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Building Integration of Solar Thermal Systems – TU1205 – BISTS

# LCA of building integrated solar systems and SimaPro program


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## AGENDA

- To discuss the **importance of the LCA method** in the Building Sustainability Assessment;
- To present the indicators used in the **assessment of the environmental performance** of a building integrated solar system;
- To present the **steps and methods for the quantification of the potential environmental impacts** using the SimaPro software;
- To present a software for the LCA of solar systems (**LCABiSTS**);
- Application to case studies.



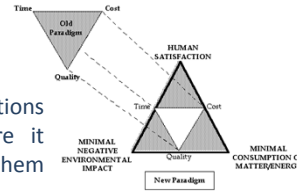
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## INTRODUCTION

- Optimizing building sustainability involves various relations between built, natural and social systems. Therefore it comprises **hundreds of parameters**, most of them interrelated and partly contradictory.
- This way, this process is only possible through a **systematic approach**.
- Sustainability assessment tools are useful to **gather** and **report** information for **decision-making** during different phases of construction, design and use of a building (holistic approach).

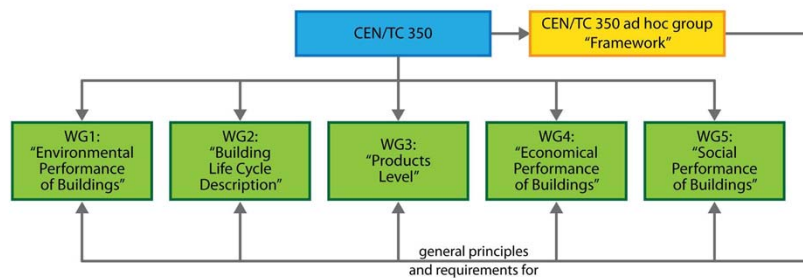


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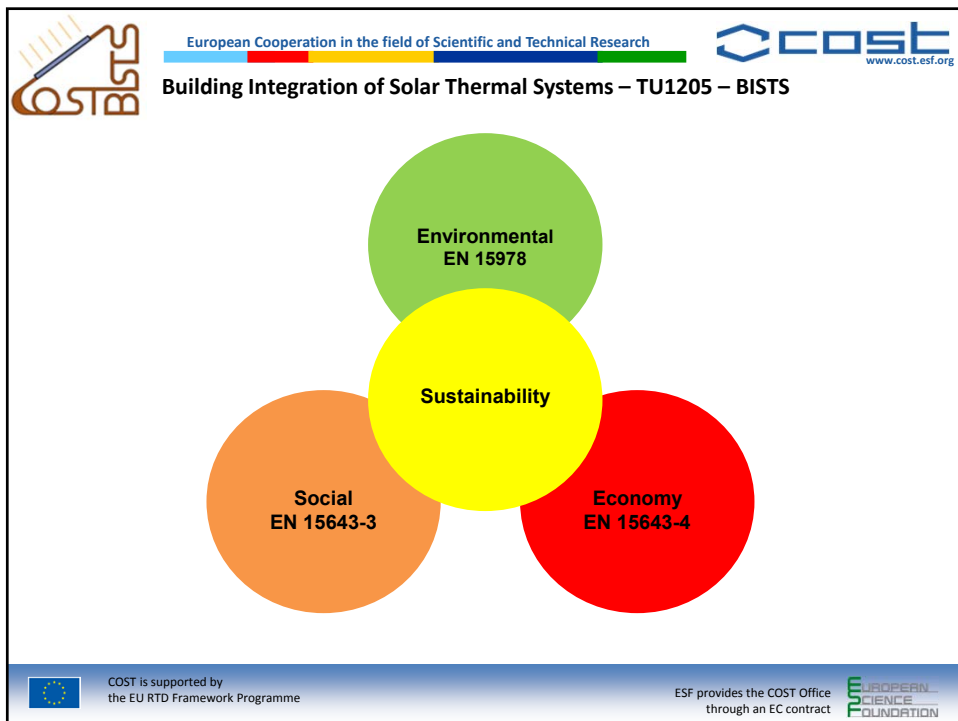
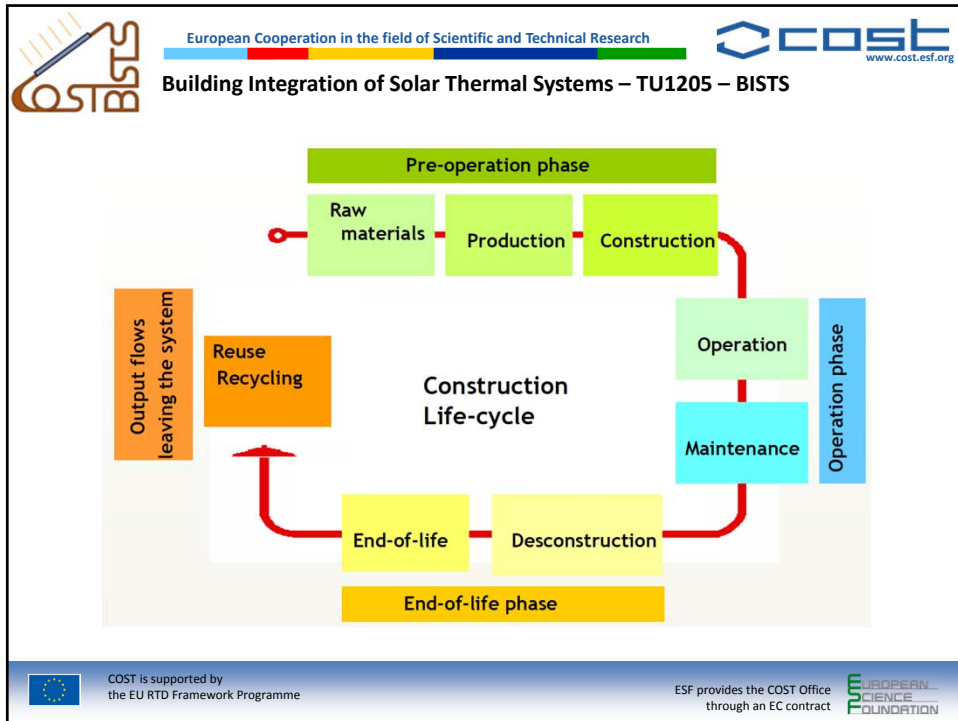
- In order to **standardize** and **promote** the **interpretation and comparison of results** from different assessment methods developed in Europe, the European Committee for Standardization (CEN) launched the Technical Committee 350 (CEN/TC 350).



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Environment  
prEN 15978

- According to standard **EN 15978:2011** the assessment of the environmental performance of a building is based in **4 types of environmental indicators (total of 22)**:

### 1 - Indicators describing environmental impacts:

Indicator	Unit
Global warming potential, GWP	kg CO <sub>2</sub> equiv
Depletion potential of the stratospheric ozone layer, ODP;	kg CFC 11 equiv
Acidification potential of land and water, AP;	kg SO <sub>2</sub> <sup>-</sup> equiv
Eutrophication potential, EP;	kg (PO <sub>4</sub> ) <sup>-3</sup> 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



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### 2 - Indicators describing resource use:


Indicator	Unit
Use of renewable primary energy excluding energy resources used as raw material	MJ, net calorific value
Use of renewable primary energy resources used as raw material	MJ, net calorific value
Use of non-renewable primary energy excluding primary energy resources used as raw material	MJ, net calorific value
Use of non-renewable primary energy resources used as raw material	MJ, net calorific value
Use of secondary material	kg
Use of renewable secondary fuels	MJ
Use of non-renewable secondary fuels	MJ
Use of net fresh water	m <sup>3</sup>




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**3 - Indicators describing additional environmental information:**

Indicator	Unit
Hazardous waste disposed;	kg
Non-hazardous waste disposed	kg
Radioactive waste disposed	kg


**4 - Indicators describing the output flows leaving the system:**


Indicator	Unit
Components for re-use	kg
Materials for recycling	kg
Materials for energy recovery (not being waste incineration)	kg
Exported energy	MJ for each energy carrier




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- Life-cycle analysis (LCA) is an analytical methodology that is aimed **to assess the resources content** and the **environmental impacts** associated with the life-cycle of a manufactured product.

Applications

Analysis of the contribution of the various life-cycle stages to the global environmental impact;

Comparison between products.

Internal and external communication.

Assessment of construction sustainability


Development of Environmental Product Declarations (EPD's)

↓

Importance


↑

Sustainability reports of companies

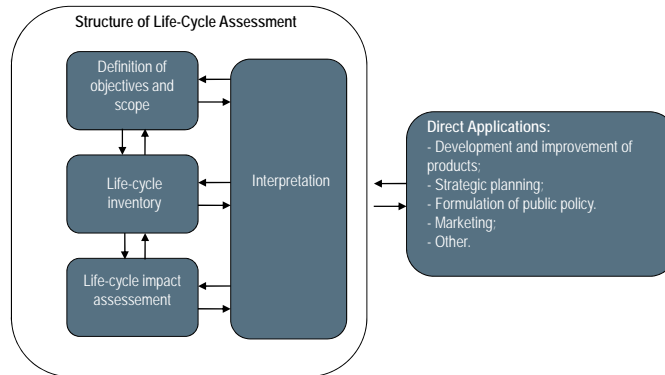


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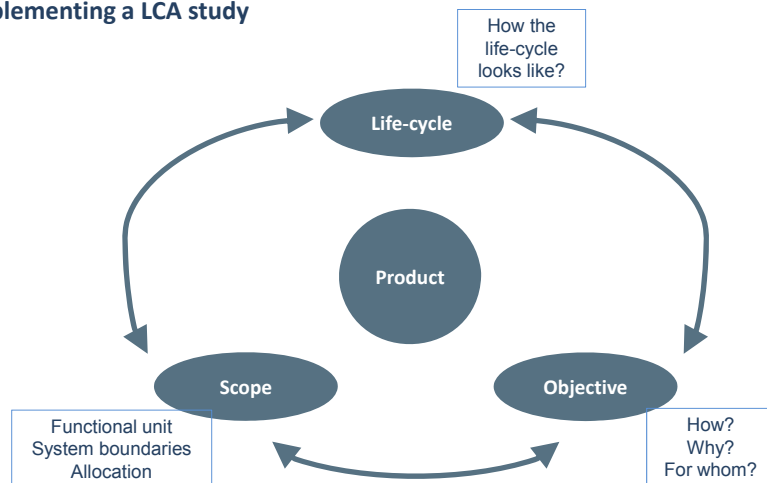
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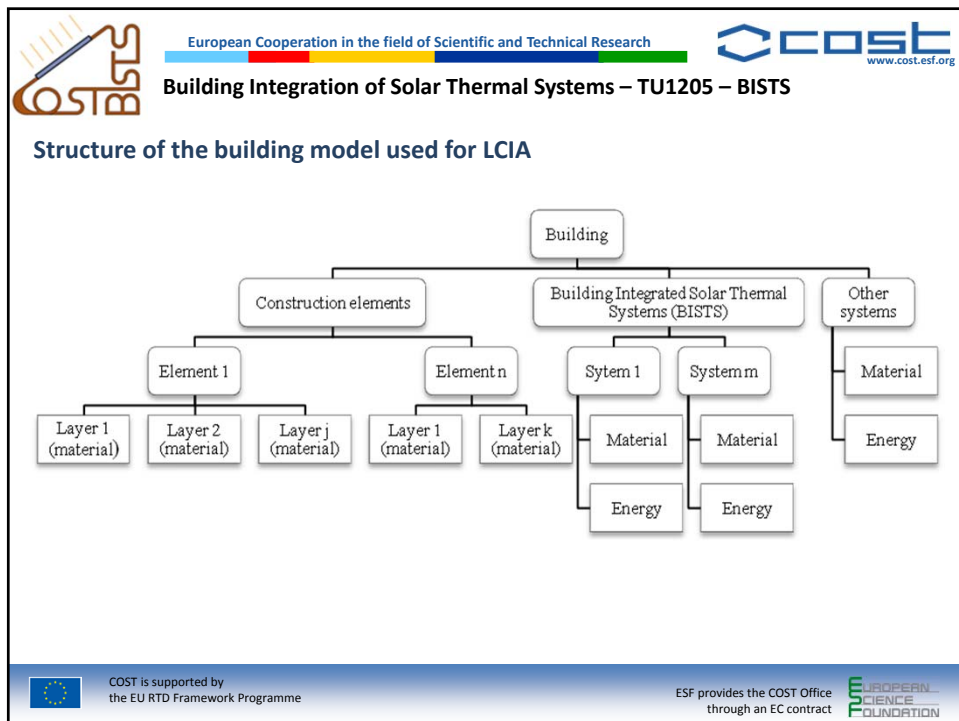
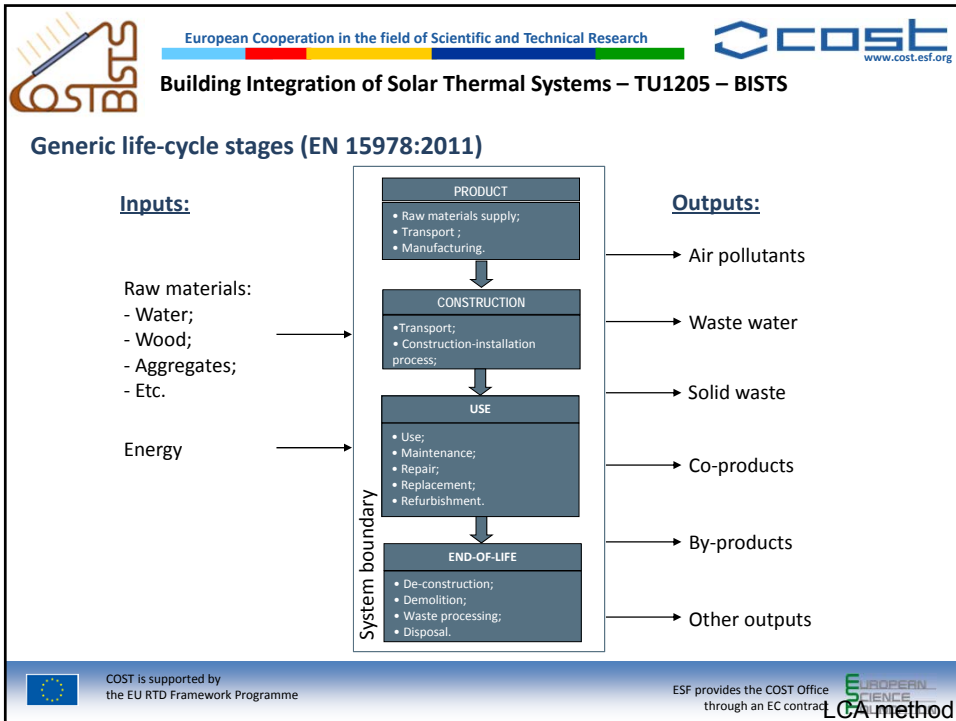


## STAGES OF LCA (according to standard ISO 1040:2006)



## Implementing a LCA study







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# Steps and methods for the quantification of the environmental impacts



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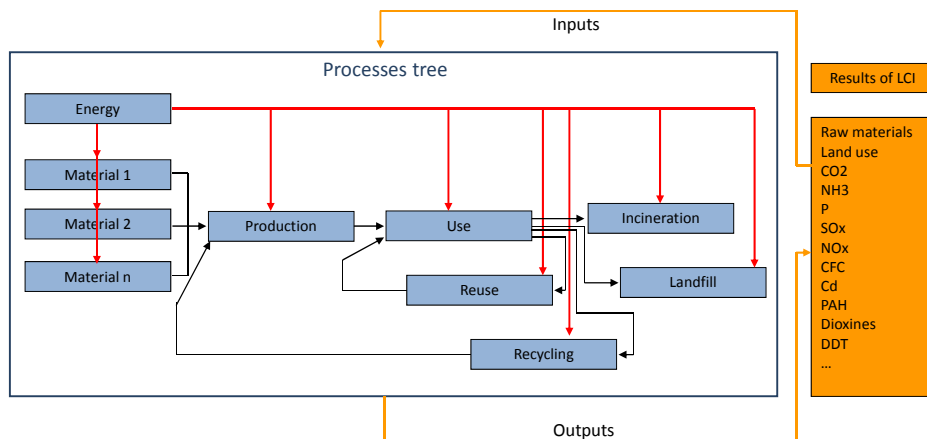
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## 1<sup>st</sup> Step: Life-cycle *Inventory* (LCI)

The goal is to **identify all inputs and outputs** of the processes tree.




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### 1<sup>st</sup> Step (cont.)

How to get LCI data?

↓ Some solutions...


1. To search for specific **Environmental Product declarations (EPDs)**
2. To use **LCI databases** of the LCA software;
3. To perform a **web search** :
  - Eco-invent center ([www.ecoinvent.org](http://www.ecoinvent.org));
  - Sustainability consultants' Webpages;
  - Google, Freepatents.com, Wikipedia;
  - *Material safety datsheets (MSDS)*
  - Ullman's Encyclopedia and other manuals;
  - Scientific journals (e.g. International Journal of LCA).
4. To **develop questionnaires** to collect specific LCI data from the company that produces the product to assess.







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### 1<sup>st</sup> Step (cont.)



#### Most used LCI Libraries at European level


➤ **Ecoinvent: Switzerland**

- contains life-cycle inventory data **for over 4000 industrial processes**, including **energy supply, resource extraction, materials supply, chemicals, metals, waste management systems and transport services**;
- has data for **different European countries contexts**;
- works with **Simapro** and **Gabi** LCA software.

➤ **Gabi datasets: Germany**


- based on **Gabi's co-operation with industry** as well as **patent, technical and scientific literature**;
- include more than **8000 entries**, covering **metals** (steel, aluminium and non ferrous metals), **organic and inorganic** intermediate products, **plastics, mineral materials, energy supply** (power grid mixes, steam, thermal energy), **end-of-life, coatings, manufacturing and electronics, construction materials, renewable materials, and textile processing.**;



  
  





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### LCI data for STCs and PVs in Ecoinvent 2.2

- Covers **building-added solar thermal systems** plus **building-added and building-integrated photovoltaic systems**.
- No information about Hybrid photovoltaic/thermal is found.

**LCI data for system components (8)**

- Auxiliary heating, electric;
- Evacuated tube panel;
- Expansion vessel;
- Water tank;
- Etc.

Data for STC's



eco/vert

↓

SimaProS


**LCI data for delivered heat (10)**

- At flat collector, multiple dwelling (HW);
- At flat collector, single house (HW and combined);
- At hot water tank, solar+electric, flat plate, multi-dwelling (WH and combined);
- At solar+wood, heating, flat plate, single family (combined);
- Etc.

**LCI data for complete systems (4)**


- STC with evacuated tube collector, single house (combined system);
- STC with flat plate collector, multi-dwelling (WH);
- STC with flat plate collector, single house (WH and combined).


Context of LCI data: Switzerland




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### LCI data for PVs in Ecoinvent 2.2

- **Included processes:** all components for the installation of a 3 kWp photovoltaic plant, including **energy use for the mounting, transport of the materials and persons** to the construction place and disposal of components after the **end of life (21 processes)**.

**LCI data for different type of cells**

- multi Si;
- single Si
- a-Si;
- CdTe;
- CIS;
- ribbon-Si.
- includes panels and laminates.

Data for PV's



eco/vert

↓

SimaProS

**LCI data for additional fixing materials (m²)**

- For flat roof installations (mounted);
- For pitched roofs installations (mounted and integrated);
- For facades installations (mounted and integrated).


**LCI data for integration/mounting in different building elements**

- Facade (integrated and mounted);
- Flat roof (mounted);
- Pitched roof (integrated and mounted).

**LCI data for produced electricity (kwh)**


- For different type of PV cells;
- For different locations (facades, flat roofs and pitched roofs);
- For different type of installations (integrated and mounted).

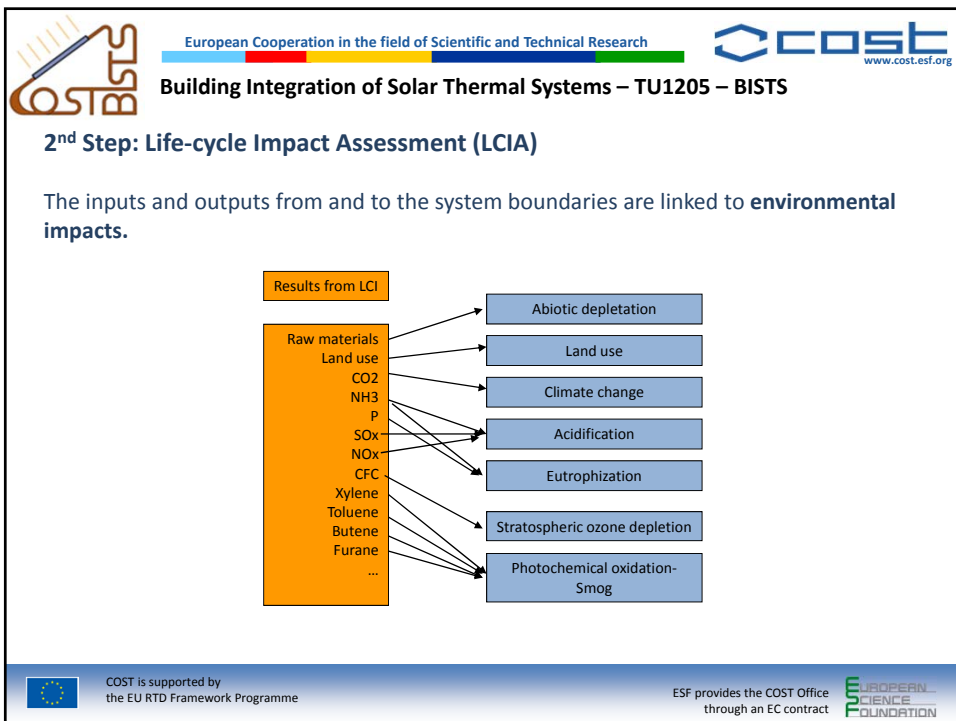
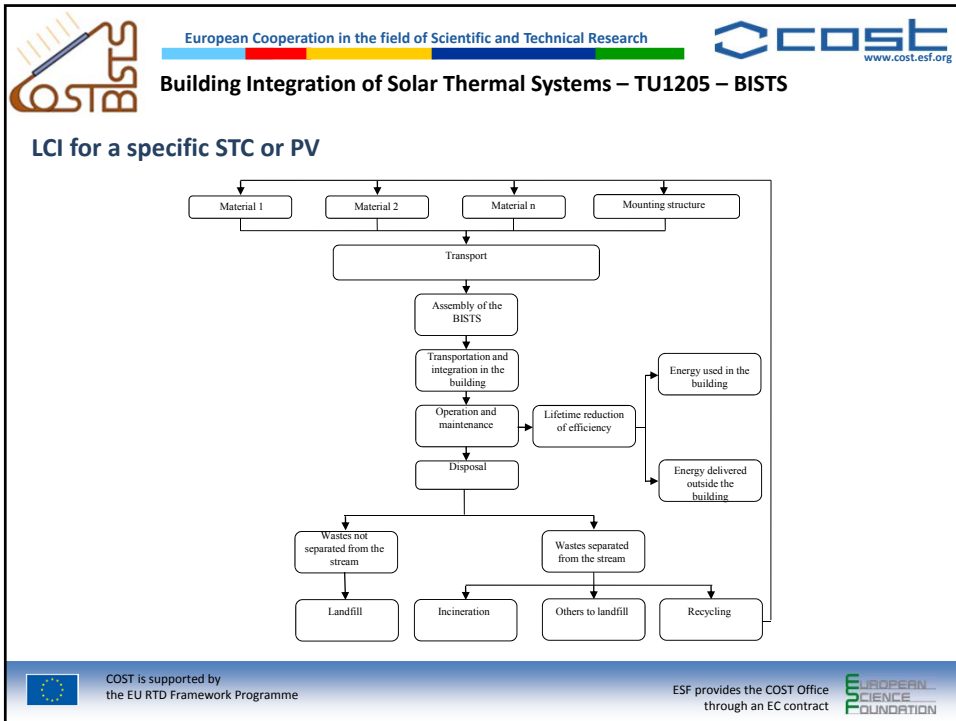
Context of LCI data: Switzerland

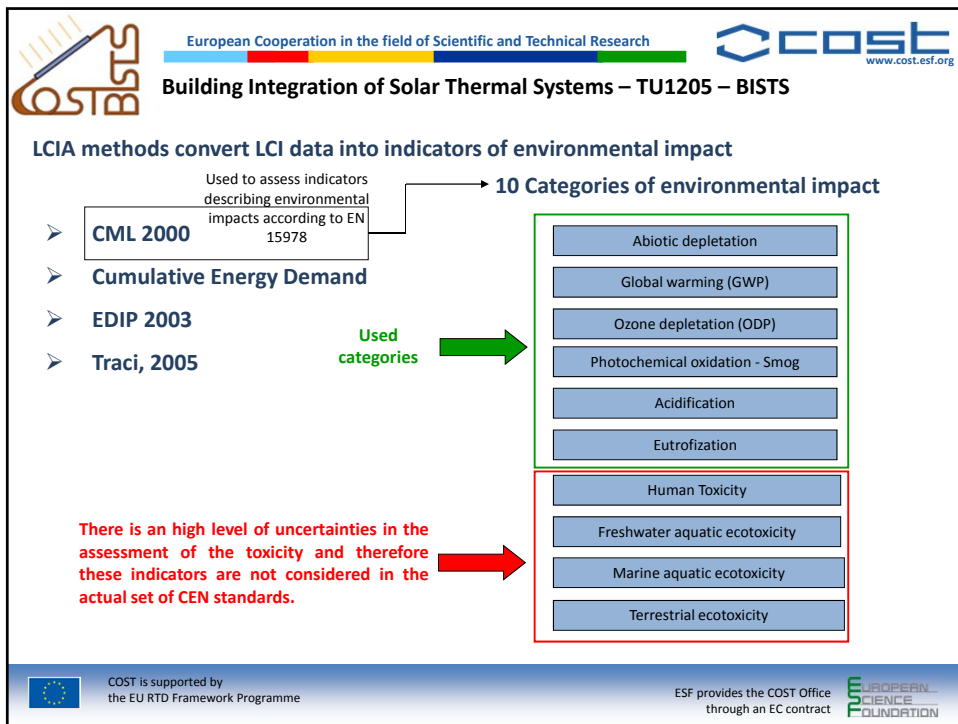


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#### Midpoint LCI methods in detail

#### Classification / characterization

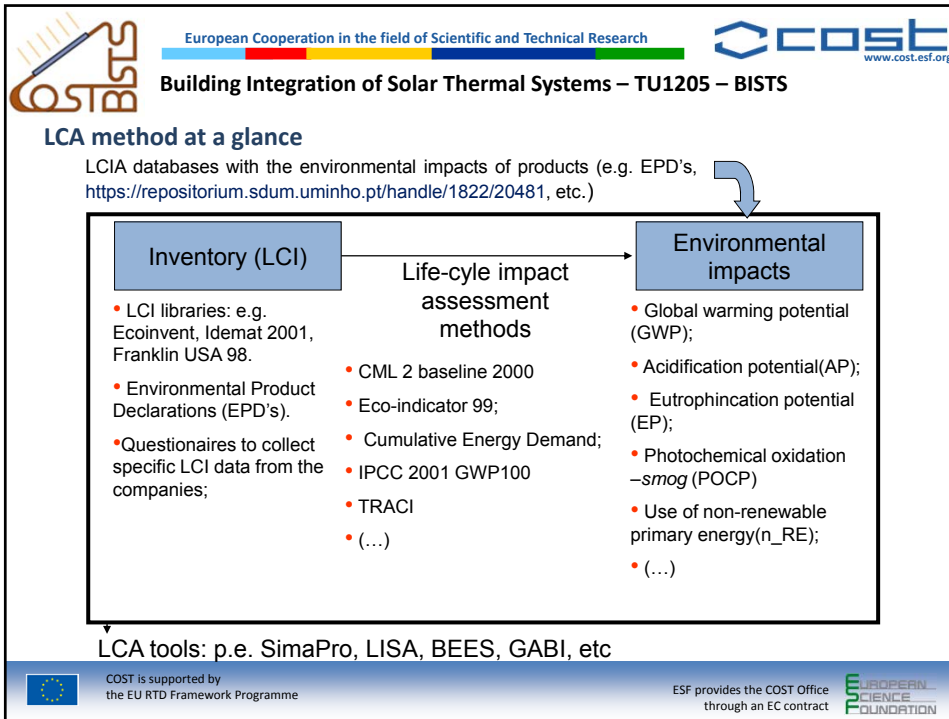
LCI result	Global warming	Acidification	Human toxicity
1000g CO <sub>2</sub>	x 1 = 1000		
10g CH <sub>4</sub>	x 21 = 210		
10g SO <sub>2</sub>		x 1 = 10	x 1,2 = 12
5g NO <sub>x</sub>		x 0,7 = 3,5	x 0,78 = 3,9
10 <sup>-6</sup> g dioxins			x 3,3e6 = 3,3
<b>Total</b>	<b>1210</b>	<b>13,5</b>	<b>19,4</b>

○ Characterization factors

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#### Life-cycle impact assessment of Building-Added STCs – results from SimaPro

STCs (Infrastructure)	Life-cycle impact category						Embodied energy	
	ADP	GWP	ODP	AP	POCP	EP	ADP_FF	ERE
Evacuated tube collector	6.74E-01	9.03E+01	8.42E-06	7.81E-01	3.26E-02	6.55E-01	1.48E+03	1.38E+02
Flat plate collector	6.81E-01	1.02E+02	9.69E-06	9.76E-01	5.00E-02	6.65E-01	1.52E+03	2.46E+02
Solar system with evacuated tube collector, one-family house, combined system	1.77E+01	2.35E+03	3.06E-04	1.58E+01	1.03E+00	1.25E+01	3.90E+04	3.68E+03
Solar system, flat plate collector, multiple dwelling, hot water	7.00E+01	1.02E+04	1.47E-03	8.44E+01	5.21E+00	6.24E+01	1.60E+05	1.85E+04
Solar system, flat plate collector, one-family house, hot water	9.83E+00	1.33E+03	1.35E-04	8.77E+00	6.24E-01	5.93E+00	2.13E+04	2.55E+03
Solar system, flat plate collector, one-family house, combined system	1.95E+01	2.74E+03	3.52E-04	1.98E+01	1.34E+00	1.39E+01	4.35E+04	5.29E+03

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# Introduction to the software LCABiSTS (under development)



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## GOALS

To assess the benefits resulting from the integration of  
solar thermal systems in buildings



To support designers

What is the environmental and economic cost-benefit relations of these systems and their contribution for the life-cycle of buildings?



### Methodology

#### Environmental performance

- According to ISO 14040 , ISO 14044 and EN 15978

#### Economic performance

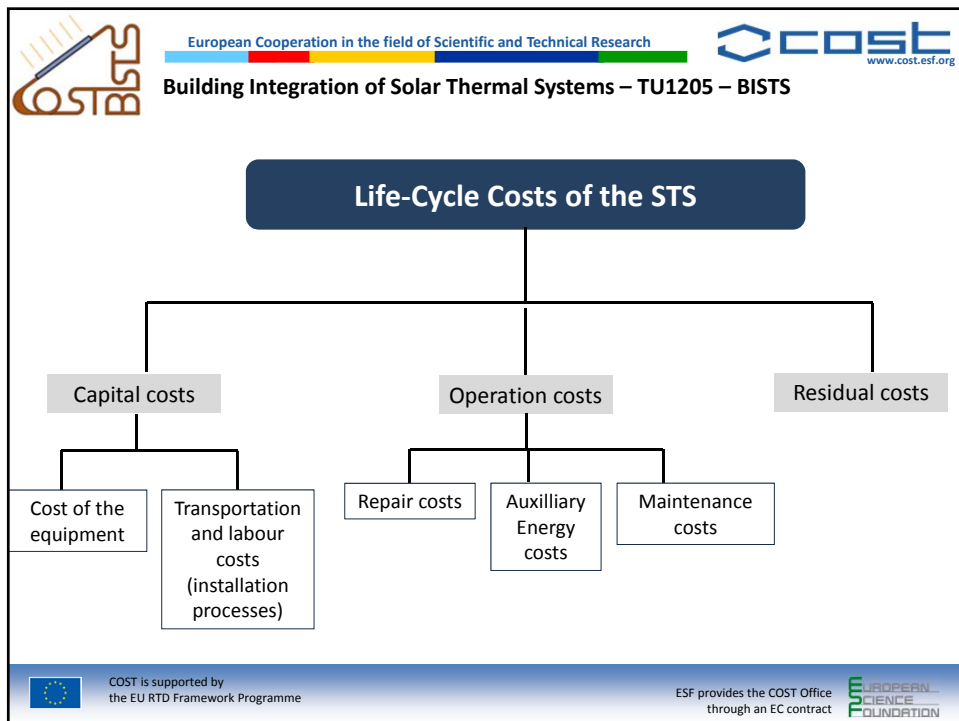
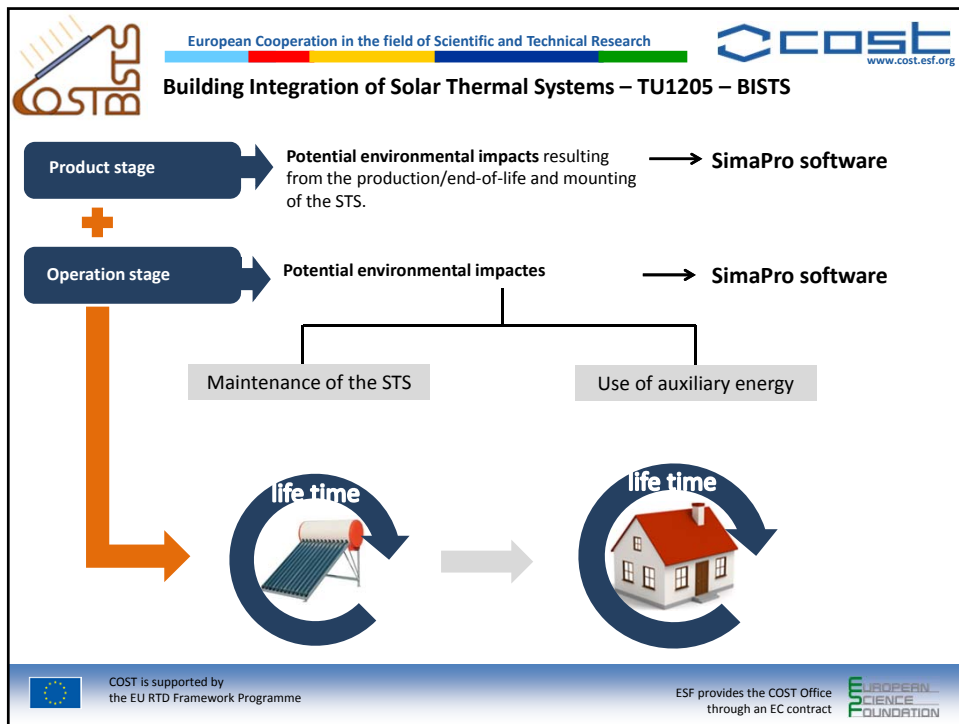
- Payback time and Net Present Value.

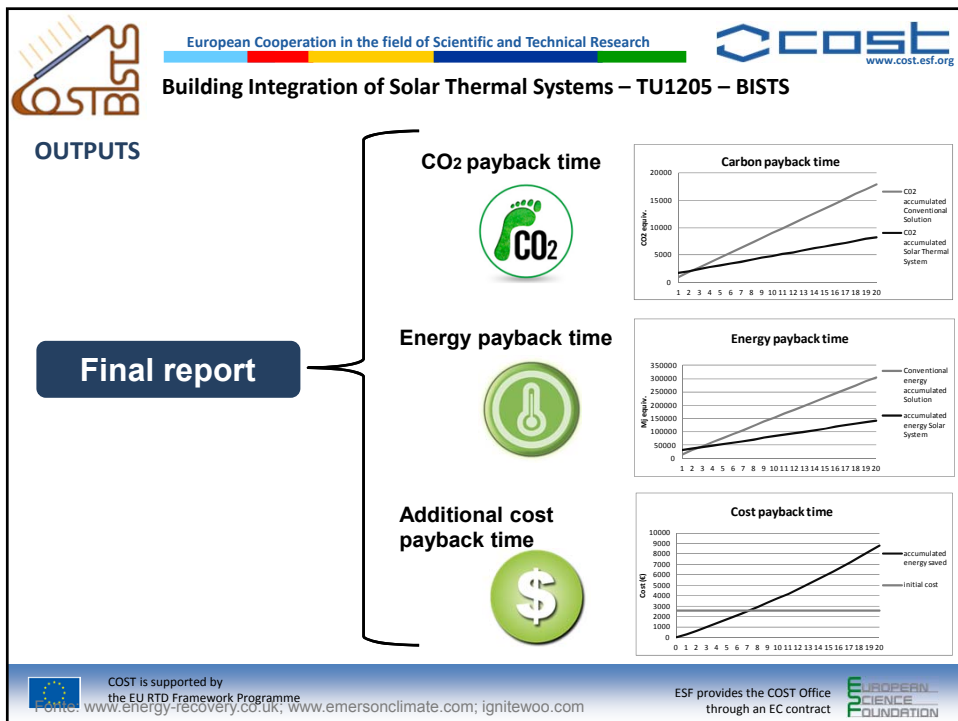
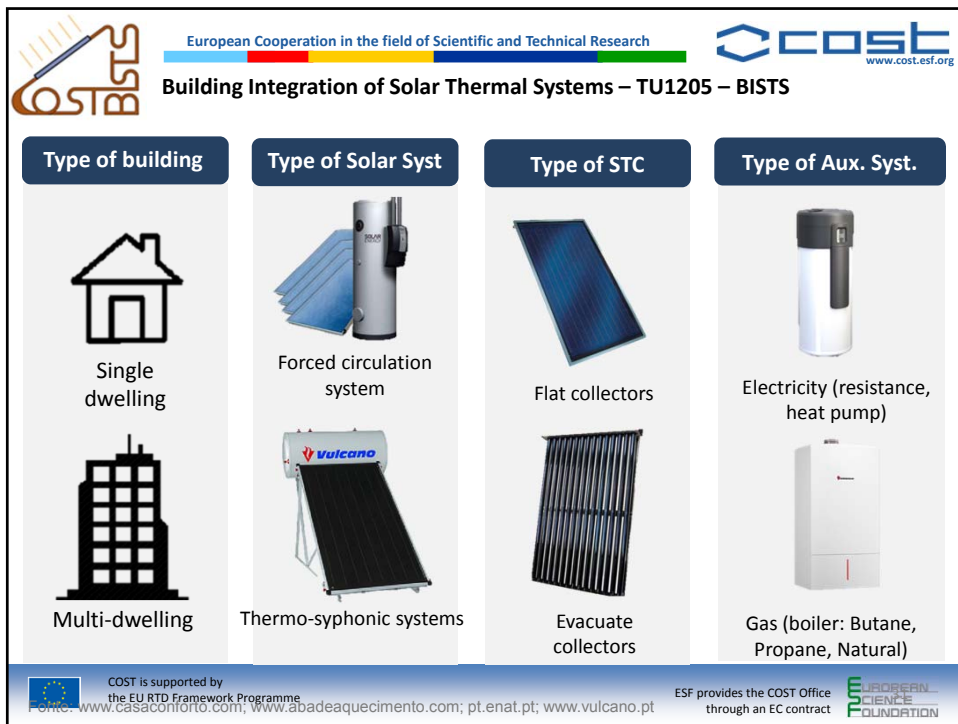


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## **Application to a case study**



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