrete does not look different from a conventional one. Dry Dock Bridge at the Forum sector, Barcelona.

In each cubic meter of new concrete that we consume, we need another cubic meter of natural crushed stone. An important part of it can be replaced, as we have already seen, by recycling used concrete that is often found on the building site or it can easily be obtained from recycling plants.

By recycling concrete, we are diminishing three environmental impacts at the same time: natural rock extraction from quarries, contamination caused by dumping used concrete and the transport energy used for transporting this material.

Doing more with less

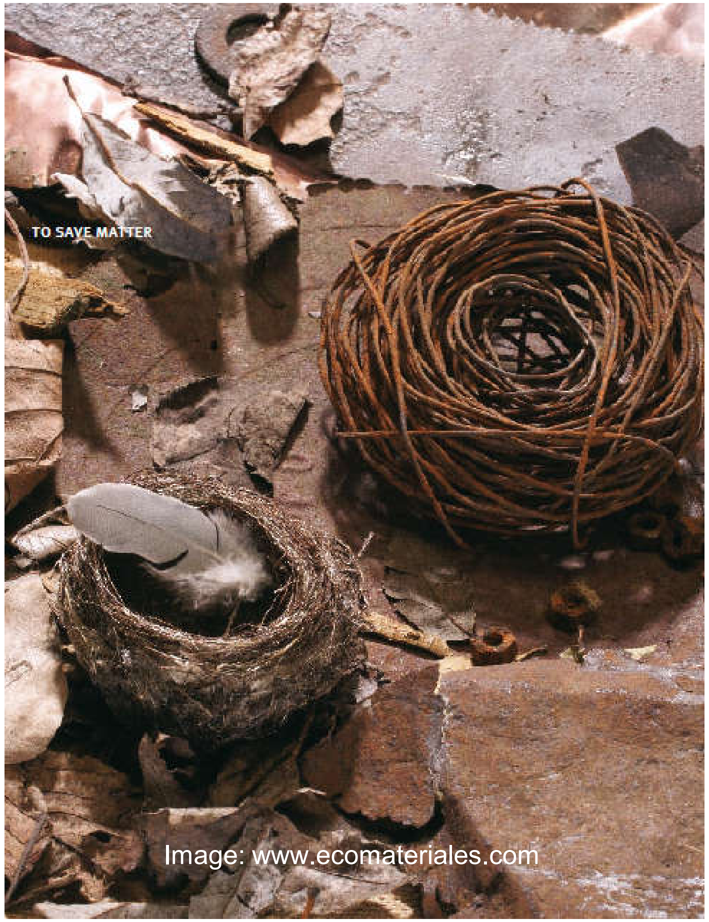


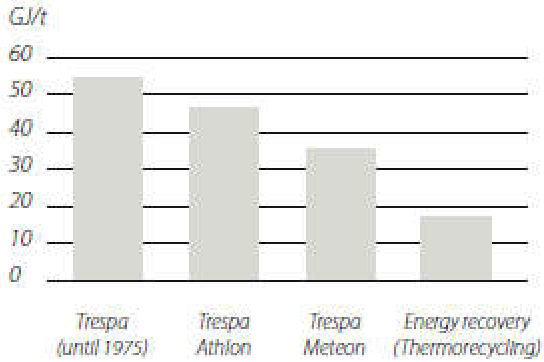
Image: www.ecomateriales.com

From the environmental point of view, there is no better material than that which we have avoided to use. By diminishing material consumption, both raw materials and energy are saved, there is less pollution, and consequently, fewer things need to be recycled.

Design has a lot to do with the optimisation of the use of the materials, and a lot of the typical construction products and systems could be made lighter.

Doing more with less

Closing the materials cycle: production and recycling.



Using less energy, proportionally.

Trespa™ façade panels, one example of the reduced material strategy.

By using products with a minimal amount of material, both raw material extraction and energy consumption is reduced.

In addition, by selecting new and improved products we are also supporting industries that strive to improve the environmental performance of their products.

Extending the lifespan

Image: www.ecomateriales.com

Aluminium is typically known as a material that has poor environmental properties.

Nevertheless, aluminium has two important advantages: recyclability and durability.

Its durability maximises its' use and its' high recyclability reduces the environmental impact by 90%.

These characteristics minimize environmental impacts enormously in comparison to other materials with similar uses.

Extending the lifespan

Aluminium window frames in the Wuppertal courthouse

Aluminium windows can be reused entirely

Square aluminium ceiling plates stacked and ready for transportation

Recycled aluminium poured into ingots for use in new applications.

Aluminum pieces can be melted and re-used practically as many times as desired without any noticeable loss of quality. Though many people are not aware, there are products made with 100% recycled aluminium.

Aluminium durability in external applications, such as curtain wall frames, is estimated to last approximately 50 years without maintenance, repair or substitution requirements.

2.1 Industry based materials

Conclusions

-The tasks of this new industry, through new demands of sustainability, is to recycle non-renewable materials by imitating the great biospheric machine from the natural world and avoiding waste deposits and their associated environmental problems.

-The ways to achieve this are already becoming evident in numerous products that we use in the building construction industry and new models that we will have to follow in the future to close the materials cycle.

2.2 Case studies

Second part (afternoon, 3h)

2.1 Showcase of sustainable materials and resources (60')
Closing the material cycle (12')
Nature based materials (16')
Industrial based materials (32')

2.2 Case studies (60')
Case study 1
Case study 2
Case study 3

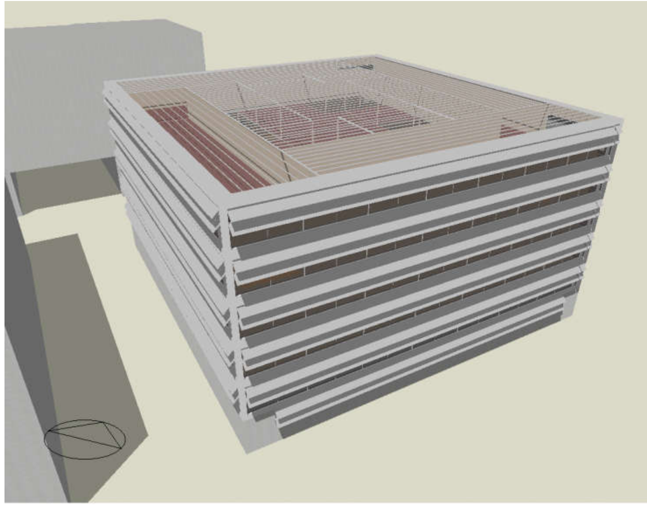
2.3 Workshop (60')
Introduction (10')
Work in groups (30')
Sharing knowledge (20')

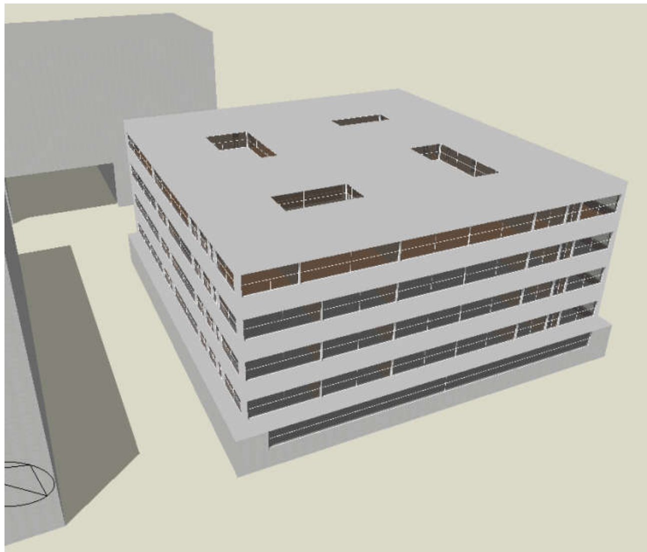
Objectives

www.saas.es

To evaluate the possibilities of CO_2-reductions in the Catalan social housing sector. Within the broad range of approaches, it was important to respect two premises: to focus on building technologies well known regionally and not to exceed the overall construction costs by more than 5% compared to a conventional building. This was done by carrying out a detailed life-cycle analysis of a 60 apartment new social housing complex.

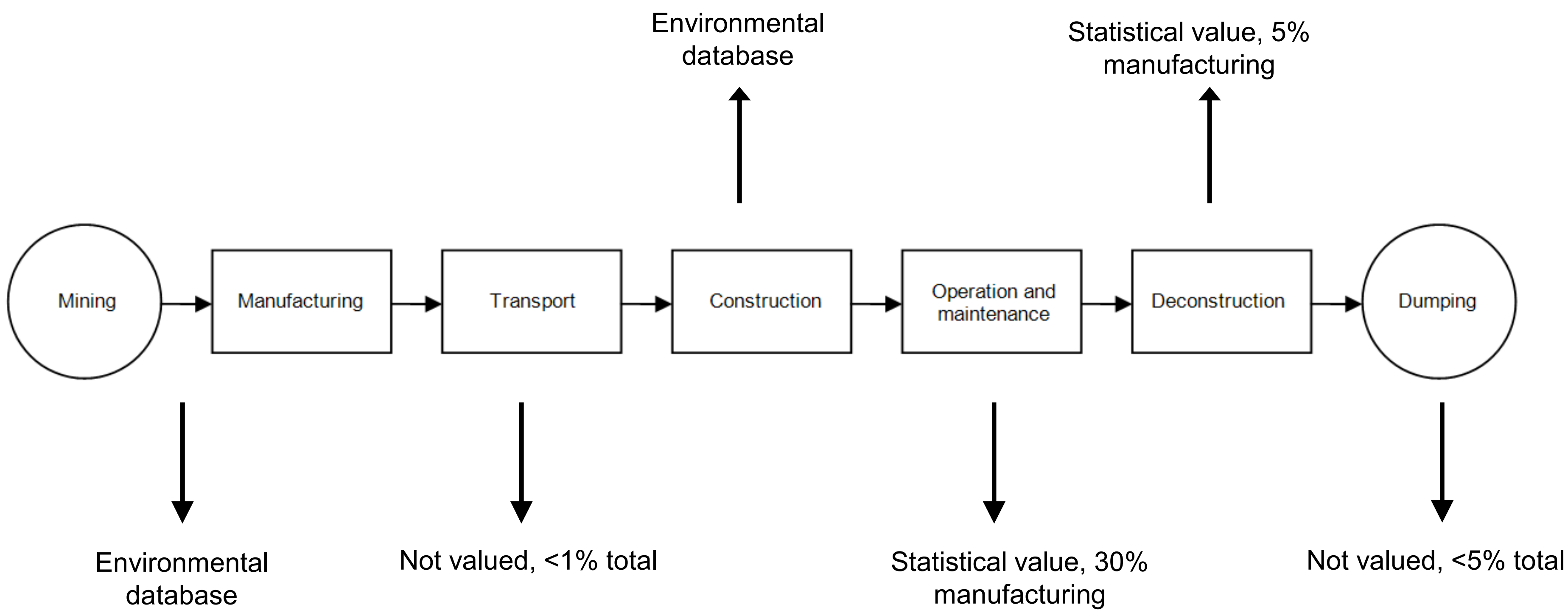
Methodology





The chosen methodology applied a very holistic approach analyzing the projected buildings' overall energy consumption and associated emissions over an expected 50 year lifecycle. These included: energy consumption and CO2-emissions related to the extraction of raw-materials, production of end-materials, the construction process, the building's use and deconstruction. In parallel, the same parameters were studied for a conventional building of the same size that fulfills minimum requirements of the current Spanish local building regulations.

Methodology



Case study

www.saas.es

The project is organised into 3 buildings with a basement, ground floor, and 3 floors, with a surface area of 7,916 m2. The complex includes flats for rent and sale (surface areas roughly 60-70 m2), 60 parking spots, private gardens on the ground floor, and a communal garden. The layout of the site makes a north-south positioning of the buildings difficult.

Analysis of principal construction systems

Roof systems (values per m² of functional unit)	Cost (€)	Weight (kg)	Energy (MJ)	Emissions ($kgCO_2$)
Green flat roof (I)	100.13	386.75	1027.76	137.33
Green flat roof (II)	88.74	372.53	1098.23	157.64
Inverted transitable flat roof (Terrazzo finish)	98.49	396.62	977.56	122.71
Inverted flat roof (PVC - recycled gravel)	54.44	350.81	615.49	84.68
Inverted flat roof (EPDM - recycled gravel)	51.61	350.15	606.87	83.48
Inverted flat roof (Bitumen - recycled gravel)	55.28	353.29	677.77	93.74
Conventional flat roof (Recycled gravel)	46.31	352.76	616.34	84.67
Conventional flat roof (cork - recycled gravel)	*49.06*	*361.69*	*35.73*	*44.60*

Cost, weight, embodied energy and CO2-emissions of analyzed roof systems

www.saas.es

A detailed analysis of different materials and compositions and of various alternatives for the main construction elements (foundations, structures, opaque façade, openings, roof, finishes, etc.) revealed the materials with less embodied energy and CO2-emissions. The necessary data was mainly extracted from the data bases of the Catalan Technology Institute ITeC (BEDECPR/ PCT). Other sources (mainly ICE and Hegger et al. 2006) as well as original research complemented the existing data.

Impacts extraction/manufactoring

Construction element	CO_2-emissions			Energy			Weight		
	Reference $KgCO_2/m^2$	Project $KgCO_2/m^2$	Red. %	Reference MJ/m^2	Project MJ/m^2	Red. %	Reference Kg/m^2	Project Kg/m^2	Red. %
Foundations and protection walls	93.67	93.67	0	1,018.23	1,018.23	0	793.21	793.21	0
Structures	168.88	154.75	8.37 %	1,912.80	1,755.53	8.22 %	556.06	548.10	1.43 %
Roofs and opaque façades	102.99	39.86	61.30 %	1,187.99	402.23	66.14 %	606.19	117.42	80.63 %
Interior divisions and elements	25.54	25.54	0	340.70	340.70	0	38.74	38.74	0
Exterior finishings	9.84	9.84	0	105.46	105.46	0	6.90	6.90	0
Interior finishings	35.94	28.83	19.78 %	350.25	263.68	42.72 %	104.12	23.93	77.02 %
Windows and solar protections	58.40	2.64	95.48 %	400.57	40.76	89.82 %	2.61	4.3	-64.75 %
Grey and waste water, drainage	16.43	13.13	20.09 %	125.25	99.46	20.59 %	39.57	19.11	51.71 %
Supply water, DHW, grey water	5.96	5.96	0	47.60	47.60	0	1.96	1.96	0
Electricity and lighting	17.13	17.13	0	145.01	145.01	0	13.34	13.34	0
Gas/fuel	0.24	0.24	0	2.36	2.36	0	0.02	0.02	0
Space conditioning and ventilation	14.25	14.25	0	139.42	139.42	0	2.95	2.95	0
Audiovisual installations, data	1.60	1.60	0	11.00	11.00	0	0.52	0.52	0
Fire protection	1.31	1.31	0	11.10	11.10	0	0.34	0.34	0
Fixed equipment	3.20	3.20	0	35.96	35.96	0	1.93	1.93	0
Total	**555.38**	**411.95**	**25.77 %**	**5,833.70**	**4,418.50**	**24.25 %**	**2,168.46**	**1,572.77**	**27.44 %**

www.saas.es

CO2-Emissions, Embodied Energy and Weight of Reference and Project Building.

In the improved project building, just two categories: foundations / protection walls and structures account for over 60% of the total emissions (248 out of 412 kgCO2/m2). It is obvious that, if more CO2-reductions are to be achieved, attention must therefore be given to reducing underground built volume (parking areas) and utilizing light weight structures as these concrete and steel intensive foundations have high associated emissions levels.

Reference building / Optimized building

	Reference building	Optimized building	CO2 emissions reduction (%)	Energy consumption saving (%)
Structure	25+5 cm waffle slab. On site concrete for pillars and beams.	25+5 cm prefabricated pre-stressed concrete slab, prefabricated pillars and beams.	3,4	3,6
Façade	14cm lime finished light brick wall, painted with two coatings of primer and two coatings of latex paint. Insulation: expanded polystyrene foam. 4 cm light brick wall, interior finish.	Ventilated façade composed of fibrocement sheets on wooden framework. Insulation: rock wool. 14 by 24 cm width of light ceramic brick	15,3	17,8
Window carpenty	Exterior carpentry made of lacquered aluminium with interruption of thermal bridge.	Exterior carpentry made of laminated Northern pine, controlled forest management and valid certificate.	5,8	3, 2
Solar protection	Venetian blind of lacquered aluminium with vertical, manually adjustable lamella, 200 to 250 mm wide.	Fixed Northern pine lamella on galvanized steel frame and Northern pine movable shutters.	7,8	4,9
Pavements	Fine terrazzo 40 x 40cm, with cement mortar on 2cm sand bed.	Linoleum 3 mm	1,7	1,9
Waste water drainage	PVC of different diameters	Polypropylene of different diameters	0,7	0,6

Construction Elements selected for Reference and Project Building

www.saas.es

Increasing the percentages of environmental improvements achieved in this project (around 26%) implies using construction solutions based on closing the materials cycle. That is, using biospheric and/or recycled materials like wood and steel.

Use of the building

Final energy consumption	Reference building	Project building	Project versus reference
Average seasonal COP	0,85	2,42	283%
Consumption	81,4 kWh/m2·a	22,5 kWh/m2·a	-72%

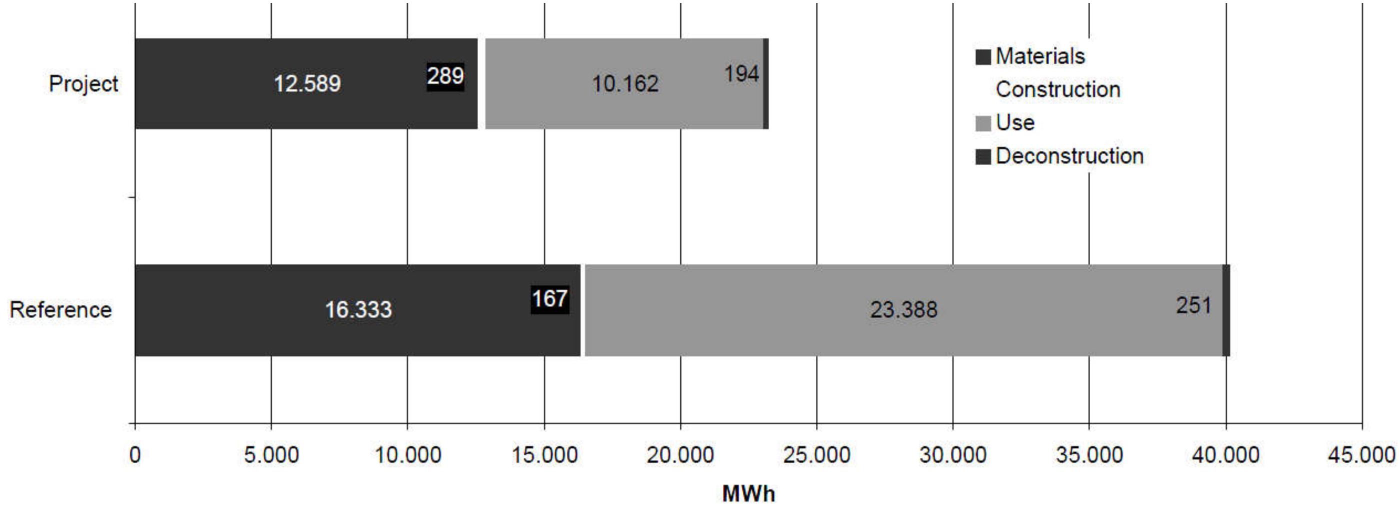
Heating and Cooling Demand for Reference and Project Building

Energy use	**Energy consumption**			**CO_2-emissions**		
	Reference	Project	Red.	Reference	Project	Red.
	kWh/m²	kWh/m²	%	$KgCO_2/m^2$	$KgCO_2/m^2$	%
Space conditioning and DHW	81.40	22.50	72%	16.28	4.50	72%
Cooking	11.67	11.67	0	2.33	2.33	0
Electric appliances	12.71	12.71	0	2.54	2.54	0
Lighting	6.85	2.06	70%	1.37	0.41	70%
Total	**112.63**	**48.94**	**57%**	**22.52**	**9.78**	**57%**

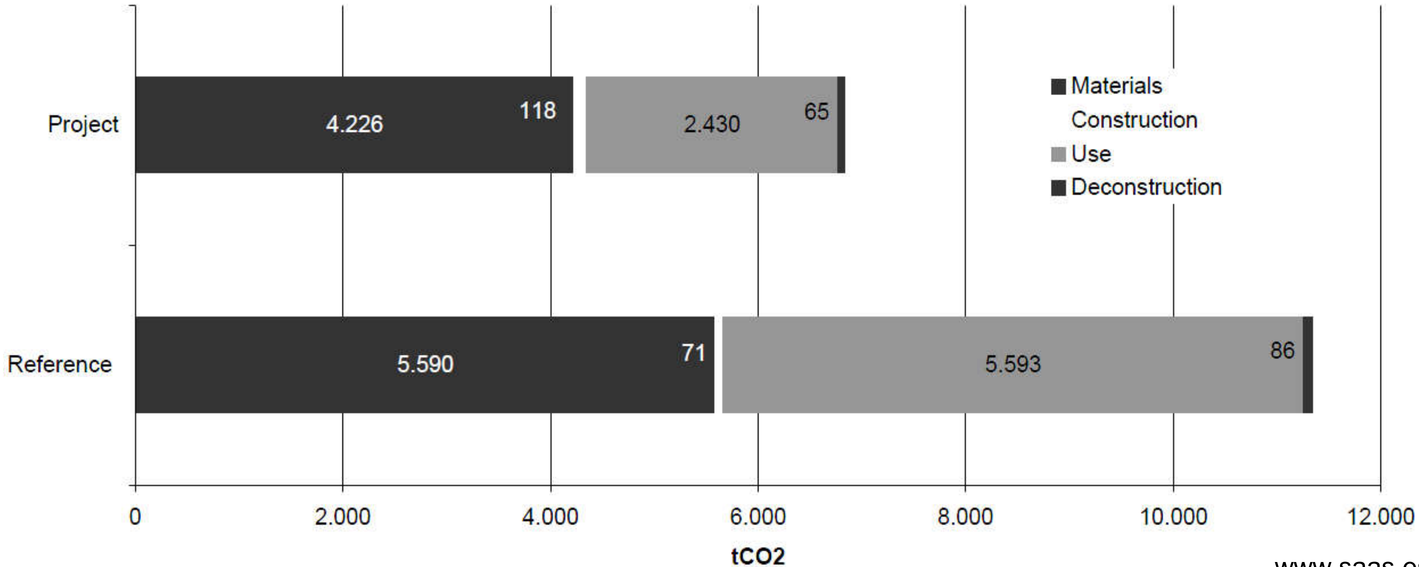
Specific Energy Consumption and CO2-Emissions for the Phase of Use for Reference and Project Building

Due to the important difference of the systems used, the average seasonal coefficient of performance in the case of the project building is nearly three times that of the reference building. Combined with the reduced energy demand in the case of the project building, the overall energy consumption for this building turns out to be over 72% less than in the reference building with conventional HVAC and DHW installations.

Results

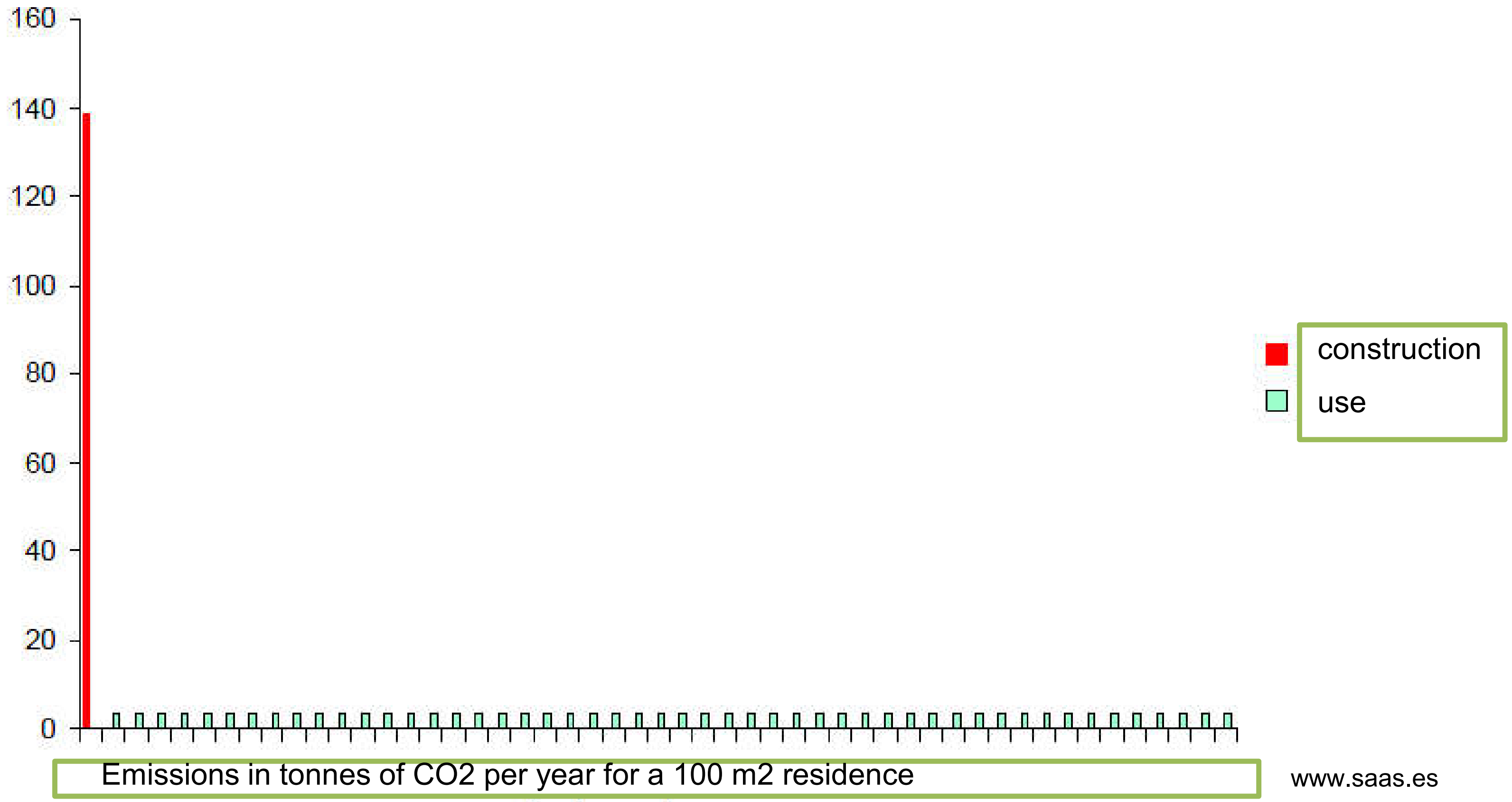


Life-Cycle Energy Consumption for Reference and Project Building.



Life-Cycle CO2-Emissions for Reference and Project Building.

Annual distribution of CO2 emissions



Although the impact of the stage of the use of a building is more significant, there is a possibility of reducing it throughout the lifecycle of a building (energy renovation), while impacts due to extraction and manufacturing of materials are produced in an instantaneous way once the construction solutions have been determined.

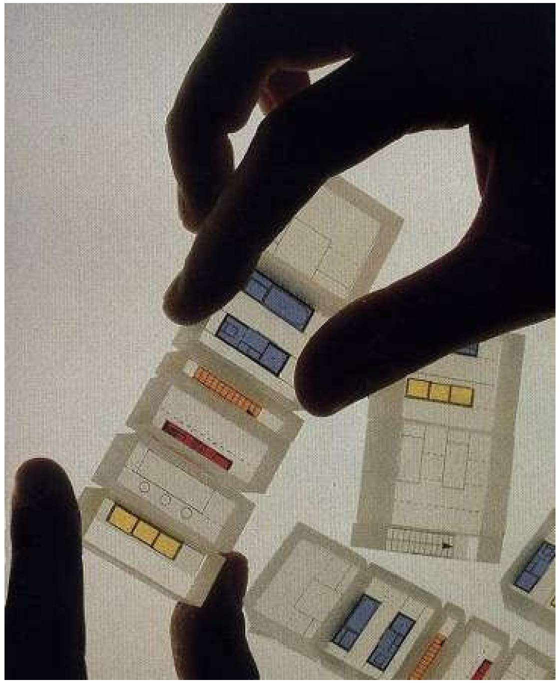
2.2 Case studies Case study 1 residential building

Conclusions

The design and construction of social housing with up to 50% CO_2-reductions in the building's overall life-cycle is absolutely feasible, using well established technology and with an additional cost of less than 5%. In this research, the main contribution to this reduction was made by demand reduction and HVAC and DHW systems using geothermal heat pumps and solar thermal collectors.

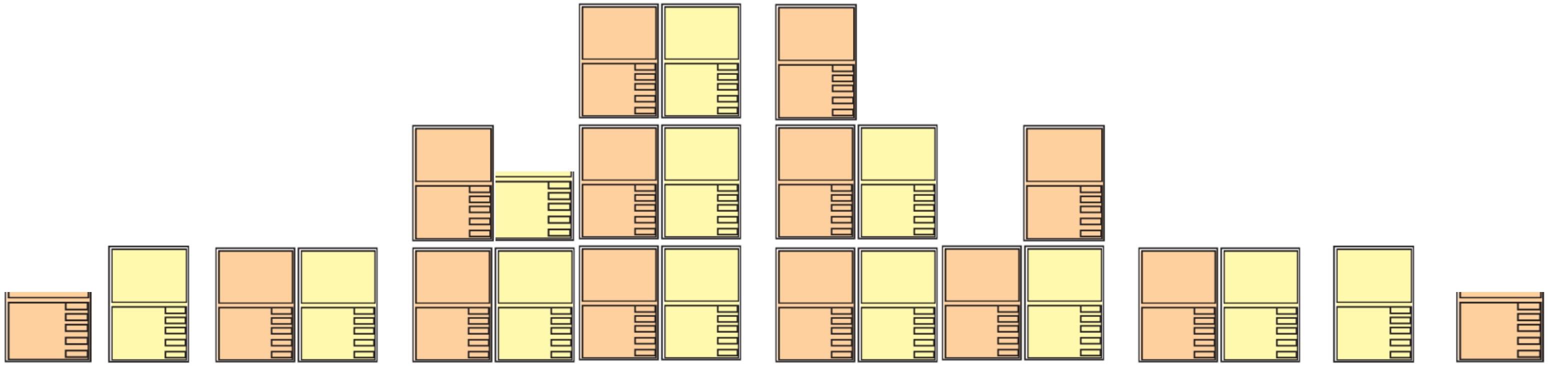
The life-cycle analysis is a necessary methodology to check the overall emissions of buildings and the embodied energy and CO_2-emissions of materials are of significant importance. Any further effort for reduction of CO_2-emissions in buildings must therefore consider materials of less environmental impact.

Objectives


Quaderns, COAC

- Investigate the **closing of the materials cycle in architecture,** quantitavely and qualitatively, with reference to residential buildings
- Relate **physical demands of sustainability** to architecture
- **Reinstate the use of** light, prefabricated constructions of environmental interest
- Analyse the **environmental impact of construction systems** – conventional and modular
- **Establish an optimised system** and the characteristics of their construction, industrial, and commercial systems

Modular systems: closing the cycles

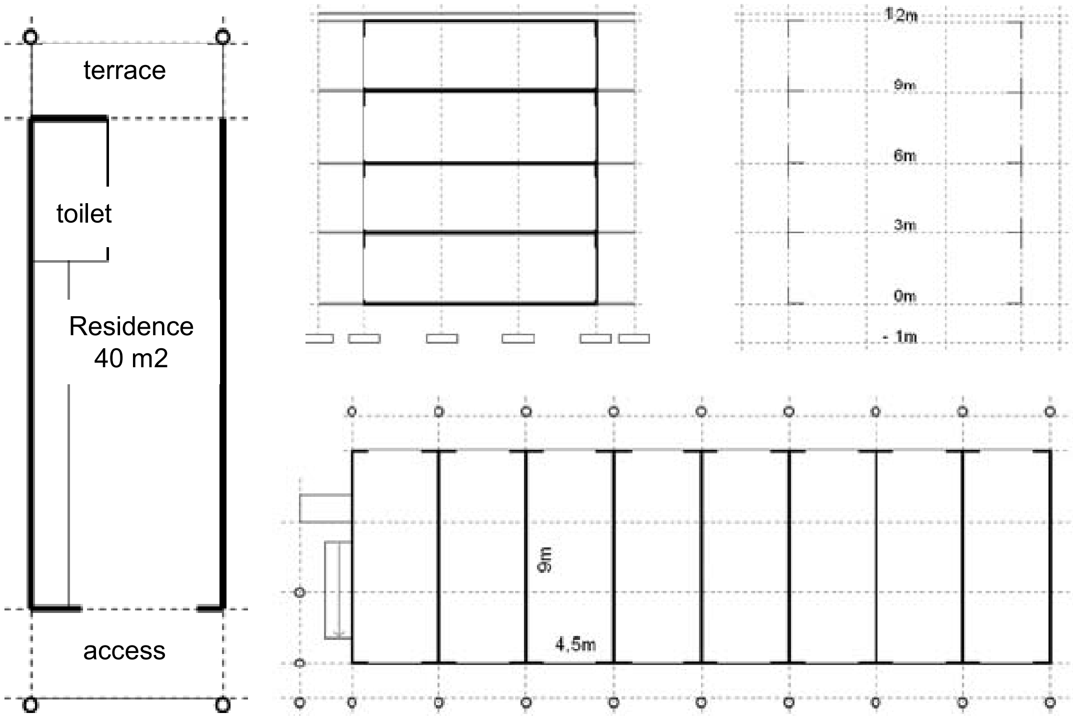


manufacturing – use – deconstuction– recycling – new use

modular systems offer potential conditions for closing cycles:

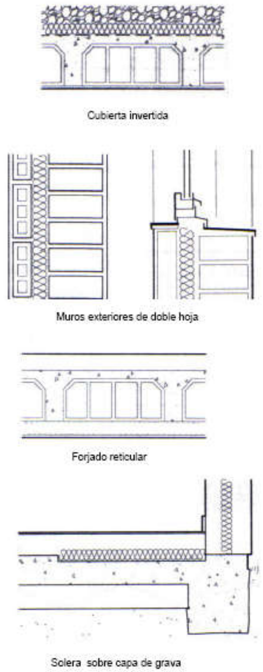
- modular coordination
- few and optimised materials
- systems that can be dismantled and retrievable components
- habitability for rent, management by the manufacturer and returning the resources to the factory.

Case study

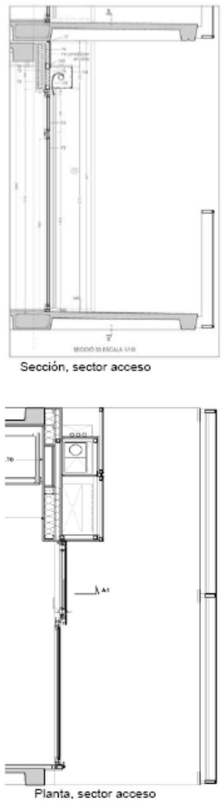


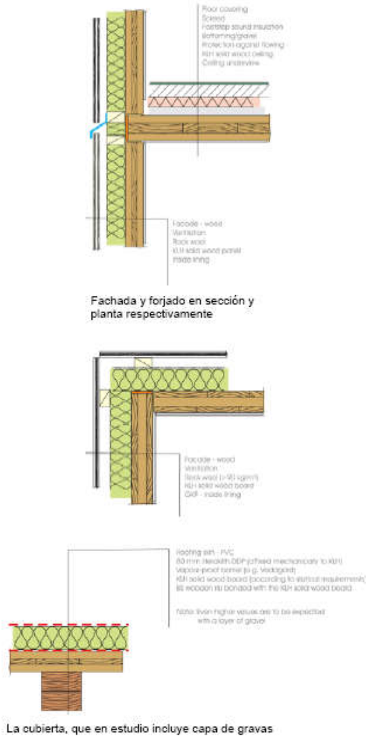
The building used in this case study is based on an existing project consisting of modular social housing (2,000 m2) that is made up of small sized units with an open plan that can be adapted to different configurations over time. It is also low cost, adaptable to different types of climate and construction technologies.

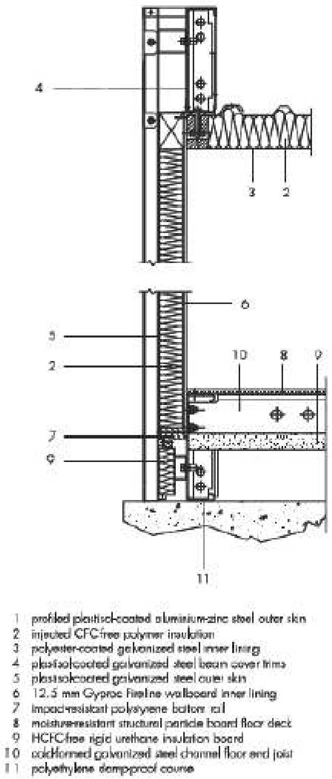
construction systems



Detalles constructivos del sistema convencional.
CTE-HE Ahorro de energía. Aplicación a edificios de uso residencial Vivienda-DAV. Monografías CTE. 2da edición revisada. Consejo Superior de los Colegios de Arquitectos de España.







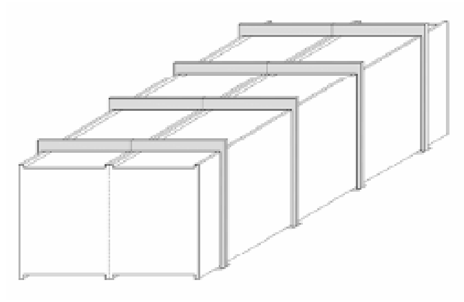
conventional

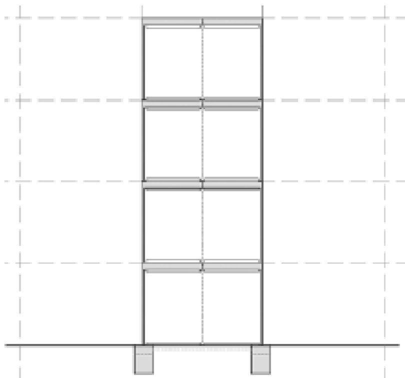
concrete
Compact Habit
(www.compacthabit.com)

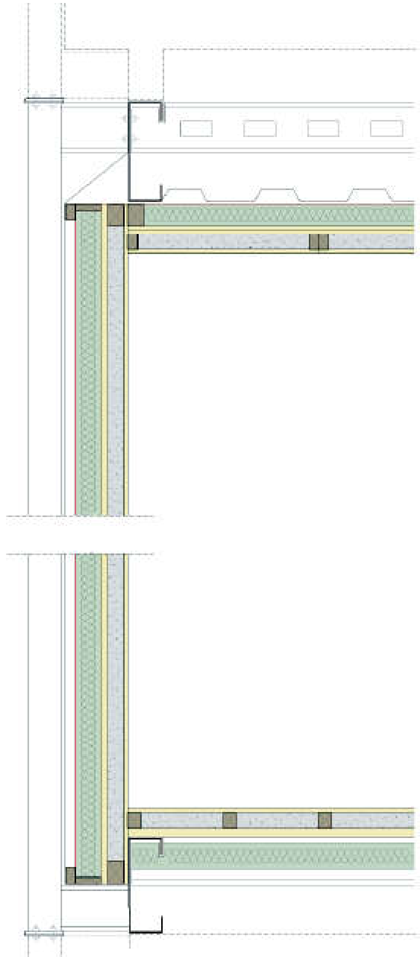
timber
diemodulfabrik (KLH)
(www.klh.at)

steel
Yorkon
(http://www.yorkon.co.uk/)

optimised modular systems







cross section

- Extraction and manufacturing: optimisation and low impact alternatives (materials that are renewable, recycled/recyclable, low energy and emissions)
- Transport: adjustment of the ISO R-668 codes and the use of lorry mounted cranes
- Construction: retrievable foundations, design through calculations (without oversizing). Elimination of specialised equipment
- Use: reducing the demand (guidelines for use and bioclimatism), increased efficiency (higher performance facilities) and renewable energies
- Maintenance: higher durability, lower quantities and impacts
- Deconstruction: removable joints, re-use, restoration or recycling

conducted evaluation

Information
- Energy and CO_2 of the materials
- Durability and replacement of materials
- Toxicity of the materials and the energy
- Material intensity of the materials

Extraction and manufacturing
- Measurements
- Estimates
- Weight, energy and CO_2 reports
- Material intensity MIPS
- Environmental and human toxicity
- Recyclability
- High impact materials
- Element/system summary

Transport
- Locations and distances
- Repercussions of loads, energy and CO_2

Construction
- On-site waste
- Factory waste
- Energy

Use
- Results of the simulation
- Energy, CO_2 and toxicity

Maintenance
- Measurements
- Estimates
- Weight, energy and CO_2 reports
- Material intensity MIPS
- Environmental and human toxicity
- Recyclability
- High impact materials
- Element/system summary

Demo-lition
- Construction waste
- Energy, CO_2 and toxicity

Cycle
- Energy and CO_2

System comparison
- Extraction and manufacturing
- Transport
- Construction
- Use
- Maintenance
- Demolition
- Summary of the cycle, by phases
- Sums of all the indicators

Phase 1/6: material production

Subsistemas	kg/m²	%	MJ/m²	%	$kgCO_2/m^2$	%
Replanteo y movimiento de tierras	0	*0,00%*	0	*0,00%*	0	*0,00%*
Cimentaciones y muros de contención	393,56	*26,87%*	289,57	*5,38%*	40,07	*6,67%*
Espacios comunes	41,71	*2,85%*	306,22	*5,69%*	30,62	*5,10%*
Estructuras	539,37	*36,83%*	1.448,21	*26,92%*	139,95	*23,31%*
Cubierta	45,39	*3,10%*	156,1	*2,90%*	25,6	*4,26%*
Fachada principal	75,62	*5,16%*	168,97	*3,14%*	15,7	*2,61%*
Divisiones y elementos inter. primarios	87,68	*5,99%*	149,16	*2,77%*	14,26	*2,37%*
Acabados exteriores	10,46	*0,71%*	9,01	*0,17%*	1,05	*0,17%*
Acabados interiores	159,73	*10,91%*	464,81	*8,64%*	52,36	*8,72%*
Cerramientos int. y ext. secundarios	36,48	*2,49%*	1.404,87	*26,11%*	173,69	*28,92%*
Saneamiento y aguas grises*	27,88	*1,90%*	143,48	*2,67%*	18,99	*3,16%*
Red de agua fría y caliente*	2,89	*0,20%*	70,14	*1,30%*	8,78	*1,46%*
Electricidad e iluminación*	19,66	*1,34%*	213,69	*3,97%*	25,24	*4,20%*
Gas/Combustible*	0,024	*0,00%*	3,47	*0,06%*	0,36	*0,06%*
Climatización/Ventilación*	4,34	*0,30%*	205,45	*3,82%*	21	*3,50%*
Audiovisuales*	0,77	*0,05%*	16,21	*0,30%*	2,36	*0,39%*
Aparatos de elevación	0,71	*0,05%*	50,6	*0,94%*	4,87	*0,81%*
Protección contra incendios*	0,042	*0,00%*	3,43	*0,06%*	0,46	*0,08%*
Equipamento fijo	18,23	*1,24%*	276,89	*5,15%*	25,13	*4,18%*
Total	**1.464,55**	***100,00%***	**5.380,28**	***100,00%***	**600,49**	***100,00%***

Data corresponding to a conventional system

Intensidad material MIPS

Materiales contados: 1.460,74kg/m²
(99,75% del total)

MIPS A+B: 1,77 kg-recursos/kg
MIPS Agua: 9,53 l/kg

Toxicidad

Materiales contados 1460,74 Kg/m²
(99,75% del total)

Tox. ambiental: 40.311,50 ECAKg/m²
Tox. humana: 6,79 HCA+HCWkg/m²

It is necessary to know in detail the compostion of the different construction systems and to have a database and program available which allows one to obtain the environmental values of a building. There are subsystems that have a large impact on the final result. In conventional solutions, the elements where mostly concrete is used (foundations and structure) and the building envelope can account for more than 60% of the weight and 45% of the CO2 emissions.

phase 2/6: transport

Material	Forma predominante	Peso transp. Tm	Densidad Tm/m³	Dens. corr.[4] Tm/m³	Vol. transp. m³	Cam./dist. u/km	Consumo[6] litros gasoil	%
Acero	Perfiles y barras	56,14	7,85	5,50	10,22	763	228,94	*2,59%*
Acero esmaltado	Puertas	3,83	7,85	0,79	4,88	217	65,13	*0,74%*
Acero galvanizado	Chapas y perfiles	9,38	7,85	3,93	2,39	436	130,93	*1,48%*
Acero lam. galvanizado	Chapas y perfiles	18,28	7,85	3,93	4,66	430	129,03	*1,46%*
Agua	De red	...	...	...	...	...	...	
Aluminio anodizado	Carpinterías	4,72	2,70	0,81	5,83	88	26,35	*0,30%*
Aluminio lacado	Chapas y perfiles	0,96	2,70	1,89	0,51	50	14,91	*0,17%*
Árido[3]	A granel	1475,61	1,50	1,20	1229,68	16283	4884,85	*55,28%*
Cemento[3]	Sacos paletizados	206,85	1,60	1,28	161,60	3472	1041,65	*11,79%*
Cerámica esmaltada	Baldosas paletizadas	8,47	1,80	1,44	5,88	257	77,09	*0,87%*
Cobre recocido	Cajas de cable y acc.	0,77	8,90	4,45	0,17	31	9,17	*0,10%*
Ladrillo cerámico	Ladrillos paletizados	188,65	1,80	1,44	131,00	2885	865,57	*9,80%*
Mortero prefabricado	Casetones paletizados	154,18	2,00	0,60	256,97	1998	599,32	*6,78%*
Neopreno	Planchas y rollos	1,14	1,20	0,84	1,36	54	16,13	*0,18%*
Poliestireno extruido	Planchas	1,01	0,03	0,02	41,99	70	20,92	*0,24%*
Polipropileno	Tubos y accesorios	2,63	0,94	0,19	13,99	255	76,45	*0,87%*
PVC	Cajas de cable y acc.	2,78	1,35	0,68	4,12	65	19,62	*0,22%*
Tablero part. madera	Mobiliario	29,00	0,80	0,16	181,26	370	111,01	*1,26%*
Terrazo	Baldosas paletizadas	72,61	2,50	2,00	36,30	921	276,21	*3,13%*
Yeso	Sacos paletizados	28,35	1,25	1,00	28,35	809	242,80	*2,75%*
							8836,06	*100%*

Resumen de indicadores

lgasoil/m²	**4,36**	**Tox. amb. ECAKg/m²**	**438,56**
MJ/m²	**188,22**	**Tox. hum. HCA+HCWkg/m²**	**0,0941**
$KgCO_2/m^2$	**15,01**		

Data corresponding to a conventional system

Analysing the impact of transport is difficult because, in many cases, this information is not available until the end of a buildings' construction. The environmental impact of CO2 emissions in proportion to the entire life cycle is less than 5%, and in most cases can be lower than 2%.

phase 3/6: construction

Subsistemas [1]	**MJ** $_{gasoil}$	**MJ** $_{electricidad}$	**kgCO$_2$** $_{gasoil}$	**kgCO$_2$** $_{electricidad}$
Replanteo y movimiento de tierras	22.342,69	…	1.781,21	…
Cimentaciones y muros de contención	1.137,06	…	90,65	…
Espacios comunes	617,85	0,60	49,26	0,04
Cubierta	…	1.270,85	…	88,12
Fachada principal	…	36,22	…	2,51
Divisiones y elementos interiores primarios	…	57,74	…	4,00
Acabados interiores	…	93,83	…	6,51
Cerramientos int. y ext. secundarios	…	1.765,89	…	122,44
Otros consumos				
Grúa de 30m de pluma, 40m de altura y 2t de peso en punta. 39.780,00MJ/mes electricidad, 5.799,92 KgCO$_2$/mes electricidad. Tiempo de uso: 12 meses. [2]	…	477.360,00	…	33.099,00
Montaje/desmontaje grúa 30m de pluma, 40m de altura y 2t de peso en punta [3]	9.969,23	…	794,77	…
Transporte de grúa 3m de pluma, 40m de altura y 2t de peso en punta [4]	1.290,28	…	102,86	…
Carga y transporte de residuos de construcción a vertedero o centro de recogida y transferencia, 15 km, camión de 7 t, cargado con medios manuales. 833,51MJ/m^3 y 217,71KgCO2/m^3. Volumen: 236,49m^3 Peso: 254,15tm [5]	197116,78	…	51486,24	…
Totales (energía primaria)	232.473,89	480.585,13	54.304,99	33.322,62

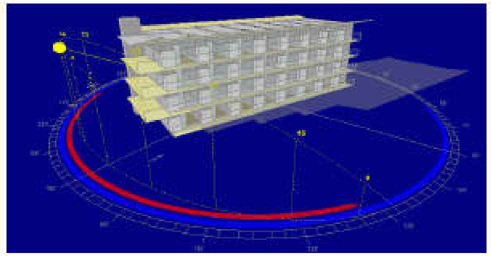
	Energía MJ	**Emisiones** kgCO$_2$	**Tox. amb.** ECAKg/m^2	**Tox. hum.** HCA+HCWkg/m^2
Total/m^2	**360,78**	**43,21**	**985,13**	**0,6971**

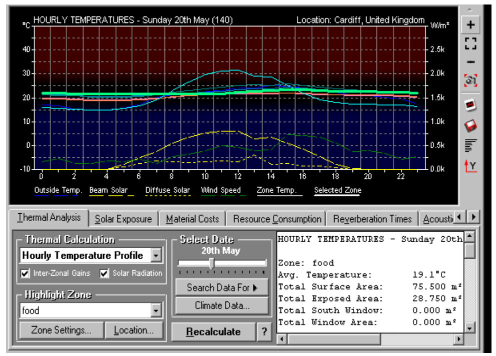
To perform this analysis, it is necessary to have detailed information available on the tools and utensils used and their energy consumption (some price databases for the construction industry offer this information). Due to the difficulty of evaluating labor costs, they are not included in this study. The environmental impact of CO2 emissions in proportion to the entire life cycle is less than 2%.

phase 4/6: use of the building

Uso	Demanda		Dem CTE[7]	Consumo (energía primaria)[8]				Superficie	Usuarios[9]	Vida útil[10]	Consumo vida útil	
	MJ/m²/año	%	est/ref en %	MJ/m²/año	%	$KgCO_2/m^2$	%	31u x 40m²	3pers. x 31u	años	MJ/m²	$KgCO_2/m^2$
Calefacción[1]	189,00	*46,8%*	104,7	198,94	*57,3%*	11,27	*33,9%*	1280	93	50	9947,21	563,68
Refrigeración[2]	27,16	*6,7%*	67,0	14,29	*4,1%*	2,58	*7,8%*	1280	93	50	714,74	128,85
Agua cal. sanit.[3]	92,16	*22,8%*	...	38,80	*11,2%*	2,20	*6,6%*	1280	93	50	1940,21	109,95
Iluminación[4]	7,42	*1,8%*	...	7,42	*2,1%*	1,34	*4,0%*	1280	93	50	370,80	66,85
Cocina[5]	42,01	*10,4%*	...	42,01	*12,1%*	7,57	*22,8%*	1280	93	50	2100,60	378,69
Electrodomésticos[6]	45,76	*11,3%*	...	45,76	*13,2%*	8,25	*24,8%*	1280	93	50	2287,80	412,44
Total	**403,50**	*100,0%*		**347,23**	*100,0%*	**33,21**	*100,0%*			(final)	**17361,36**	**1660,45**
Climatizac. + ACS	**308,32**			**252,04**	(final)	**16,05**				(final)	**12602,16**	**802,47**
Climatizac. + ACS				**277,29**	(primaria)					(primaria)	**13864,62**	**802,47**
	Tox. amb.	**9773,6**	ECA kg/m²			**Tox. hum.**	**5,496**	HCA+HCW kg/m²				

There are different tools for evaluating in detail the demand and consumption of energy in a building. In this study, only HVAC and hot water consumption are accounted for, and the use of appliances and lighting is not included in the analysis. The environmental impact of CO2 emissions in proportion to the entire life cycle varies according to bioclimactic strategies and energy systems used. It can is roughly between 50% and 70%.





phase 5/6: maintenance

Subsistema	Peso kg/m²	%	Energía MJ/m²	%	Emisiones $KgCO_2/m^2$	%
Espacios comunes	1,8100	*4,40%*	16,69	*4,07%*	2,1300	*4,11%*
Cubierta	5,3800	*13,08%*	33,55	*8,19%*	4,8900	*9,43%*
Divisiones y elementos int. prim.	0,4400	*1,07%*	0,20	*0,05%*	0,0180	*0,03%*
Acabados exteriores	1,7000	*4,13%*	10,51	*2,56%*	1,5100	*2,91%*
Acabados interiores	25,0600	*60,94%*	171,61	*41,87%*	22,5400	*43,48%*
Cerramientos exteriores e inter.	6,4800	*15,76%*	158,76	*38,74%*	18,9400	*36,53%*
Red de agua fría y caliente	0,0020	*0,00%*	0,25	*0,06%*	0,0250	*0,05%*
Electricidad e iluminación	0,0014	*0,00%*	0,13	*0,03%*	0,0180	*0,03%*
Climatización / Ventilación	0,0350	*0,09%*	3,18	*0,78%*	0,3300	*0,64%*
Audiovisuales	0,0002	*0,00%*	0,02	*0,00%*	0,0022	*0,00%*
Aparatos de elevación	0,2100	*0,51%*	14,92	*3,64%*	1,4400	*2,78%*
	41,1200	*100,00%*	**409,82**	*100,00%*	**51,8432**	*100,00%*

Intensidad material MIPS
Materiales contados: 41,12kg/m^2
(100% del total)
MIPS A+B: 1,43 kg-recursos/kg
MIPS Agua: 11,68 l/kg

Toxicidad
Materiales contados: 41,12kg/m^2
(100% del total)
Tox. ambiental: 726,92 ECA Kg/m^2
Tox. humana: 0,20 HCA+HCW kg/m^2

In this phase, it is necessary to define the lifespan of the building and its' components. In this case it is 50 years. The technical criteria for replacing the different construction systems can come from manufacturers, maintenance databases or a bibliography. The elements which impact the most are interior surface finishes and openings, which attribute to almost 80% of energy consumption and CO2 emission.

phase 6/6: demolition

Demolición *in situ*	Volumen	Energía		Emisiones	
	m^3	$MJ_{electric}$	MJ_{gasoil}	$KgCO_{2\ electric}$	$KgCO_{2\ gasoil}$
Demolición volumen sobre rasante [1]	6489,60	29852,16	831836,93	2069,88	66315,89
Remoción de cimentaciones [2] y [3]	366,08	12767,04	113887,49	885,24	9079,36
Relleno con tierras de aportación [4] y [5]	412,00	0,00	58964,68	0,00	4700,80
Subtotales		**42619,20**	**1004689,10**	**2955,11**	**80096,05**

[1] Valores extraídos de la partida E211U030 del Banco PR/PCT del ITeC
[2] Valores extraídos de la partida E2131353 del Banco PR/PCT del ITeC
[3] Valores extraídos de la partida E2R6506A del Banco PR/PCT del ITeC
[4] Valores partida E2A11000 del Banco PR/PCT del ITeC y estimaciones propias
[5] Valores extraídos de la partida C1311120 del Banco PR/PCT del ITeC

	Energía	Emisiones	Tox. amb.	Tox. hum.
	MJ	$KgCO_2$	ECA Kg/m^2	HCA+HCW kg/m^2
Total/m^2	**516,4**	**41,0**	**1217,98**	**0,304**

Fase 6/6 Derribo: Residuos generados y reciclaje [9.7]

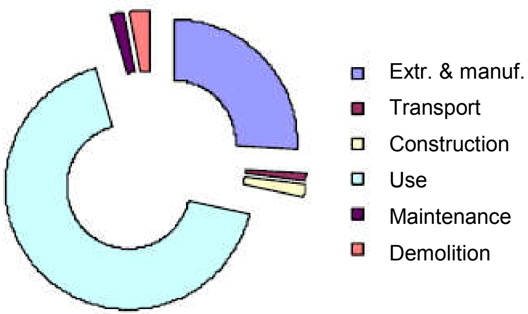
Obra in situ

	Cantidades		***Reciclaje*** [1]		
Grupos de residuos [2]	*kg/m²*	*Tm*	*% hab.*	*Tm*	*% obra*
Pétreos	1242,73	2520,27	0	0,00	*0,00%*
Yeso	21,70	44,01	0	0,00	*0,00%*
Plásticos	3,17	6,43	50	3,21	*0,12%*
Madera	23,82	48,31	50	24,15	*0,87%*
Especiales	23,50	47,66	0	0,00	*0,00%*
Metales	55,58	112,72	90	101,45	*3,65%*
Totales	**1.370,51**	**2779,39**		**128,81**	***4,63%***
				63,52	**Kg/m^2**

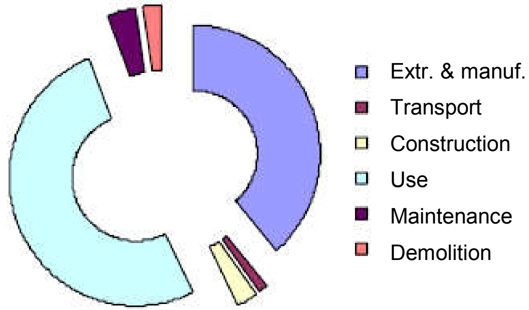
Total material reciclado (obra in situ): **4,63%**

Selective seperation and waste management is usually applied to a specific area, differentiating the processes of dumping, incineration, and re-use/recycling. In conventional buildings, most of the waste (about 80%) is inert. The environmental impact of CO2 emissions in proportion to the entire life cycle is low, namely around 2% in conventional buildings.

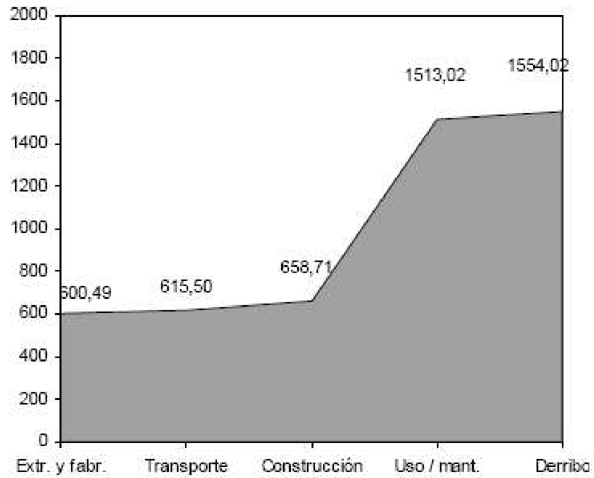
Life cycle



Energy consumption



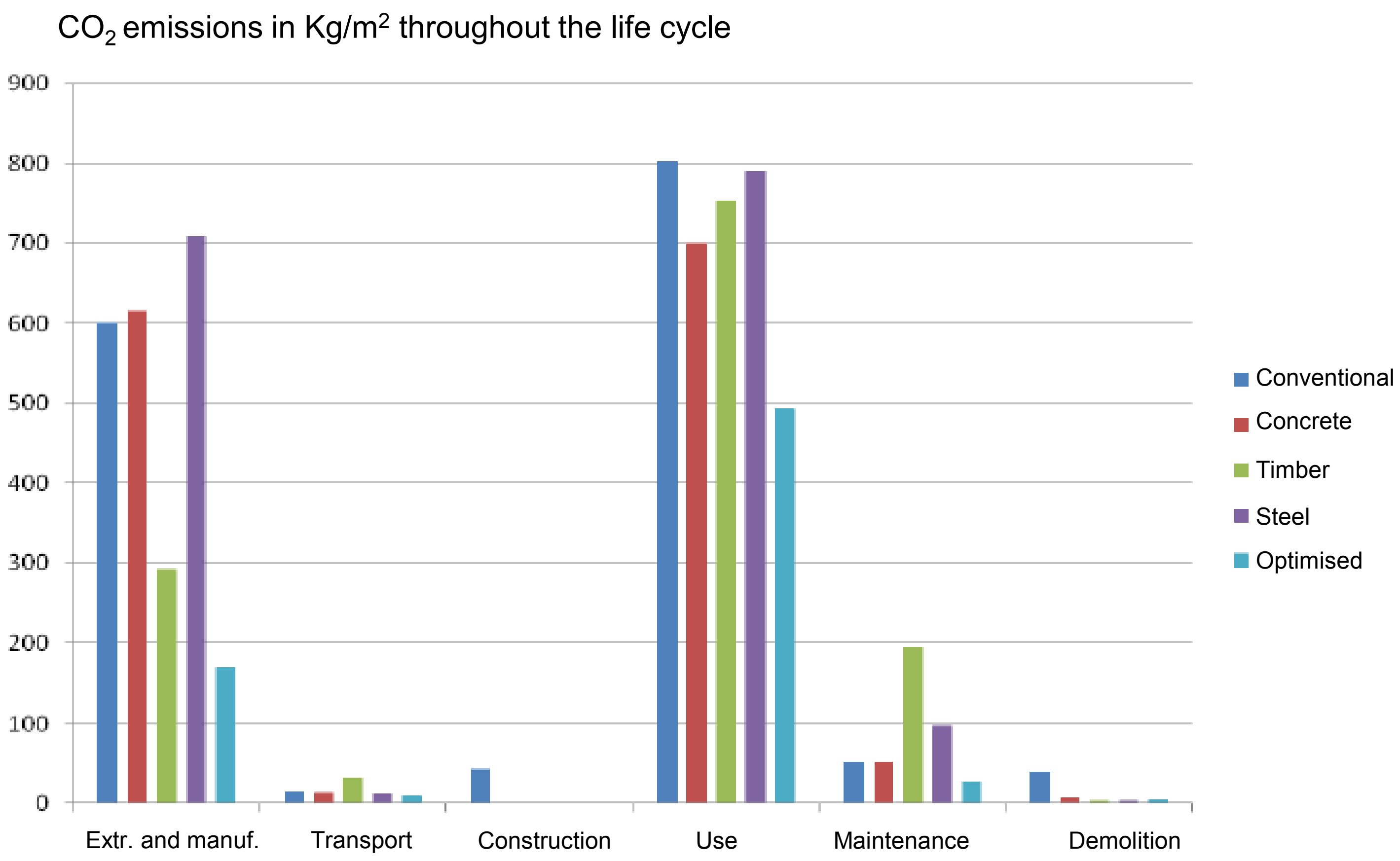
CO_2 emissions



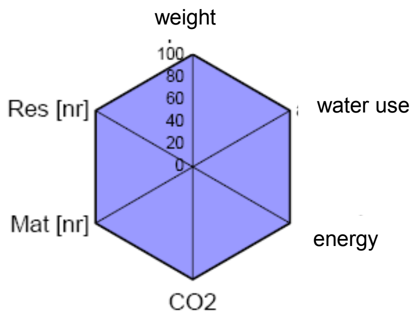
Accumulated CO_2 emissions

The life cycle analysis of a building helps identify the most relevant phases of the environmental impact as well as their intensity over time. Typically, the extraction/manufacturing and use of the building is where most of the impact is concentrated and lies between 85 and 100%.

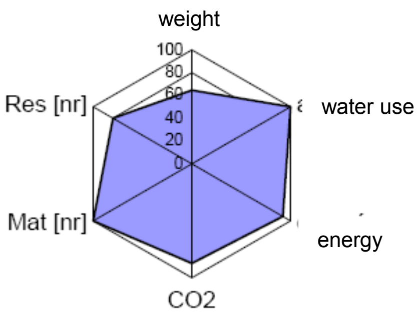
Comparative analysis: CO2 and phases



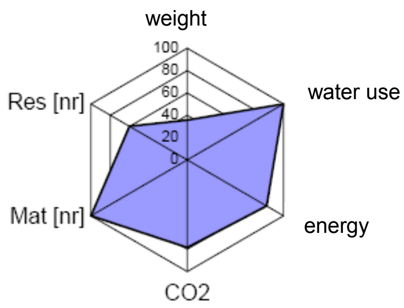
Comparative analysis: life cycle



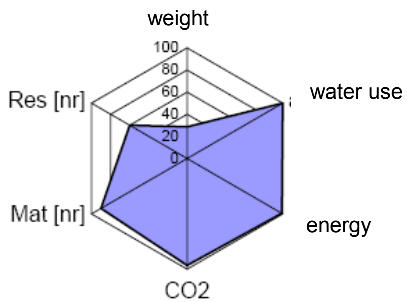
Conventional (base)



Concrete (Compact Habit)

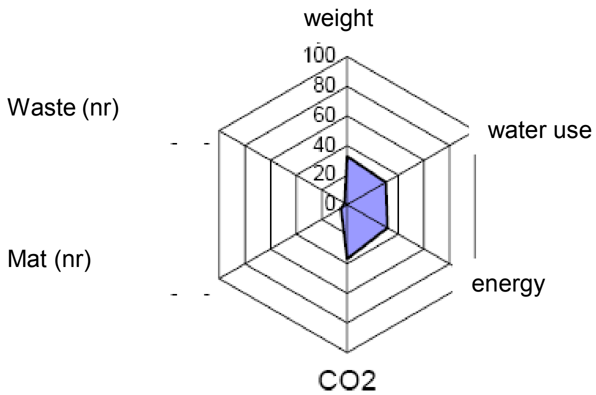


Timber (Diemodulfabrik KHL)



Steel (Yorkon)

Res [nr]	Non-recycled waste
Mat [nr]	Non-recycled material

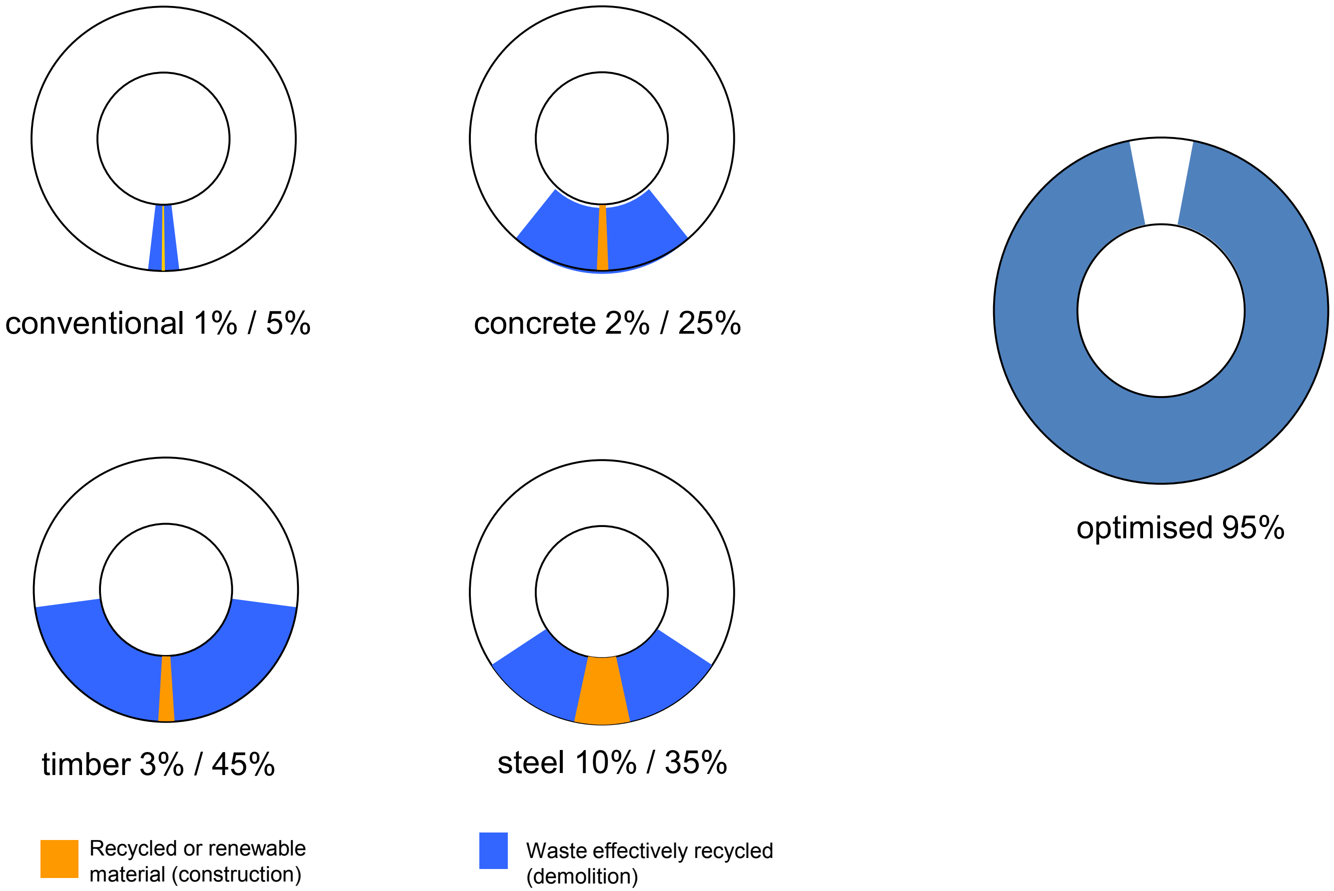


Optimised

Waste (nr): waste generated not recycled – Mat (nr): used non recycled material

Comparative analysis: closing the cycle

Material that is ultimately recycled



commercial management, closing the cycle

In addition to rethinking the industry, it is necessary to reconsider the commercial aspects which have the following advantages:

- habitability as a service
- offers that can be adapted to changing demands
- low environmental impact and unused sites
- technological developments in housing and the systems used
- schedule, project, and construction in a shorter time frame
- non-immobilised capital: no need to purchase
- cost that is equal or lower than the market price

Starting point

Bauen für die 2000-Watt Gesellschaft

- In order to reach the “2000 Watt compatibility”, it is essential to consider and optimise transport energy, operational energy as well as construction energy.
- The construction energy in refurbishment is, considering grey energy, about half as high compared to a new construction. If it is possible to use the site efficiently with energy refurbishment of a compact building volume of high efficiency, the “2000 Watt compatibility“ can, under circumstances, be reached more easily than with a new construction. If this is not the case, a new replacement construction might be a more reasonable strategy in terms of energy.

Goal

The case studies of refurbishment demonstrate what the factors in buildings are for reducing grey energy and grey greenhouse gas emissions, and what relevance they have in comparison to space heating. In addition, it is interesting to observe what factors influence the construction energy of a building element. Likewise, the particularities of the calculations for refurbishments will be looked into. The influence of the scope of intervention is of particular interest and especially the methodological issues that arise in the calculation method from the Technical Specification SIA 2032 Grey Energy.

Methodology

In the Technical Specification SIA 2032 Grey Energy, the methodology for determining grey energy and grey greenhouse gas emissions for new constructions and refurbishments is defined. The calculation is based on unitary principles (assessment limits, methods, payback period). In this task, the elements were arranged in accordance to the element costs division (EKG: Elementkostengliederung) and not to the Technical Specification SIA 2032 Grey Energy. The Technical Specification SIA 2040 Energy Efficiency Path additionally considers the total primary energy. In five cases of restauration, the construction energy is determined. In those cases, the decisive parameters are non-renewable primary energy and grey greenhouse gas emissions. The case studies include a school, retirement home, and a block of flats. The evaluation is particularly informed by the following parameters: size and compactness of the building, the magnitude of the refurbishment on the construciton elements (scope of intervention) and the choice of materials.

2.2 Case studies **Case study 3 - comparison**

Refurbishment and Additional Storeys of the Housing Estate Glatt I (Block D)

Rendering of the renewed housing block

- Desired standard: Minergie-P Modernisierung
- Compactness Ah/AE: 1.46
- Window surface area Aw/AE: 17.3 %
- Floor area: 1'500 m2
- Conditioned floor area : 1'369 m2
- Heating demand with efficient ventilation: 53 MJ/m2
- Space heating: District heating from a waste incineration plant

2.2 Case studies **Case study 3 - comparison**

Refurbishment of the Housing Estate Paradies (House B)

Exterior of the unrestored housing block

- Desired standard : Minergie-Modernisierung
- Compactness Ah/AE: 1.04
- Window surface area Aw/AE: 17.2 %
- Floor area: 3'290 m2
- Conditioned floor area: 2'894 m2
- Heating demand with efficient ventilation: 77 MJ/m2
- Space heating: Geothermal heat pump

2.2 Case studies **Case study 3 - comparison**

Refurbishment of the Retirement Home Dorflinde

Rendering of the southern facade of the Dorflinde development

- Desired standard: Minergie-Neubau
- Compactness Ah/AE: 0.70
- Window surface area Aw/AE: 9.9 %
- Floor area: 10'533 m2
- Conditioned floor area: 9'843 m2
- Heating demand with efficient ventilation: 88 MJ/m2
- Space heating: District heating from a waste incineration plant

2.2 Case studies **Case study 3 - comparison**

Refurbishment school building Milchbuck

Elevation of the southern facade of the development (Walter Mair)

- Standard reached: Minergie-Modernisierung
- Compactness Ah/AE: 1.06
- Window surface area Aw/AE: 16 %
- Floor area: 9'595 m2
- Conditioned floor area: 8'033 m2
- Heating demand with efficient ventilation: 239 MJ/m2
- Space heating: wood pellets

2.2 Case studies **Case study 3 - comparison**

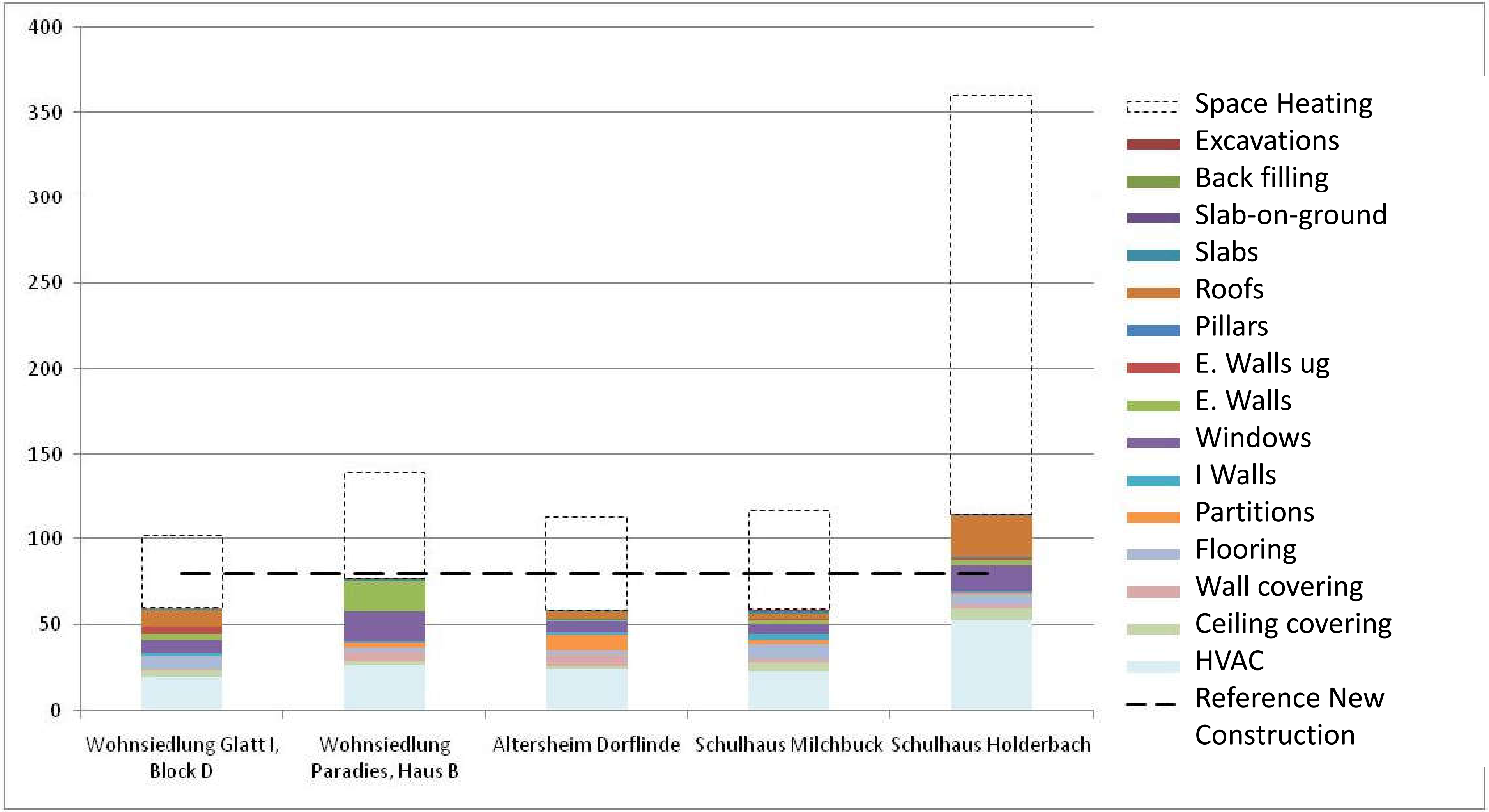
Refurbishment of the Holderbach School

Elevation of the renewed school building (Photo: Beat Bühler)

- Standard reached: Minergie-Modernisierung
- Compactness Ah/AE: 2.29
- Window surface area Aw/AE: 29 %
- Floor area: 3'800 m2
- Conditioned floor area: 3'057 m2
- Heating demand with efficient ventilation: 300 MJ/m2
- Space heating: Geothermal heat pump

2.2 Case studies **Case study 3 - comparison**

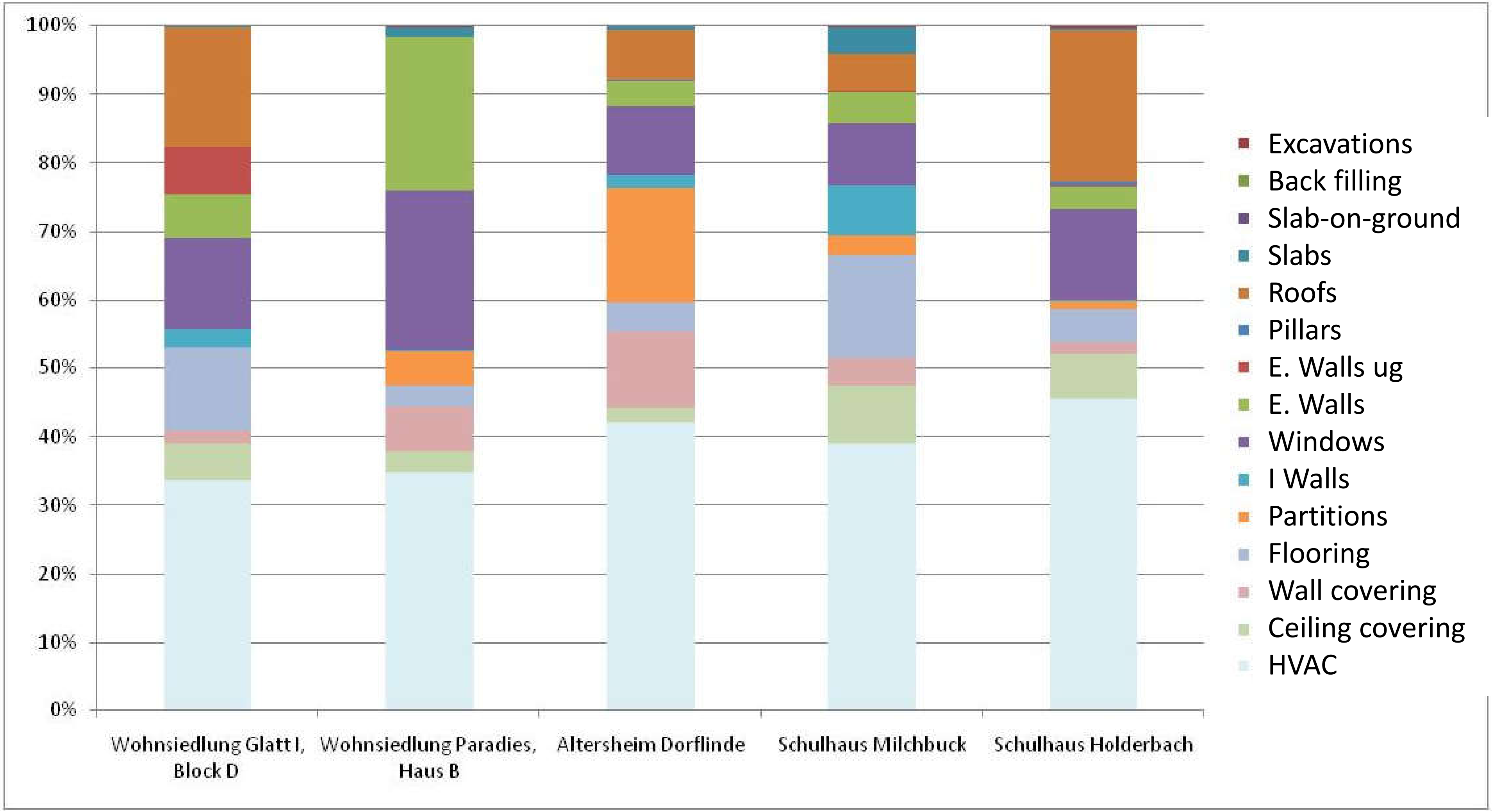
Results



Grey Energy (= primary energy from nonrenewable sources) in comparison to space heating, MJ/m2

2.2 Case studies **Case study 3 - comparison**

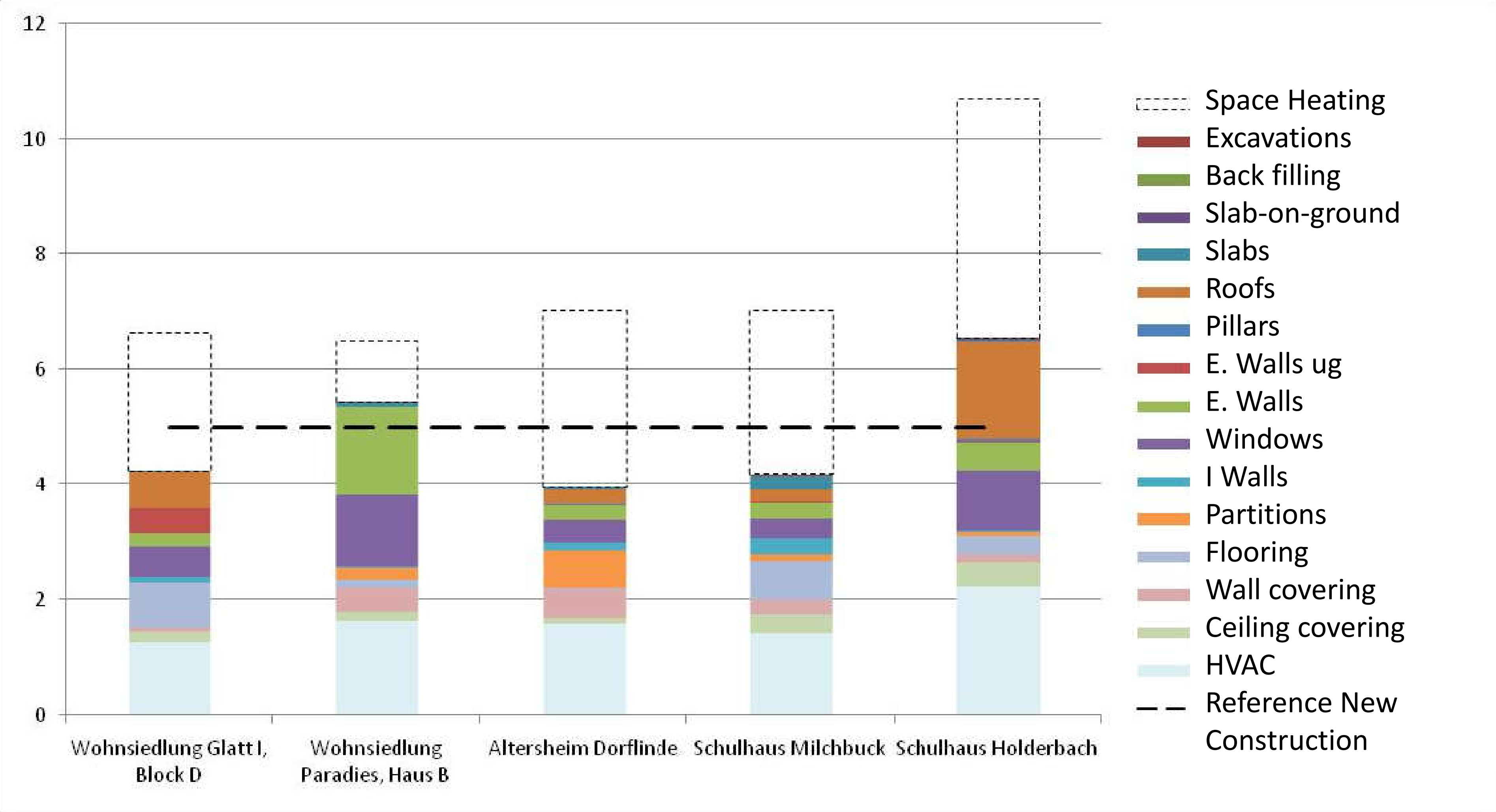
Results



Grey Energy (= primary energy from nonrenewable sources), percentages according to elements

2.2 Case studies **Case study 3 - comparison**

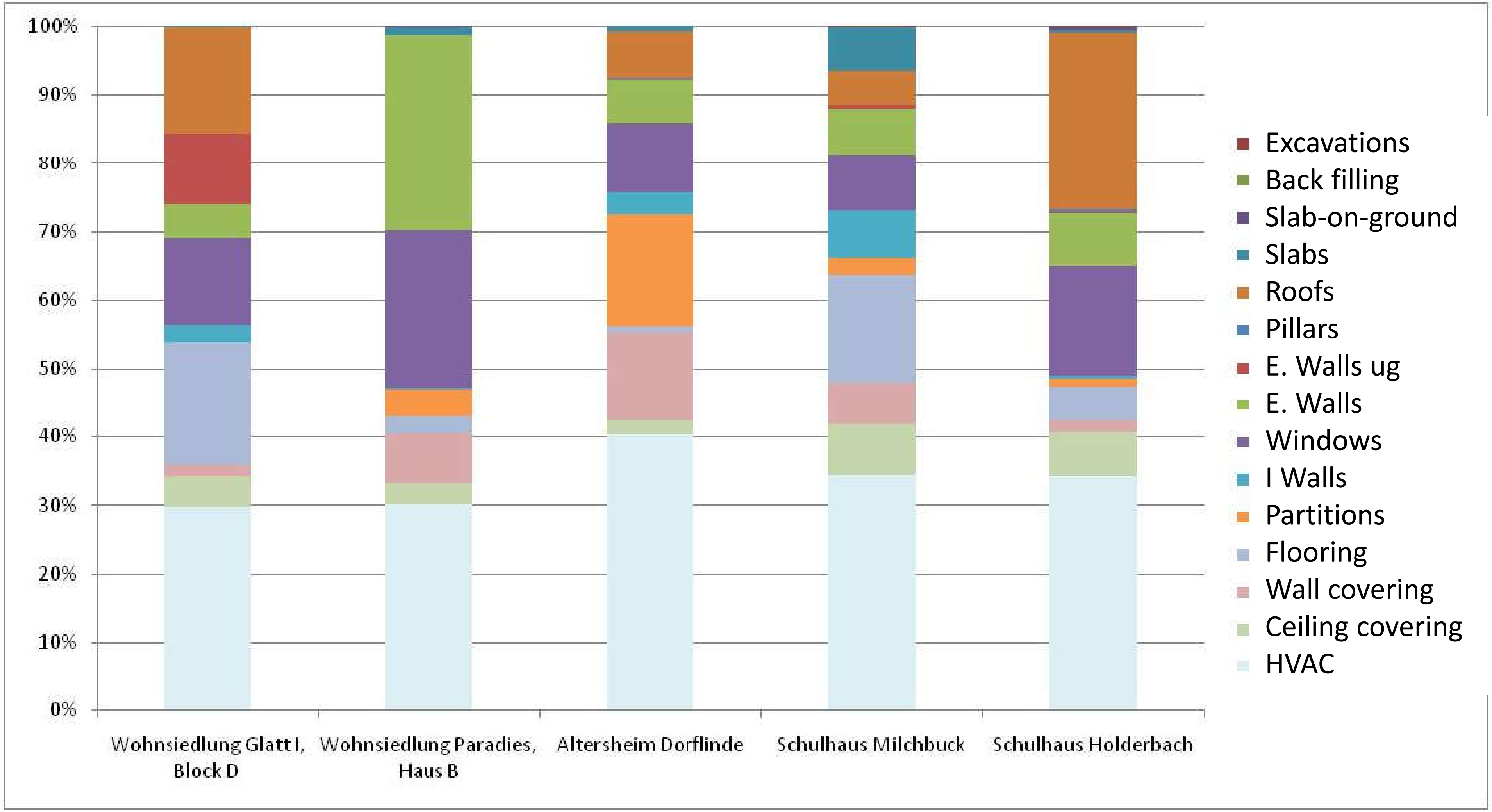
Results



Grey greenhouse gas emissions in comparison to space heating, kg/m2

2.2 Case studies **Case study 3 - comparison**

Results



Grey greenhouse gas emissions, percentages according to elements

2.2 Case studies **Case study 3 - comparison**

Roofs

	GlattI	Paradies	Dorflinde	Milchbuck	Holderbach	SIA-Bauteile
Grey Energy	18 %	0 %	7 %	5 %	22 %	-
Greenhouse gas emissions	16 %	0 %	7 %	5 %	26 %	-
Depth of intervention	0.33	0.00	0.23	0.40	0.81	-
Specific value of grey energy/m2	32 MJ	-	18 MJ	8 MJ	31 MJ	11-59 MJ
Specific value of greenhouse gas emissions/m2	2.0 kg	-	1.2 kg	0.5 kg	2.1 kg	0.7-3.9 kg

The prominent elements of the flat pavillions of Holderbach result in high proportions and high specific values for the metal roofing. The high proportions of Glatt I is due to, on the one hand, the large surface area of the three-storey building and, on the other hand, the additional storeys.

2.2 Case studies **Case study 3 - comparison**

Exterior wall – ground floor and upper floors

	Glattl	Paradies	Dorflinde	Milchbuck	Holderbach	SIA-Bauteile
Grey Energy	6 %	23 %	4 %	6 %	3 % -	
Greenhouse gas emissions	5 %	29 %	7 %	7 %	8 % -	
Depth of intervention	0.40	0.71	0.33	0.28	0.59 -	
Specific value of grey energy/m2	10 MJ	24 MJ	6 MJ	10 MJ	7 MJ	7-29 MJ
Specific value of greenhouse gas emissions/m2	0.5 kg	2.2 kg	0.8 kg	1.0 kg	0.9 kg	0.5-2.1 kg

The thickness of the insulation isn´t the determining factor, but the different insulating systems that show the striking differences. The lowest value of grey energy is achieved by the Holderbach building despite the large proportion. Milchbuck and Holderbach do not have insulation provided in the exterior wall except for specific points with interior insulation, which is why the specific value is low and the space heating is higher.

2.2 Case studies **Case study 3 - comparison**

Windows + exterior doors

	Glattl	Paradies	Dorflinde	Milchbuck	Holderbach	SIA-Bauteile
Grey energy	13 %	23 %	10 %	9 %	13 %	-
Greenhouse gas emissions	13 %	23 %	10 %	8 %	16 %	-
Depth of intervention	0.16	0.23	0.11	0.13	0.30	-
Specific value of grey energy/m2	50 MJ	79 MJ	55 MJ	42 MJ	50 MJ	21-82 MJ
Specific value of greenhouse gas emissions/m2	3.4 kg	5.5 kg	3.8 kg	2.7 kg	3.5 kg	1.5-5.6 kg

Windows are, in most cases, replaced during refurbishments and are important for this reason. The ratio of the window in reference to the total heated floor area can be used as an indicator, and the material composition of the window and frame should be considered.

2.2 Case studies **Case study 3 - comparison**

Partition walls / Interior doors

	Glattl	Paradies	Dorflinde	Milchbuck	Holderbach	SIA-Bauteile
Grey energy	0 %	5 %	17 %	3 %	1 %	-
Greenhouse gas emissions	0 %	4 %	16 %	3 %	1 %	-
Depth of intervention	0.00	0.16	0.44	0.05	0.06	-
Specific value of grey energy/m2	-	26 MJ	22 MJ	36 MJ	21 MJ	9-18 MJ
Specific value of greenhouse gas emissions/m2	-	1.4 kg	1.5 kg	2.3 kg	1.3 kg	0.5-1.1 kg

In the case of the Dorflinde project, the scale ratio as well as the specific values are the highest, due to the massive room structures.

2.2 Case studies **Case study 3 - comparison**

HVAC

	Glattl	Paradies	Dorflinde	Milchbuck	Holderbach	SIA-Bauteile
Grey energy	34 %	35 %	42 %	39 %	46 %	-
Greenhouse gas emissions	30 %	30 %	40 %	34 %	34 %	-
Depth of intervention	1.00	1.00	1.00	1.00	1.00	-
Specific value of grey energy/m2	21 MJ	27 MJ	25 MJ	23 MJ	53 MJ	8-50 MJ
Specific value of greenhouse gas emissions/m2	1.3 kg	1.6 kg	1.6 kg	1.4 kg	2.2 kg	0.6-3.1kg

The proportions of the HVAC installations is strikingly high in all projects. The controlled ventilation system has a large proportion in Glatt I, Dorflinde and Paradies.

Conclusion

•When comparing space heating with construction, grey energy along with greenhouse gas emissions should be taken into account, as these usually have a higher proportion during the construction phase.

•The approximate values of the Energy Efficiency Path give an initial scale for the construction estimate.

•When calculating the construction energy in the preliminary design, it is recommended to consider the factors of proportions and material composition for optimising construction elements.

•There are few defined elements that are focused on when defining parameters for refurbishments such as HVAC, windows, exterior walls, and roofs.

2.2 Case studies Case study 1 residential building

Conclusions

Currently there are methodologies and tools help us assess how close or not a specific type of building is to closing the materials cycle.

It is possible to keep up to 95% of the materials in a closed cycle by constantly recycling them through industrial or natural means.

Closing the materials cycle is typically around 5%, but could be as high as 95%. In this range, many improvement strategies can be introduced.

In the building industry, the key to closing the materials cycle is not found in a specific material, construction system, or a building type, but in the resource management in the life cycle.

Second part (afternoon, 3h)

2.1 Showcase of sustainable materials and resources (60')
Closing the material cycle (12')
Nature based materials (16')
Industrial based materials (32')

2.2 Case studies (60')
Case study 1 residential (30')
Case study 2 workplace (30')

2.3 Workshop (60')
Introduction (10')
Work in groups (30')
Sharing knowledge (20')

2.3 Workshop **Introduction**

Objectives

1. Propose an alternative vision to the professional practice of design, specifications, and putting to use of construction materials.
2. Review, put into practice, and strengthen the knowledge acquired throughout the day.
3. Exchange the points of view contributed by different profiles of people from the audience.
4. Integrate this diverse knowledge into a discussion on solutions for these problems.
5. Compare two construction solutions of different environmental impacts and determine design and management criteria to achieve minimal impact.

Option 1: concrete wall

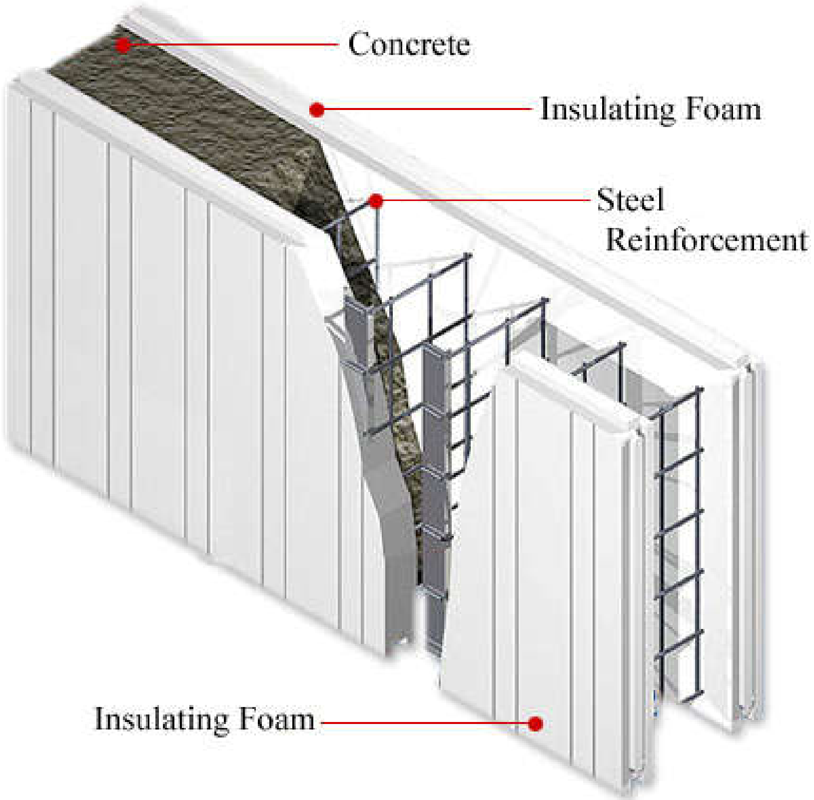


Image: Monster construction

Option 2: timber wall

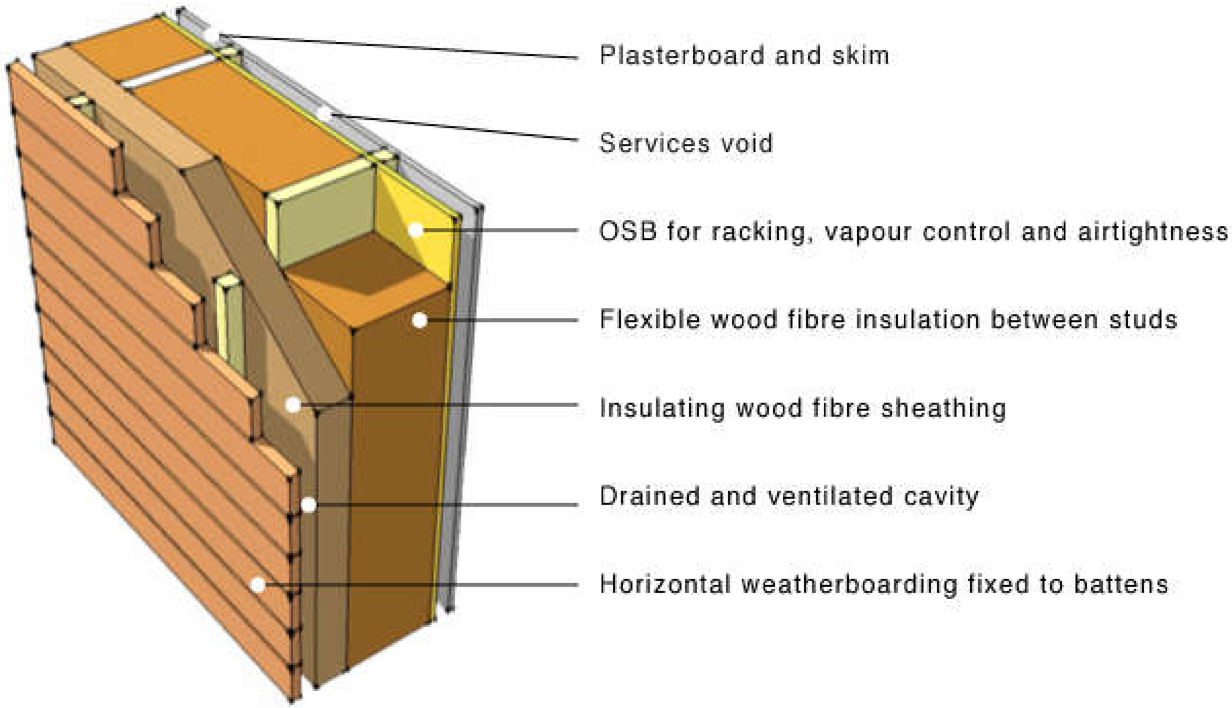


Image: Greenspec

Proposed project

1. Form groups of no more than four people, combining people of different backgrounds into each group.
2. Determine the qualitative environmental advantages and disadvantages for every phase of the lifecycle of a building.
3. Select the option that has the least environmental impacts, based on approximate but well-argued deliberations.
4. Review the possible restrictions (building code compliance, costs, technology available on the market, acceptability, etc.)
5. Determine the criteria to improve the selected construction solution.

Presenting the conclusions

1. Each group will elaborate their conclusions following the given order of the proposed project.
2. These conclusions will be outlined on a sheet that will be handed in at the end of the session.
3. The conclusions will be brought together in an open-discussion session where all the participants can exchange their opinions.

Tools/Resources

Ebert, Essig, Hauser (2011), Green building certification systems, Regensburg, DETAIL

Hegger, Auch-Schwelk, Fuchs, Rosenkranz (2006), Construction Materials Manual, Munich, DETAIL

Dittrich, Giljum, Lutter, Polzin (2012), Green economies around the world?, Seri, Vienna

Material resources and waste, 2012 update, EEA, Copenhagen, 2012

Bioregional, Waste & Resources Action Programme, Reclaimed building products guide, http://www2.wrap.org.uk/downloads/Const_Product_Guide_Version_4.1.ea02c783.2962.pdf

Bribián, Capilla, Usón,(2011) Life cycle assessment of building materials: Comparative analysis of energy and environmental impacts and evaluation of the eco-efficiency improvement potential. Building and Environment. 46: 1133-1140

Anderson, (1998), Mid-Course correction, The Peregrinzilla Press, Atlanta

Woolley, Kimmins, Harrison, Harrison, (1997), Green Building Handbook, E&FN Spoon, London

Berge, (2000), The ecology of building materials, Architectural Press, Burlington

Wadel, (2009), La sostenibilidad en la arquitectura industrializada, UPC, Barcelona

Bahamón, Sanjinés, (2008) Del desecho a la arquitectura, Parramón ediciones, Barcelona

Status Seminar «Research and Construction in Context with Energy and the Environment» / Grey Energy and Greenhouse Gas Emissions in Restaurations/ Yvonne, Fürer / www.stadt-zuerich.ch/nachhaltiges-bauen

Courses

The WorldGBC Europe Regional Network has organized the development of a series of green building courses intended to support Green Building Councils in bringing quality education to their markets.

If you found this course informative you may be interested in our other offerings.

- ❑ Financial Considerations for Green Buildings
- ❑ Legal Requirements & Green Building Certifications
- ❑ Building Enveloped for Green Buildings
- ❑ Sustainable Materials & Resources
- ❑ Creating & Managing Greener Workspaces
- ❑ Creating & Managing Greener Schools
- ❑ Managing Green Building Projects

The following materials were created in an open source format by qualified training developers selected by WorldGBC's Europe Education Advisory Group. Although a standard set of these materials was developed for the European region, their structure is modular and may have been adapted nationally by your local GBC.

EDUCATION ADVISORY GROUP

Steven Borncamp – RoGBC

Dominika Czerwinska – WGBC

This course was created with the help of:

societat orgànica
environmental consulting
energy – materials – waste – water
www.societatorganica.com

societat orgànica environmental consulting

The technical system of the dominant industrial production model is based on a growing consumption of resources, which are extracted from nature causing environmental impacts and diminishing their reserves. Once the use of the products has been exhausted, the materials return to the environment as waste, often causing serious contamination problems. This procedure works against a long-term development model. Therefore, it is necessary to create a model that is sustainable.

Societat Orgànica is a consultancy promoting the sustainability paradigm in the building sector, considering the closing of the material cycle as a necessary condition in order to achieve sustainability. We develop the tools and information about the material flows in order to evaluate the sustainability of building.

Consulting

We provide knowledge and practical solutions in the regulatory, technological, informational and management areas, with the goal of reducing environmental impacts. We offer consultancy services for all different phases of architectural projects in the fields of energy, materials, water and waste.

Teaching

Our education & training projects provide the basis for a successful reorientation of the professional practice and support, through concepts and tools, the importance sustainability should have in the future of the building sector agents.

Communication

We explain environmental issues to a great number of technicians, professionals, installers, manufacturers and managers of the building sector, as well as the general public, proposing visions, missions, concepts, knowledge and tools.

R&D&i

The research&development projects Societat Orgànica is involved in create new knowledge, tools and applications that affect the material and energy aspects of buildings, as well as activities inside the building.

Greening

Our greening projects incorporate sustainability criteria in the production structure of firms and institutions, as part of a cyclical process of improving the environmental quality. Beginning with the analysis of operations and the obtaining of benchmarks; it continues by identifying improvement strategies and the design of new tools and culminates with the monitoring and evaluation of the results.

societat orgànica
environmental consulting
www.societatorganica.com

c. Europa 15, 2. 4.
08028 Barcelona.
+34 93 4307653
so@societatorganica.com

THANK YOU!

WORLD GREEN BUILDING COUNCIL

Europe Regional Network