# Recycling and sustainable development

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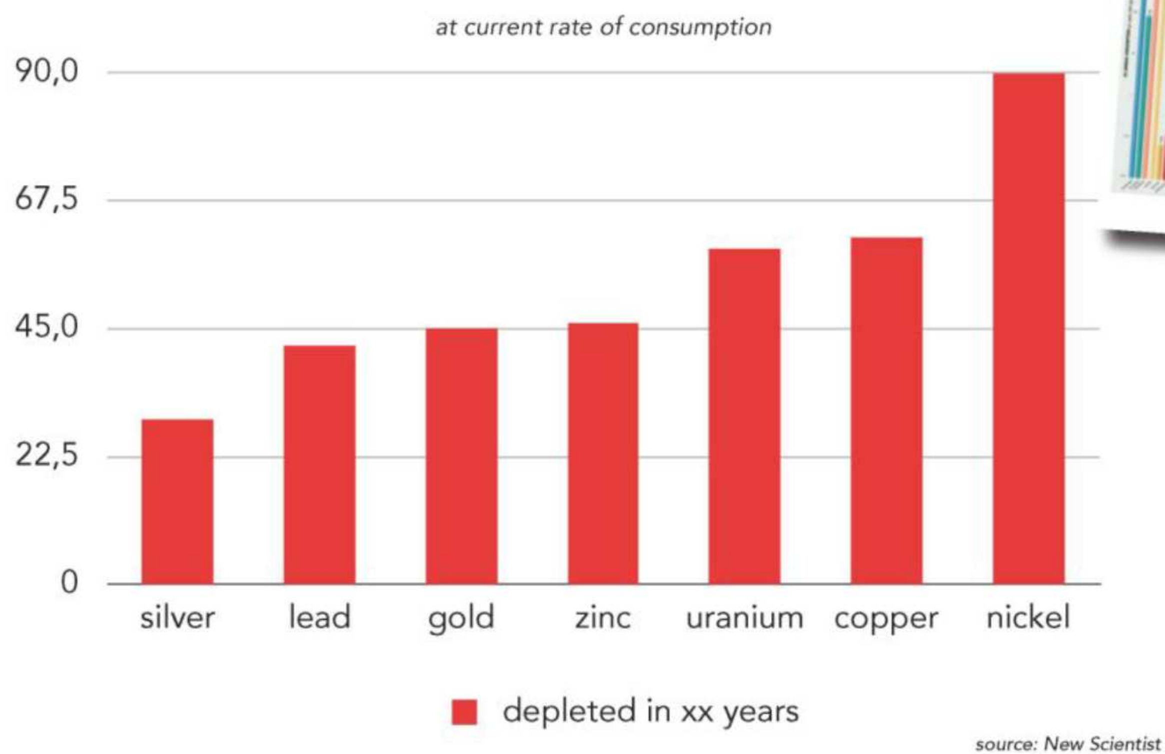
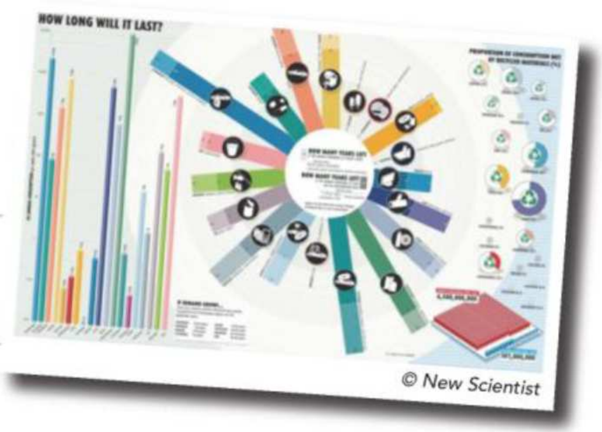
*Timisoara, December 17th, 2013*

# Ascertainment

## Extinction of resources



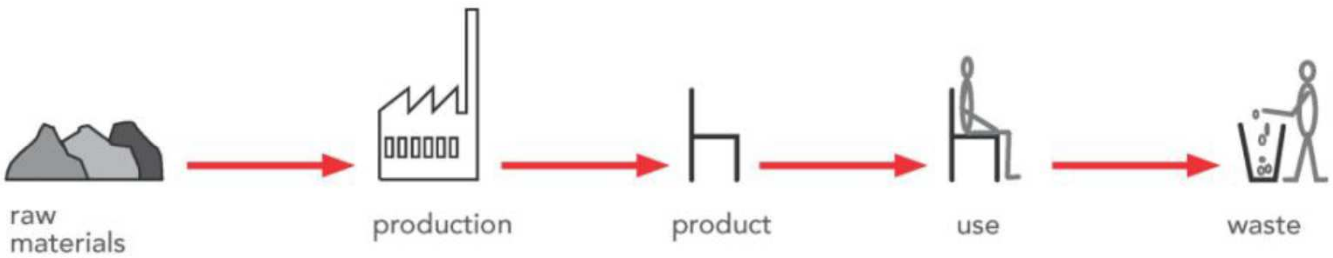
# Ascertainment

- Ascertainment
  - We are living in a limited world
    - Energy
    - Natural resources
    - Space (urban planing)
    - Capacity of adaptation of natural environment
- Ascertainment → behavior
  - Consuming
  - Architecture
  - Civil engineering
  - ….

# Concepts and principles

Eco-efficiency and eco-beneficiency

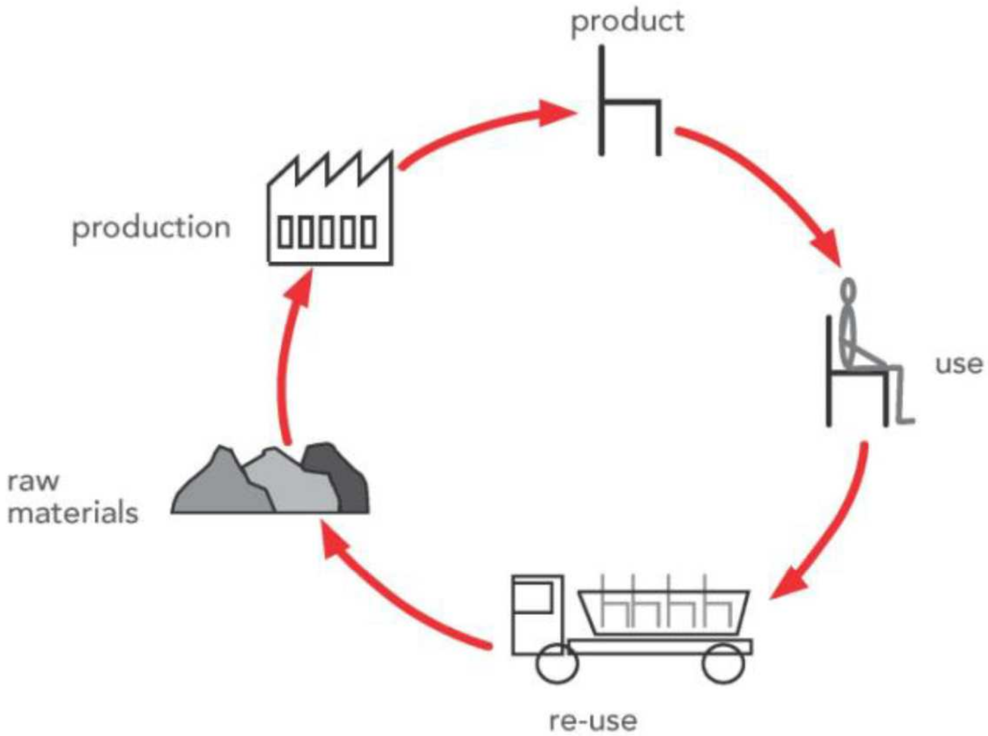
# Eco-beneficiency




OLD LINEAR ECONOMY - is about ownership

*SOURCE: S. BECKERS (d'après M. BRAUNGART –EPEA, Cradle to Cradle)*

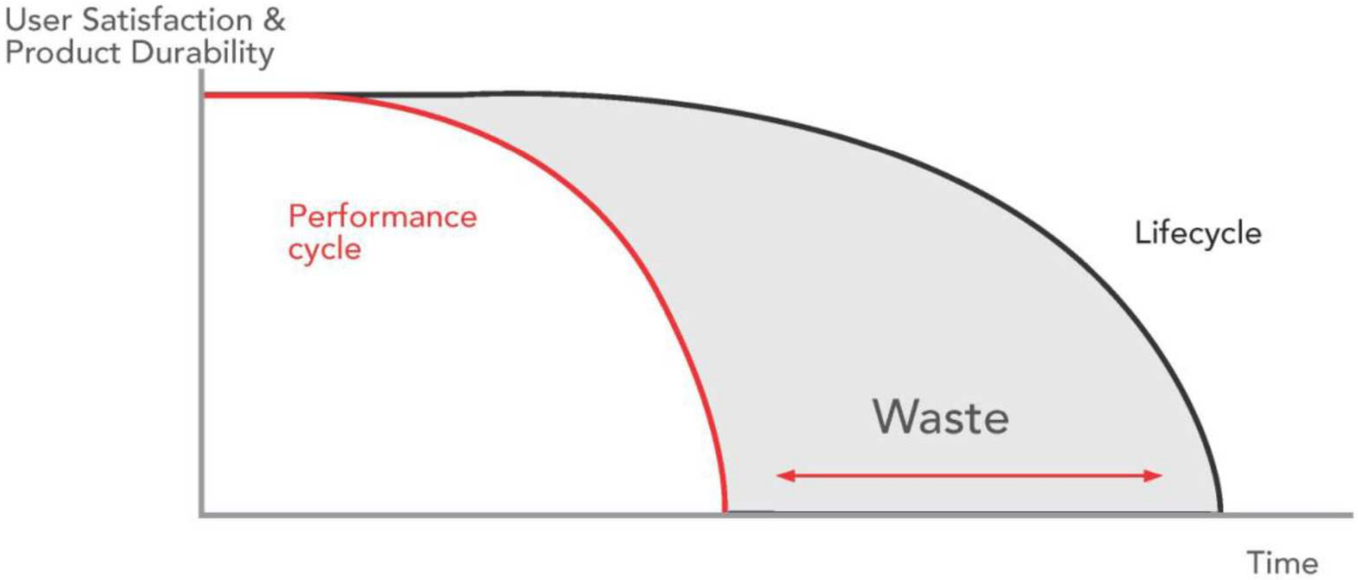
# Eco-beneficiency




C2C - TECHNICAL NUTRIENT CYCLE

*SOURCE: S. BECKERS (d'après M. BRAUNGART –EPEA, Cradle to Cradle)*

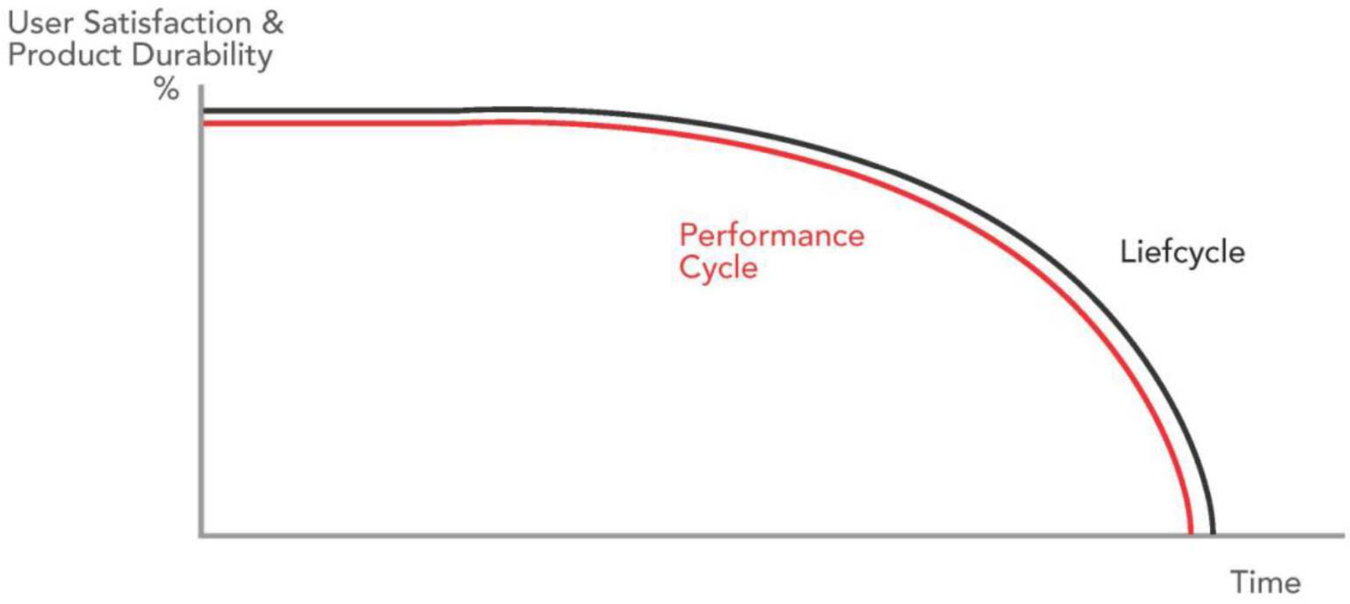
# Eco-beneficiency




**Life cycle versus Performance cycle**

*SOURCE: S. BECKERS (d'après M. BRAUNGART –EPEA, Cradle to Cradle)*

# Eco-beneficiency

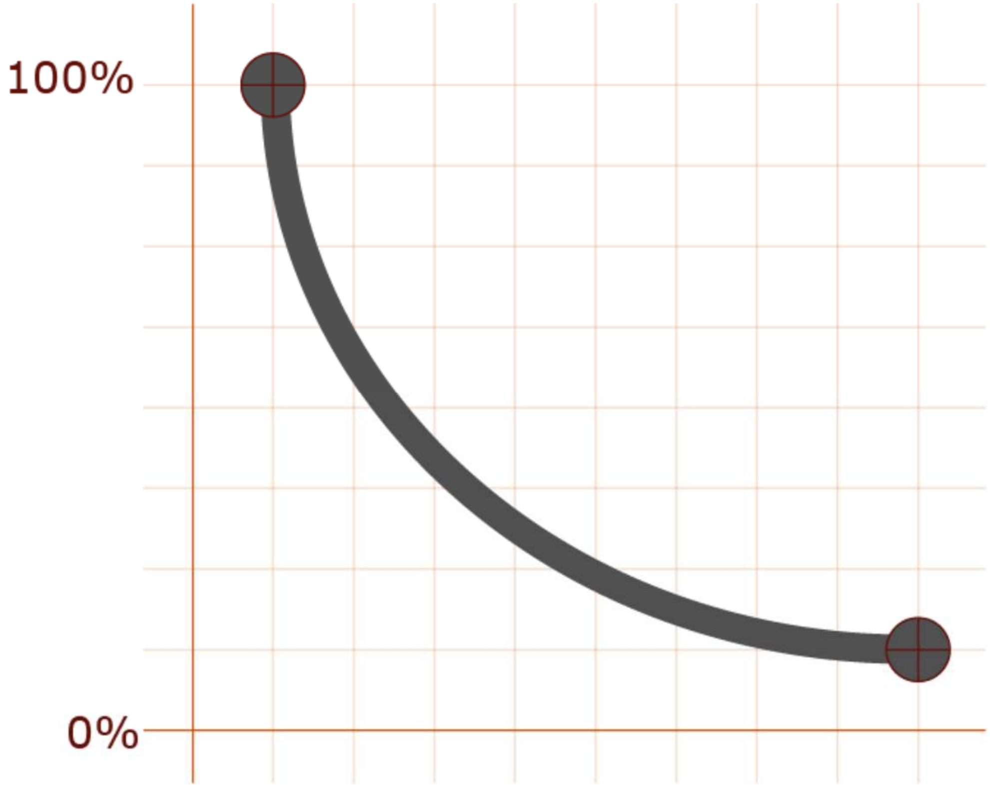



**Life cycle versus Performance cycle**

*SOURCE: S. BECKERS (d'après M. BRAUNGART –EPEA, Cradle to Cradle)*

# Eco-beneficiency

## Craddle to grave

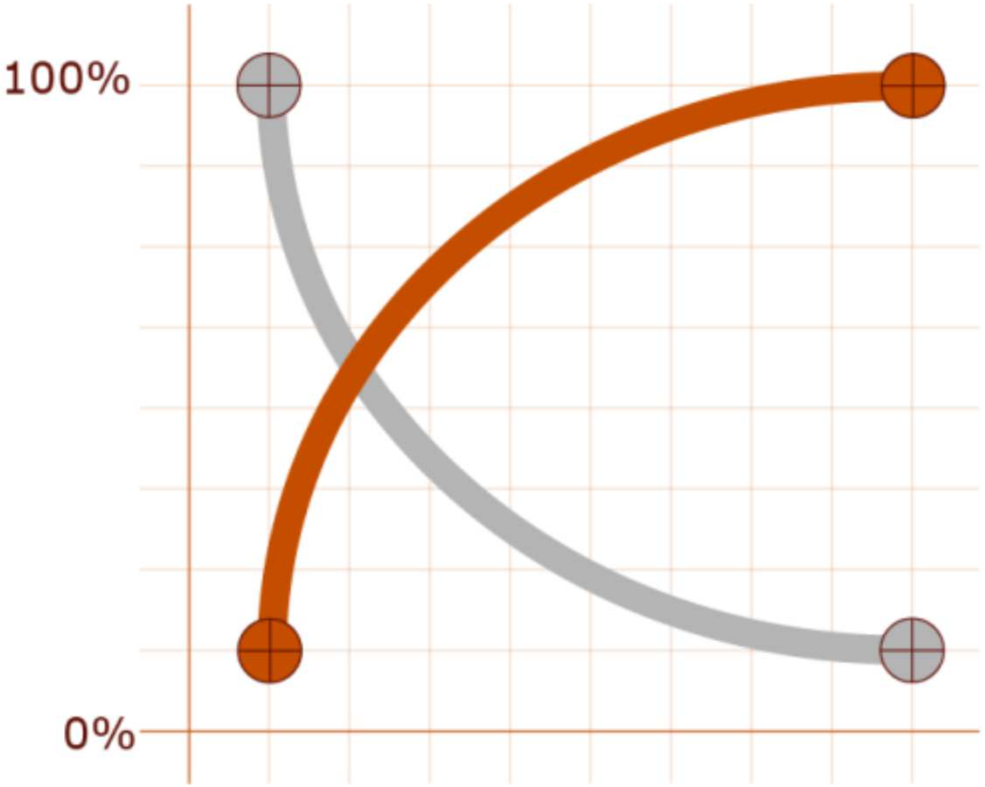



Reduce,
Avoid,
Minimize,
Prevent..

*SOURCE: S. BECKERS (d'après M. BRAUNGART –EPEA, Cradle to Cradle)*

# Eco-beneficiency

## Craddle to craddle




Eco-beneficiency = BETTER

DEFINE,
INCREASE,
SUPPORT,
OPTIMIZE

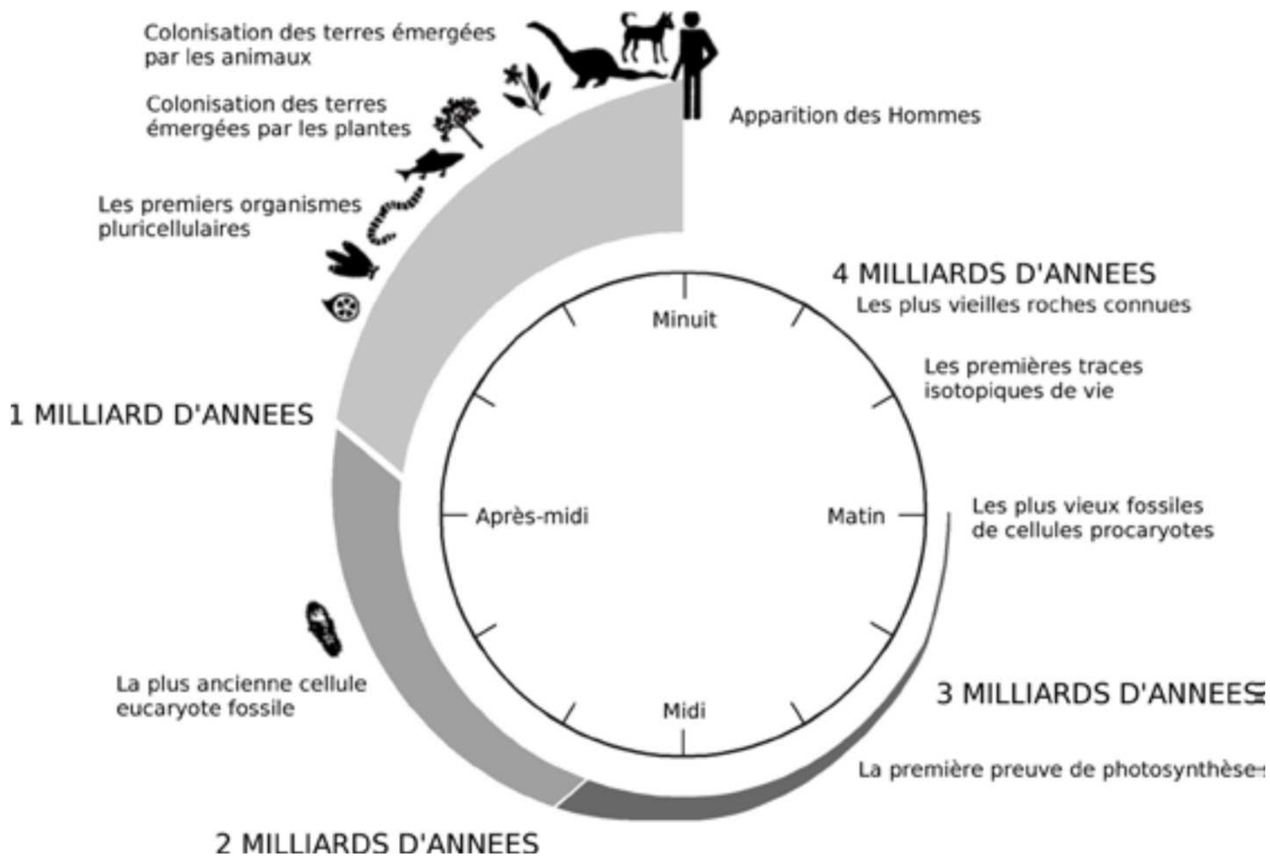
Eco-efficiency = LESS BAD

*SOURCE: S. BECKERS (d'après M. BRAUNGART –EPEA, Cradle to Cradle)*

# Eco-beneficiency

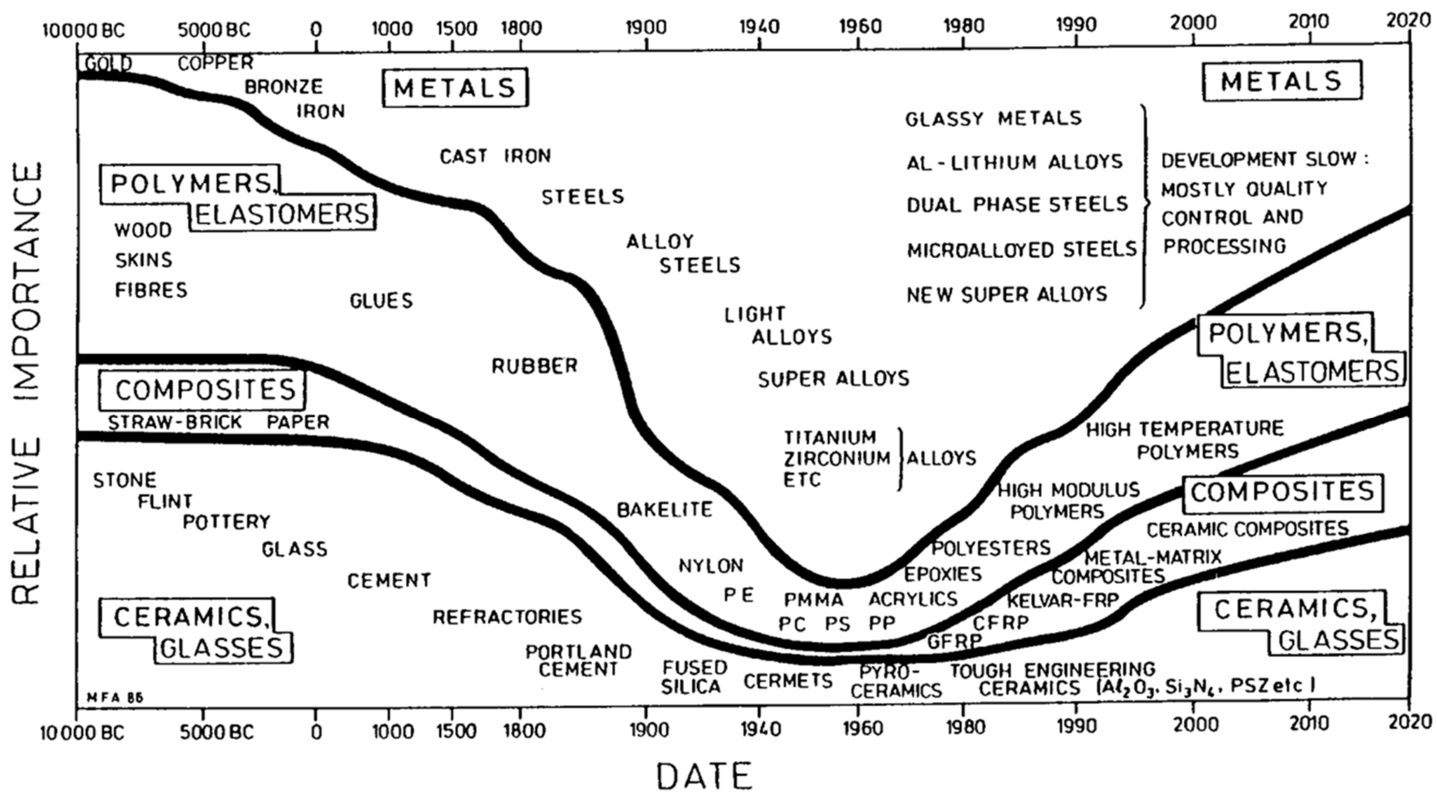
## Evolution of HUMANS

The dial 12 h is 4.5 billion years of the Earth.
First Men appear at 11 h 59 min and 43 sec



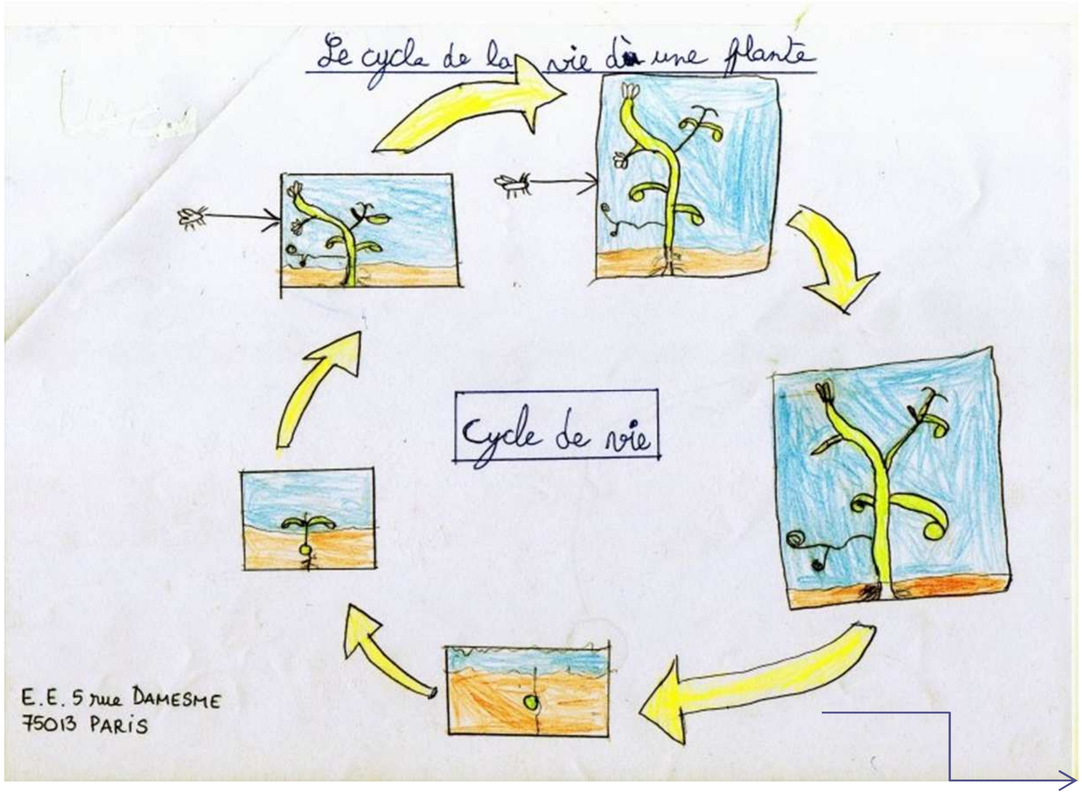
# Eco-beneficiency

## Evolution of materials



# Eco-beneficiency

Biological life cycle




= nutriment

# Eco-beneficiency

Design wastes as « nutriments »

Design products as « service products »

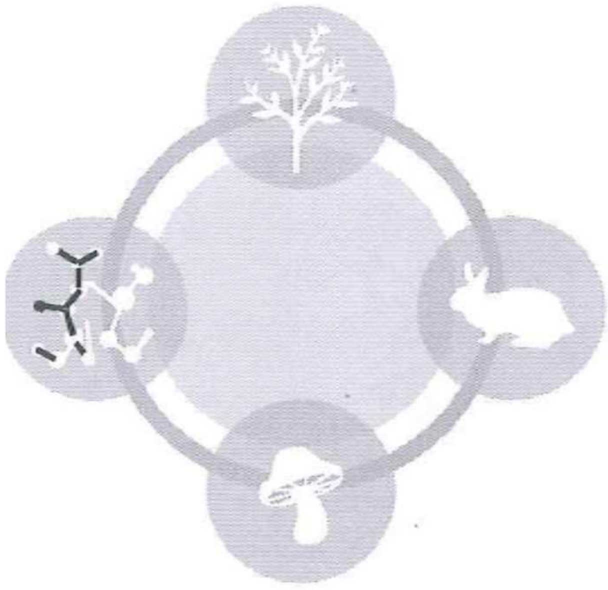
- design for disassembly
- better correspondance between performance cycle and life cycle
- easy adaptation of buildings (notion of over-cycling)

Advantages(3)

- no unnecessary waste
- less use of natural resources
- technical nutriments are permanently circulating …

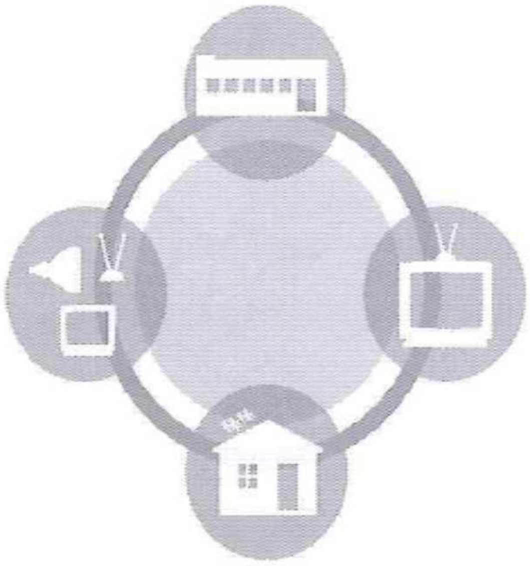
# Eco-beneficiency

Biosphere



MÉTABOLISME BIOLOGIQUE

Technosphere



MÉTABOLISME TECHNOLOGIQUE

*« It is needed to separate bio- et techno- cycles if we want to avoid a product becomes a waste (p.e. wood + varnish) »*

*SOURCE: S. BECKERS (d'après M. BRAUNGART –EPEA, Cradle to Cradle)*

# Recycling and reuse

3R strategy

# Recycling and reuse

3 R strategy

***reduction***: technology for reducing the production of waste (technology)

***reuse***: technology for giving a new use for end-product,

***recycling:*** technology for giving a new life cycle

# Recycling and reuse

Gains

*selective harvesting of paper and cardboard*

Conservation

*historical testimony: heritage conservation*

Saving materials

*cast bells in wartime*

Saving resources

*recycling 1 kg of aluminum can save about 8 kg of bauxite, 4 kg of chemicals and 14 kWh of electricity*

# Recycling and reuse

Saving resources

Municipal wastes

Combustion at 900-1000°C

Post-combustion treatments

Supplying

Cribbling

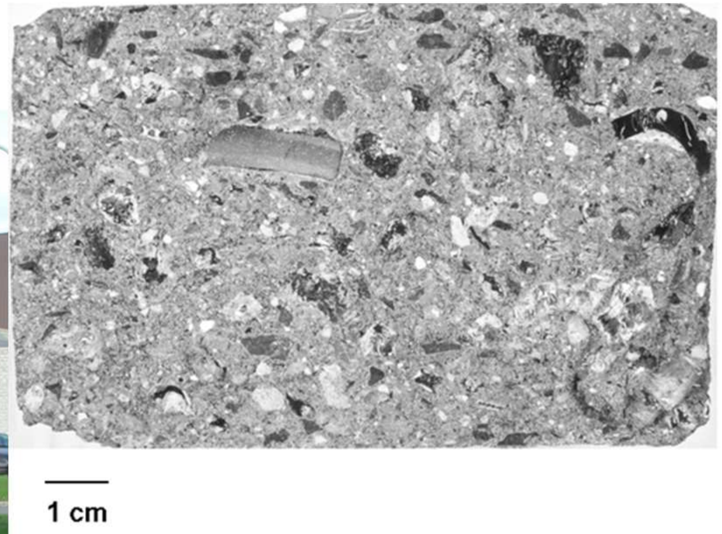
Separation
(10 – 20 weeks)

Maturation

# Recycling and reuse

## Saving resources

Industrial process – 10% MSW slags




| | |
|---|---|
| Splitting resistance(N/mm²) | 4.05 ± 0.53 |
| Water absorption (%) | 6.61 - 6.29 |
| Abrasion (mm) | 0.98 - 1.36 |

*Source : Utilisation des mâchefers d'incinérateur d'ordures ménagères dans la fabrication des pavés en béton. L. Courard, R. Degeimbre, A. Darimont, A.-L. Laval, L. Dupont et L. Bertrand. Mater. Struct., 35 (Juillet 2002), 365-372.*

# Recycling and reuse

Become useful

Mobilier dans la maison en papier d’Elis Stenman (Pigeon Cove, Massachusets
Source: Elfers, J. & Schuyt, M., « Les bâtisseurs de rêves »

*www.paperhouserockport.com*

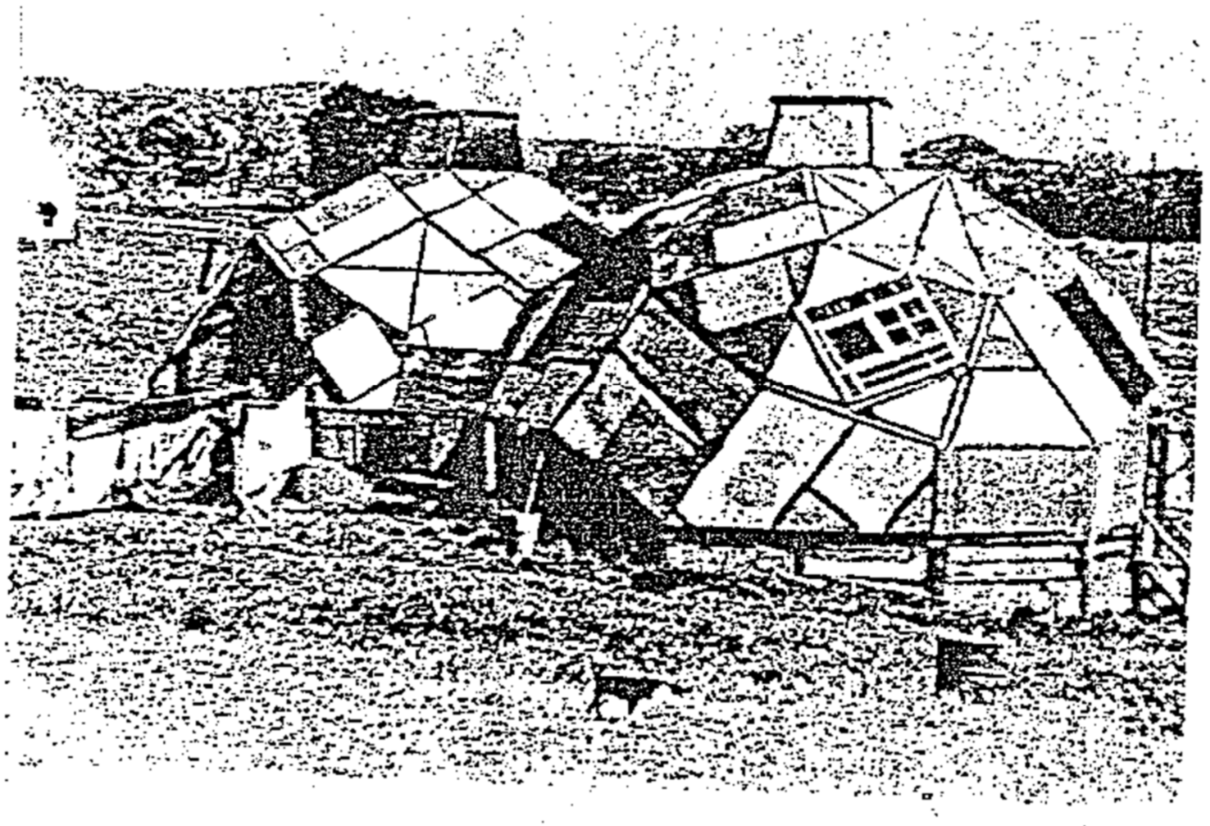
# Recycling and reuse

Sentimental

*Palace of postman Cheval (Photo G. Thérin)*

# Recycling and reuse

## Contest



*Dômes en matériaux de récupération, réalisés par une communauté de hippies, sous la direction de Buckminster Fuller, Colorado, 1965*
*Source: Elfers, J. & Schuyt, M., « Les bâtisseurs de rêves »*

# Recycling and reuse

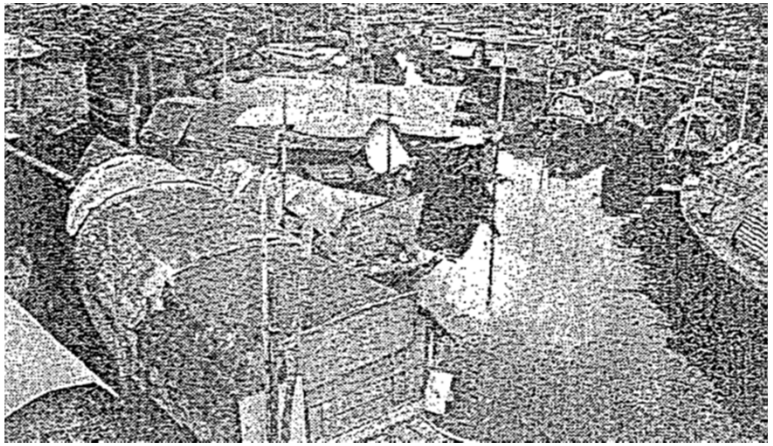
Create

**Baldaccini, César - "Compression" - Compression 1960 - Métal compressé, pots d'échappement d'automobiles**


**Baldaccini, César - "Compression" - (1960)**

# Recycling and reuse

## Survive



Maisons de marchands pauvres à Bangkok
Source: Gabor, M., « Maisons sur l’eau »

Ramasseurs de déchets dans un bidonville de Jakarta en Indonésie

# Conditions for recycling

Sustainable development

# Conditions for recycling

Balance between the deposit and the market

- Exemple: demolition and road construction
- Recycling on site = 50% total saving
  - 70% transportation
  - 20% materials costs
  - 10% taxes for landfill

Barriers to recycling

- Transportation
- Standardization

# Conditions for recycling

Evaluation of recycling opportunity

- Technical
  - Waste characterisitcs
  - Durability
  - Constance of properties
- Logistics and economy
  - Deposit and transportation
  - Constance production
  - Conditioning
  - Distance

# Conditions for recycling

Evaluation of recycling opportunity

- Environmental and economical
  - Decreasing quantities for landfilling
  - Regulatory obligation elimination
  - Taxes

We do not recycle ...

*anything, no matter how, at any price.*

# Conditions for recycling

Needs for civil engineering

**materials,**

**aggregates,**

**binders,**

**additives**,

… *decreasing quantities but increasing quality*

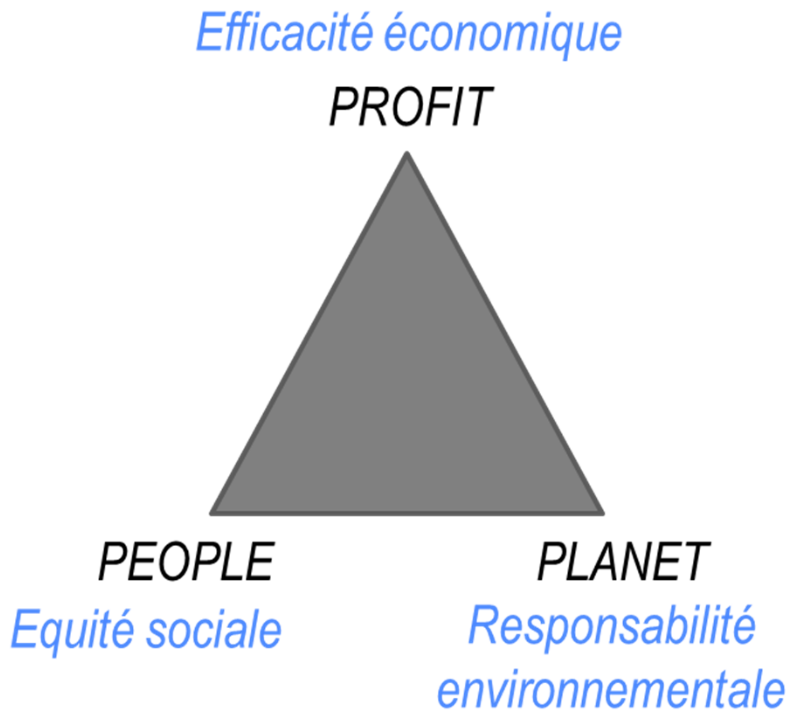
# Construction *vs* environment

Difficult relationship

# Construction *vs* environment

Environment

- ***natural***
- ***social***
- ***economic***




*A development that meets the needs of present generations without compromising the ability of future generations to meet their own (Brundtland report, 1987)*

# Construction vs environment

## Social environment

- at European level, 7.5% of total employement is created by construction industry,
- at European level, construction industry represents 28.1% of manufacturing industry employment.

# Construction vs environment

## Economical environment

- construction industry consumes between 40 and 50% of natural resources for materials,
- construction industry consumes 40% of energy and produces 40% of $CO_2$ et 50% of wastes produced in the world,
- construction industry consumes a lot of self-generated wastes but also by-products from other industries and municipal wastes.

# Construction vs environment

Economical environment

- Production of wastes
  - France (2007): 343 millions tons of wastes by construction industry:
  - Public works: 295 millions tons, mainly recycled (because 95% inerts)
  - Building : 48 millions tons, less recycled (because only 65% inerts and sorting under development)

# Construction vs environment

Reduction of energy consumption in buildings and greenhouse gas emissions

- Insulation
- Bioclimatic design
- Renewable energies

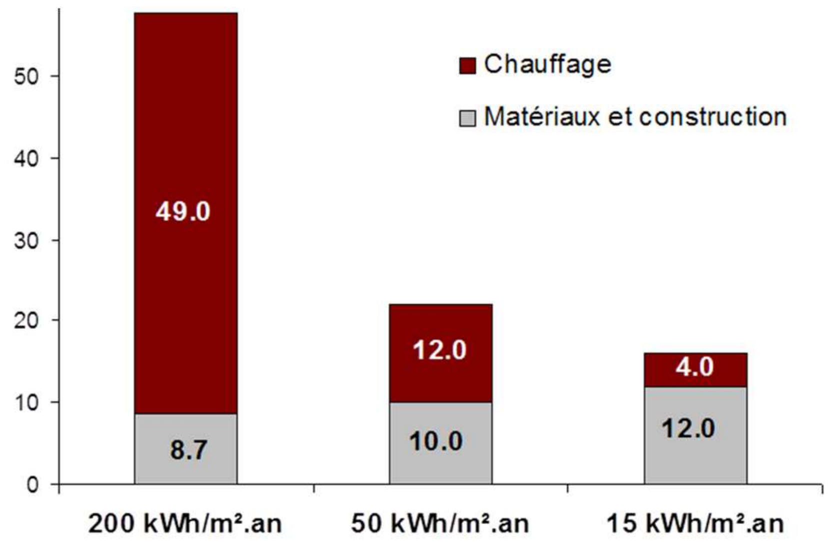
# Construction vs environment

Development of materials and alternative techniques for buildings

Increasing energetic performances of buildings

Increase of material selection impact on building efficiency

Need for new materials



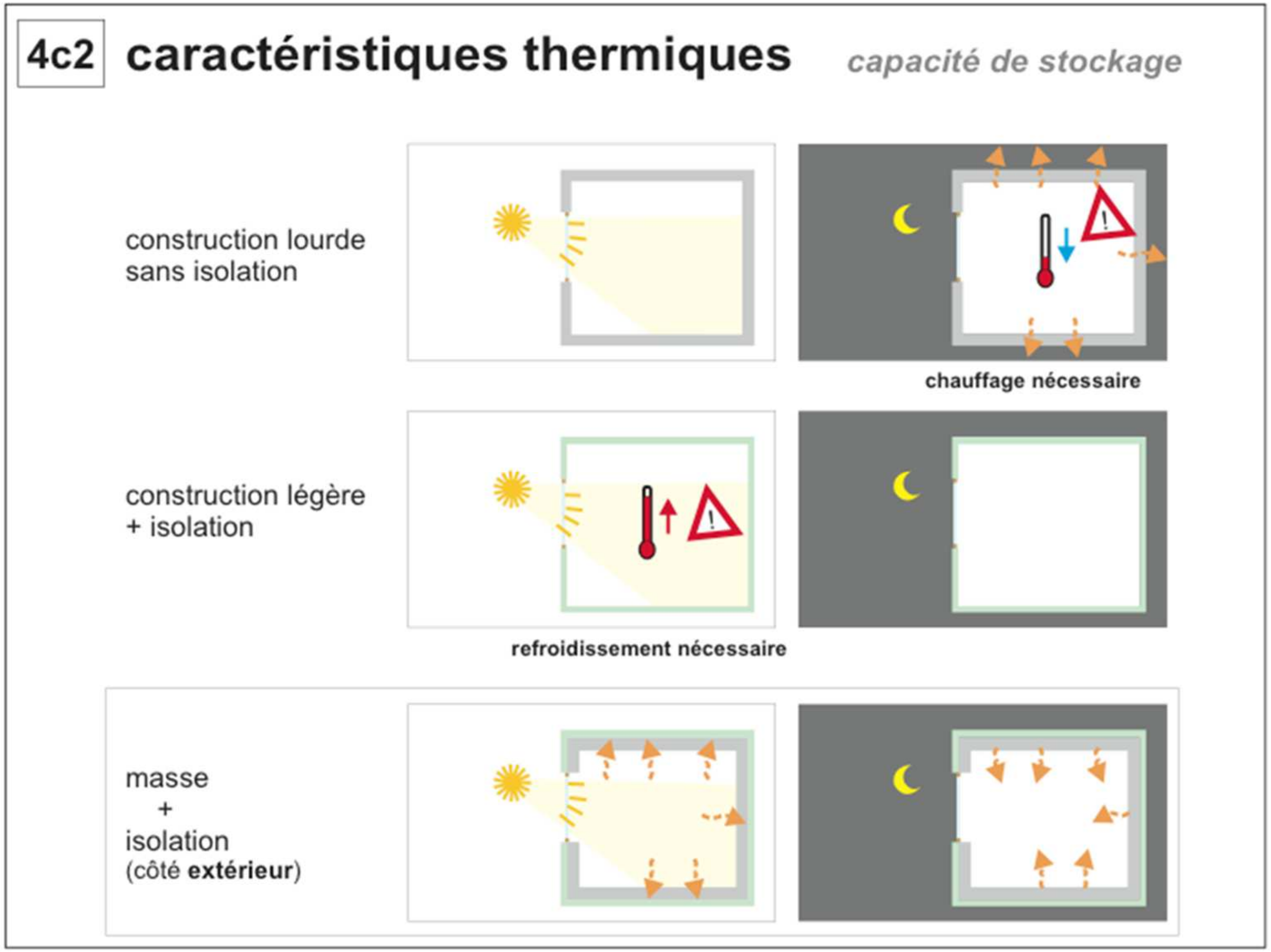

***Source : G. Escadeillas, Métamorphoses, Liège, 2011)***

# Construction vs environment

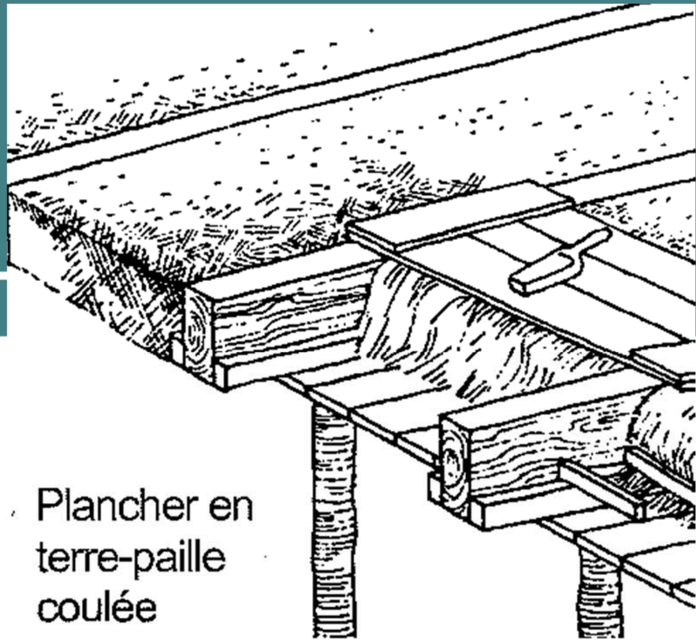
Development of materials and alternative techniques for buildings

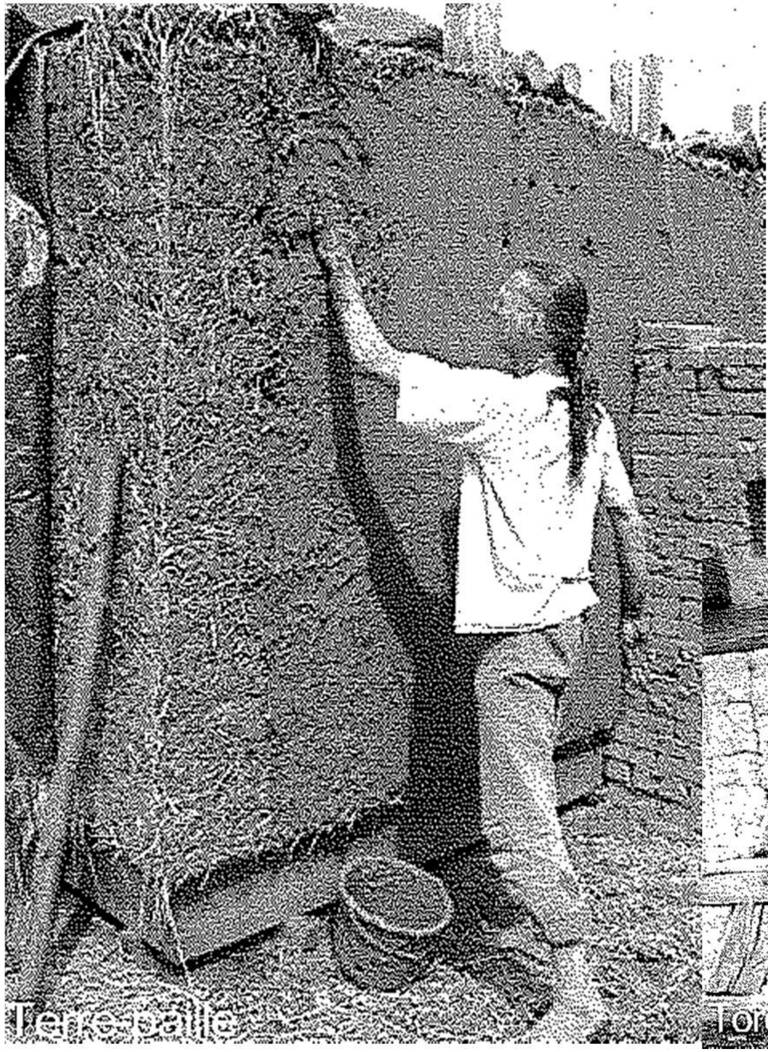
- Limiting energy consumption during service life,
- To be safe,
- Contributing to « comfort » concept,
- Production technology with low environmental impact (energy, wastes, ..)

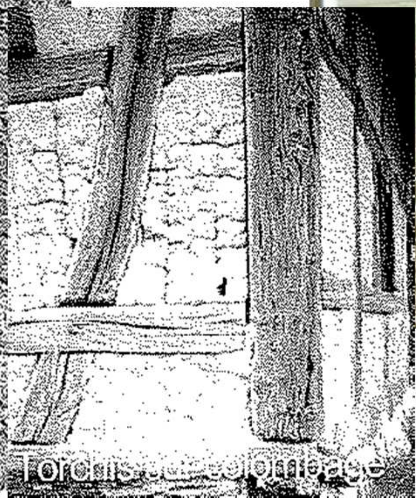
# Construction vs environment



# Natural materials



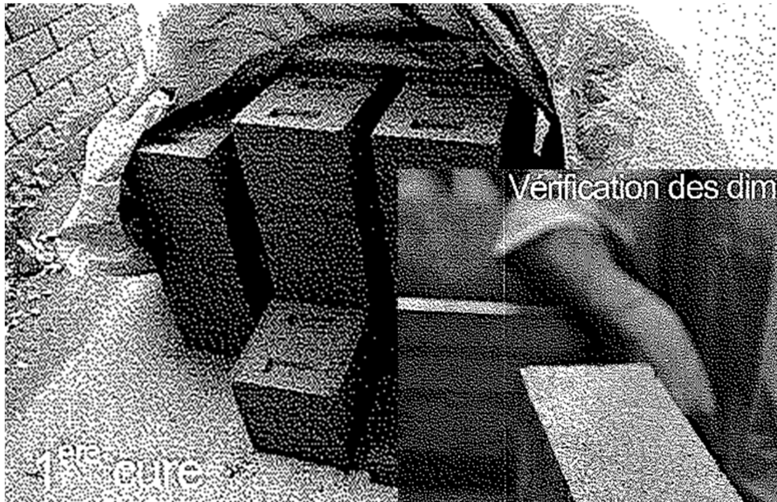



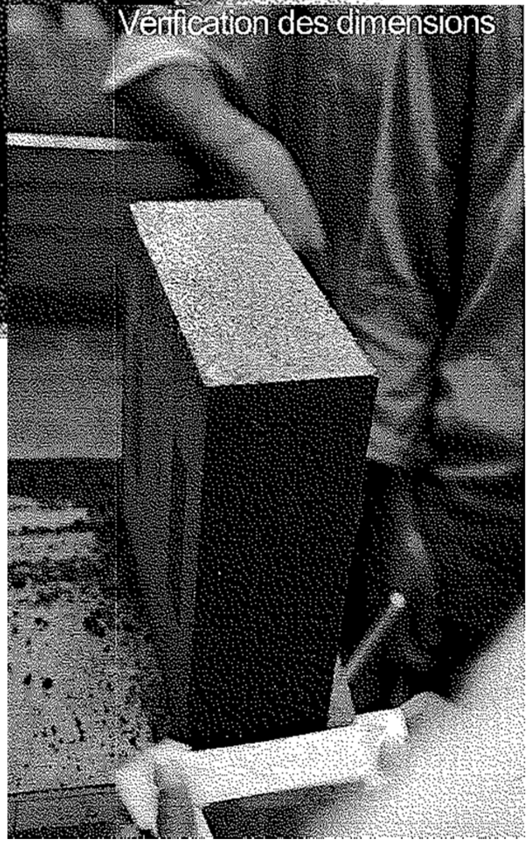

# Natural materials

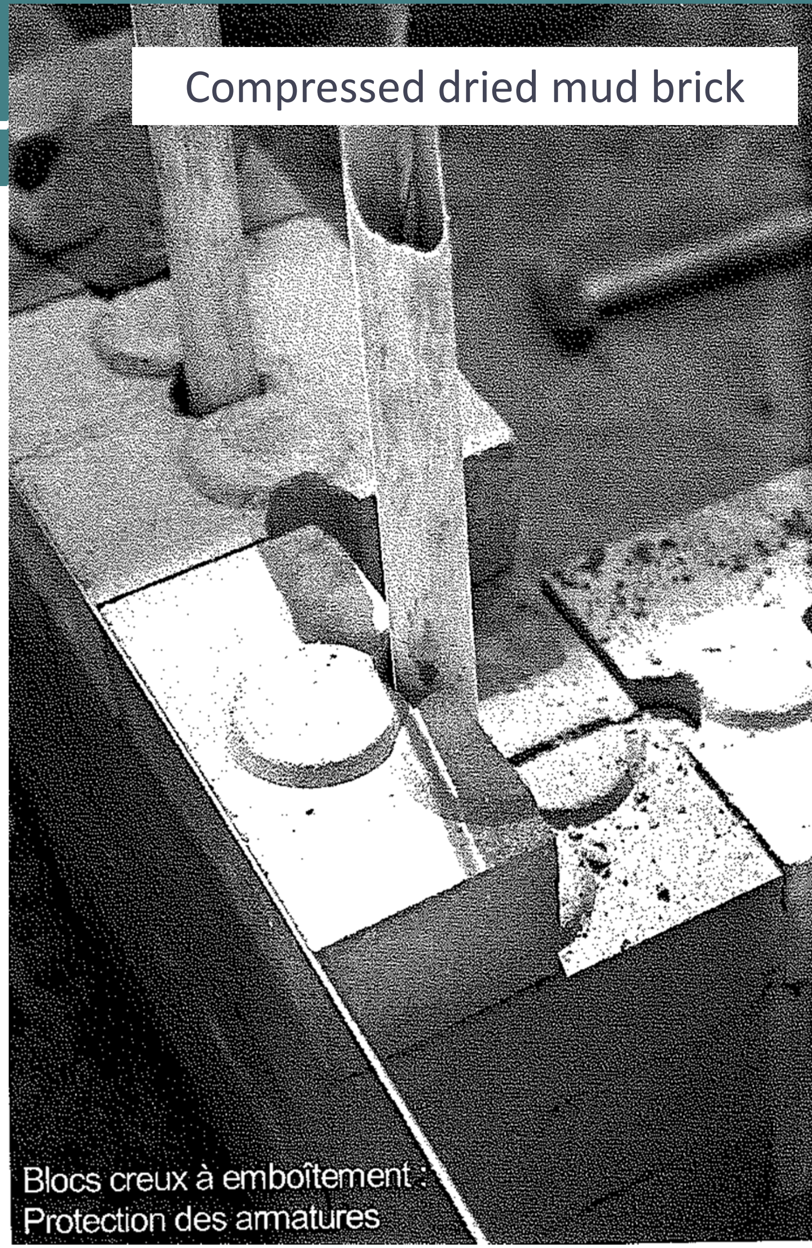
Shibam, Yemen: adobe technique
(dried mud brick in the sun)

# Natural materials

Compressed dried mud brick



# Natural materials

## Renewable materials

## Woodden concrete

- Mix of wood chips and cement paste
- For wall production
- Thermal insulation: $\lambda$ = 0.09 W/m.°K (cellular concrete block $\lambda$ = 0.12 W/m.°K and silicate brick $\lambda$ = 0.27 W/m.°K)

# Natural materials

Renewable materials

AGROMOB Project (2011-2013) Increasing thermal inerty of woodden structural buildings with bio-sourced materials.

# Natural materials

Renewable materials

aPROpaille Project (2011-2013) The use of straw blocks in construction industry

# Natural materials

Renewable materials

# Selection criteria

Grey energy

# Selection criteria

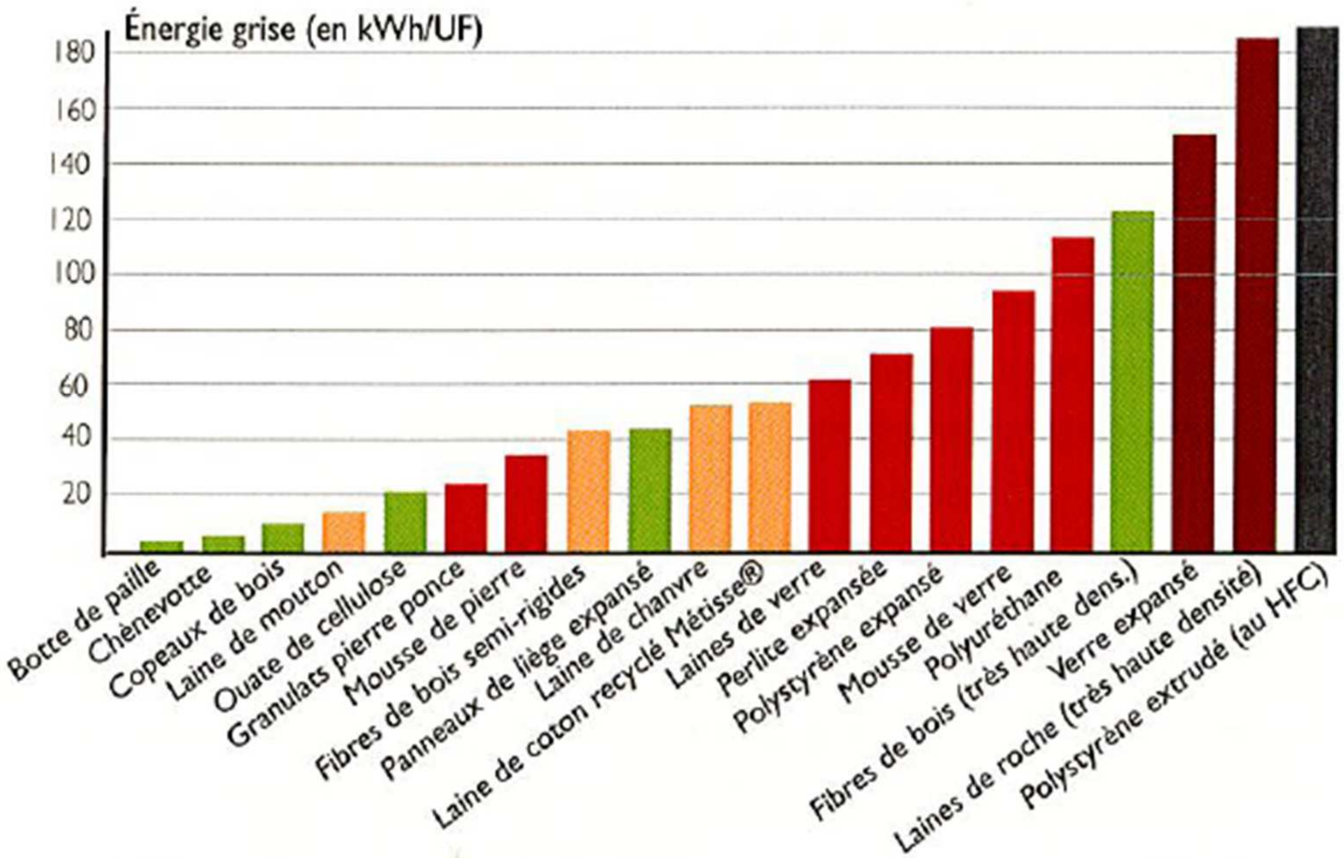
## Grey energy of materials (kWh/m³ ou T)

machines d'extraction,

carburant pour le transport,

consommation d'électricité pour la transformation,

pétrole utilisé pour la production.




*Source : Isolation thermique et écologique J.P. Oliva et S. Courgey (d'après G. Escadeillas, Métamorphoses, Liège, 2011)*

# Selection criteria

Energy consumption for $1m^3$ reinforced concrete

| Material/operation | Energy (GJ) |
|---|---|
| Cement | 1.58 |
| Sand and aggregates | 0.27 |
| Steel reinforcement | 2.25 |
| Formwork | 0.43 |
| Transportation and casting | 0.34 |
| Demolition and waste treatment | 0.27 |
| TOTAL | 5.14 |

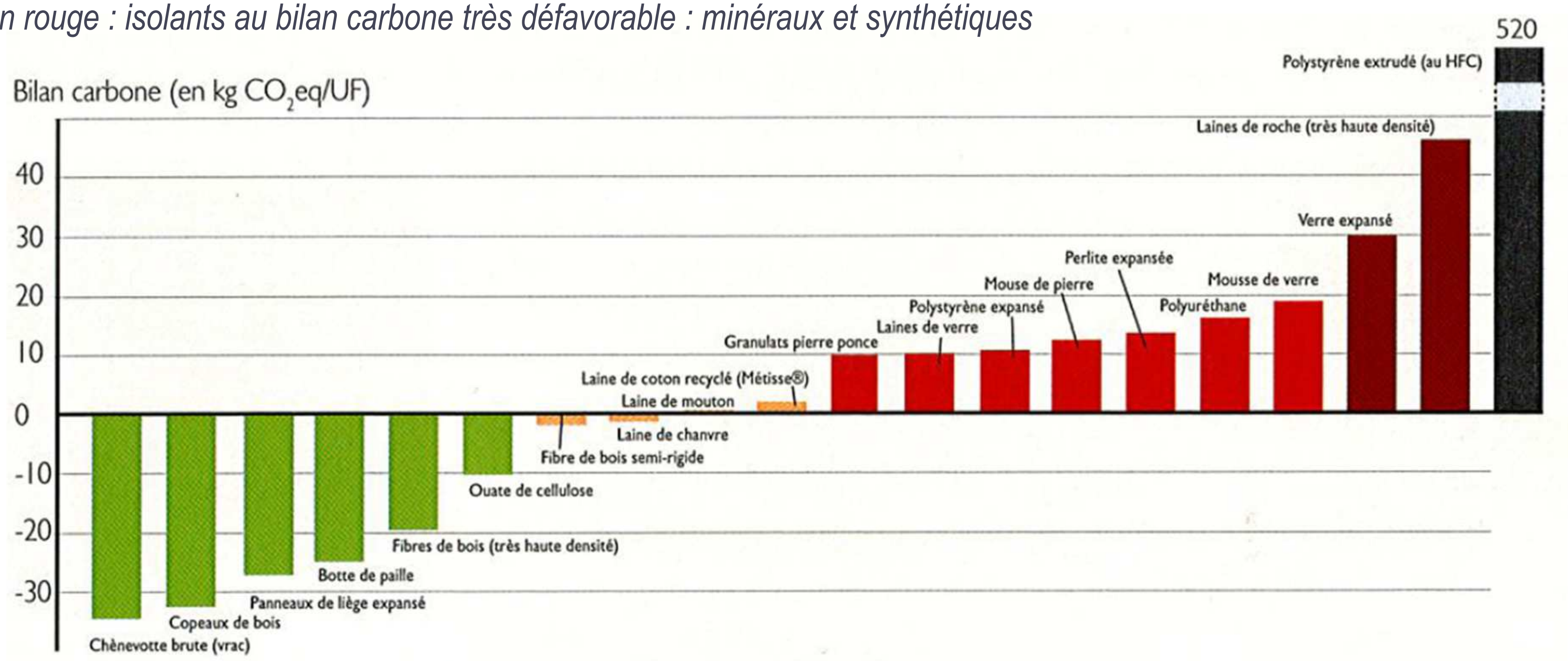
# Selection criteria

*En vert : isolants « puits de carbone » peu transformés ou denses*

*En jaune : isolants neutres : laines végétales*

*En rouge : isolants au bilan carbone très défavorable : minéraux et synthétiques*

Greenhouse gas emission




« Bilan $CO_2$ » de 1 m² de divers isolants pour une épaisseur correspondant à une résistance thermique de 5 m²K/W.

***Source : Isolation thermique et écologique J.P. Oliva et S. Courgey (d'après G. Escadeillas, Métamorphoses, Liège, 2011)***

# Applications

## Industrial hall

# Application: industrial hall

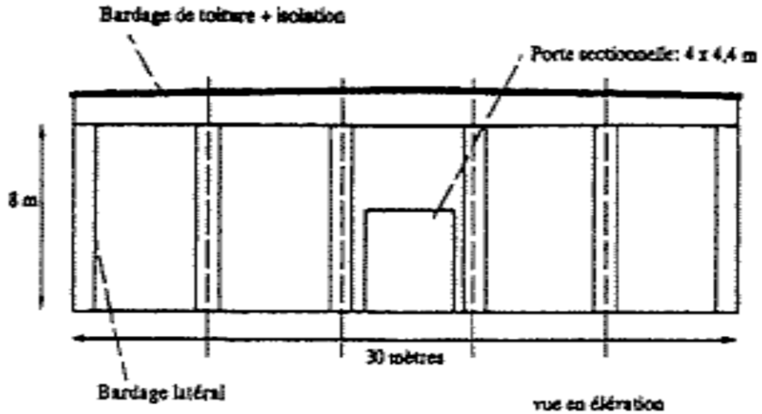
Comparison industrial hall

Case study

beams/colums reinforced concrete

beams/colums steel

beams laminated wood and colums RC




*Evaluation environnementale des matériaux et des procédés de construction : application de l'analyse de cycle de vie à la construction d'un hall industriel. L. Courard, Ph. Teller. Mater. Struct., 34 (Août-Septembre 2001), 404-412.*

# Application: industrial hall

Comparison industrial hall

Calculation of « ecopoints » for the production of 1 m³ concrete

| Rejets | Béton fondation | | | Béton propreté | | |
|---|---|---|---|---|---|---|
| | Émissions spécifiques | Éco-facteurs | Éco-points | Émissions spécifiques | Éco-facteurs | Éco-points |
| **Consommation énergie** (MJ) | | | | | | |
| Équivalent énergétique | 1239 | 0,497 | 615,4 | 810 | 0,497 | 402,3 |
| **Émissions atmosphériques** (g) | | | | | | |
| CO (monoxyde de carbone) | 504 | 0,775 | 390,1 | 335 | 0,775 | 259,4 |
| NOx (oxyde d'azote) | 886 | 6,541 | 5797,9 | 710 | 6,541 | 4644,1 |
| SO2 (dioxyde de soufre) | 429 | 2,468 | 1059,3 | 210 | 2,468 | 518,7 |
| HCl (acide chlorhydrique) | | 6,541 | 0,0 | | 6,541 | 0,0 |
| NH3 (ammoniaque) | 0,220 | 16,771 | 3,7 | 0,180 | 16,771 | 3,0 |
| N2O (oxyde nitreux) | 39 | 37,915 | 1491,2 | 25 | 37,915 | 928,9 |
| Comp. organiques volatils | 80 | 10,722 | 862,3 | 78 | 10,722 | 837,3 |
| CO2 (dioxyde de carbone) | 508360 | 0,009 | 4772,2 | 501760 | 0,009 | 4710,3 |
| **Rejets dans l'eau** (g) | | | | | | |
| COD (demande chimique en oxygène) | 0,126 | 4,074 | 0,5 | 0,096 | 4,074 | 0,4 |
| BOD (demande biologique en oxygène) | 0,042 | 11,735 | 0,5 | 0,032 | 11,735 | 0,4 |
| Nitrates | 0,008 | 22,896 | 0,2 | 0,008 | 22,896 | 0,2 |
| **Déchets solides** (g) | | | | | | |
| Déchets industriels | 18572 | 0,099 | [illegible] | 7784 | 0,099 | [illegible] |
| **TOTAL** | - | - | 16445 | - | - | 12817 |

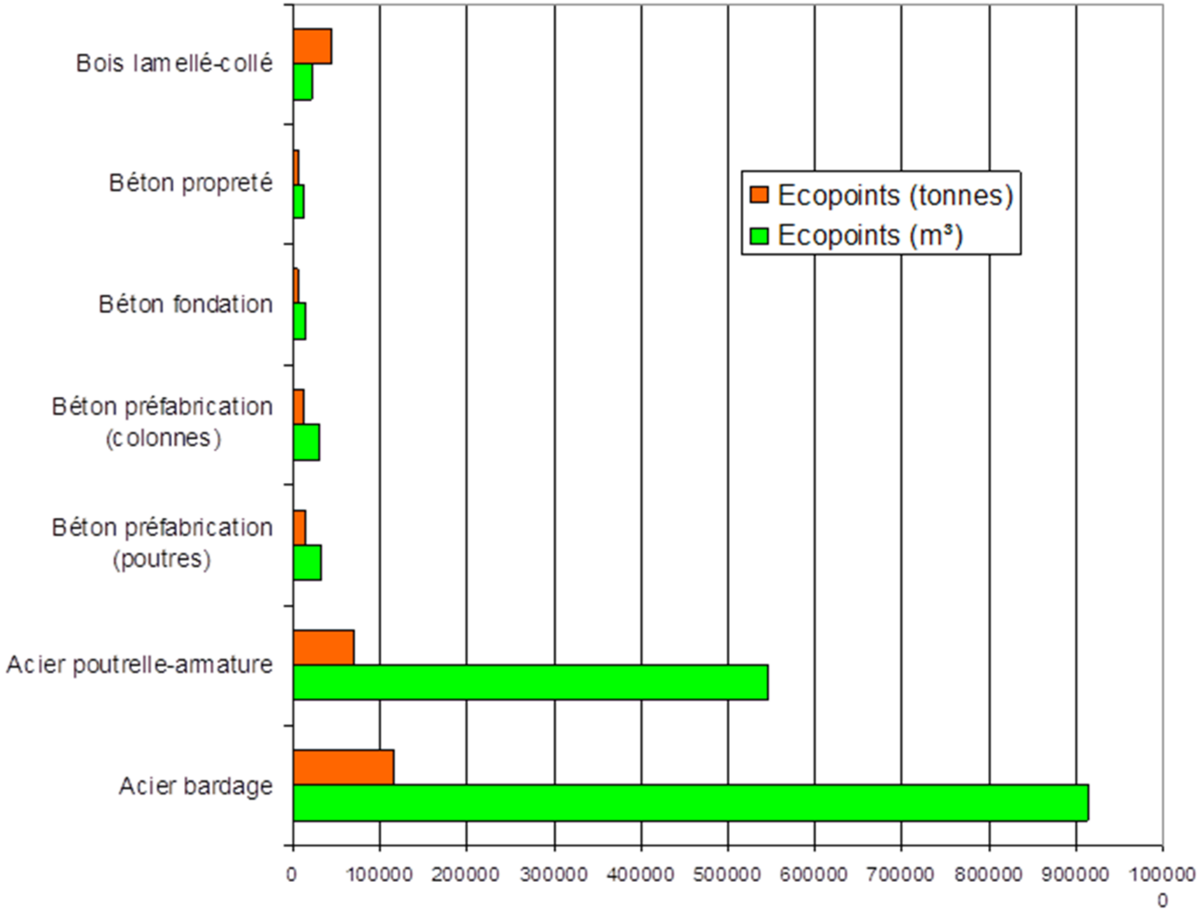
# Application: industrial hall

## Comparison industrial hall

| **Matériau** | **Ecopoints ($m^3$)** | **Ecopoints (tonnes)** |
|---|---|---|
| Acier bardage | 914525 | 116520 |
| Acier poutrelle-armature | 547380 | 69730 |
| Béton préfabrication (poutres) | 33847 | 14403 |
| Béton préfabrication (colonnes) | 31682 | 13656 |
| Béton fondation | 16445 | 7091 |
| Béton propreté | 12817 | 5800 |
| Bois lamellé-collé | 22075 | 44150 |

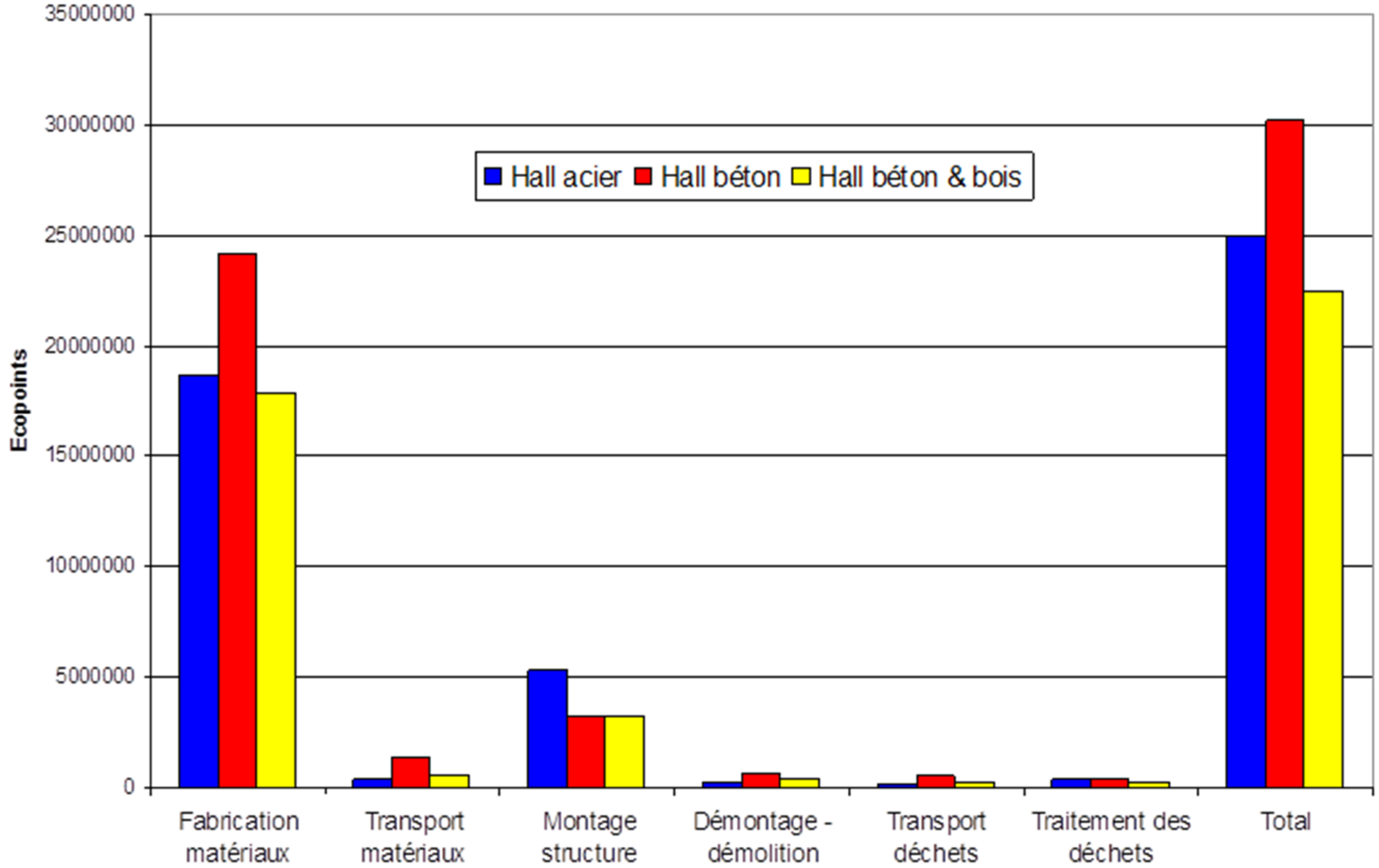
# Application: industrial hall

## Comparison industrial hall



# Application: industrial hall

Comparison industrial hall



# Conclusions and prospects

Tomorrow, materials

# Conclusions

Our concepts must change.....

To be free from products identified as"harmful", "toxic", ...

To follow personal preferences based  on respect, ecological intelligence, wellness, ...)

To promote diversity

To develop nutrition materials

***Nature did it ... why can not we?***


Mulțumesc
Merci
Takk
Hvala
Dziękuję
Dank u
Grazie
Danke
Gratias
Arigato
Efkaristos