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C-TAC Research Centre

The use of Generic LCIA Databases in the Process of Building Sustainability Assessment – the case of SBToolPT

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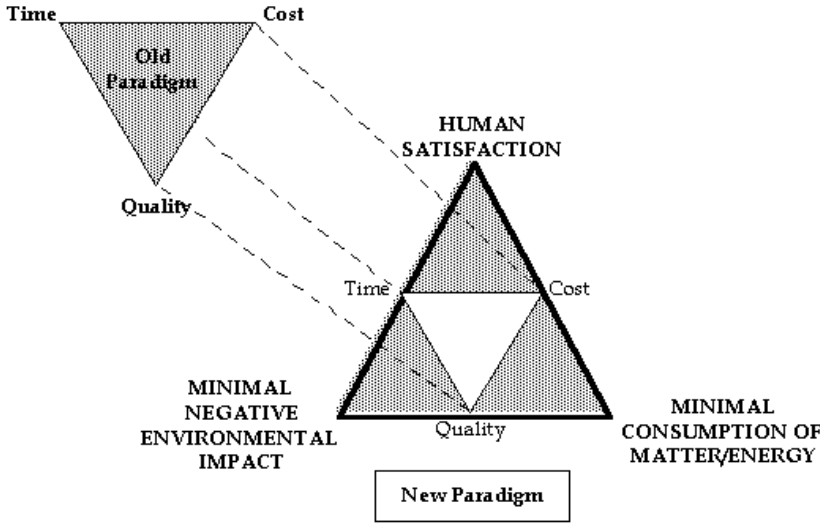
AGENDA

- To approach the **environmental indicators** assigned in LCA **that should be considered in sustainability rating systems**.
- To **present and discuss the main difficulties in the integration of those indicators;**
- To **present solutions for practical use of LCA in rating systems**.

INTRODUCTION

- A building project can only be regarded as sustainable when all the various dimensions of sustainability are balanced: **environmental, economic, social and cultural.**



- The purpose of sustainability assessments is to **gather and report information for decision-making** during different phases of construction, design and use of a building.

- It is widely recognized in the field of the Sustainability Assessment that **Life Cycle Assessment (LCA) is a conceptually preferable method for assessing the environmental effects of a material or product.**

Nevertheless…

The adoption of environmental LCA in buildings and other construction works is **a complex and tedious task as**:

A construction incorporates **hundreds or thousands of individual products**;

Tens of companies are involved in the whole life-cycle;

The expected life-cycle of a building is **exceptionally long**, tens or hundreds of years and therefore there are **many uncertainties**;

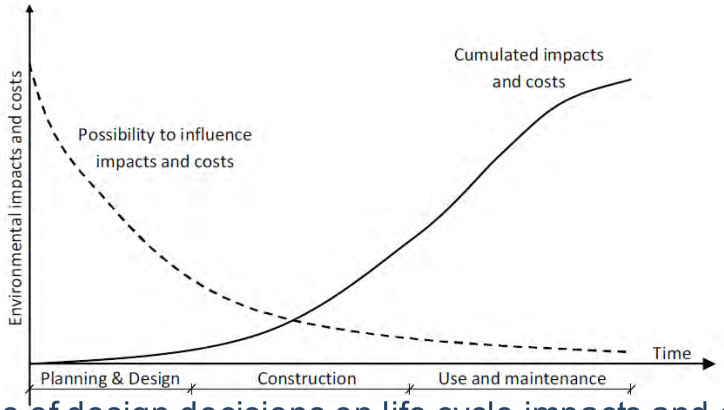
- For those reasons **LCA tools are not widely used by most stakeholders**, including those designing, constructing, purchasing or occupying buildings.

- Above all they are used and developed **only by experts**, **most times at academic level**.

In order to overcome this situation…

- It is necessary to provide **sound methods for assessment**.

- These methods are particular useful if they were developed to support designers **since the early stage of design.**



Influence of design decisions on life cycle impacts and costs (source: UNEP,)

At an early stage the designer

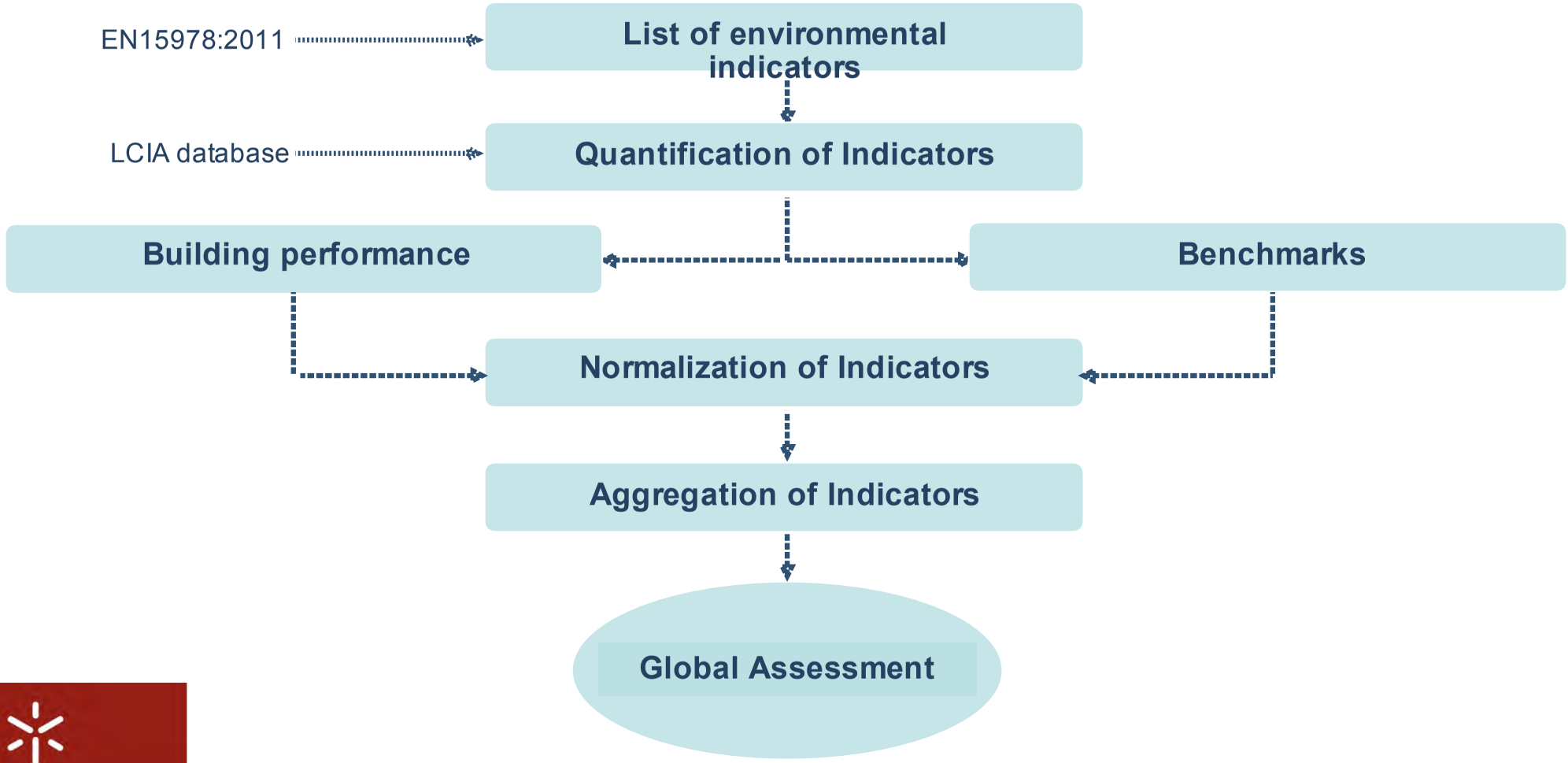
Knows	Do not knows
• The dimensions of the building; • The construction system to be used; • The estimated quantities of construction elements (m2 of floors, external and internal walls, roofs, etc.)	• The specific type of material to be used (e.g. concrete type) • The accurate quantity of materials; • The real losses resulting from materials handling; • The manufacture of each material (specific environmental data and transportation); • The construction processes.

- In order to **standardize, facilitate the interpretation of results and comparison** between different building assessment methods developed within the European Countries, CEN (European Centre of Normalization) started the Technical Committee 350 (CEN/TC 350).

- EN15978:2011 sets the **environmental indicators** and method that should be used in the standardized environmental assessments of buildings.

- Based in the CEN/TC 350, a series of building sustainability rating tools, especially to be used since the early stage of design is being developed in Portugal.

STEPS FOR LCIA IN SBToolPT



ENVIRONMENTAL INDICATORS IN SBTool^PT

Dimension	Categories	Indicators	PID
DA - Environmental	C1 – Climate change and outdoor air quality	• Life-cycle environmental impacts (based in indicators describing environmental impacts)	P1
	C2 – Land use and biodiversity	• Urban soil use	P2
		• Land waterproofed index	P3
		• Pre-developed land use	P4
		• Use of local plants	P5
		• Heat-island effect	P6

Focus of the presentation

ENVIRONMENTAL INDICATORS IN SBToolPT (cont.)

Dimensions	Categories	Indicators	PID
DA – Environmental	C3 - Energy Efficiency	• Primary energy consumption	P7
		• In-situ energy production from renewables	P8
	C4 – Materials and solid waste	• Building materials re-use	P9
		• Building materials recycling content	P10
		• Use of certified organic materials	P11
		• Use of cement substitutes materials on concrete	P12
		• Household waste management	P13
	C5 – Water efficiency and effluents	• Fresh water consumption	P14
		• Water reuse and recycling	P15

LIST OF INDICATORS DESCRIBING ENVIRONMENTAL IMPACTS

- To potentiate the use of **the materials EPD,** SBToolPT is based in the same list of indicators that describe environmental impacts:

Indicator	Unit
Global warming potential, GWP	kg CO2 equiv
Depletion potential of the stratospheric ozone layer, ODP	kg CFC 11 equiv
Acidification potential of land and water; AP	kg SO2- equiv
Eutrophication potential, EP;	kg (PO4)3 - equiv
Formation potential of tropospheric ozone photochemical oxidants, POCP	kg Ethene equiv
Abiotic Resource Depletion Potential for elements; ADP_elements	kg Sb equiv
Abiotic Resource Depletion Potential of fossil fuels ADP_fossil fuels	MJ

QUANTIFICATION OF INDICATORS

EPD **is available**

EPD **is not available** or in **early design phase**

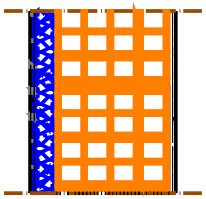
EPD

LCIA Database

Environmental performance

LCA DATABASE

Building element



Single wall with the support element in masonry of bored brick (22cm), with reinforced plaster, on continuous insulation from outside

Ref: PExt 1

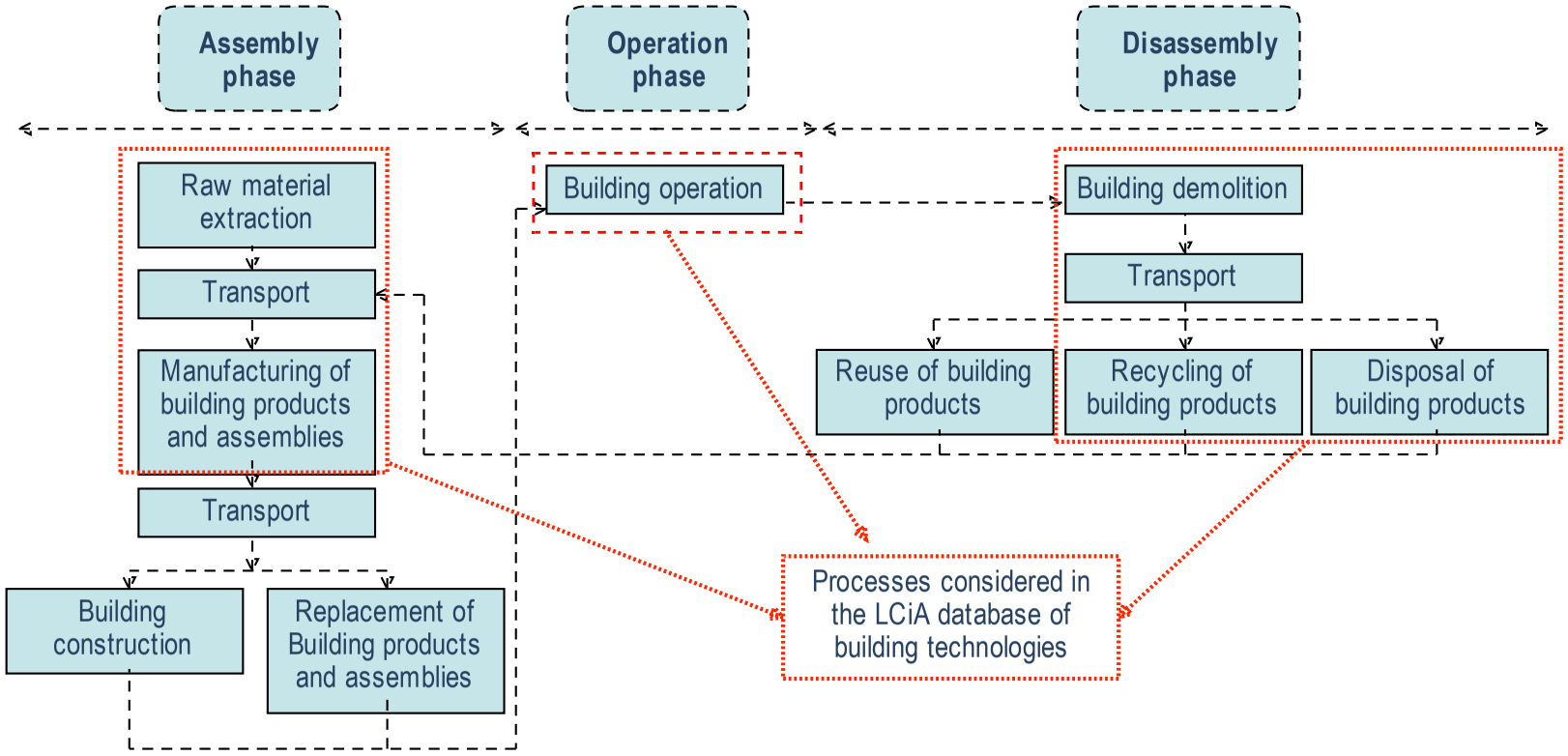
Life-cycle phase	Environmental LCA impact categories						Embodied energy	
	ADP	GWP	ODP	AP	POCP	EP	ENR	ER
Cradle-to-gate	2,48E-01	5,00E+01	3,02E-06	1,16E-01	1,23E-02	1,45E-02	5,63E+02	5,39E+01
End of life	1,12E-01	1,65E+01	2,67E-06	7,60E-02	2,90E-03	1,58E-02	2,57E+02	1,57E+00
Total	3,60E-01	6,65E+01	5,69E-06	1,92E-01	1,52E-02	3,03E-02	8,20E+02	5,54E+01

Comments: Considered Materials: Bored brick, armed plaster (exterior coating), expanded polystyrene moulded in plates (isolation), laying mortar and plaster (inner coating)

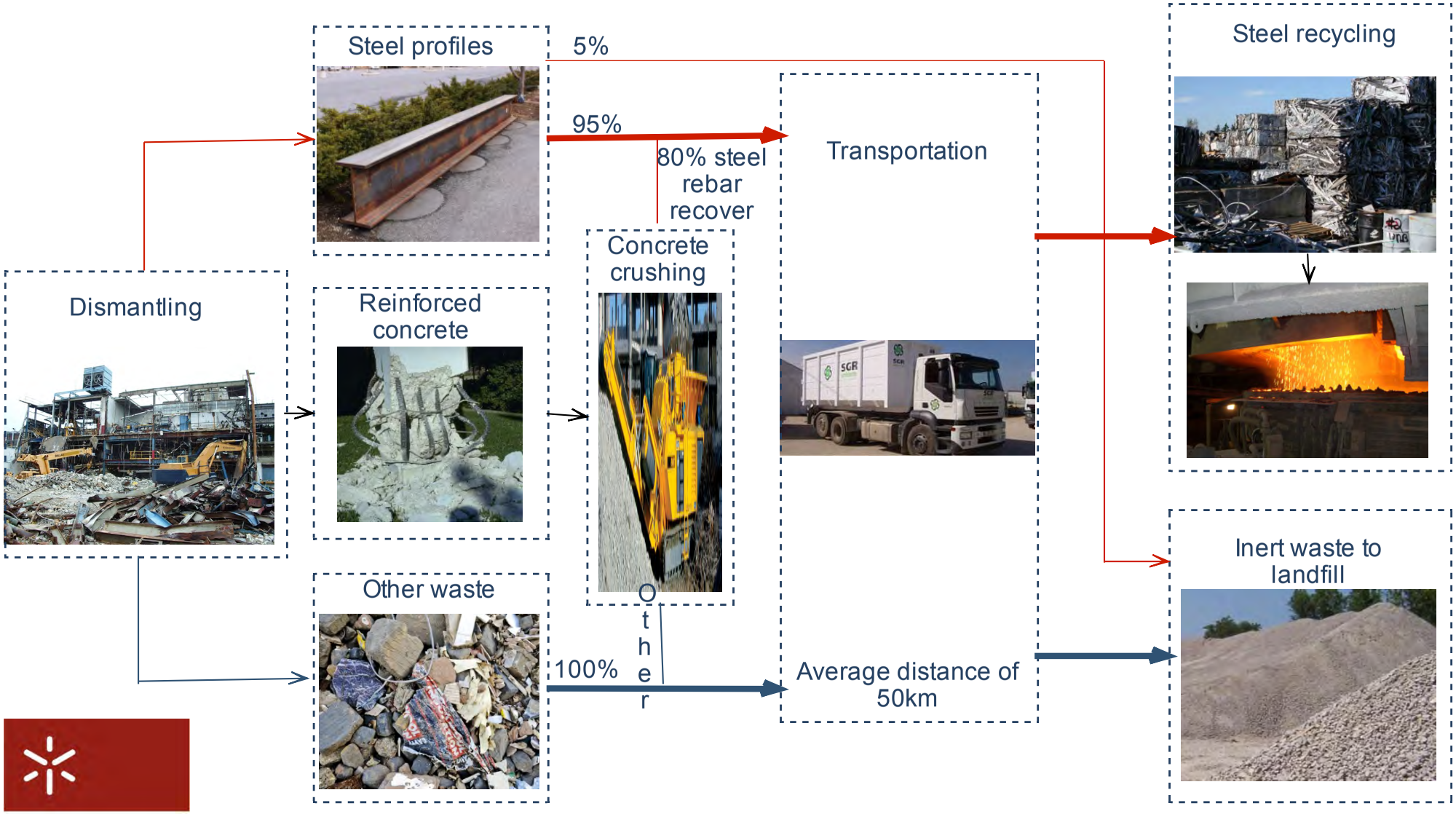
LCA Method(s): CML 2 baseline 2000 version 2.04 (to evaluate the environmental impact) and Cumulative Energy Demand version 1.04 (to evaluate the energy)

LCI Libraries: Ecoinvent system process

Typical life-cycle of a building and **covered processes.**



Considered **end-of-life scenario**



Quantification of the **life-cycle impacts**

Previous LCiA studies

Input or Output	Units	DBR	Diamond Grind	Mill and Fill
Total Energy	BTU	-4.67E+08	-4.94E+07	-6.07E+08
Fossil Fuels	BTU	-4.46E+08	-4.93E+07	-5.44E+08
Coal	BTU	-1.35E+08	-1.35E+06	-2.43E+07
Natural Gas	BTU	-1.68E+08	-2.59E+06	-3.07E+08
Petroleum	BTU	-1.42E+08	-4.53E+07	-2.13E+08
CO_2	g	3.54E+07	2.20E+06	3.53E+07
CO	g	3.69E+05	1.01E+04	8.43E+04
NO_x	g	7.98E+04	1.89E+04	1.65E+05
SO_x	g	2.78E+04	8.78E+02	1.29E+04
CH_4	g	5.83E+04	4.31E+03	8.06E+04
$PM_{2.5}$	g	1.90E+04	1.43E+03	7.91E+03
PM_{10}	g	6.39E+04	1.69E+03	2.31E+04
SO_2	g	3.70E+03	1.58E+02	6.42E+04
N_2O	g	3.22E+02	1.05E+01	6.17E+02
VOC	g	7.68E+03	1.72E+03	1.81E+04

Specific average LCI Data

Generic LCI databases

LCA software

IPCC

CML

CED

Indicators
Global warming potential, GWP
Depletion potential of the stratospheric ozone layer, ODP
Acidification potential of land and water; AP
Eutrophication potential, EP;
Formation potential of tropospheric ozone photochemical oxidants, POCP
Abiotic Resource Depletion Potential for elements, ADP_elements
Abiotic Resource Depletion Potential of fossil fuels, ADP_fossil fuels
Embodied renewable energy, MJ

QUANTIFICATION OF THE WHOLE BUILDING LC IMPACTS

- They **are quantified in a bottom-up** approach (i.e. from building components scale to whole assembly):

1st Step: Quantification of the embodied impacts in the building components

Embodied impacts in non-linear components

$\sum$ Ai*li

+

Embodied impacts in linear components

(Structurs)

÷ Time boundary of the LCA Assessment (years) ÷ Net floor area of the building (years) = **Whole building embodied environmental impacts (/m2.year)**

Total embodied impacts in building components

2nd Step: Quantification of the whole building life-cycle impacts

Whole building embodied environmental impacts (/m2.year) + Environmental impacts of the maintenance scenarios (/m2.year) + Environmental impacts of the operation energy (HVAC + hot water) (/m2.year) = **Total life-cycle impacts of whole building (/m2.year)**

Whole building LC impacts
Global warming potential (Kg CO2 equiv./ m2.year);
Depletion potential of the stratospheric ozone layer, (Kg CFC-11 equiv./ m2.year);
Acidification potential of land and water (Kg SO2 equiv./ m2.year)
Eutrophication potential, (Kg PO4 equiv./m2.year)
Formation potential of tropospheric ozone photochemical oxidants (Kg C2H4 equiv./ m2.year)
Abiotic Resource Depletion Potential for elements (Kg C2H4 equiv./ m2.year)
Abiotic Resource Depletion Potential of fossil fuels (MJ)

- The **quantification of the environment impacts is also done both for the conventional and best practices**:

  Conventional practice: it is a virtual building that as the same volume and shape of the building under assessment, but that uses the local/regional **conventional building technologies and materials**.

  Best practice: it is a virtual building **that has only 25% percent of the impact of a conventional building**.

NORMALIZATION OF PARAMETERS

- The objective is to **avoid the scale effects** in the aggregation of parameters inside each indicator and to solve the problem that some parameters are of the type "**higher is better**" and others "**lower is better**".

- It is a way to **compare the performance** of the solution with the best and conventional practices (Benchmarks):

- As an example, **the normalization** of the total Global Warming Potential **is done as following:**

Notation: P_{GWP}
Unit: kg CO2.eq./m2/year
Value: 100
Conventional value: 140
Best practice: 35

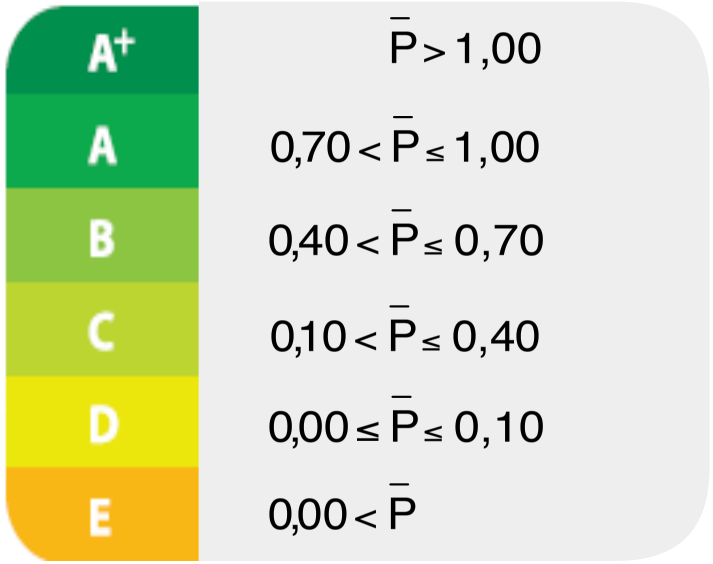
$$\overline{P_{GWP}} = \frac{P_{GWP} - P_{GWP*}}{P_{GWP}^{*} - P_{GWP*}} = \frac{100 - 140}{35 - 140} = 0{,}38$$

- Besides of turning **dimensionless the value of the parameters**, it converts values between best and reference practices into a scale bounded between **0 (reference/conventional value) and 1 (best value)**.

- Excellent practices will have a **score above 1** and performances bellow the conventional will have a **negative normalized value**.

Best practice

Conventional practice



AGGREGATION OF PARAMETERS

- The objective is to **synthesize in one value** the average environmental performance of a construction inside each category.

- The methodology uses a **complete aggregation method**:

$$I_{ENV} = \sum_{i=1}^{n} w_i . \overline{P_i}$$

with,
IENV – Weighted average of all normalize environmental parameters;
wi – Weight of the *i*th parameter;
P_i - Normalised value of the *i*th parameter.

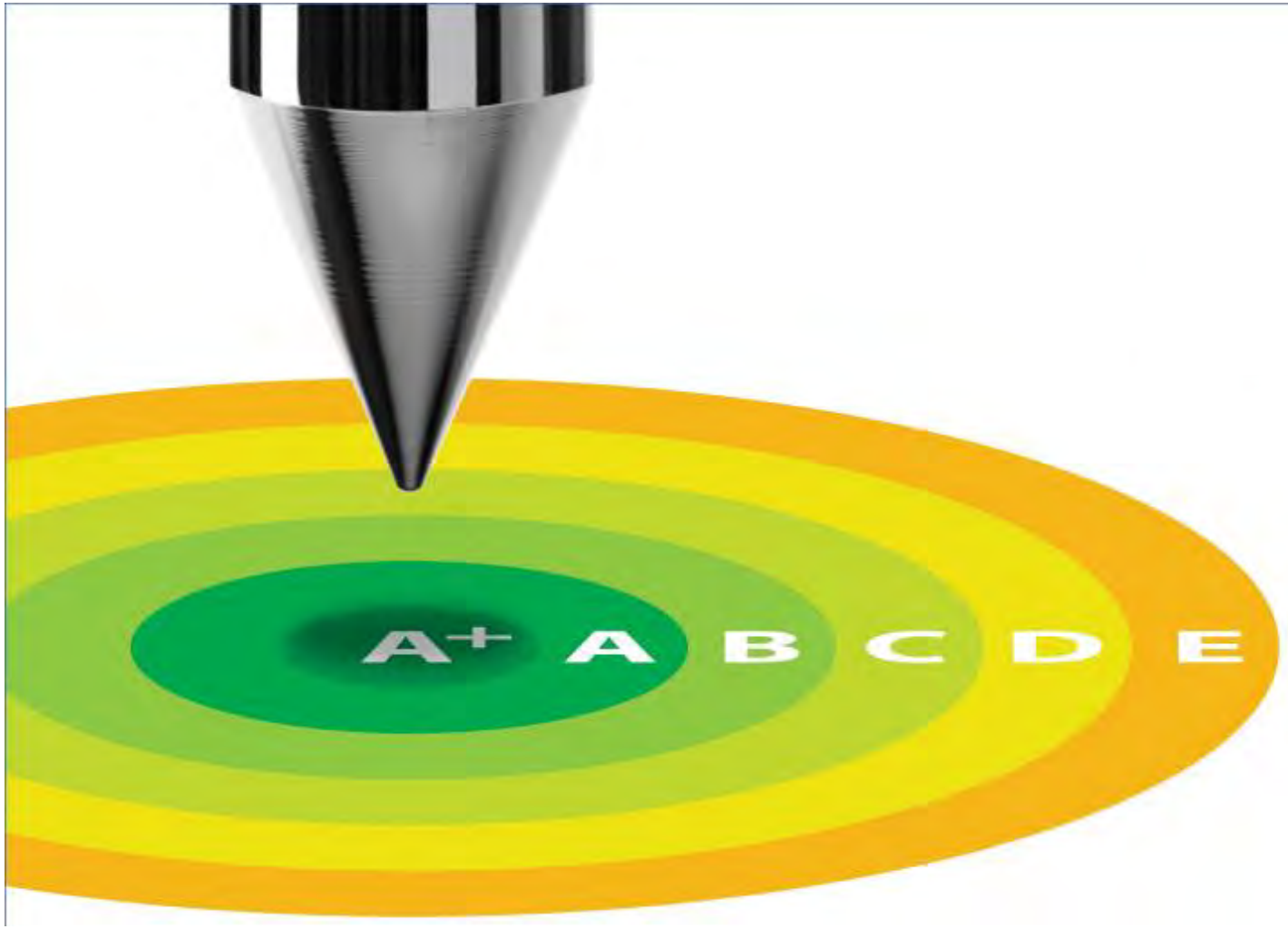
- The default **weights** are based in TRACI method.

CONCLUSIONS

- Sustainable design, construction and use of buildings are based on the **evaluation of the environmental pressure**, **societal aspects** (related to the users and the local building codes) and **life-cycle costs;**

- **LCA is considered the best approach available** to accurate assess the environmental performance of a product;

This work is aimed to be a contribution to support decision-making towards the improvement of the environmental life-cycle performance of buildings.



THANK YOU…

Data base in English available at:
https://repositorium.sdum.uminho.pt/handle/1822/20481

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