D2EPC

Building performance assessment towards Next generation EPCs

FREDERICK RESEARCH CENTER

Energy performance & LCA Indicators Analysis for EPCs

Paris A. Fokaides

Frederick University, Cyprus

Session 3: Advancements in buildings sustainability assessment

Energy performance & LCA Indicators Analysis for EPCs
Introduction

- Sustainability Assessment constitutes an internal aspect of the energy analysis of buildings.
- Despite the fact that numerous methodologies for assessing the sustainability performance of buildings are developed, as of today, circularity indicators are still not integrated into the information provided in EPCs to building owners and user.
- D^2EPC project envisions and aspires the development of a set of environmental indicators, which will enrich the building sustainability assessment.
- Novelty in the field is based on the fact that the information required for the extraction of these indicators results from BIM documents.

This session presents the D2EPC approach on integrating sustainability and life cycle indicators into EPCs

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The D^2EPC Approach

- **Propose of LCA related indicators**, which demonstrate the environmental performance of buildings for their introduction in the next-generation EPCs
- **Implementation of a comprehensive literature review** on the LCA of the energy performance of buildings, the type and functional units of the LCA Indicators for EPCs to be used
- **Consideration of the required input and associated output resources** for the calculation of the selected indicators in the D^2EPC platform
- **Definition of the calculation procedures**, selection of calculation procedures for the LCA indicators by knowing what the input precisely is (whether it is included in BIM software or not)
- **Integration of the LCA methodology** in the whole range of services related to the construction industry and the EPC process

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The D^2EPC Approach

- **Observation of the environmental footprint** for each construction material and each category of the structural element
- **Drafting of a 17 environmental indicators data results terms list** which are asset indicators and may be calculated through the combination of materials bill of quantities, derived by a BIM document, and buildings materials EPDs
- **Drafting of a 25 energy indicators data results terms list** which can be employed as operational indicators
- **Examination and identification of existing BIM tools in the BIM software**
- **Definition of innovative aspects and drafting of a list of lacks and deficiencies of current BIM documents** regarding their information needed by LCA for generating data exchange formats to share information and how they can be enriched

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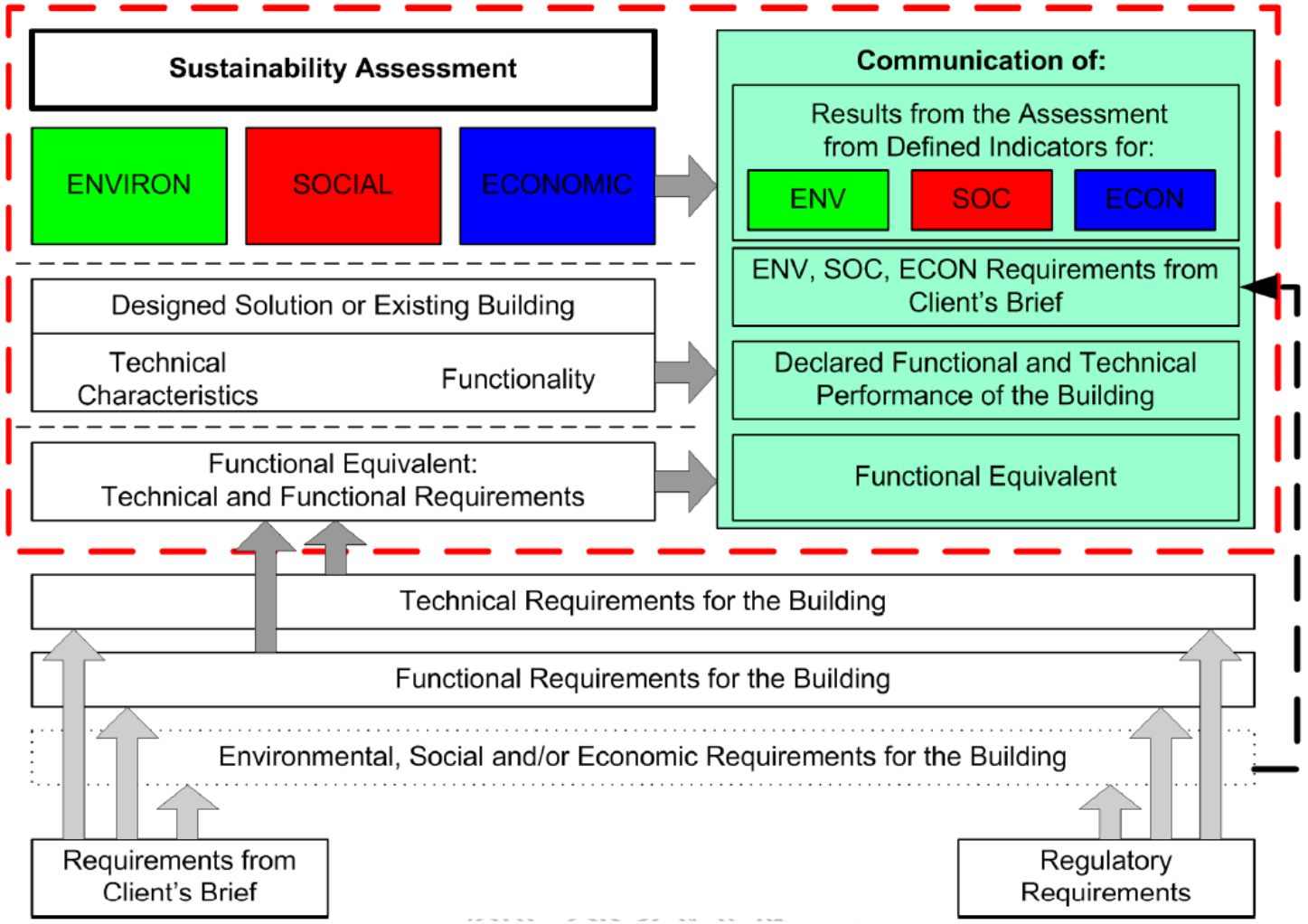
The concept of sustainability assessment of buildings according to EN 15978



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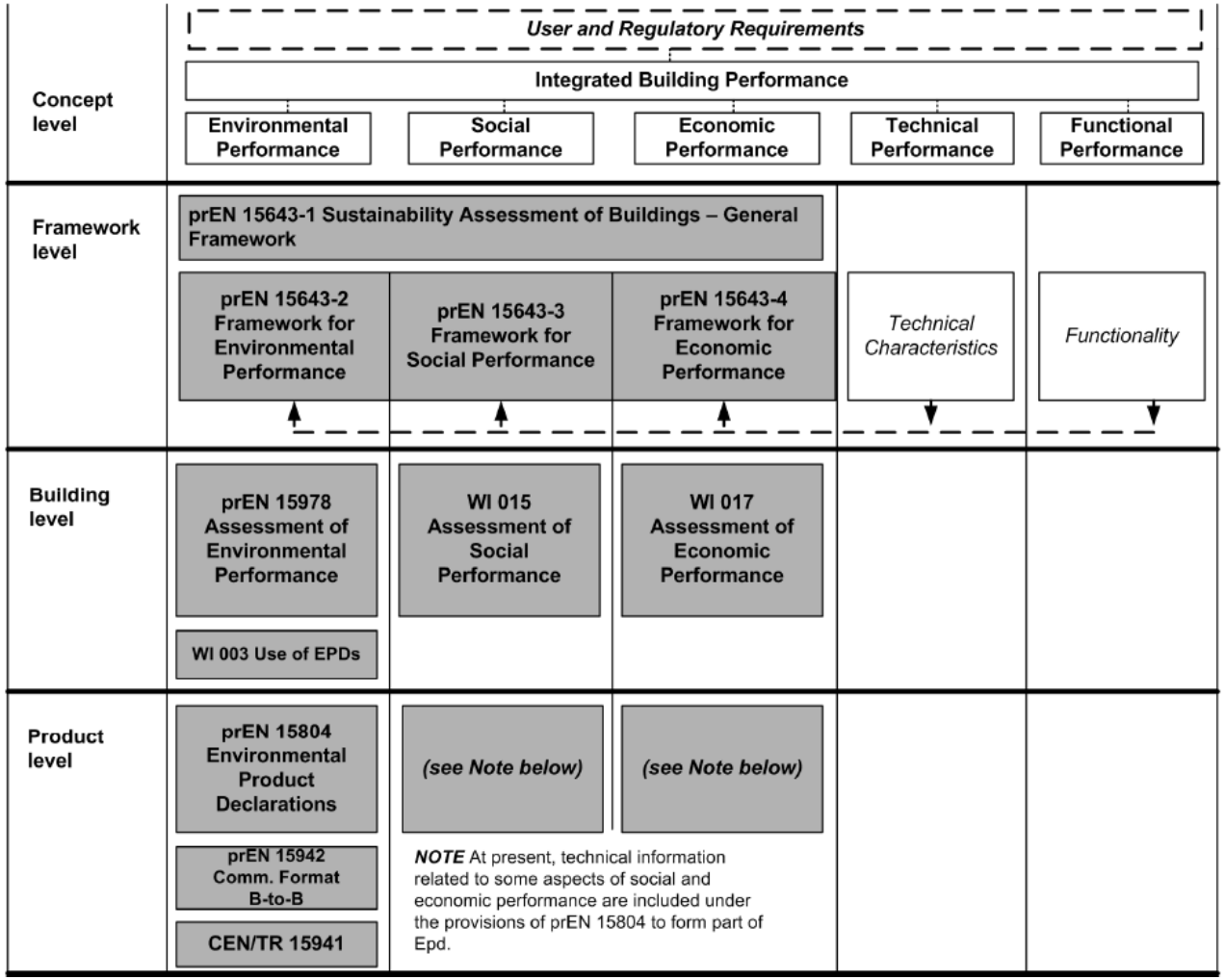
The work program of CEN/TC 350



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LCA Methodologies

Methodology	Developed by	Country of origin
CML2002	CML	Netherlands
Eco-indicator 99	PRé	Netherlands
EDIP97 – EDIP2003	DTU	Denmark
EPS 2000	IVL	Sweden
Impact 2002+	EPFL	Switzerland
LIME	AIST	Japan
LUCAS	CIRAIG	Canada
ReCiPe	RUN + PRé + CML + RIVM	Netherlands
Swiss Ecoscarcity 07	E2+ ESU-services	Switzerland
TRACI	US EPA	USA
MEEuP	VhK	Netherlands

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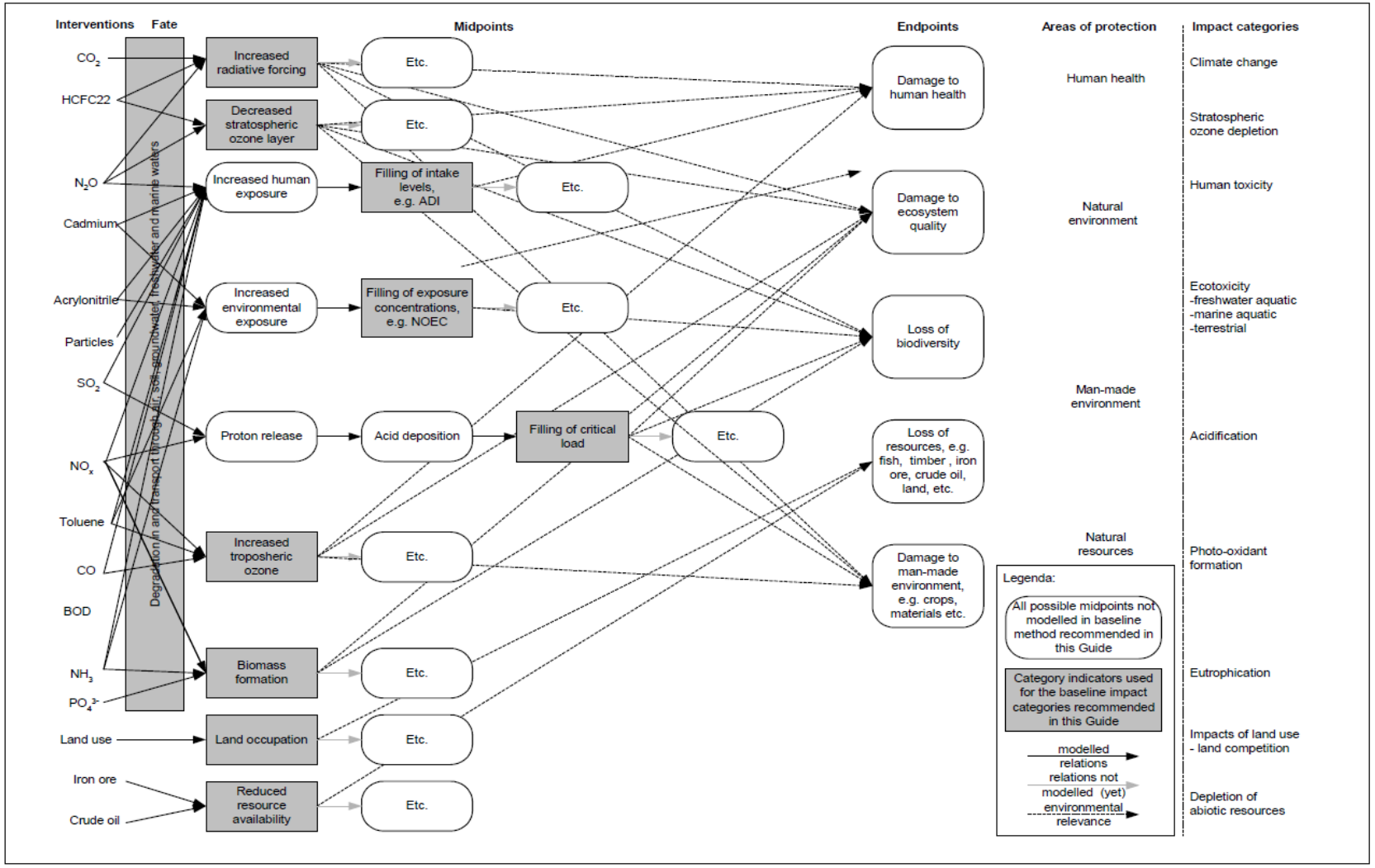
Impact categories and pathways covered by the CML methodology



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Level(s) Scheme

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Development of environmental indicators - Level(s)

- As **Level(s)** is the most recent European approach to assessing and reporting on the sustainability performance of buildings throughout their entire life cycle, this standard was chosen following this activity. Using existing standards, the Level(s) approach provides a shared identity for sustainable development, offering a foundation for quantifying, analyzing, and understanding the life cycle, and targets a variety of circularity features, delivering indicators that can better clarify how to expand the functionality of the building. **Each indicator within the Level(s) framework is intended to correlate the effect of the specific building with European sustainability goals.**
- Following the investigation for the appropriate environmental indicators investigated in WP2, Task 2.3, this case study is based on **LCA analysis** of the D^2EPC **New Wing pilot building**. The New Wing building is located in Frederick's University Campus and it is a mixed-use building. A digital procedure is followed in order to compute the environmental impact of the building, and it is described. The analysis is performed based on the **Level(s)** environmental indicators.

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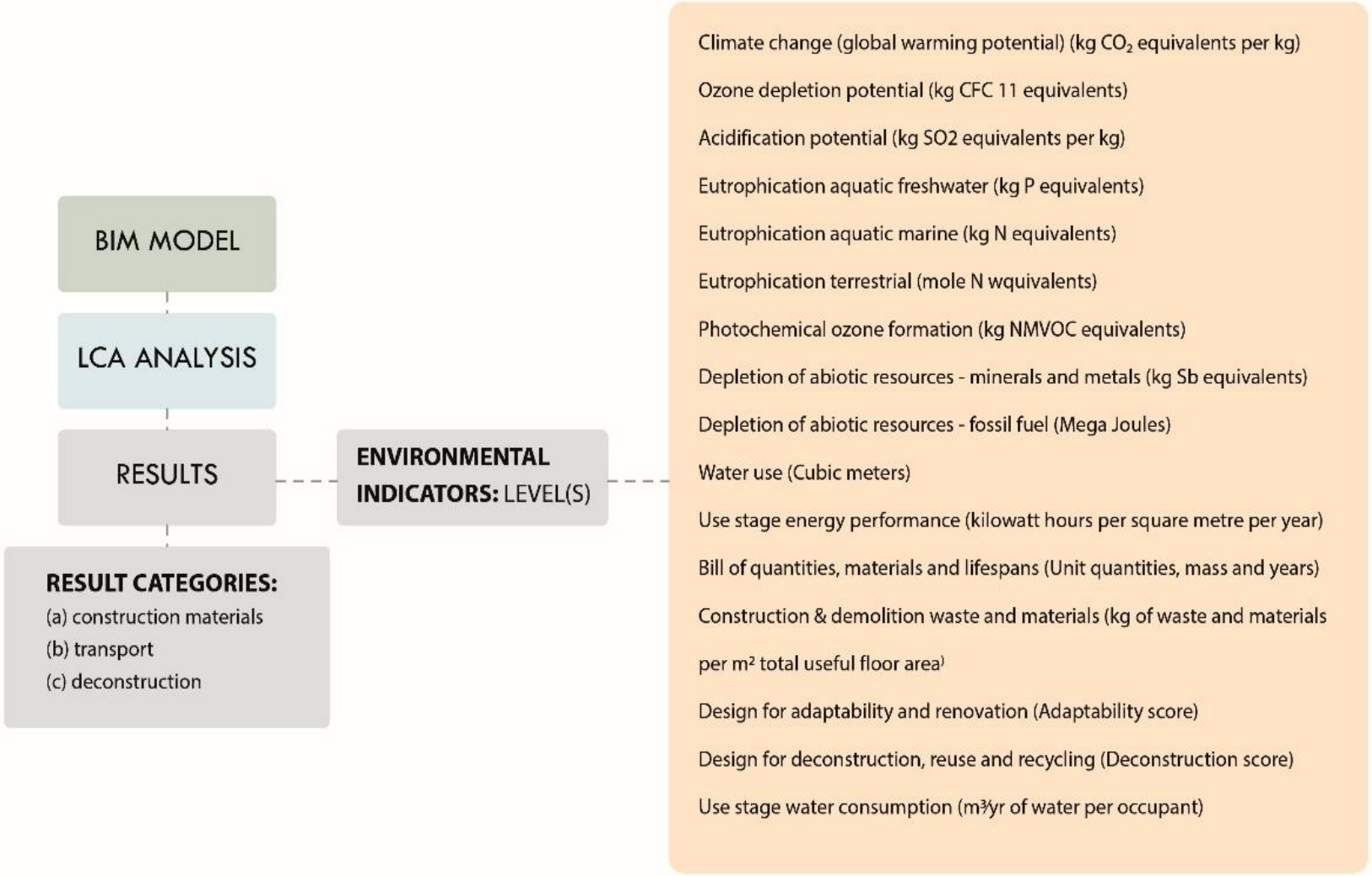
LCA analysis procedure for the development of environmental indicators



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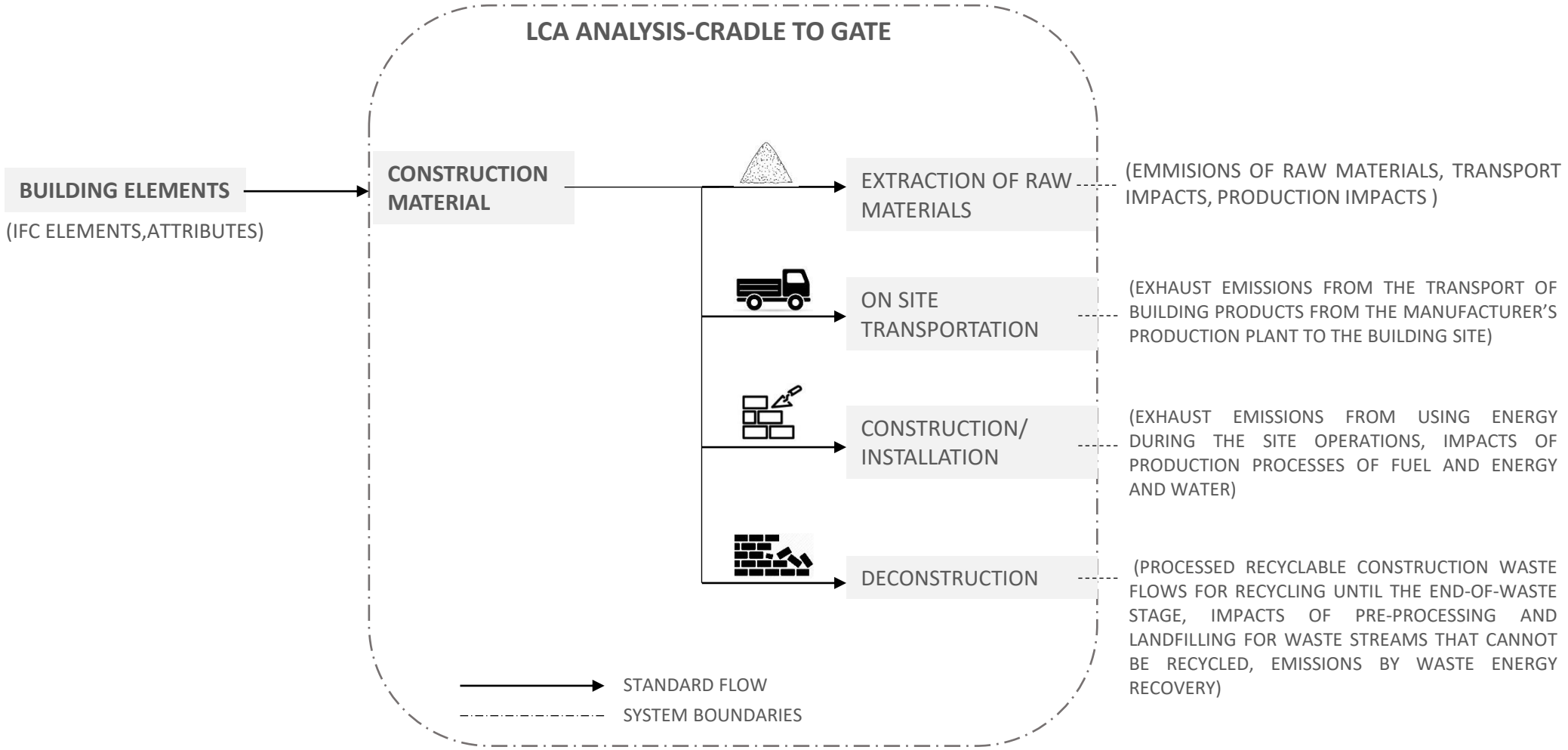
LCA analysis for the development of environmental indicators



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Results LCA analysis according to EN 15978

A1-A3 Construction Materials	**Raw material supply (A1) includes emissions generated when raw materials are taken from nature, transported to industrial units for processing and processed.** Loss of raw material and energy are also taken into account. Transport impacts (A2) include exhaust emissions resulting from the transport of all raw materials from suppliers to the manufacturer's production plant as well as impacts of the production of fuels. Production impacts (A3) cover the manufacturing of the production materials and fuels used by machines, as well as handling of waste formed in the production processes at the manufacturer's production plants until the end-of-waste state.
A4 Transportation to site	**A4 includes exhaust emissions resulting from the transport of building products from the manufacturer's production plant to the building site** as well as the environmental impacts of the production of the used fuel.
A5 Construction/installation process	**A5 covers the exhaust emissions resulting from using energy during the site operations**, the environmental impacts of production processes of fuel and energy and water, as well as handling of waste until the end-of-waste state.
B1-B5 Maintenance and material replacement	The environmental impacts of maintenance and material replacements (B1-B5) **include environmental impacts from replacing building products after they reach the end of their service life.** The emissions cover impacts from raw material supply, transportation, and production of the replacing new material as well as the impacts from manufacturing the replacing material as well as handling of waste until the end-of-waste state.
B6 Energy use	The considered use phase energy consumption (B6) impacts include **exhaust emissions from any building level energy production** as well as the environmental impacts of production processes of fuel and externally produced energy. Energy transmission losses are also taken into account.
B7 Water use	The considered use phase water consumption (B7) impacts include the **environmental impacts of production processes of fresh water and the impacts from waste water treatment.**
C1-C4 Deconstruction	The impacts of deconstruction include **impacts for processing recyclable construction waste flows for recycling (C3) until the end-of-waste stage** or the impacts of pre-processing and landfilling for waste streams that cannot be recycled (C4) based on the type of material. Additionally, deconstruction impacts include emissions caused by waste energy recovery.

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Design building elements with attributes cont'd

- **Analysis LCA.** Through the plug in, the **BIM attributes are matched with a library of materials based on Level(s) database**. Before proceeding with the analysis, it is needed to check the materials if the correct match has been made.

All results of the indicators are received via tables and graphs.

STRUCTURAL TYPE	MATERIAL
SLAB	Metal - Stud Layer
SLAB	Plasterboard
SLAB	Air Barrier - Air Infiltration Barrier
SLAB	Ceramic Tile
SLAB	Concrete, Sand/Cement Screed
WINDOW	Glass
WINDOW	Window Frame
COLUMN	Glass
COLUMN	Plasterboard
COLUMN	Concrete, Sand/Cement Screed
COLUMN	Gypsum Wall Board
EXTERNAL WALL	Air Barrier - Air Infiltration Barrier
EXTERNAL WALL	Concrete, Sand/Cement Screed
EXTERNAL WALL	Gypsum Wall Board
EXTERNAL WALL	Metal - Aluminium
EXTERNAL WALL	Glass
EXTERNAL WALL	Masonry - Concrete Block
ROOF	GRC - Glass Reinforced Concrete
ROOF	Concrete - Sand/Cement Screed
ROOF	GFRC
DOOR	Door - Frame/Mullion
DOOR	Door - Handle
DOOR	Door - Glazing
DOOR	Door - Architrave
DOOR	Door - Panel
DOOR	Door - Frame
DOOR	Glass

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Example for the Total Power numerator indicators

Total Power/ Occupancy	$\frac{\text{total power consumption}}{\text{total number of occupants}}$
Total Power/ Occupancy*Hours	$\frac{\text{total power consumption}}{\text{total number of occupants} * \text{hours of occupants in the building}}$
Total Power/ Area	$\frac{\text{total power consumption}}{\text{total surface area}}$
Total Power/ Volume	$\frac{\text{total power consumption}}{\text{total volume of the building}}$

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Development of energy indicators - D^2EPC energy indicators

Usage	Indicator Name	Indicator Description	Units
Power consumption of the building	Total Power/Occupancy	This indicator shows the ratio of the total power consumption of the building in kWh over the total number of occupants	kWh/occupants
	Total Power/Occupancy-Hours	This indicator shows the ratio of the total power consumption of the building in kWh over the total number of hours that occupants spend in the building	kWh/h*occupants
	Total Power/Area	This indicator displays the ratio of the total power consumption of the building in kWh over the total surface area of the building	kWh/m2
	Total Power/Volume	This indicator displays the ratio of the total power consumption of the building in kWh over the total volume of the building	kWh/m3
Heating Consumption	Heating consumption per energy carrier/Occupancy	This indicator shows the ratio of the heating power consumption per energy carrier of the building in kWh over the total number of occupants	kWh/occupants
	Heating consumption per energy carrier/Occupancy-Hours	This indicator shows the ratio of the heating power consumption per energy carrier of the building in kWh over the total number of hours that occupants spend in the building	kWh/h*occupants
	Heating consumption per energy carrier/Area	This indicator displays the ratio of the heating power consumption per energy carrier of the building in kWh over the total surface area of the building	kWh/m2
	Heating consumption per energy carrier/Volume	This indicator displays the ratio of the heating power consumption per energy carrier of the building in kWh over the total volume of the building	kWh/m3
Cooling Consumption	Cooling consumption per energy carrier/Occupancy	This indicator shows the ratio of the cooling power consumption per energy carrier of the building in kWh over the total number of occupants	kWh/occupants
	Cooling consumption per energy carrier/Occupancy-Hours	This indicator shows the ratio of the cooling power consumption per energy carrier of the building in kWh over the total number of hours that occupants spend in the building	kWh/h*occupants
	Cooling consumption per energy carrier/Area	This indicator displays the ratio of the cooling power consumption per energy carrier of the building in kWh over the total surface area of the building	kWh/m2
	Cooling consumption per energy carrier/Volume	This indicator displays the ratio of the cooling power consumption per energy carrier of the building in kWh over the total volume of the building	kWh/m3
Weather Normalization	Weather-Normalized Heating & Cooling Energy Consumption [11]	A positive number means usage was added. A Negative Number is good. It means usage was avoided compared to the Weather Normalized Usage from the Baseline Year. And a Positive Number is bad. It means usage actually went up compared to the Weather Normalized Usage from the Baseline Year.	---

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Development of energy indicators - D^2EPC energy indicators cont'd

Usage	Indicator Name	Indicator Description	Units
Lighting Consumption	Lighting/Occupancy	This indicator shows the ratio of the total lighting power consumption of the building in kWh over the total number of occupants	kWh/occupants
	Lighting/Occupancy-Hours	This indicator shows the ratio of the total lighting power consumption of the building in kWh over the total number of hours that occupants spend in the building	kWh/h*occupants
	Lighting/Area	This indicator displays the ratio of the total lighting power consumption of the building in kWh over the total surface area of the building	kWh/m2
	Lighting/Volume	This indicator displays the ratio of the total lighting power consumption of the building in kWh over the total volume of the building	kWh/m3
Electrical Appliances Energy Consumption	Electrical Appliances Energy Consumption /Occupancy	This indicator shows the ratio of the total energy consumption of the electrical appliances in the building in kWh over the total number of occupants	kWh/occupants
	Electrical Appliances Energy Consumption /Occupancy-Hours	This indicator shows the ratio of the total energy consumption of the electrical appliances in the building in kWh over the total number of hours that occupants spend in the building	kWh/h*occupants
	Electrical Appliances Energy Consumption /Area	This indicator displays the ratio of the total energy consumption of the electrical appliances in the building in kWh over the total surface area of the building	kWh/m2
	Electrical Appliances Energy Consumption /Volume	This indicator displays the ratio of the total energy consumption of the electrical appliances in the building in kWh over the total volume of the building	kWh/m3
Domestic Hot Water Consumption	DHW consumption per energy carrier/Occupancy	This indicator shows the ratio of the DHW power consumption per energy carrier of the building in kWh over the total number of occupants	kWh/occupants
	DHW consumption per energy carrier/Occupancy-Hours	This indicator shows the ratio of the DHW power consumption per energy carrier of the building in kWh over the total number of hours that occupants spend in the building	kWh/h*occupants
	DHW consumption per energy carrier/Area	This indicator displays the ratio of the DHW power consumption per energy carrier of the building in kWh over the total surface area of the building	kWh/m2
	DHW consumption per energy carrier/Volume	This indicator displays the ratio of the DHW power consumption per energy carrier of the building in kWh over the total volume of the building	kWh/m3

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