SEMINAR

Life Cycle Assessment

Is renewable Energy profitable?

20th September 2018

Lucía Serrano Luján

Universidad Rey Juan Carlos

MATENER2018

ICMAB INSTITUT DE CIÈNCIA DE MATERIALS DE BARCELONA

EXCELENCIA SEVERO OCHOA

Index

- How does LCA assess products´ profitability?
  - What LCA is
  - LCA Indicators

- LCA: The great picture
  - ISO definition
    - Goal and scope
    - Inventory
    - Impacts assessment

Large scale?
Low cost?

Life Cycle Assessment


Silicio purificado
Proceso de crisol y estirado con germen de boro
Recorte del lingote
Corte en "obleas"
Difusión de fósforo
Texturizado
Serigrafía
Célula solar
Conexionado de células
Laminado
Montaje del marco
Módulo fotovoltaico

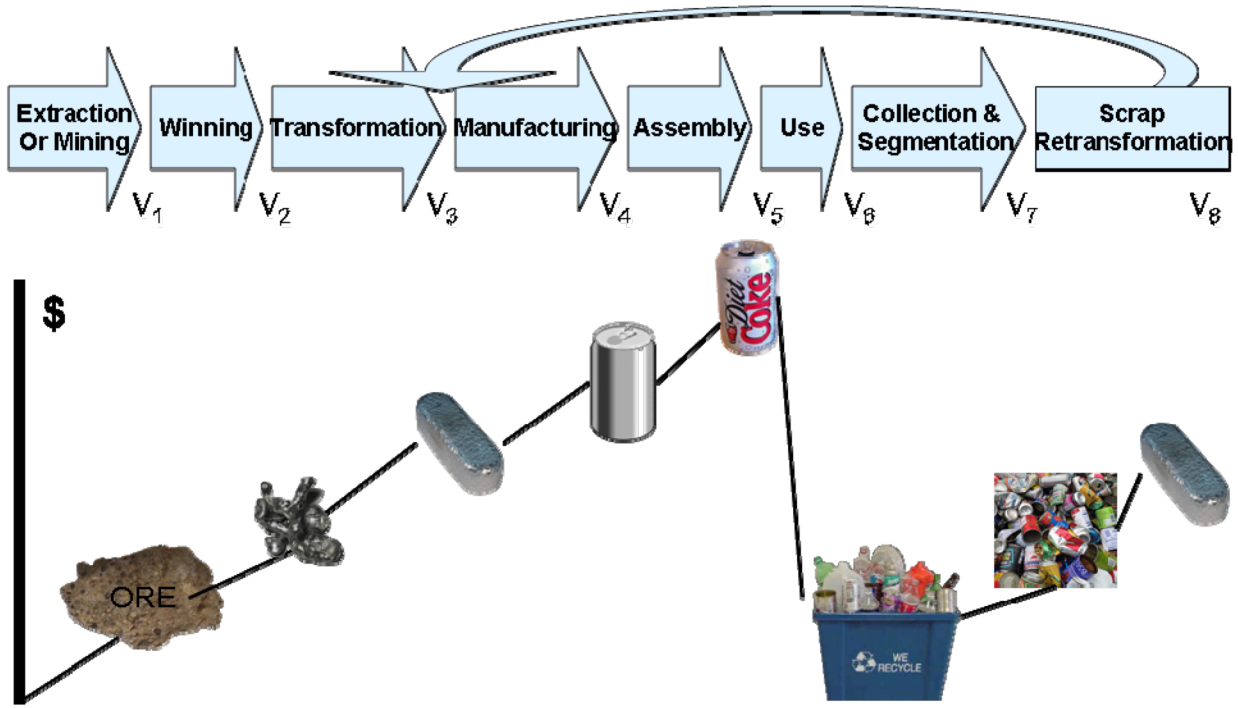
Is it possible assessing the value of a product or service with no link to….

..country,

..coin,

.. politics?

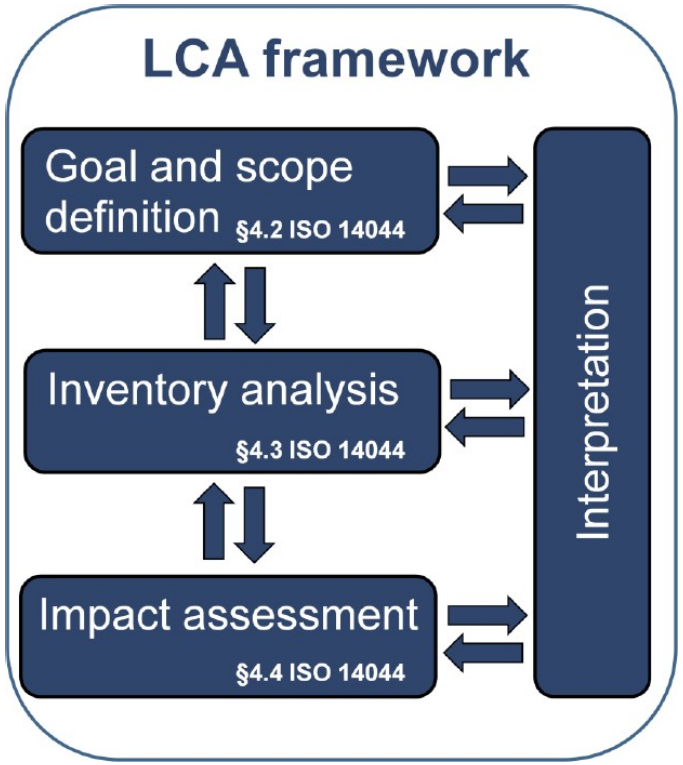
How can we calculate the overall cost?

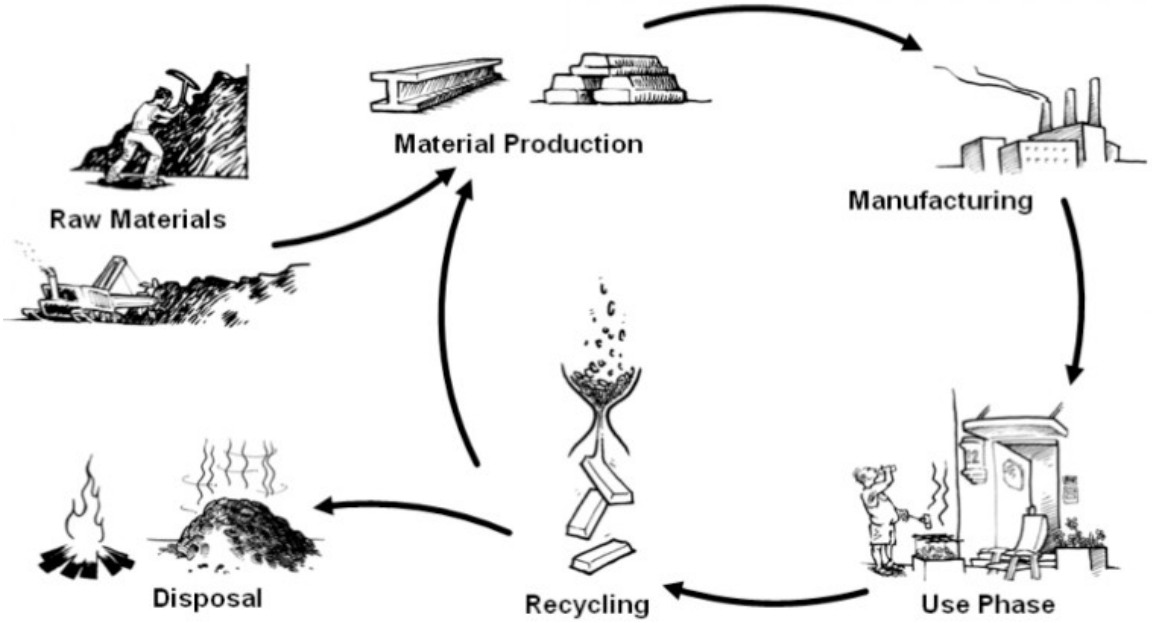


Embodied energy in the product as cost estimation. http://dx.doi.org/10.1109/ISSST.2009.5156777

What is Life Cycle Assessment or LCA?

- ISO 14040 series





CRADLE TO GRAVE ANALYSIS

It quantifies all relevant emissions and resources consumed and the related environmental and health impacts and resource depletion issues that are associated with any goods or services.

Life Cycle Analysis

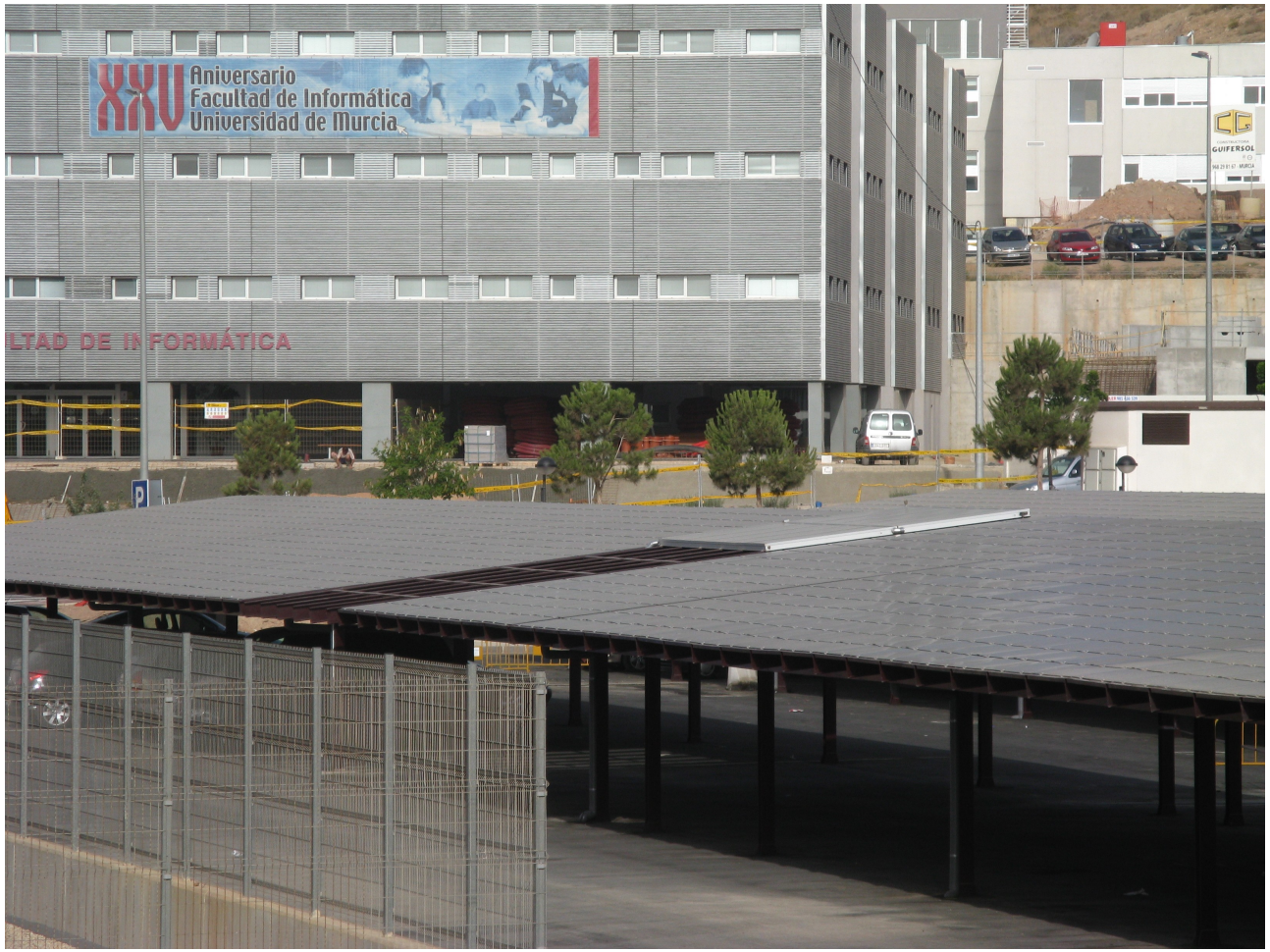
EMBODIED ENERGY?

ENERGY PAYBACK TIME?

Environmental benefits of parking--integrated photovoltaics: a 222 kWp experience

L. Serrano--Luján, R. García--Valverde, N. Espinosa, M. S. García--Cascales, J.M. Sánchez--Lozano, A. Urbina, Prog. Photovolt: Res. Appl. ***2015****, 23, 253.*

LCA applied to 222kWp Photovoltaic Generator

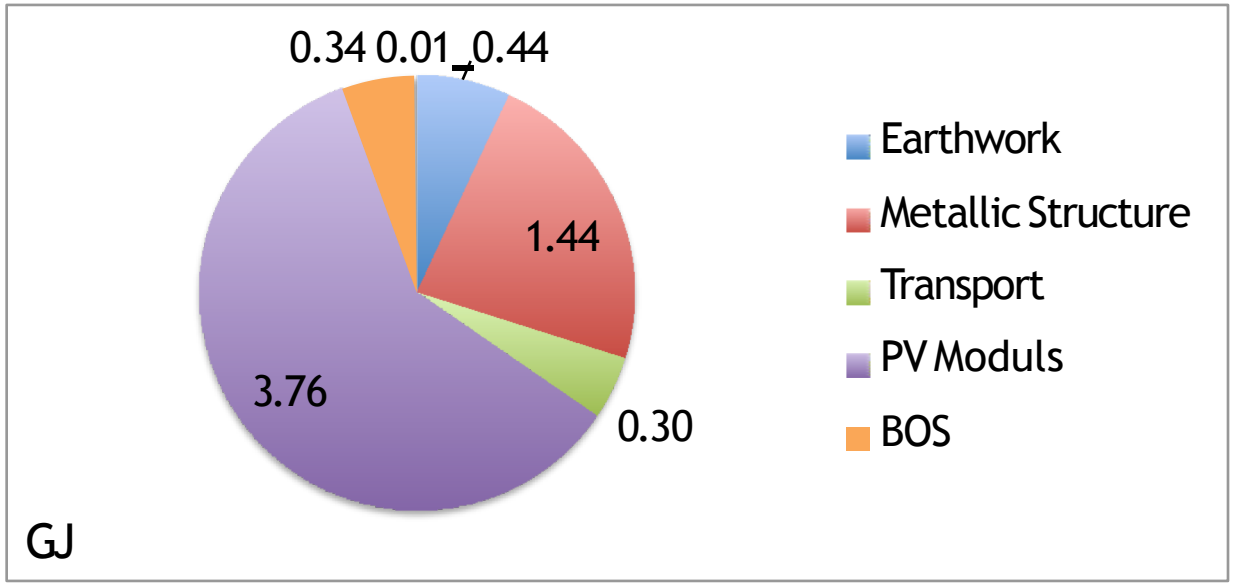


222 kWp

3144 CdTe modules

7º tilted

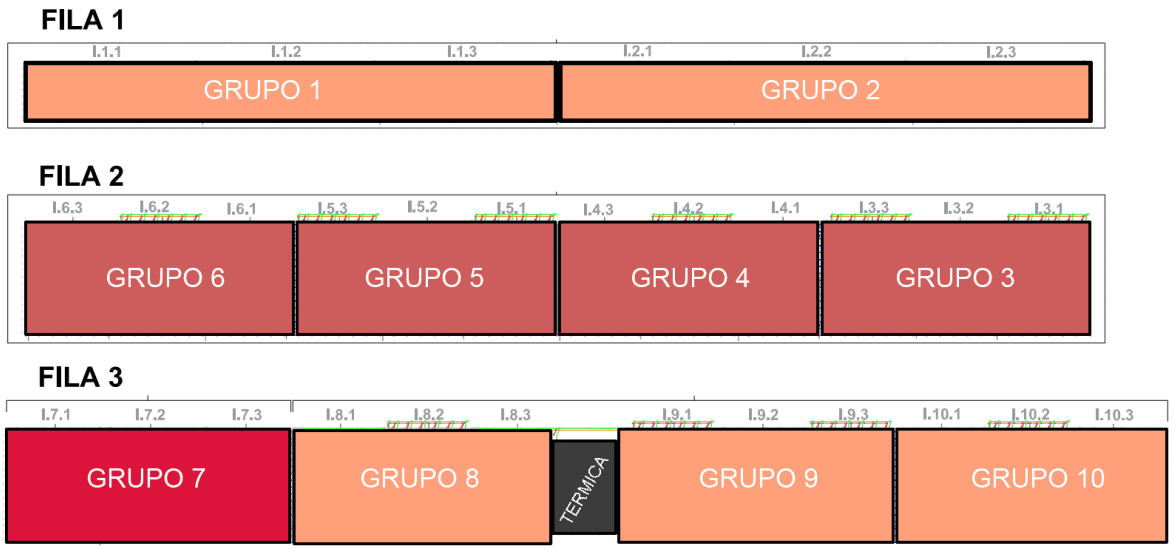
LCA applied to 222kWp Photovoltaic Generator

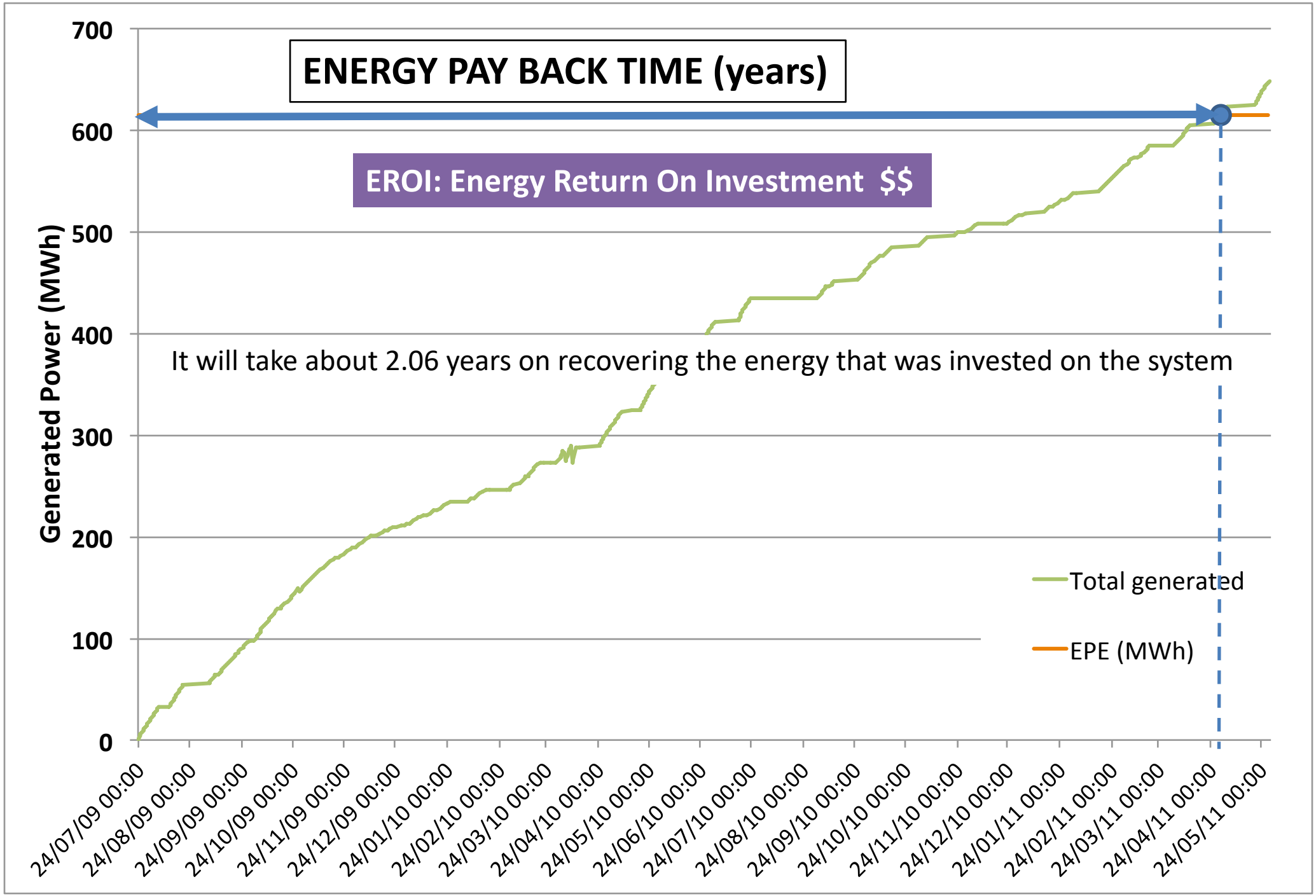


TOTAL EMBEDDED ENERGY: 6.31 GJ

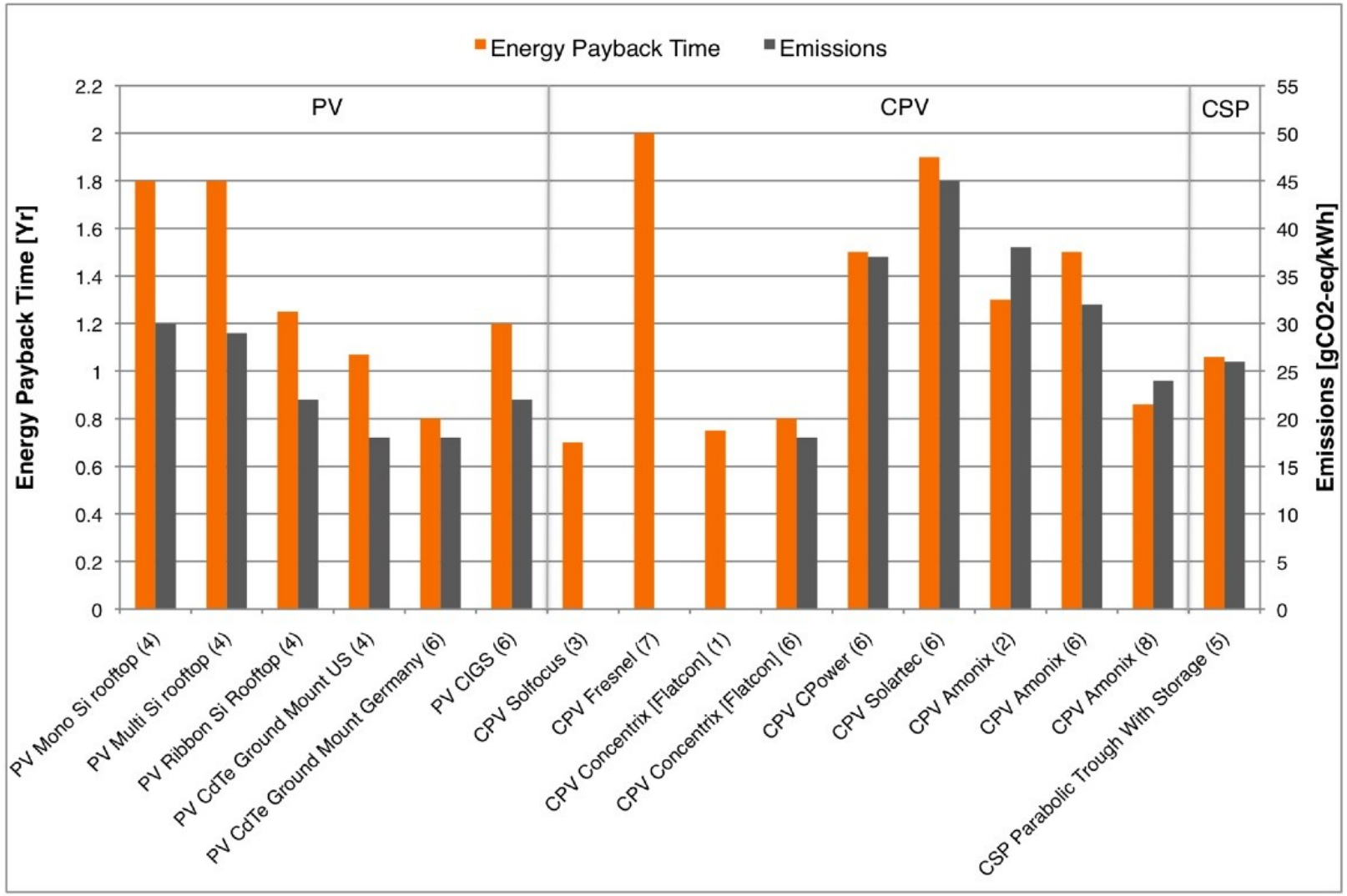
LCA applied to 222kWp Photovoltaic Generator

Monitoring system




ENERGY PAY BACK TIME (years)
EROI: Energy Return On Investment $$
It will take about 2.06 years on recovering the energy that was invested on the system
Generated Power (MWh)
700
600
500
400
300
200
100
0
Total generated
EPE (MWh)
24/07/09 00:00
24/08/09 00:00
24/09/09 00:00
24/10/09 00:00
24/11/09 00:00
24/12/09 00:00
24/01/10 00:00
24/02/10 00:00
24/03/10 00:00
24/04/10 00:00
24/05/10 00:00
24/06/10 00:00
24/07/10 00:00
24/08/10 00:00
24/09/10 00:00
24/10/10 00:00
24/11/10 00:00
24/12/10 00:00
24/01/11 00:00
24/02/11 00:00
24/03/11 00:00
24/04/11 00:00
24/05/11 00:00

Energy Payback Time and GHG Emissions



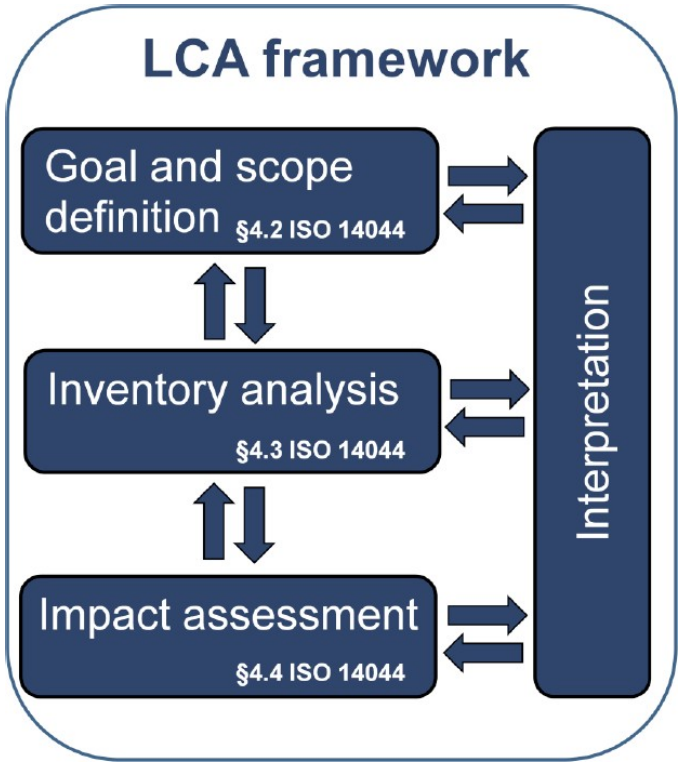
Source: www.greentechmedia.com

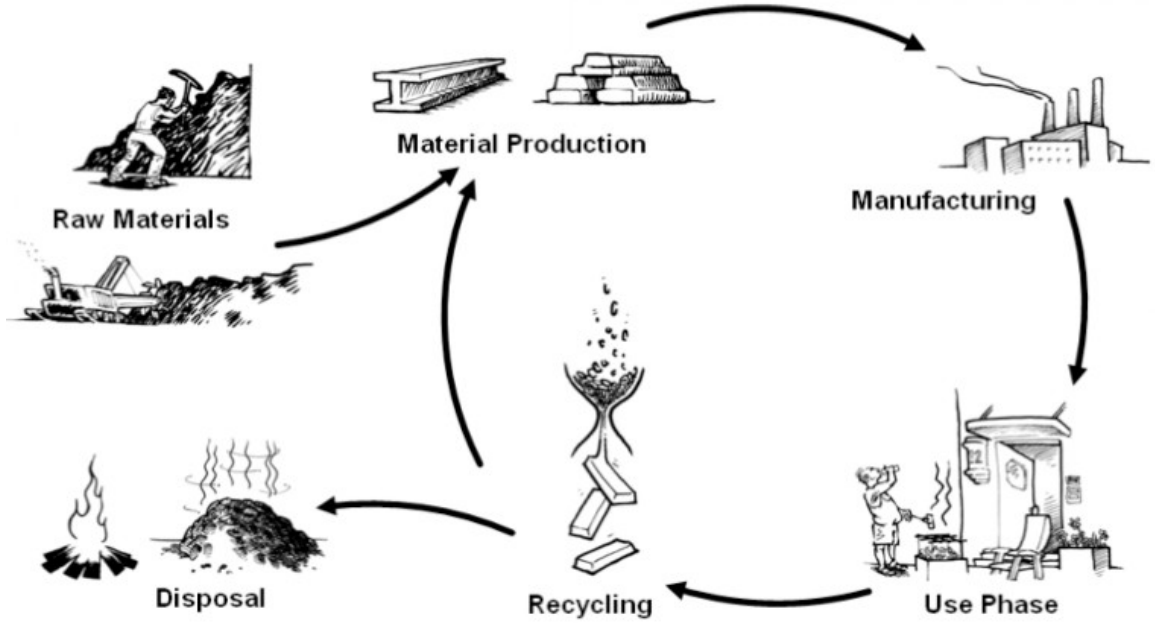
LCA
Concept

https://www.youtube.com/watch?v=eg-E1FtjaxY

What is Life Cycle Assessment or LCA?

- ISO 14040 series

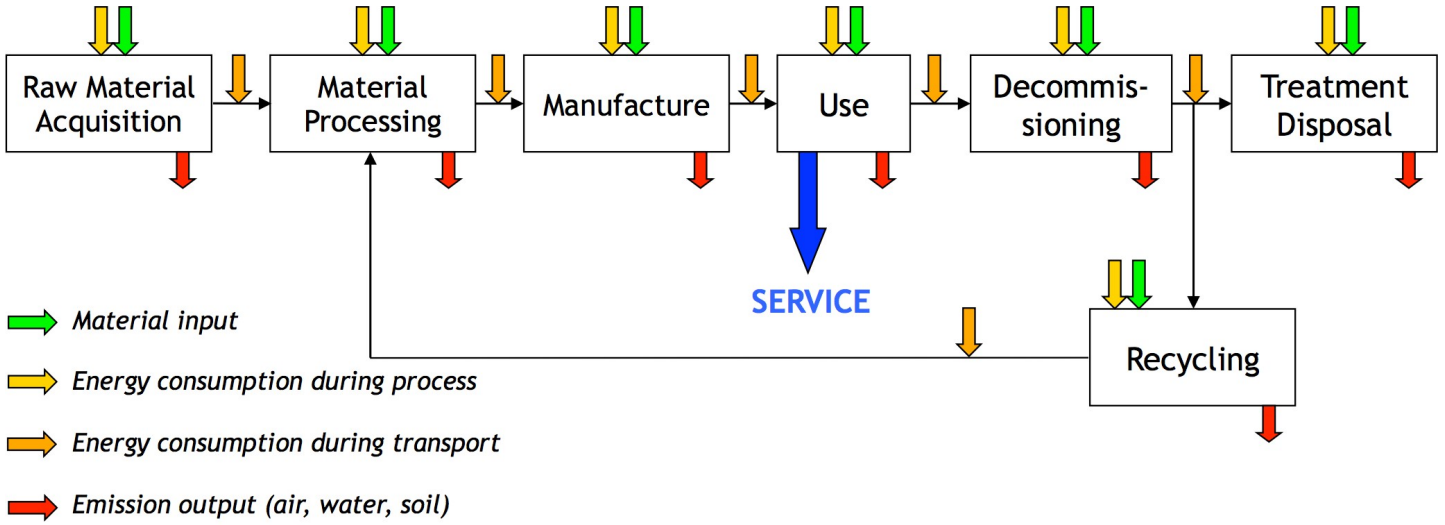


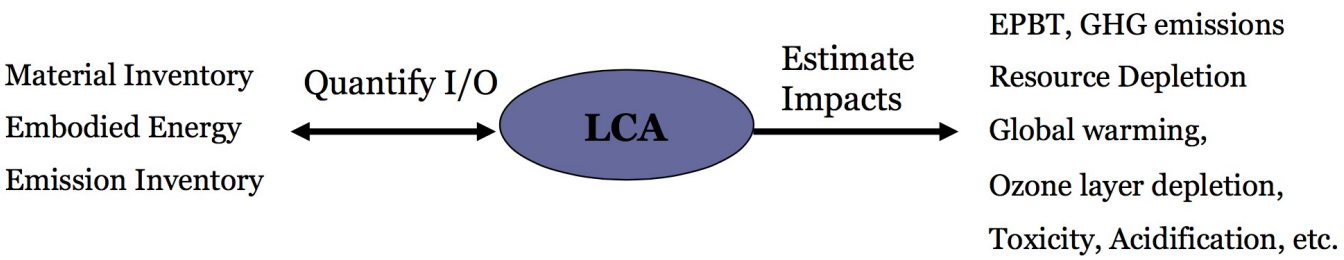


CRADLE TO GRAVE ANALYSIS

It quantifies all relevant emissions and resources consumed and the related environmental and health impacts and resource depletion issues that are associated with any goods or services.

Definition


Raw Material Acquisition
Material Processing
Manufacture
Use
Decommis-sioning
Treatment Disposal
SERVICE
Recycling
Material input
Energy consumption during process
Energy consumption during transport
Emission output (air, water, soil)


Material Inventory
Embodied Energy
Emission Inventory
Quantify I/O
LCA
Estimate Impacts
EPBT, GHG emissions
Resource Depletion
Global warming,
Ozone layer depletion,
Toxicity, Acidification, etc.

Applications

- Planning environmental strategies
- Development and improvement of products
- Marketing (*Ecolabelling*)
- Products and services comparisons
- Assessment of legal commitment
- Selection of environmental indicators and measurements techniques

Who uses LCA?

- **Industry:** environmental picture. Industrial associations, such as Canadian Wood Council, International Copper Association, International Lead and Zinc Research Organization, International Iron and Steel Institute; International Aluminium Institute and the Nickel Development Institute, PlasticsEurope – http://lca.plasticseurope.org--
- **Governments:** development of environmental politics
- **Universities:** I+D in LCA methodologies and data

Applications

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Applications

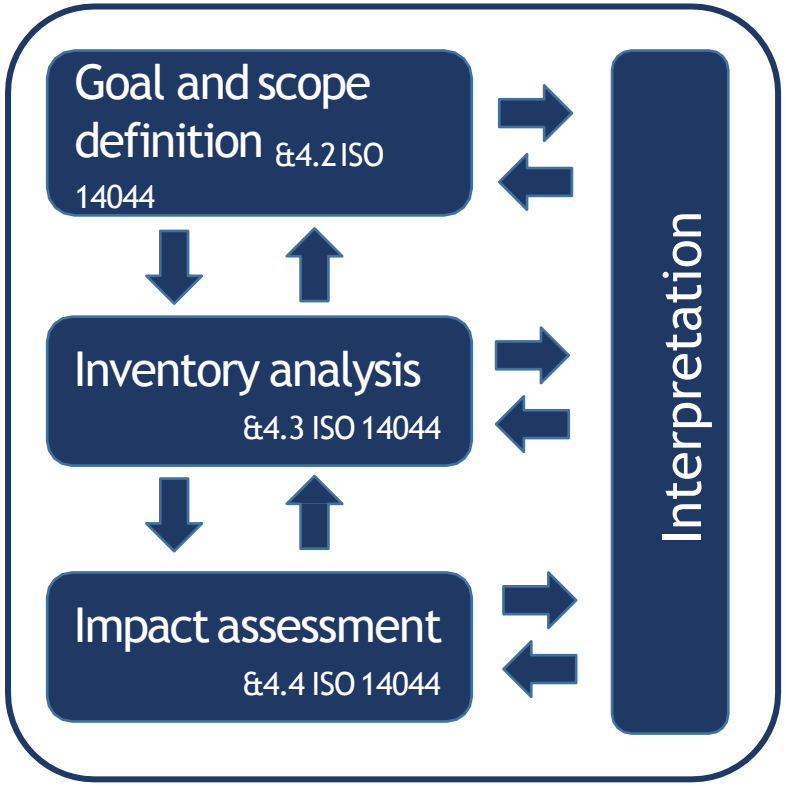
There are many marketing applications, but…

- How can we assess it?
- What do “green”, “ecofriendly”, “organic” mean?
- How do we measure it?


www.toyota.co.il
TOYOTA
Min. Emission
Max. Emission
PRIUS
Min. Emission
Max. Emission
Today
Tomorrow
Toyota

Methodology

- ISO 14044 series

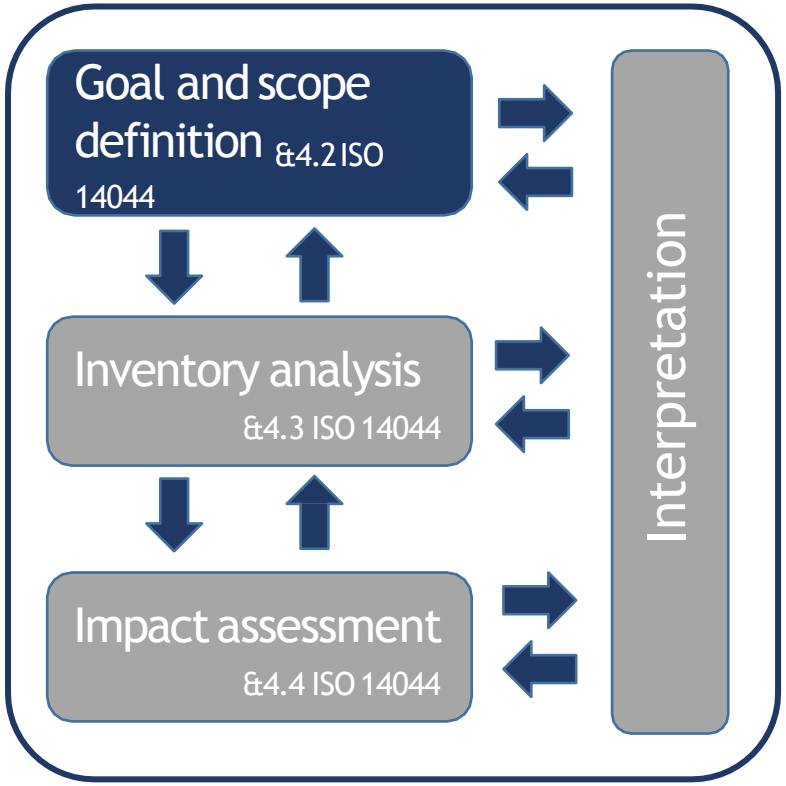


Direct applications:

- Development and improvement of products
- Strategical planning
- Marketing
- Environmental legislation

Methodology

1. Goal and Scope

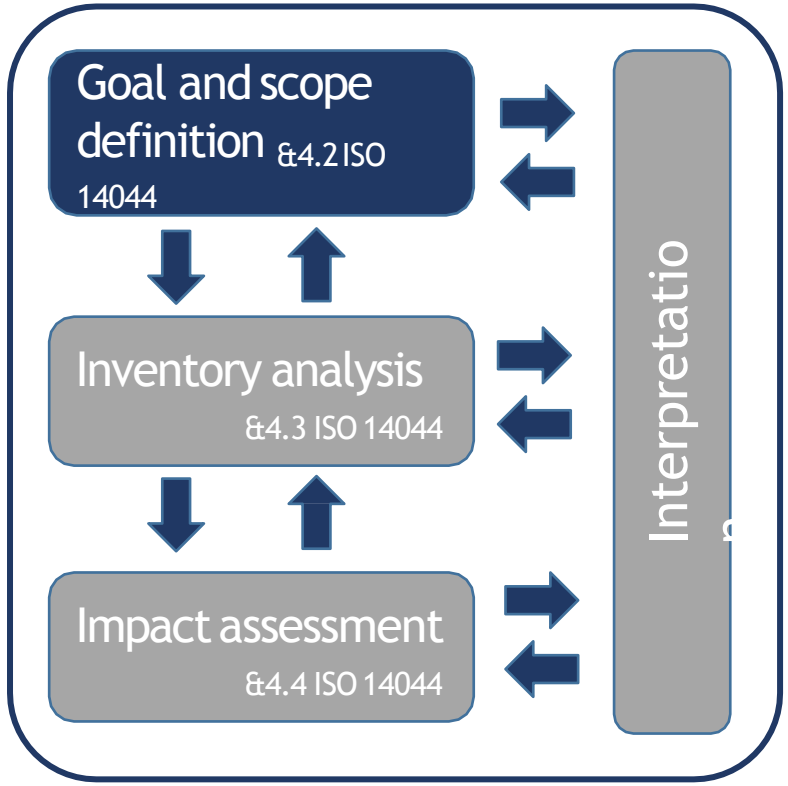


1.1 Goal

- Application: marketing, development and improvement of products, etc.
- Goal: scientific publication, intern report, private report.
- Audience: engineers, executives, customers, etc.
- Comparative analysis?

Methodology

1. Goal and Scope



1.2 Scope

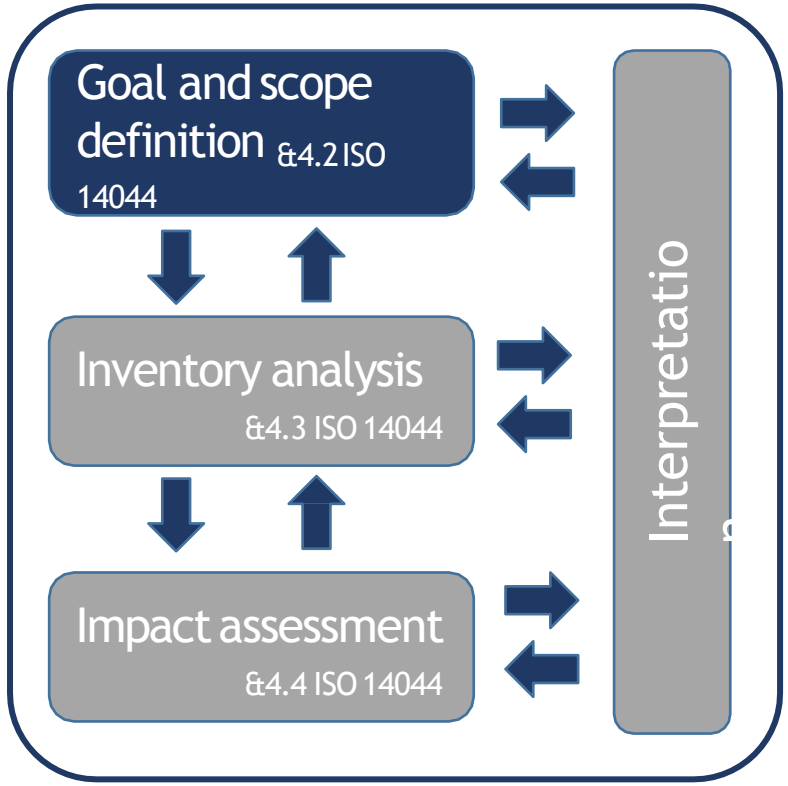
- *Product application*
- *Functional Unit*
- *Reference flow*

- System description
- *System boundaries*
- *Allocation*

- Impact categories and impacts assessment methods
- *Data (requirement - quantity and quality)*

Methodology

1. Goal and Scope



1.2 Scope

- *Functional Unit (FU)*

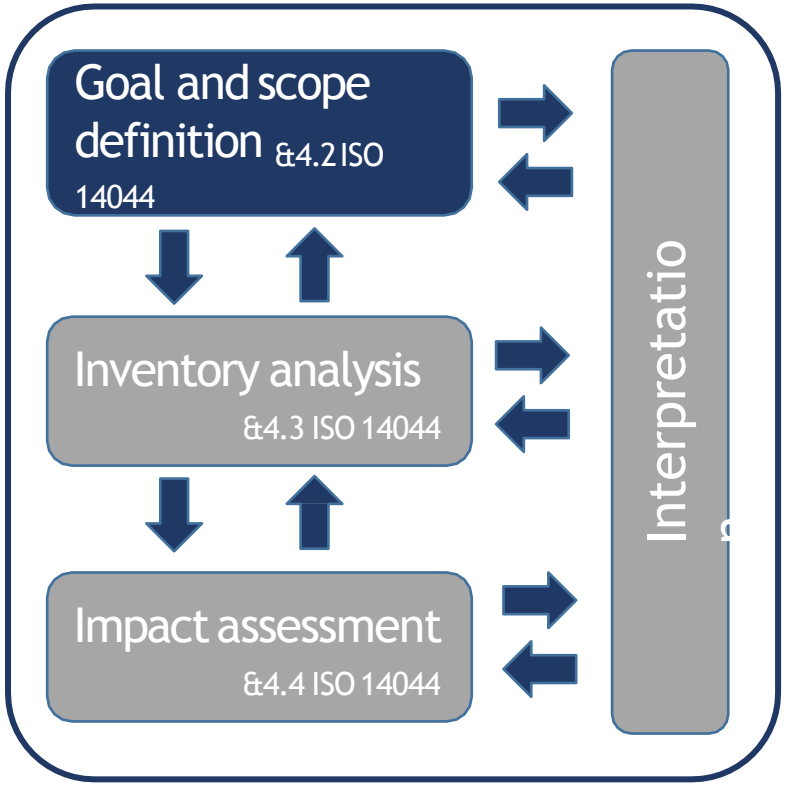
It names and quantifies the qualitative and quantitative aspects of the function(s) along the questions "what", "how much", "how well", and "for how long".

E.g. Complete coverage of 1 m2 primed outdoor wall for 10 years at 99.9 % opacity

When comparing two products the FU should be equivalent.

Methodology

1. Goal and Scope



1.2 Scope

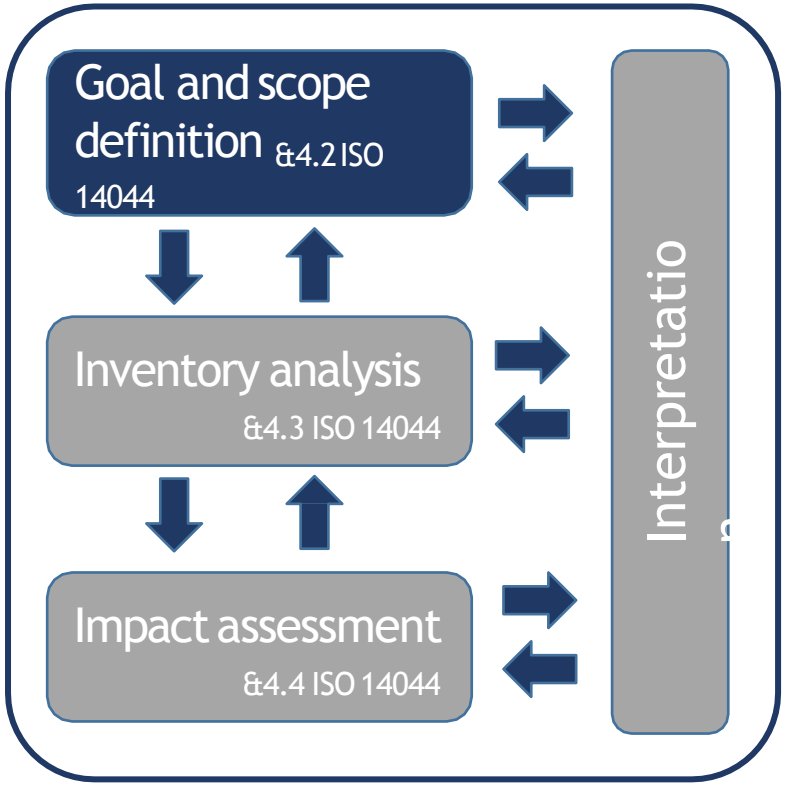
- *Reference flow*

It is the flow (or flows in case of multifunctional processes) to which all other input and output flows (i.e. all elementary flows and non–reference product and waste flows) quantitatively relate.

All data have to be scaled to this flow.

Methodology

1. Goal and Scope

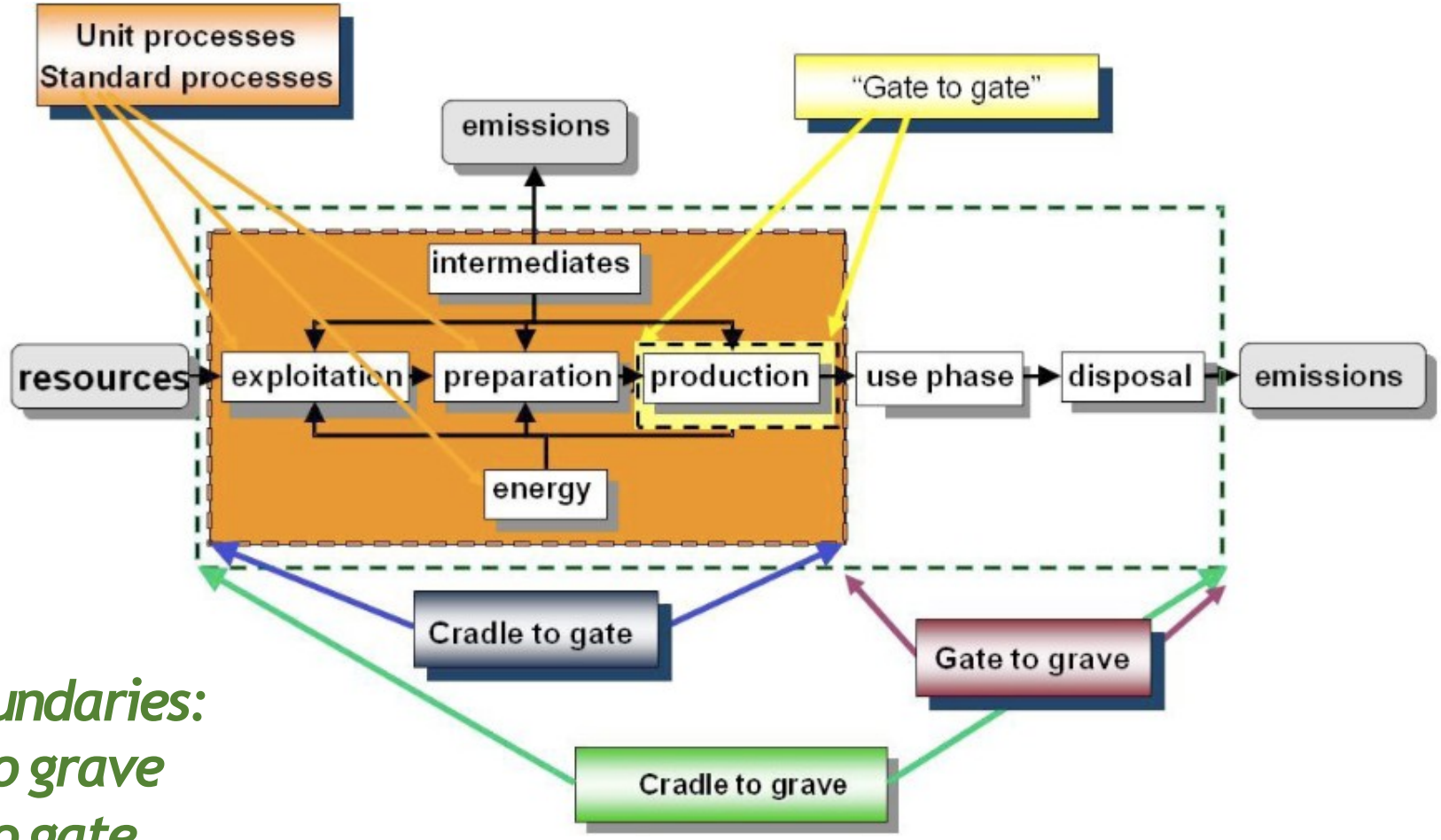


1.2 Scope

- *System boundaries*

The *cut-off criteria* are defined: it refers to the omission of not relevant life cycle stages, activity types, specific processes and products and elementary flows from the system model.

e.g. "95 %" relates to cutting off about 5 % of the total environmental impact (or of a selected impact category)

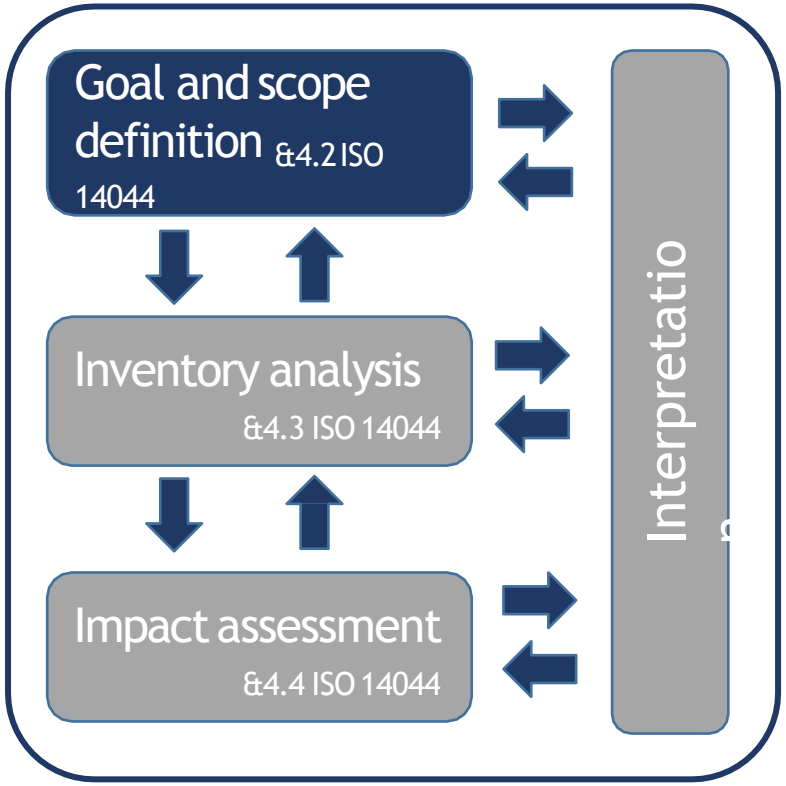


System boundaries:

- *Cradle to grave*
- *Cradle to gate*
- *Gate to grave*
- *Gate to gate*

Methodology

1. Goal and Scope



1.2 Scope

- *Data (quality requirements)*

Previous description of data quality:

Data acquisition:
- Calculated, measured or estimated.
- % primary/secondary data

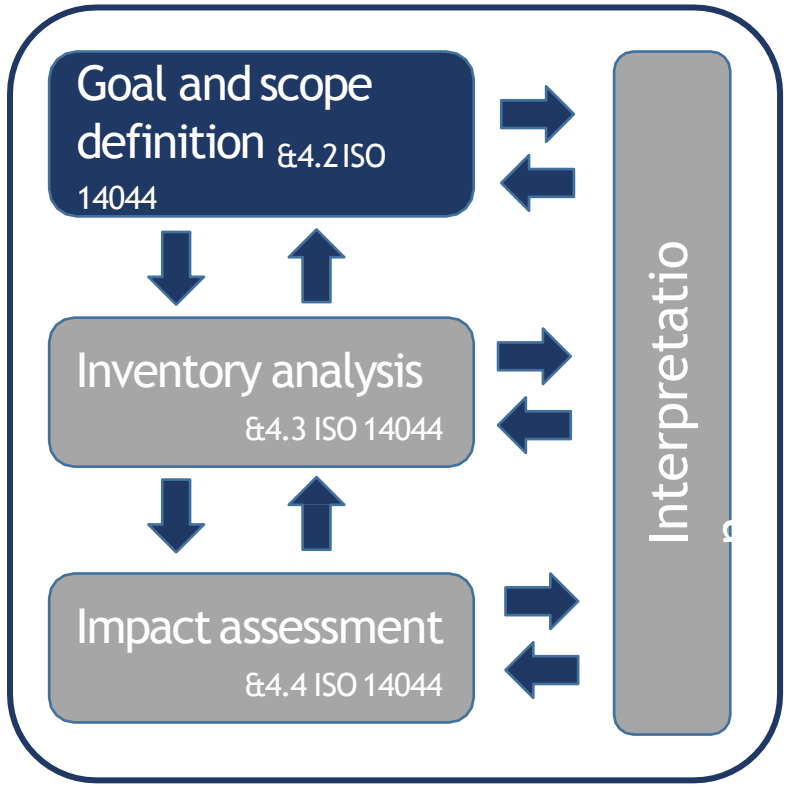
Temporal reference: When the data were obtained.

Geographical reference: for which region or country the data are relevant.

Technology: Are the secondary data based on old technology?

Methodology

1. Goal and Scope



1.2 Scope

- *Data (quality requirements)*

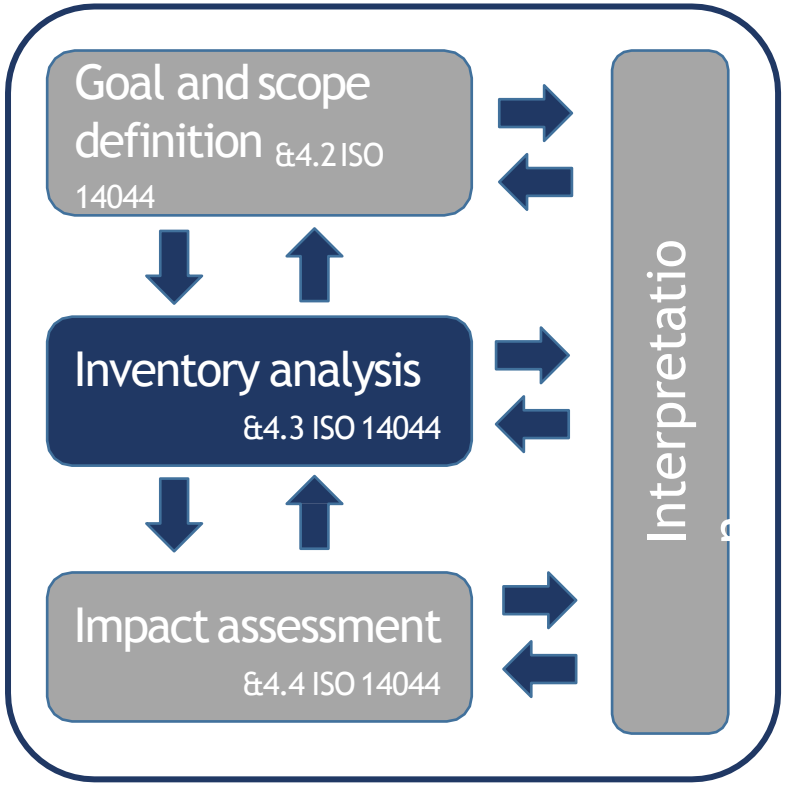
Precision: Which is the precision data is presented?

Completeness: Are there some data missed?

Representativeness, consistency and reproducibility.

Methodology

2. Inventory Analysis

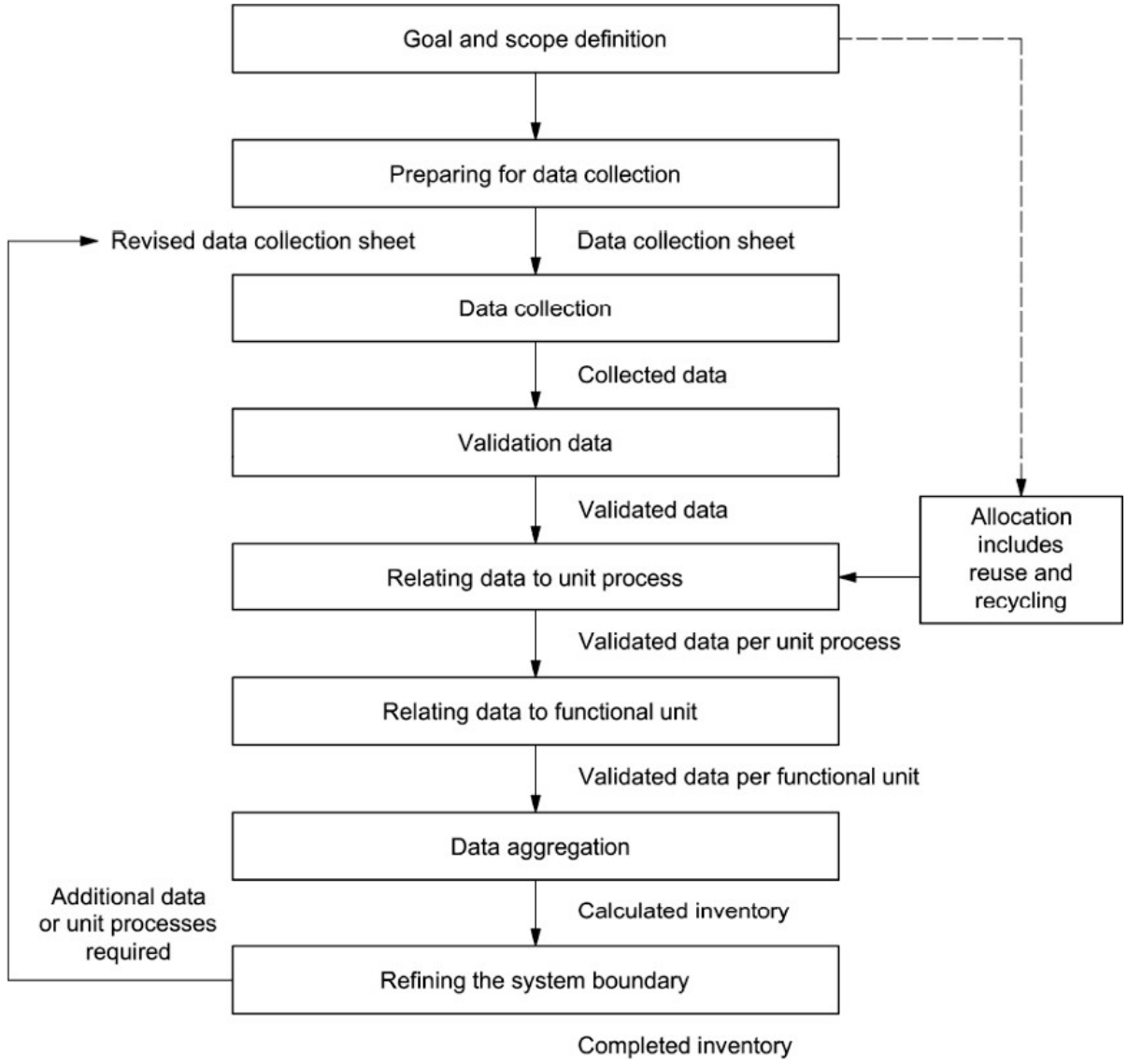


Compilation and quantification of the life cycle I/O of the product or one of its processes (ISO 14041)

It includes:

1. Data compilation
2. Life Cycle Inventory tables development

Data collection and calculation process



Databases to develop the LCI

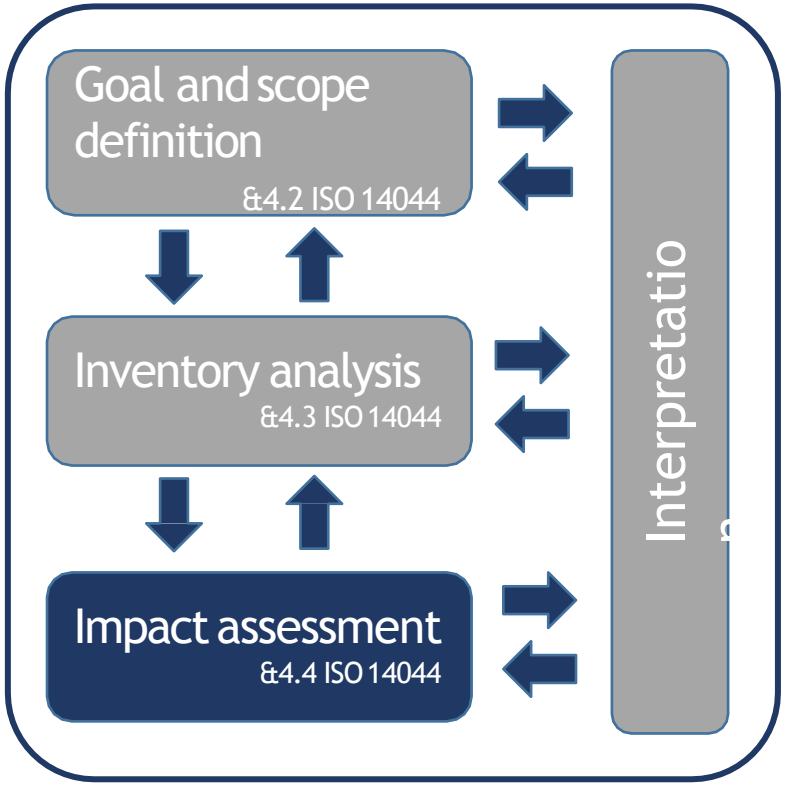
- **Ecoinvent** database. One of the most used worldwide (http://www.ecoinvent.org)
- **Energy research Centre of the Netherlands (ECN). (https://www.ecn.nl)**
- **Center for Environmental Assessment of Product and Material Systems** http://www.cpm.chalmers.se/CPMDatabase/Start.asp
- **US LCI database**
- **US Input Output database**
- **Dutch Input Output database**
- **Danish input Output database**
- **LCA food database**
- **Industry data**
- **Japanese Input Output database**
- **IVAM**

LCI Journals

- The International Journal of Life CycleAssessment.
- Journal of Life Cycle Assessment, Japan.
- Journal of Industrial Ecology.
- Energy and Environmental Science
- Renewable energy journals:
  - Solar Energy
  - Solar Energy Materials and solar cells
  - Renewable Sustainable Energy Review
  - Energy
  - Energy Policy
- **Nature Sustainability**

Methodology

3. Life Cycle Impact Assessment



Life Cycle Impact Assessment (LCIA) is the phase in an LCA where the inputs and outputs of elementary flows that have been collected and reported in the inventory are translated into impact indicator results related to human health, natural environment, and resource depletion.

The inputs and outputs are **classified** into impact categories and its potential impacts are **quantified** by applying *characterization factors*.

Methodology

3. Life Cycle Impact Assessment

Impact analysis methodologies

1. Problem oriented or mid point. *Global warming potential or ozone layer depletion (Such as TRACI or CML)*
2. Damaged--oriented or end point. *Damage to human health, damage to ecosystem quality or damage to resources, etc. (For instance EcoIndicator 99)*

Methodology

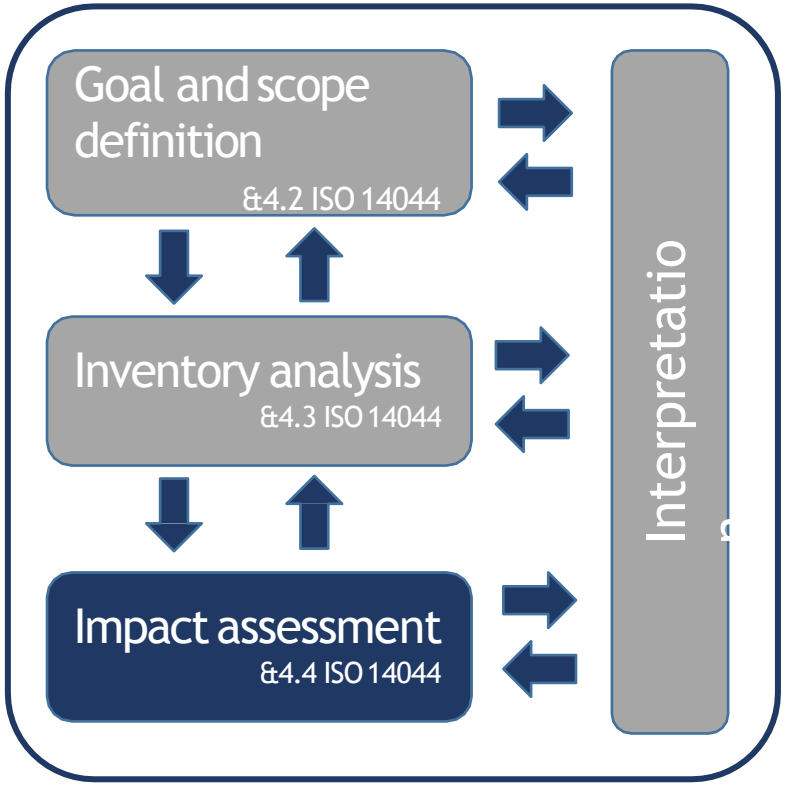
3. Life Cycle Impact Assessment

Some common environmental impact categories (problem oriented) according to LCAFood:

- **Global warming** is a warming of the atmosphere, which causes climate changes. Some of the biggest human contributors to global warming are the combustion of fossil fuels like oil, coal and natural gas. Global warming potential are in the LCAFood database presented in g CO2--equivalents.
- **Acidification** is caused by acids and compounds which can be converted into acids that contributes to death of fish and forests, damage on buildings etc. The most significant man made sources of acidification are combustion processes in electricity and heating production, and transport. Acidification potentials are in the LCAFood database presented in g SO2-- equivalents.
- **Eutrophication** also called nutrient enrichment causes algal bloom in inlets and springs causing oxygen depletion and death of fish. Emissions of nitrogen to the aquatic environment, especially fertilizers from agriculture contribute to eutrophication. Also oxides of nitrogen from combustion processes are of significance. Eutrophication potentials are in the LCAFood database presented in g NO3-- equivalents.
- **Photochemical smog** formation occurs when Volatile Organic Compounds (VOC's) are released in the atmosphere and oxidized in the presence of oxides of nitrogen (NOx). The most significant VOC's emissions from unburnt petrol and diesel and the use of organic solvents, like paints. Photochemical smog attacks organic compounds in plants, animals and materials exposed to air, causing problems in the respiratory tract in humans. For agriculture it causes a reduction in yield. Photochemical smog formation potentials are in the LCAFood database presented in g ethane equivalents.
- **Ozone depletion**: Stratospheric ozone is broken down as a consequence of man--made emissions of halocarbons (CFC's, HCFC's, haloes, chlorine, bromine etc.). The ozone content of the stratosphere is therefore decreasing and thinning of ozone layer, often referred to as the ozone hole. The consequences are increased frequency of skin cancer in humans and damage to the plants.
- **Land use**: Area of land used in the production of a product, for example agricultural land. Land use is presented in hectare year (ha*yr) or in m2* yr.

Methodology

3. Life Cycle Impact Assessment



Life Cycle Impact Assessment (LCIA) elements

Compulsory:

1. Selection of impact categories
2. Classification
3. Characterization

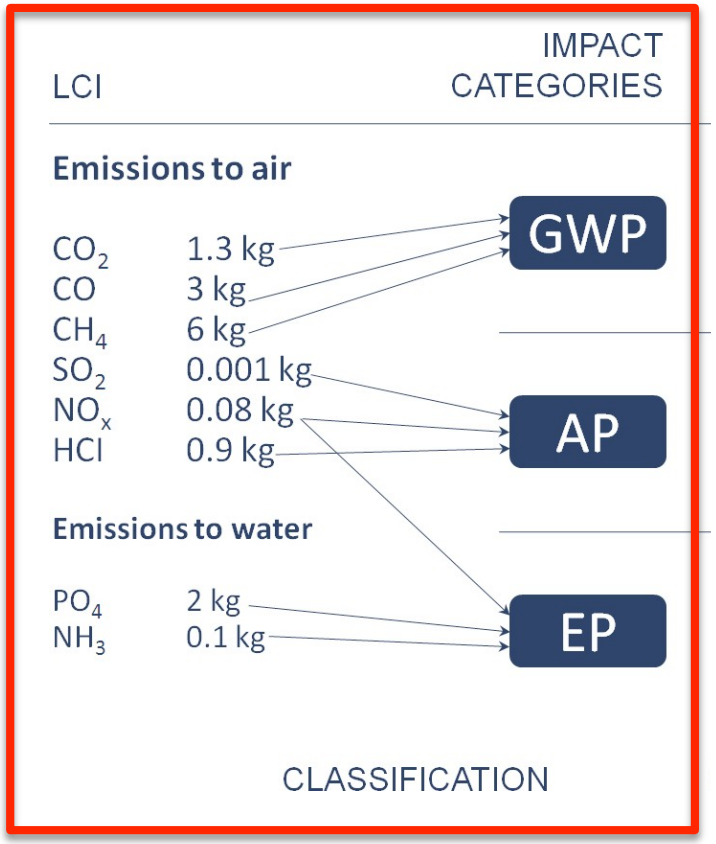
Optional:

- Normalization
- Grouping
- Weighting

Methodology

3. Life Cycle Impact Assessment

Inputs and outputs are classified into impact categories

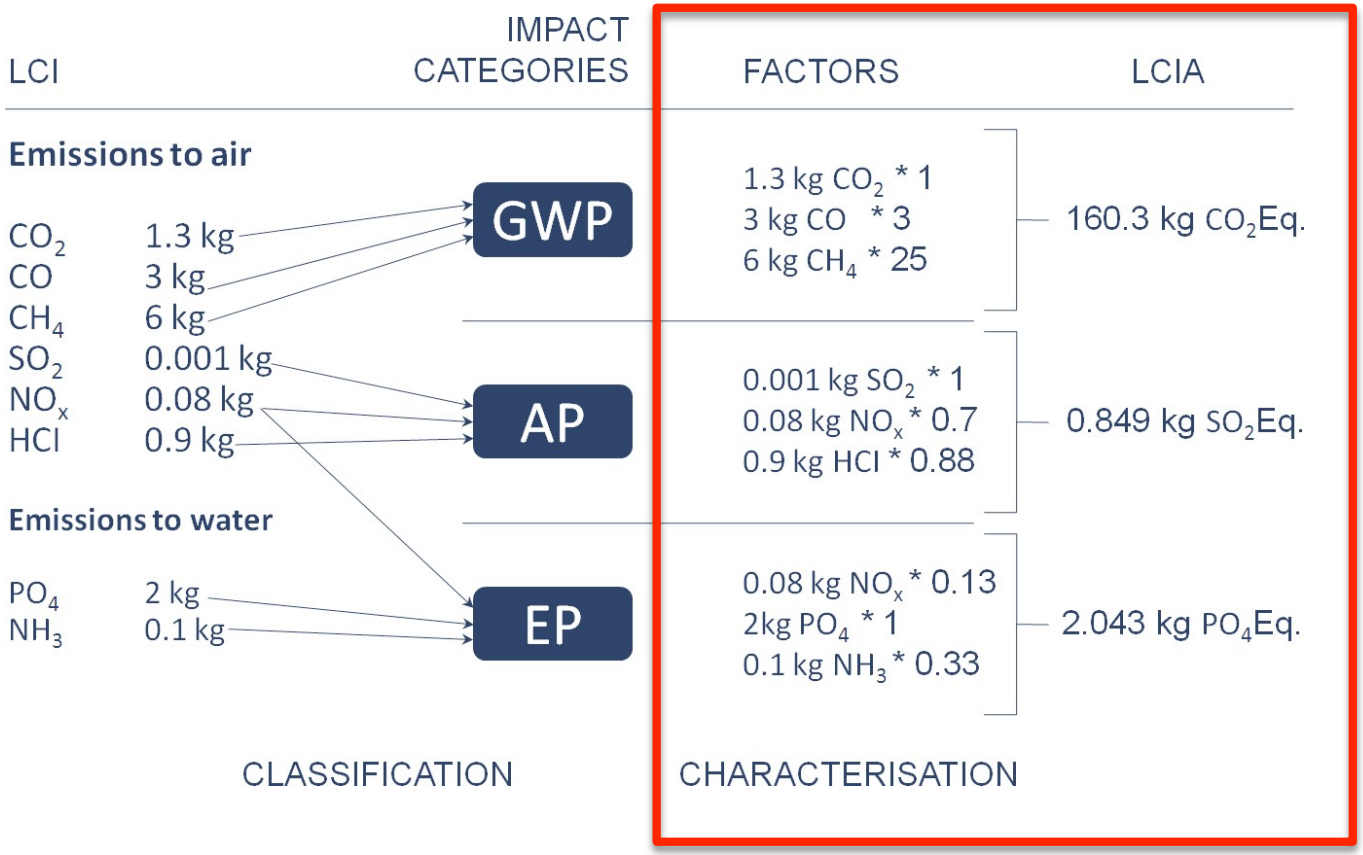


- Global Warming Potential
- Acidification Potential
- Eutrophication Potential

Methodology

3. Life Cycle Impact Assessment

Its potential impacts are quantified by the characterization factors.



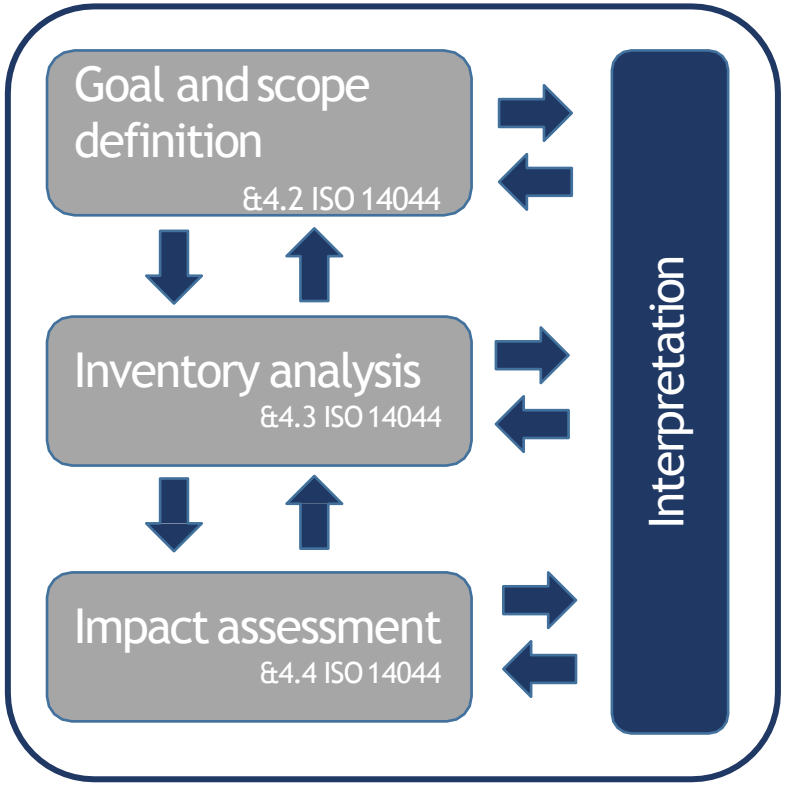
Global Warming Potential

Acidification Potential

Eutrophication Potential

Methodology

4. Interpretation



Identification of relevant aspects

- Inventories: energy consumption, material flows, residues, emissions, etc.
- Impact category indicators
- Relevant contributions per process unit or process group (Transport, thermic process, etc.)

Evaluation

- Revision of incomplete data
- Revision of sensibility (uncertainties in data, assumptions, etc.)
- Revision of consistency (results and methods)

Conclusions and reports

ISO 14044 (Basic elements of reference report)

1. Administrative Information
   a) Name and Address of LCA Practitioner (who conducted the LCA study)
   b) Date of Report
   c) Other Contact Information or Release Information
2. Definition of Goal and Scope
3. Life Cycle Inventory Analysis (data collection, calculation procedures, LCI table)
4. Life Cycle Impact Assessment (methodology, results)
5. Life Cycle Interpretation
   a) Results
   b) Assumptions and Limitations
   c) Data Quality Assessment
6. Critical Review (internal and external)
   a) Name and Affiliation of Reviewers
   b) Critical Review Reports
   c) Responses to Recommendations

LCA tools

- Excel (limited, cheap)
- SimaPro (Licence, http://www.pre.nl)
- Gabi Software (Licence, http://www.gabi--software.com)
- Umberto (Licence, http://www.umberto.de/en/)
- OpenLCA (http://www.openlca.org)

Thank you for your attention

QUESTIONS?

Lucia.serrano@urjc.es