A Comparative Analysis of Life Cycle Impact Assessment Methods for Building Materials

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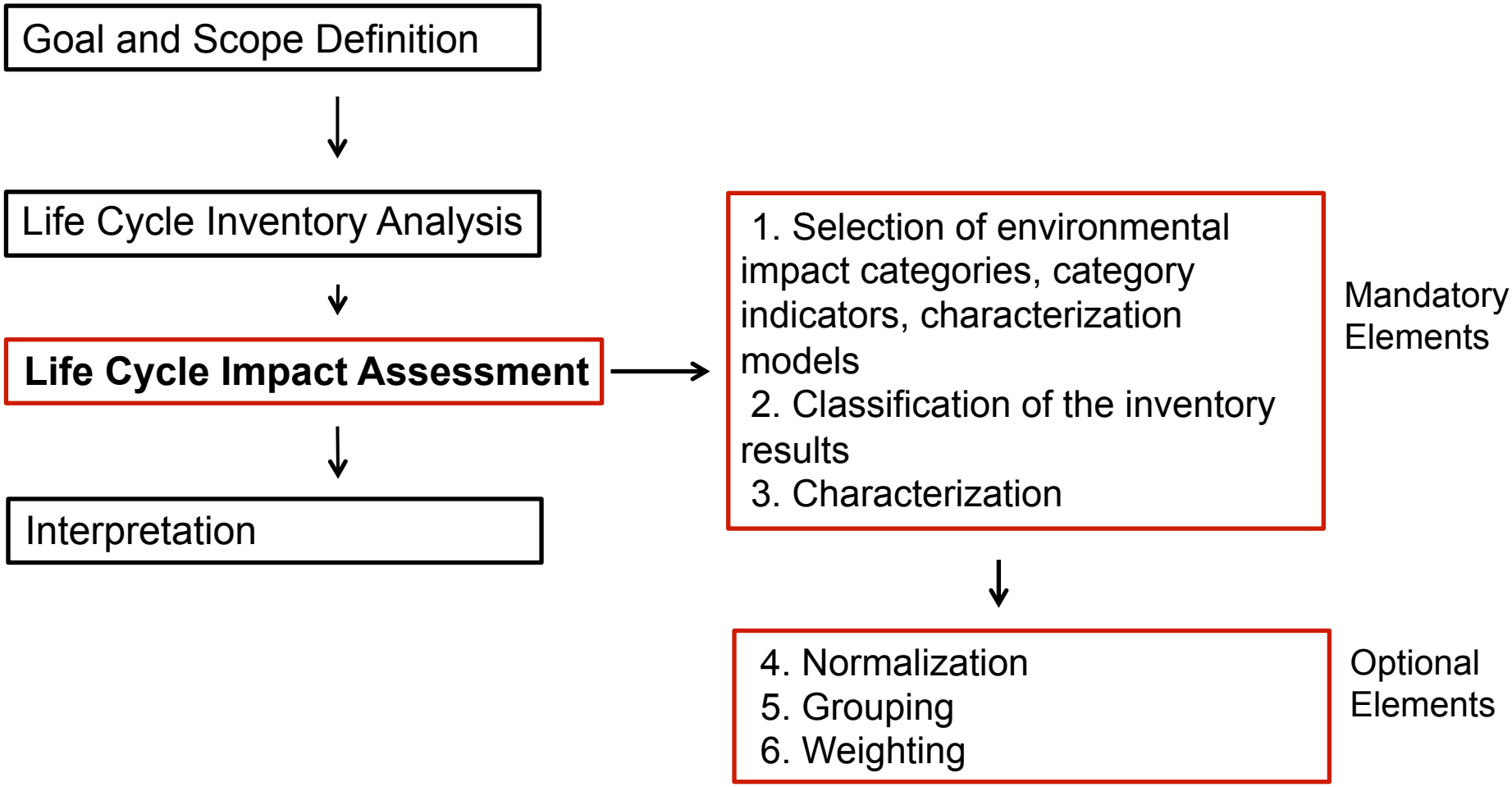
Life Cycle Assessment (LCA) is a commonly used method evaluated environmental impacts of a product or service in the entire life cycle defined as "cradle to grave".

Life Cycle Impact Assessment (LCIA) is a phase of the life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product

(ISO 14040, 2006a).



Elements of LCIA (ISO 14042, 2000)

*** Selection of the IMPACT CATEGORIES and CATEGORY INDICATORS**

*** CLASSIFICATION**

the emissions and resources in the LCI are assigned to the selected impact category or categories.

*** CHARACTERIZATION**

category indicator results are calculated for each impact category using a characterization factor (CF) that is derived from the characterization model

* $Si = \sum s\ CF(s)\ X\ Emission\ Inventory(s)$

(S= impact score of a building product, i= impact category, s denotes the chemical)

*** NORMALIZATION**

The results of each impact category are divided by a reference value.

* $N_i = S_i / Nf_i$

N=normalized result, i=impact category, S=impact score of a product, Nf = normalization factor.

*** GROUPING**

The impact categories are sorted and possibly ranked in a given hierarchy like high, medium, and low priority.

*** WEIGHTING**

importance degrees of environmental impact categories are specified according to the region or country that the method is developed.

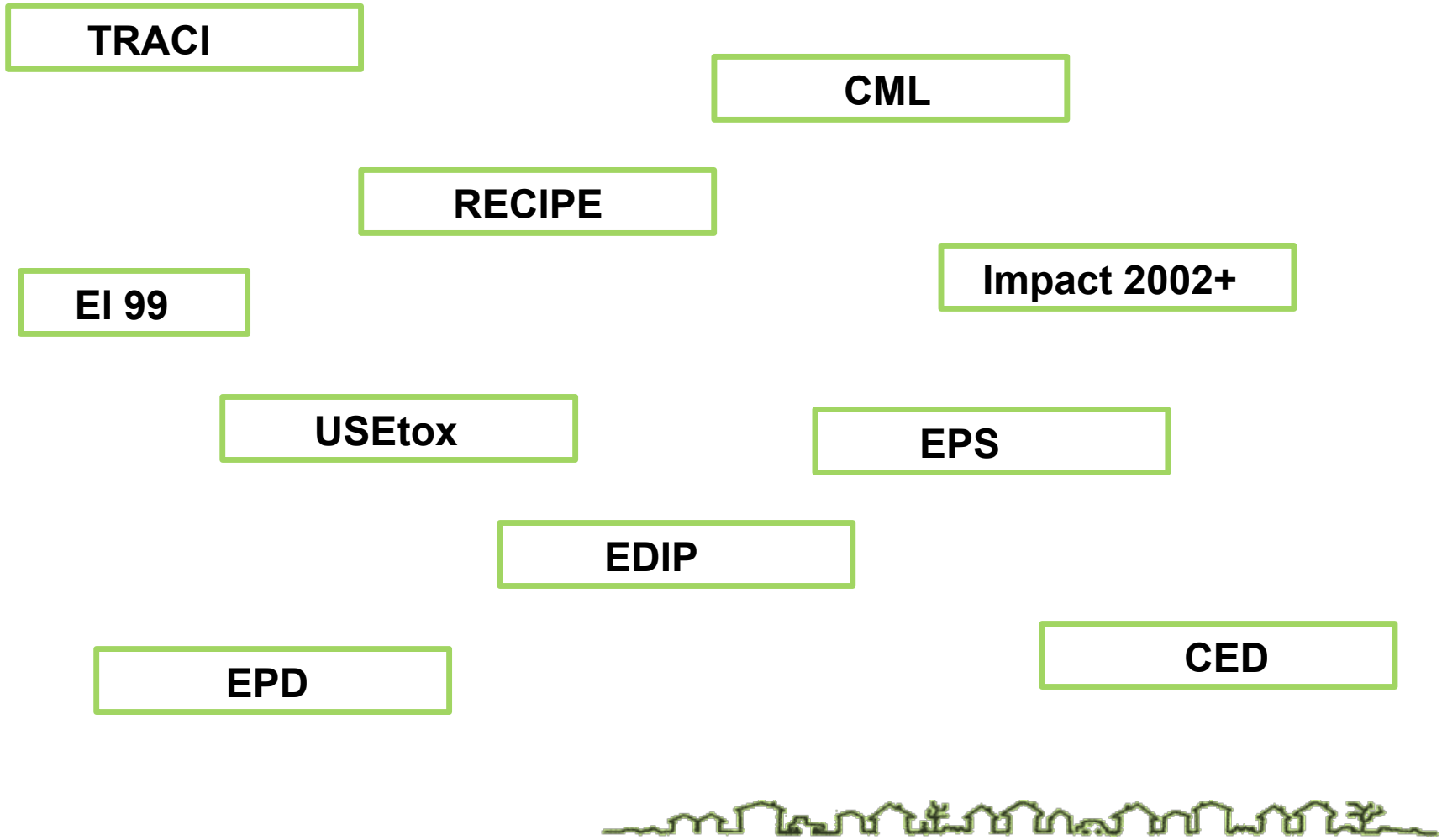
Approach Differences Among the Methods

* **Mid-point approach method** stops quantitative modeling before the end points and link LCI results to midpoint categories.

* **End-point approach method** quantifies the environmental impacts at an endpoint level in the environmental mechanism for all impact categories.

* **Method which combine mid-end approaches** quantifies the environmental impacts at endpoint and midpoint levels.

Many Life Cycle Impact Assessment Methods for products



The Aim of The Study

to evaluate and compare current LCIA methods for building materials.

* **BEES** (Building for Environmental and Economic Sustainability)

* **Bre- Environmental Profiles** (Building Research Establishment)

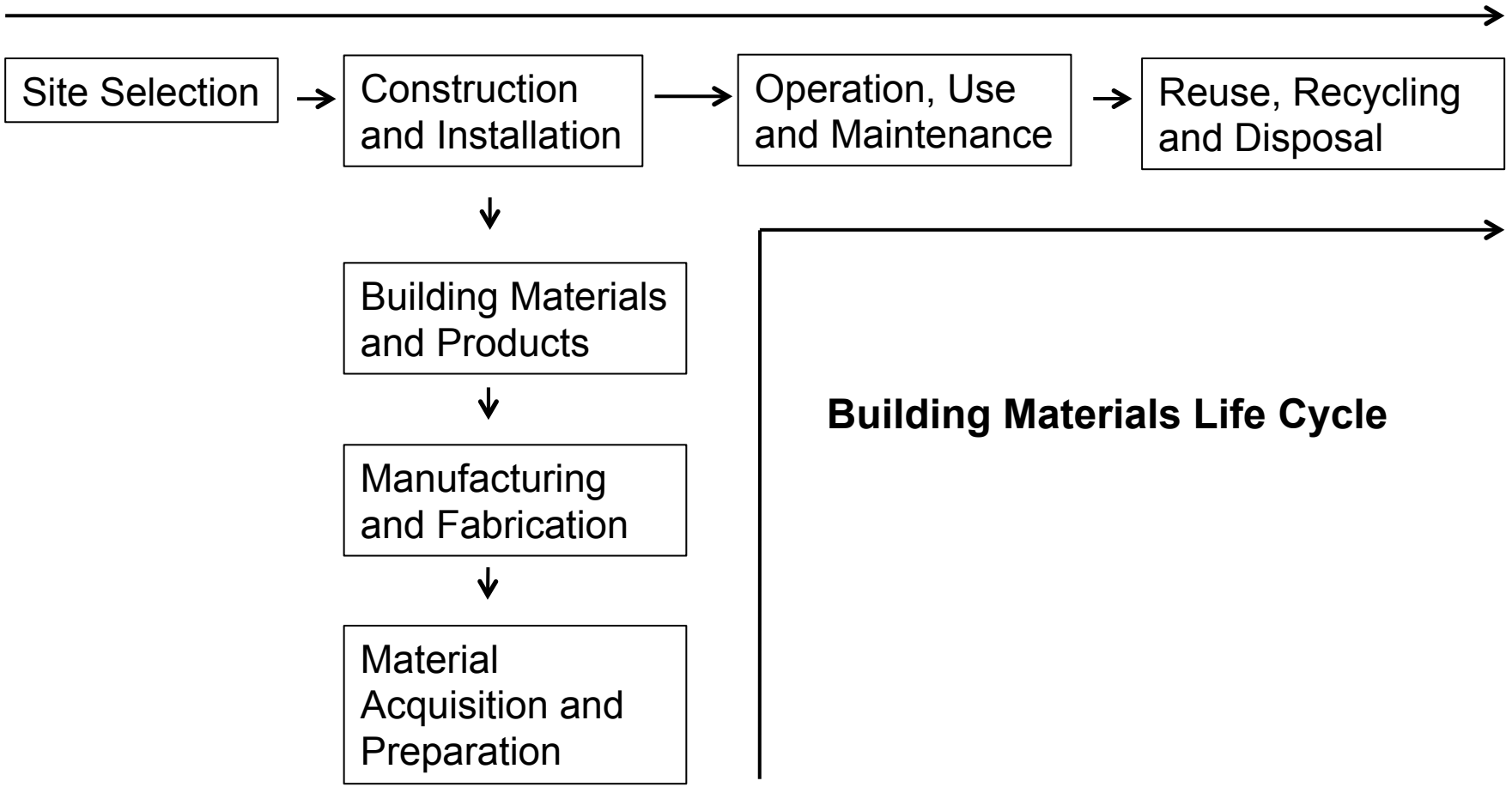
* **BPIC / ICIP** (Building Products Innovation Council -Industry Cooperative Innovation Programme)

* **ATHENA Impact Estimator**

* **BEPAS** (Building Environmental Performance Analysis System)

* **BELES** (Building Environment Load Evaluation System)

Facility and material life cycle



Important environmental inputs for LCIA of the building materials

* type and quantity of the materials, process energy, process water

* short or long transportation distances and transportation types

* durability and the useful life of the building materials

* the effect of the building materials on building energy consumption

* type and frequency of the maintenance

* disposal methods

* recycling and reuse properties of the building materials

Important environmental impacts for LCIA of the building materials

- the effects on air quality such as global warming, ozone depletion etc.
- the effects on water quality such as eutrophication, acidification, etc.
- soil effects as alteration of soil, etc.
- the consumption of non-renewable resources
- human health effects

Analysis of existing LCIA Methods for Building Materials

1. Approach Differences

* Mid- Point Approach Methods

- **BEES**
- **Bre- Environmental Profiles**
- **BPIC / ICIP**
- **ATHENA Impact Estimator**
- **BELES**

* End- Point Approach Methods

- **BEPAS**

2. Selection of Environmental Impact Categories

	Global Warming	Ozone Depletion	Eutrophication	Acidification	Fossil Fuel Depletion	Smog Formation	Mineral Resource Depletion	Land use	Water Depletion	Waste	Ecological Toxicity	Airborne sus. particulates	Human Toxicity	Indoor Air Quality	Ionizing Radiation	Noise	Transport Pollution	Human Health	Ecosystem Damage	Resources	Energy Depletion	**Numbers of the categories**
BEES	x	x	x	x	x	x	x	x	x		x	x		x								12
Bre- En.	x	x	x	x	x	x	x		x	x	x		x				x					12
BPIC/ICIP	x	x	x	x	x	x	x	x	x		x		x	x	x	x						14
BEPAS	x	x	x	x	x	x	x		x	x	x	x										11
Athena	x	x	x	x	x	x		x														7
BELES																		x	x	x	x	4

3. Selection of Environmental Impact Category Indicators

	BEES	Bre-Env.P.	BPIC-ICIP	BEPAS	Athena	BELES
Global Warming	GWP	GWP	GWP	GWP	GWP	
Ozone Depletion	CFC-11 eq.	CFC-11 eq.	CFC-11 eq.	CFC-11 eq.	CFC-11 eq.	
Eutrophication	N eq.	PO_4 eq.	PO_4 eq.	NO_3 eq.	N eq.	
Acidification	H+ eq.	SO_2 eq.	SO_2 eq.	SO_2 eq.	H+ eq.	
Fossil Fuel D.	Kg	Toes	MJ	SCE(standard cool energy)	MJ	
Smog Formation	NO_x eq.	Kg. ethane	Kg. NMVOC	Ethylene eq.	NO_x eq.	
Mineral Resource	Kg	Tonne	Kg	Kg		
Land Use	TED		Hectare. year		TED	
Water Depletion	Litre	Litre	Kilo Litre	m^3		
Waste		Tonne		Kg		
Ecological Tox.	2,4D		kg.1,4-DB	Pb		
Airborne Sus P.	MicroDALYs			Kg		
Human Toxicity		Kg toxicity	1,4-DBeq. DALY'			
Indoor Air Q.	Total VOCs emissions		No methods			
Ionizing Rad.			Kg U235			
Noise			No methods			
Transport Pol.		Tonne. km				
Human Health						DALY/ m^2
Ecosystem Dam.						PDF.m^2. year
Resources						Fe/m^2
Energy Dep.						Ce/m^2

4. Normalization

BEES	The amount of emissions per person per year in the US
Bre- Environmental Profiles	Annual environmental impact created by a British citizen
BPIC / ICIP	The environmental impact per person per year in Australia
Athena Impact Estimator	Total annual emissions in Canada / Canadian population
BELES	The total environmental load per unit building area of China
BEPAS	Normalization is not used.

5. Weighting

Panel methods, where a group of experts representing different stakeholders are asked to provide their weighting factors .

Willing to pay methods, where the weighting factors are expressed in monetary costs according to the estimated economic damage incurred in an impact category or to what is necessary to prevent the damage itself.

Distance-to-target methods, where the weighting factors are calculated as a function of some type of target values, which are often based on political decisions.

5. Weighting

BEES	Panel method- AHP method, user-defined, considered to be equal to all the effects.
Bre- Environmental Profiles	Panel method-- Eco-points system
BPIC / ICIP	Panel method-- Delphi method
Athena Impact Estimator	Panel method
BELES	Panel method
BEPAS	"Willing to pay" method

Conclusions

1. Most of the methods evaluated in the scope of the study are based on midpoint approach methods.

One of the advantages of using midpoint approach is the reduction of the uncertainties in the method. The other is to enable to develop a method that combines with mid and endpoint approaches.

2. Different environmental impact categories are assessed in the LCIA methods discussed.

Waste, human toxicity, IAQ, dust and noise are at least evaluating impact categories. These environmental impact categories should be considered in the life cycle of building materials.

3. When examined the CF used in the calculation of environmental impacts, there is a consensus for global warming and ozone depletion.

However, there is no consensus on globally representative characterization models for regional impact categories.

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LIFE CYCLE IMPACT ASSESSMENT (LCIA)

Identifying best existing practice for characterization modeling in life cycle impact assessment

Michael Z. Hauschild · Mark Goedkoop · Jeroen Guinée · Reinout Heijungs · Mark Huijbregts · Olivier Jolliet · Manuele Margni · An De Schryver · Sebastien Humbert · Alexis Laurent · Serenella Sala · Rana Pant

4.The amount of emissions per person per year is mostly used as normalization factor in LCIA methods for building materials.

Geographic and time coverage are important in order to calculate the factors.

5. Although weighting is an optional phase, all the methods include this phase. Panel method is mostly used in these methods.

For LCIA of building materials, it is necessary to determine the importance degree of environmental impact categories for a region or a country.

The disadvantage of the distance to target method is that weighting coefficient may change depending on the policy of countries.

Use of willing to pay method depends on the determination of economic values of the selected environmental damages for LCIA methods.

The most accurate findings for LCA are usually obtained where product, process, technology, and location-specific data for a building material being studied is used.

THANK YOU..

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