LIFE CYCLE ASSESSMENT (LCA) & ENVIRONMENTAL PRODUCT DECLARATION (EPD)

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Co-Founder & managing director
Agenda

- Introduction Daxner & Merl GmbH
- LCA of Buildings – general introduction
- LCA of Buildings in context with DGNB certification
- EPDs in context with LCA and DGNB certification
- Examples of building LCAs
who we are…

Daxner & Merl (Vienna, Austria)
Sustainability consulting, life cycle engineering and research

LCA | carbon footprint
Life cycle assessment enables you to holistically manage your environmental impacts. (more...)

EPD
Environmental product declarations for your product (more...)

environmental management
Implementing environmental protection with suitable management systems (ISO 14001, EMAS), labels (OÜZ), ...

sustainable buildings
We are specialised in sustainable construction. (more...)

building certification
Promoting an integral planning process, we support you in building certification (DGNB, ...

strategy & reporting
We offer customised solutions and workshops for your sustainability strategy and reporting...
LCA of Buildings – general introduction
Life cycle assessment

Definition according to ISO 14040/14044

compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle
Life cycle thinking

- raw material extraction
- processing of intermediates
- production
- transport & delivery
- use
- recycling & reuse
- deposition – thermal treatment / landfill

Daxner & Merl GmbH
www.daxner-merl.com
Phases according to ISO 14044

LCA structure:
- goal & scope definition
  - §4.2 ISO 14044
- life cycle inventory
  - §4.3 ISO 14044
- life cycle impact assessment
  - §4.4 ISO 14044

Application:
- product development
- process optimisation
- strategic planning
- policies
- marketing
- EPD / building certification
- others
Principle of LCA

**life cycle impact assessment** -
emissions to the environment (soil, water and air) result in environmental impacts

**global warming potential** (CO2, CH4, etc.);
**photo chemical ozone creation** (ethene, etc.);
**acidification** (SO2, NOx, etc.);
**eutrophication** (phosphates, NOx, etc.);
**toxic impact on humans & ecosystems** (heavy metals such as lead, Cd; PCB, etc.)

**life cycle inventory** -
energy, raw materials, products, waste, emissions

**life cycle steps**
raw material extraction → processing of intermediates → production

**life cycle phases**
production phase → use phase → end of Life

Input | Output
Input | Output
Input | Output
Input | Output
Input | Output

**Principle of LCA**
LCA of Buildings in context with DGNB certification
Procedure

• Adapted on the site
• Embedded in the regional system
• Inclusion of sustainability indicators already in an early design phase
• Life cycle perspective from raw material extraction to final disposal (cradle to grave) including all perspectives for circularity
• Materials and building operation energy
• Individual analysis – adapted to goal and scope of DGNB and beyond
Procedure

• **Preliminary design and draft planning:**
  Calculation of environmental impacts of parts of the building (building components, technical equipment) and assessment of the whole building with a screening LCA – generic data sufficient, necessary to get full ration in the DGNB certification

• **Detailed design:**
  Analyse, evaluate and control concrete alternatives for relevant building aspects with life cycle assessment in detail. Basis for building certification - manufacturer and location specific data like EPD

• **As built LCA of the building for DGNB final rating**
System boundaries according DGNB

Construction phase
- Raw material supply
- Transport
- Manufacturing of building products
- Transport
- Building construction

Use phase
- Use of building products
- Energy demand
- Water demand
- Maintenance & replacement
- Modernisation

End of Life
- Demolition, dismantling
- Transport
- Waste treatment and recycling & final disposal

System boundary
- Transport
- Reuse, Recycling, Energy recovery

DGNB System boundaries

Modernisation

Reuse, Recycling, Energy recovery

Transport
System boundaries according DGNB

**Functional unit:** 1 m² NFA (Gross volume) * a of the buildings life cycle

Construction: ⇒ Proof for the “as built building”
Use: ⇒ Scenario over 50 years of use (most cases, production facilities 20 a)
End of Life: ⇒ Scenario dismantling and recycling/reuse/disposal

**System boundary** is the building itself without outdoor facilities

⇒ Construction (super structure), fit out and technical equipment (HVAC)
Data and data collection

Background data: LCA-data for the used building materials & used energy carriers

- EPDs in accordance with EN 15804
- Independent reviewed data according ISO 14044 and EN 15804
- Generic data according EN 15804 (with 10 – 20 % surcharge)
**EPDs in context with LCA and DGNB certification**

*ISO 14025* - Type III environmental declarations - Principles and procedures

*EN 15804* - Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products

*EN 15978* - Sustainability of construction works - Assessment of environmental performance of buildings - Calculation method
Environmental communication (acc. ISO 14020)

Type I: Environmental labels (ISO 14024)

Type II: Self declaration (ISO 14021)

Type III: Verified environmental product declaration (EPD) (ISO 14025)
Type III – EPD program operators

Members: 16 European established program operators
Type III – environmental product declarations (EPD)

• …neutral tool to communicate the environmental characteristics of a product – externally reviewed & based on consistent rules

• …documents the environmental performance over the entire product life cycle = “environmental footprint“ based on life cycle assessment
Type III – environmental product declarations (EPD):
Organisation according to ISO 14025

- Independent program operator
- Independent experts and manufacturers developing calculation rules (PCR)
- Expert advisory board from science and independent organisations
- Forum for interested parties (stakeholder)
- LCA experts
- Independent verifiers
Type III – environmental product declarations (EPD) creation process

1. Development of product category rules (if not in place)
2. Data collection (manufacturer + LCA expert)
3. Calculation of life cycle assessment (LCA expert)
4. Preparation of EPD (manufacturer + LCA expert) & confidential background report (LCA expert)
5. Independent third party verification (external verifier)
6. Revision of EPD & background report
7. Final review and publication by the program operator
EPD content – product specifications (1)
Information provided by the manufacturer

- Product / Service description
- Application
- Technical data
- Delivery status
- Base materials
- Manufacture
- Optional: Specific appendix for certification schemes

PCR Guidance documents refer to product specific rules for different applications depending on the nature of products or services (e.g. building materials, energy, chemical products, food & beverages, textiles, furniture & other goods, metal, plastic & glass products, etc.)
EPD content – life cycle assessment

calculated for a **declared unit:**

- [1 m², 1 kg, 1 m³, 1l, 1 package, 1 Joule, 1 kWh, 1 MJ etc., 1 Pkm] – multiplied with amount of each material installed in the building
- for each life cycle stage according to the modules (EN 15978 – LCA of buildings)
- A (Product stage)
- B (use stage)
- C (waste treatment)
- D (Credits and loads beyond the system boundary)

With the information from the **EPDs** the calculation of the **material related contribution** to the total **building LCA result** can be calculated.
EPD example – heavy plates made of steel

**5. LCA: Results**

The following table contains the LCA results for a declared unit of 1 ton of heavy plate produced by voestalpine Grobölküh GmbH.

### DESCRIPTION OF THE SYSTEM BOUNDARY (X – INCLUDED IN LCA; MND – MODULE NOT DECLARED)

<table>
<thead>
<tr>
<th>PRODUCT STAGE</th>
<th>CONSTRUCTION STAGE</th>
<th>USE STAGE</th>
<th>END OF LIFE STAGE</th>
<th>BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>A3</td>
<td>MND</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>A4</td>
<td>MND</td>
<td>MND</td>
<td>MND</td>
<td></td>
</tr>
<tr>
<td>A5</td>
<td>MND</td>
<td>MND</td>
<td>MND</td>
<td></td>
</tr>
<tr>
<td>B1</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B2</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B3</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B4</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B5</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B6</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B7</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C3</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C4</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### RESULTS OF THE LCA – ENVIRONMENTAL IMPACT: 1 ton of heavy plate

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>A1-A3</th>
<th>C3</th>
<th>C4</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global warming potential</td>
<td>t CO₂-eq</td>
<td>2.15E-3</td>
<td>0.00E-0</td>
<td>5.02E-3</td>
<td>1.12E-3</td>
</tr>
<tr>
<td>Acidification potential of surface water</td>
<td>t SO₂</td>
<td>7.50E-4</td>
<td>0.00E-0</td>
<td>4.91E-4</td>
<td>6.38E-4</td>
</tr>
<tr>
<td>Acidification potential of precipitation</td>
<td>t H₂SO₄</td>
<td>6.85E-5</td>
<td>0.00E-0</td>
<td>6.08E-5</td>
<td>9.60E-5</td>
</tr>
<tr>
<td>Fossil fuel energy (bio-fuel replacement)</td>
<td>t CO₂</td>
<td>1.72E-1</td>
<td>0.00E-0</td>
<td>3.02E-1</td>
<td>2.74E-1</td>
</tr>
<tr>
<td>Acidification potential of groundwater</td>
<td>t HCl</td>
<td>1.72E-4</td>
<td>0.00E-0</td>
<td>2.17E-4</td>
<td>1.35E-4</td>
</tr>
<tr>
<td>Acidification potential of heavy metals</td>
<td>t Cd</td>
<td>1.72E-4</td>
<td>0.00E-0</td>
<td>2.17E-4</td>
<td>1.35E-4</td>
</tr>
</tbody>
</table>

### RESULTS OF THE LCA – RESOURCE USE: 1 ton of heavy plate

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>A1-A3</th>
<th>C3</th>
<th>C4</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renewable primary energy as energy carrier</td>
<td>GJ</td>
<td>1.51E+3</td>
<td>0.00E-0</td>
<td>1.27E+3</td>
<td>1.34E+3</td>
</tr>
<tr>
<td>Renewable primary energy as heat carrier</td>
<td>GJ</td>
<td>1.51E+3</td>
<td>0.00E-0</td>
<td>1.27E+3</td>
<td>1.34E+3</td>
</tr>
<tr>
<td>Total use of renewable primary energy resources</td>
<td>GJ</td>
<td>1.51E+3</td>
<td>0.00E-0</td>
<td>1.27E+3</td>
<td>1.34E+3</td>
</tr>
<tr>
<td>Non-renewable primary energy as energy carrier</td>
<td>GJ</td>
<td>0.00E+0</td>
<td>0.00E-0</td>
<td>0.00E+0</td>
<td>3.00E+0</td>
</tr>
<tr>
<td>Non-renewable primary energy as heat carrier</td>
<td>GJ</td>
<td>0.00E+0</td>
<td>0.00E-0</td>
<td>0.00E+0</td>
<td>3.00E+0</td>
</tr>
<tr>
<td>Total use of non-renewable primary energy resources</td>
<td>GJ</td>
<td>1.51E+3</td>
<td>0.00E-0</td>
<td>1.27E+3</td>
<td>1.34E+3</td>
</tr>
<tr>
<td>Use of secondary material</td>
<td>t</td>
<td>1.72E-4</td>
<td>0.00E-0</td>
<td>2.39E-4</td>
<td>3.20E-4</td>
</tr>
<tr>
<td>Use of primary material</td>
<td>t</td>
<td>1.72E-4</td>
<td>0.00E-0</td>
<td>2.39E-4</td>
<td>3.20E-4</td>
</tr>
<tr>
<td>Use of fossil fuel</td>
<td>t</td>
<td>4.43E-2</td>
<td>0.00E-0</td>
<td>2.71E-2</td>
<td>6.25E-2</td>
</tr>
</tbody>
</table>

### RESULTS OF THE LCA – OUTPUT FLOWS AND WASTE CATEGORIES: 1 ton of heavy plate

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>A1-A3</th>
<th>C3</th>
<th>C4</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazardous waste disposed</td>
<td>t</td>
<td>4.65E-4</td>
<td>0.00E-0</td>
<td>2.47E-3</td>
<td>1.74E-3</td>
</tr>
<tr>
<td>Non-hazardous waste disposed</td>
<td>t</td>
<td>2.48E-1</td>
<td>0.00E-0</td>
<td>2.39E-1</td>
<td>1.89E-1</td>
</tr>
<tr>
<td>Industrial waste</td>
<td>t</td>
<td>2.00E-3</td>
<td>0.00E-0</td>
<td>1.03E-3</td>
<td>5.00E-4</td>
</tr>
<tr>
<td>Water (in power plant)</td>
<td>t</td>
<td>3.00E-3</td>
<td>0.00E-0</td>
<td>3.00E-3</td>
<td>3.00E-3</td>
</tr>
<tr>
<td>Water (in heavy metal)</td>
<td>t</td>
<td>3.00E-3</td>
<td>0.00E-0</td>
<td>3.00E-3</td>
<td>3.00E-3</td>
</tr>
<tr>
<td>Exported electrical energy</td>
<td>MWh</td>
<td>9.50E+6</td>
<td>0.00E-0</td>
<td>9.50E+6</td>
<td>9.50E+6</td>
</tr>
<tr>
<td>Exported thermal energy</td>
<td>MWh</td>
<td>9.50E+6</td>
<td>0.00E-0</td>
<td>9.50E+6</td>
<td>9.50E+6</td>
</tr>
</tbody>
</table>

**Life cycle impact assessment of voestalpine heavy plates**
Use phase – Energy demand for heat & power

calculated for a building over one 1 year per NFA:
- Considering the technical equipment
- Considering the origin of energy carriers (oil, gas, wood, waste energy…)
- Considering the correct power grid mix
- Considering all relevant consumption sources (heating, warm water, cooling, ventilation, lighting, transport, etc.)
Goal of LCA beyond certification

• Buildings cause in all phases of their life cycle emissions and resource consumption: from construction until end of life
• The emissions going into air, water and soil causing manifold environmental impacts
• These impacts are exemplary global warming, ozone depletion, summer smog, forest dieback, fish mortality, eutrophication of water and soil, toxic effects, etc. and influencing finally human health and quality of life
• Therefore, in order to protect finally humans, the goal is to reduce all emissions from buildings to a minimum
• To ensure resources for future generations resource depletion has to be avoided
Building – LCA as a significant component of the DGNB rating system

LCA result is compared against benchmarks and gets credits for each indicator

The indicators map the environmental profile of the building

Life cycle impact assessment using CML for DGNB (from EPDs or other databases)

Life cycle inventory: energy for operation of the building over 50 years

Life cycle inventory for all materials (construction, replacement, EoL for 50 years)
Example: visualisation of an LCA result allocated to the life cycle phases:
Examples of building LCAs
LCA of the EGGER office building (DGNB Platin)

EPDs form a consistent data base and according to the mass of each material they contribute to the total LCA result.
Carbon Footprint – example office building

Comparison of improvement from design to implementation.

Reduction of the carbon footprint
from 55 kg CO$_2$e/m$^2$y to 18 kg CO$_2$e/m$^2$y
= improvement by factor 3
= 1.000 t CO$_2$e saved
over a service life of 50 years
= equal to annual GHG-emissions of almost 70 Austrians
What’s the value of EPDs in building LCA and certification?

- **Reliable** communication of a product’s environmental performance, externally verified
- **Holistic results** referring to the entire **life cycle** of a product
- **Transparent** source for product information for all material related certification criteria
- Advantages for **building certification** or **sustainable procurement programs**