CO2olBricks

Life Cycle Analysis of a Building

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LCA Definitions

Life-cycle analysis – evaluation of product's (or system's) direct and indirect influence over environment and society during all stages of it's existence: production, installation ,exploitation and destruction.

Life-cycle assessment – evaluation of factors established during the process of life-cycle analysis, using economic or multi-criteria analysis methods due to different types of elements set by existing political force.

Life-cycle analysis – is the **method** which includes stages of actions evaluating possible actions and interpreting results due to an influence of a product or a process to a raw material, energy and environment in a period of their existence ("from-cradle-to-grave"). On the ground of this description, common proposition of LCA – possibility of raw material second use.

The main **principle** of LCA – all products turn waste.

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Establishment and Application of LCA

The principle of LCA – net energy analysis, which developed in1970-1980;

Coca Cola company was the first to perform the analysis of their production (beverage containers) applying LCA principle in 1969;

The first ISO standards, describing LCA methodology in1997-2000;

Directive 2005/32/EB of the European Parliament and of the Council establishing a framework for the setting of ecodesign Requirements for Energy-using Products.

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LCA Principles

Why life (existence) cycle?

The answer:

Law of energy conservation

“Energy does not appear from nowhere and does not disappear and one form of energy can turn or be turned into another form of energy”

The main indexes currently used while performing LCA – primary energy and discharge.

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Life Cycle Phases

System's life cycle is described by the **period from production** of it's component material until **destruction** of the system and treatment of waste. Three large phases can be attributed to the life cycle:

- Creation;
- Exploitation;
- Destruction.

Creation - production, transport and installation, **exploitation** – operation and maintenance (preventive, corrective, liquidation of accidents), **destruction** – taking down(demolishment) and treatment of waste (utilization, remake).

Life Cycle's Phases

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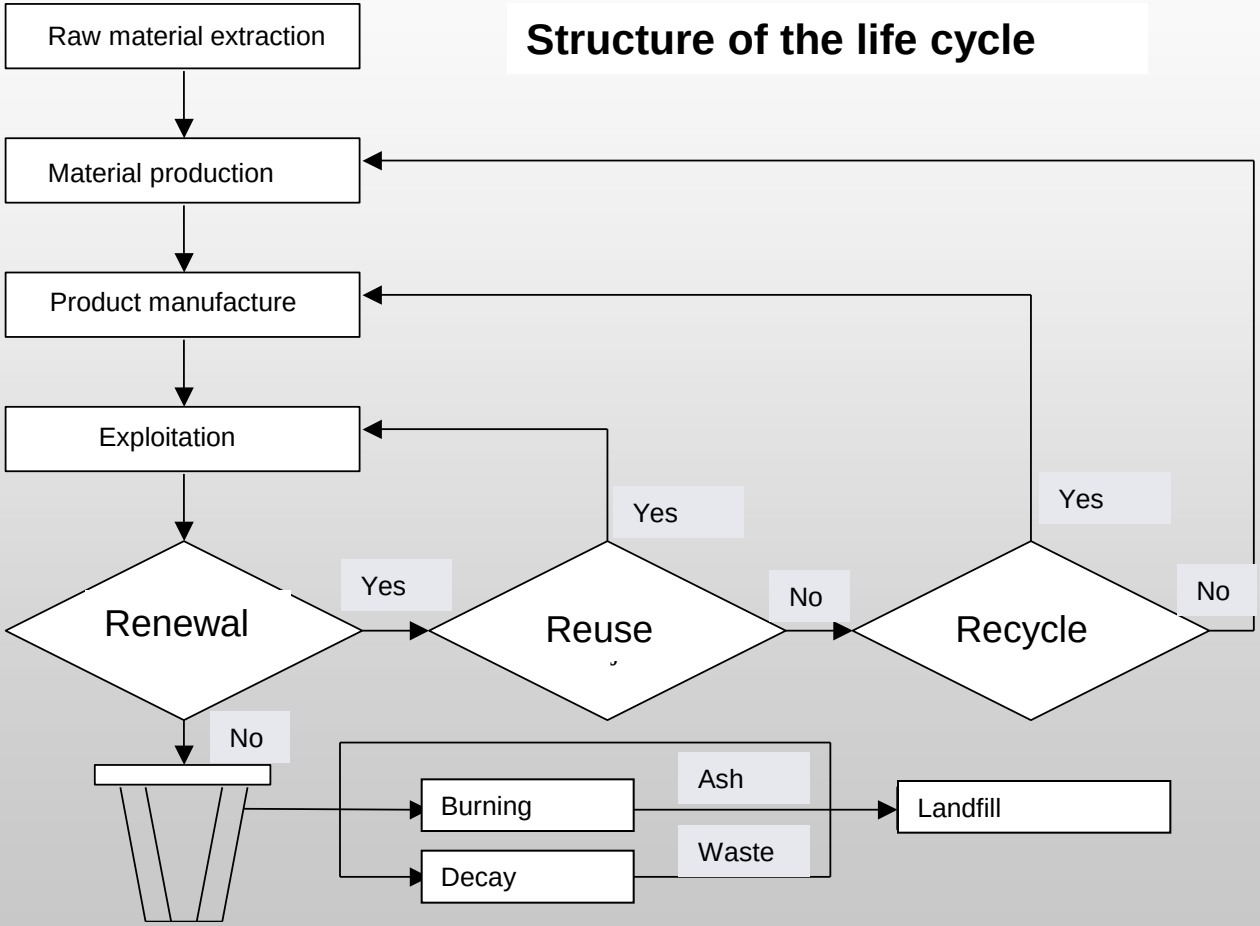
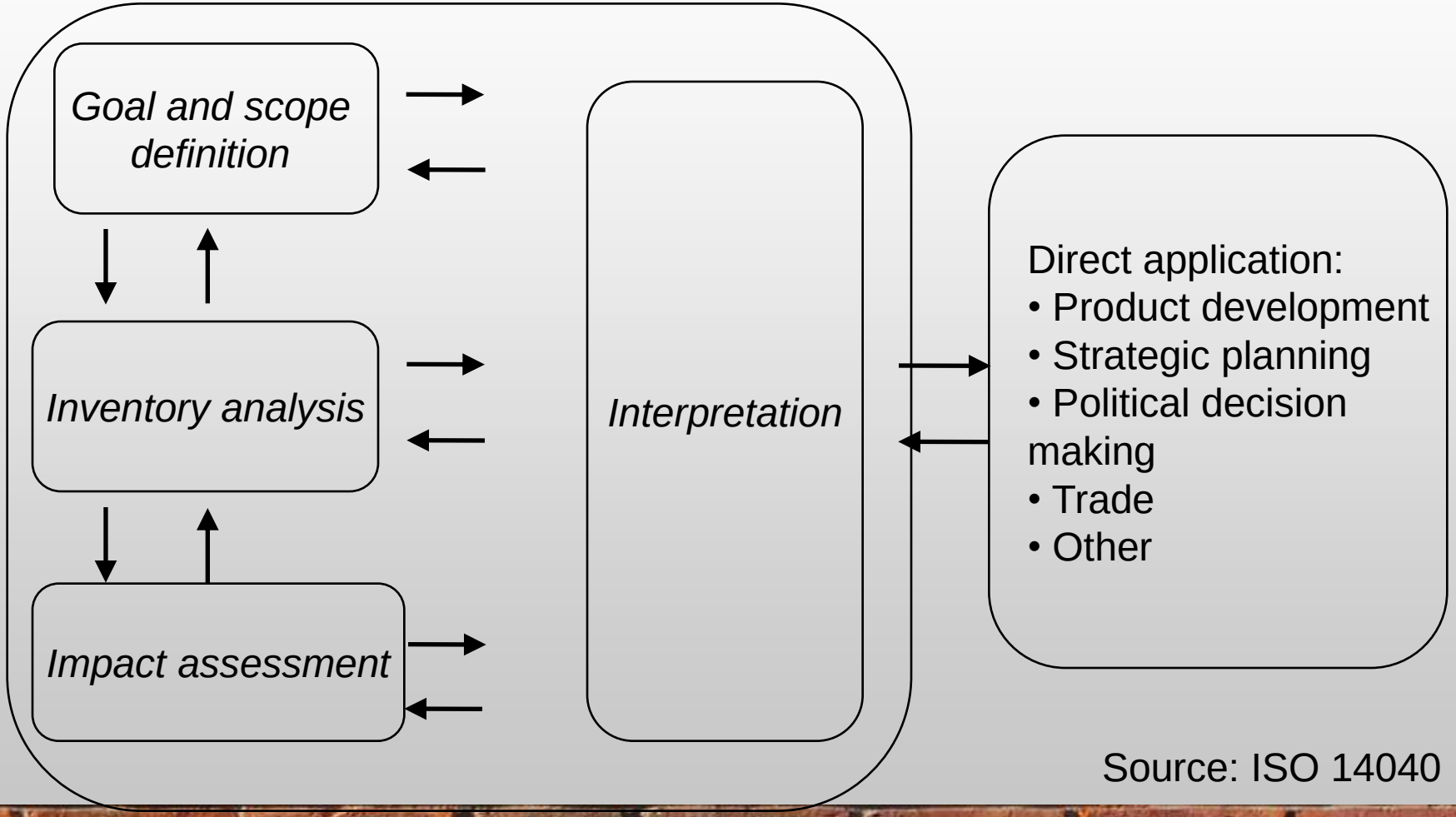
Common algorithm of a product's (system's) life cycle



Evaluating negative impact of a product's life cycle on environment, remake is considered as positive impact on environment

Stages of LCA

There are 4 stages of LCA:



Source: ISO 14040

Stages of LCA

1. Goal and scope stage determines **boundaries** of the system, analysis **assumptions**, **bounds** and **course**, according to which further research will be performed. It is very important to contemplate **all phases of LCA** at the very beginning because the rest part of the research will be found on the goal and scope descriptions. Each phase will be researched during **all four stages of LCA** (or not). **Only necessary components** are to be included in analysis which are described by the goal of analysis.
2. Inventory analysis **Elementary flows** related to investigated system's life cycle **are determined** quantitatively and qualitatively. That is all ongoing processes within the framework of materials and energy **inlet** and **outlet** of waste and pollution **flows**.
3. Impact assessment **The results of inventory analysis are converted** into suitable indexes which would allow to evaluate specific environmental impact of investigated system.
4. Interpretation. Results of the study and all options and assumptions are **evaluated considering their reliability. Conclusions and recommendations** are given.

Stages of LCA

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Main steps of stages of LCA:

1. Goal and scope definition
- LC definition
- Functional unit
- System boundaries and data
- Quality requirements
- Critical review

2. Inventory analysis
- Data acquisition
- Adjustment of system boundaries
- Calculation

Principles of systematic analysis– separation of system, process and elementary flows

3. Impact assessment
- Definition of impact categories
- Classification
- Calculation (conversion)

4. Interpretation
- Evaluation of assumptions and options and their correspondence to the goal and scope stage

Principled Scheme of Building's Life Cycle

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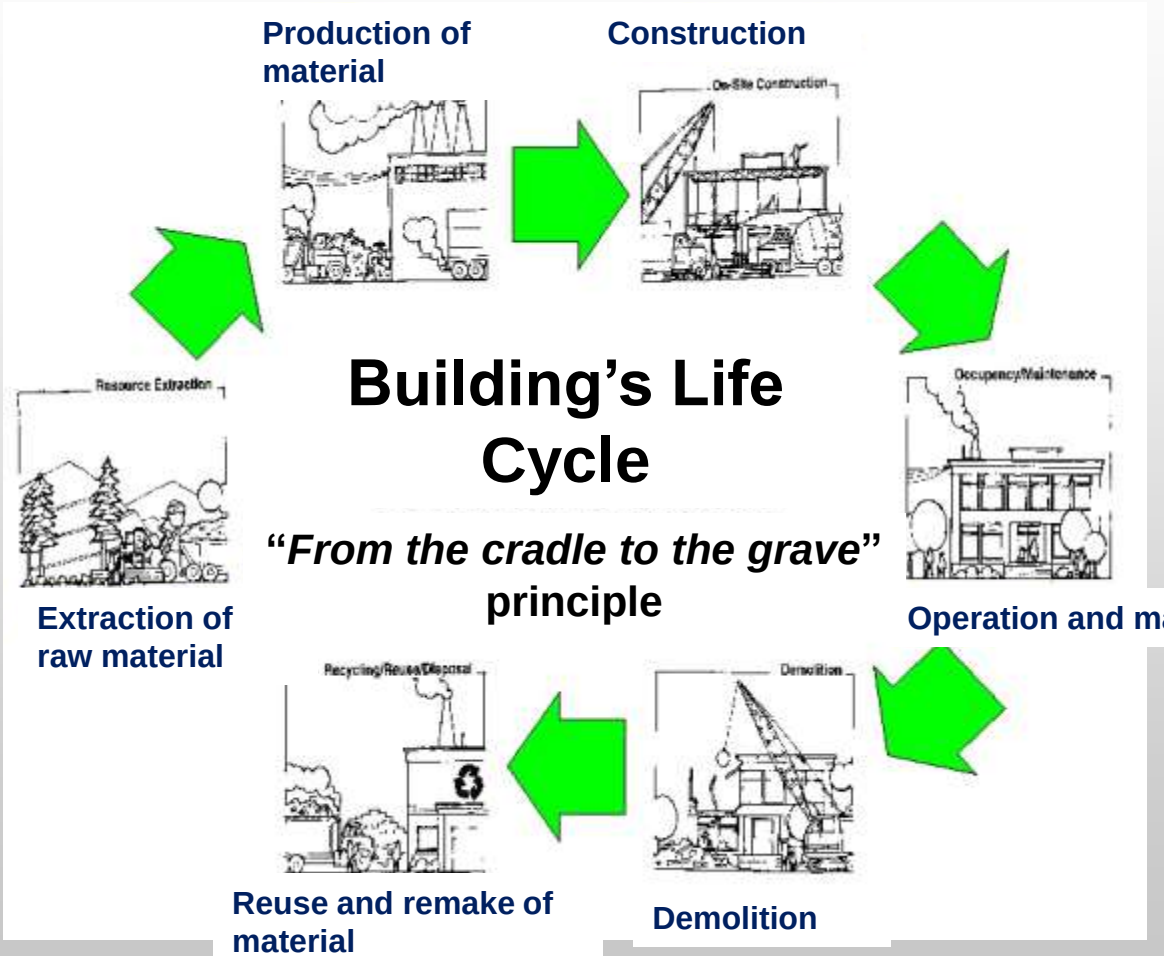

Creation phase: Division of a building into elements

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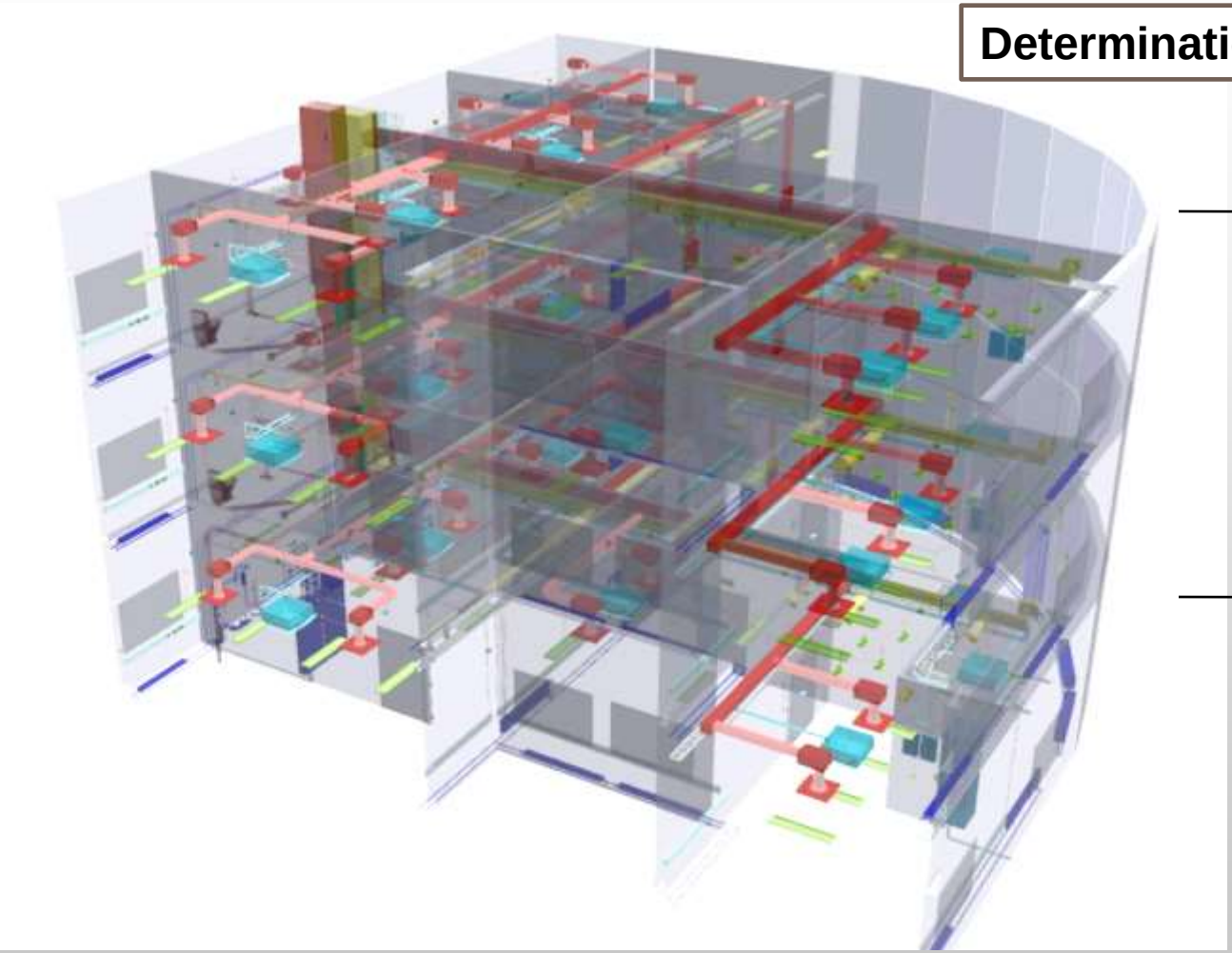
Determination of goals and scope



→ Construction:
- Element 1
- Element 2

…
- Element n

→ Engineering systems:
- Element 1
- Element 2

…
- Element n

Creation phase: Division of the elements into building materials

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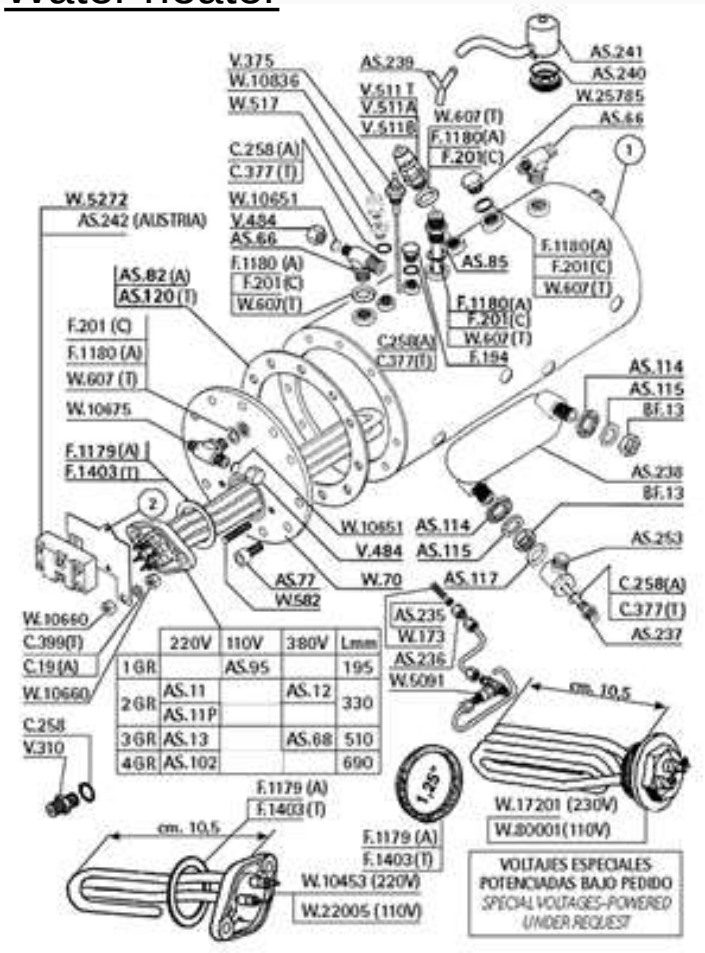
Water heater



Inventory analysis

→

Metals and their alloy :

- Steel
- Copper
- Aluminium
- Brass

Plastics:

- Polythene
- Polypropylene
- Polivinyl chloride

...

→ Quantity?

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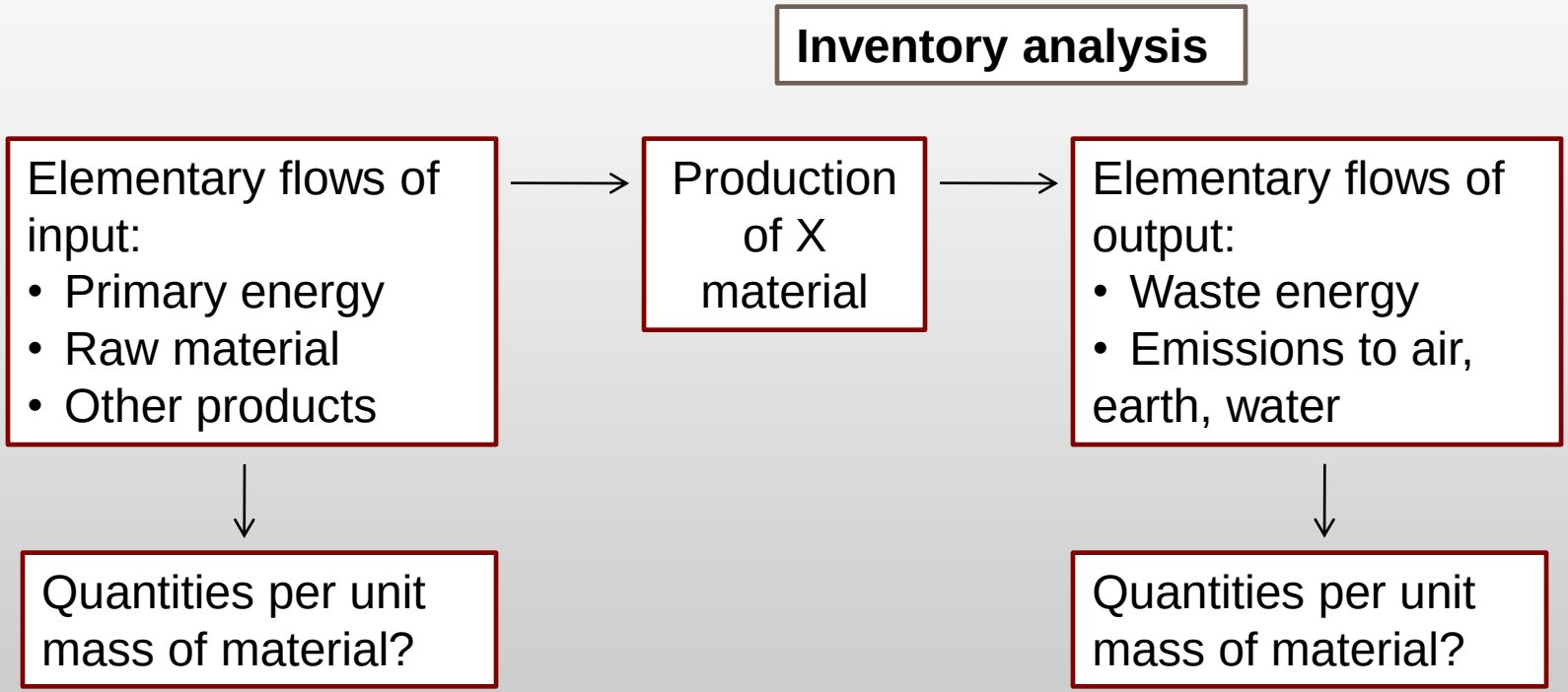
Creation phase: Division of material production process into elementary flows



Creation phase: Material's energy content

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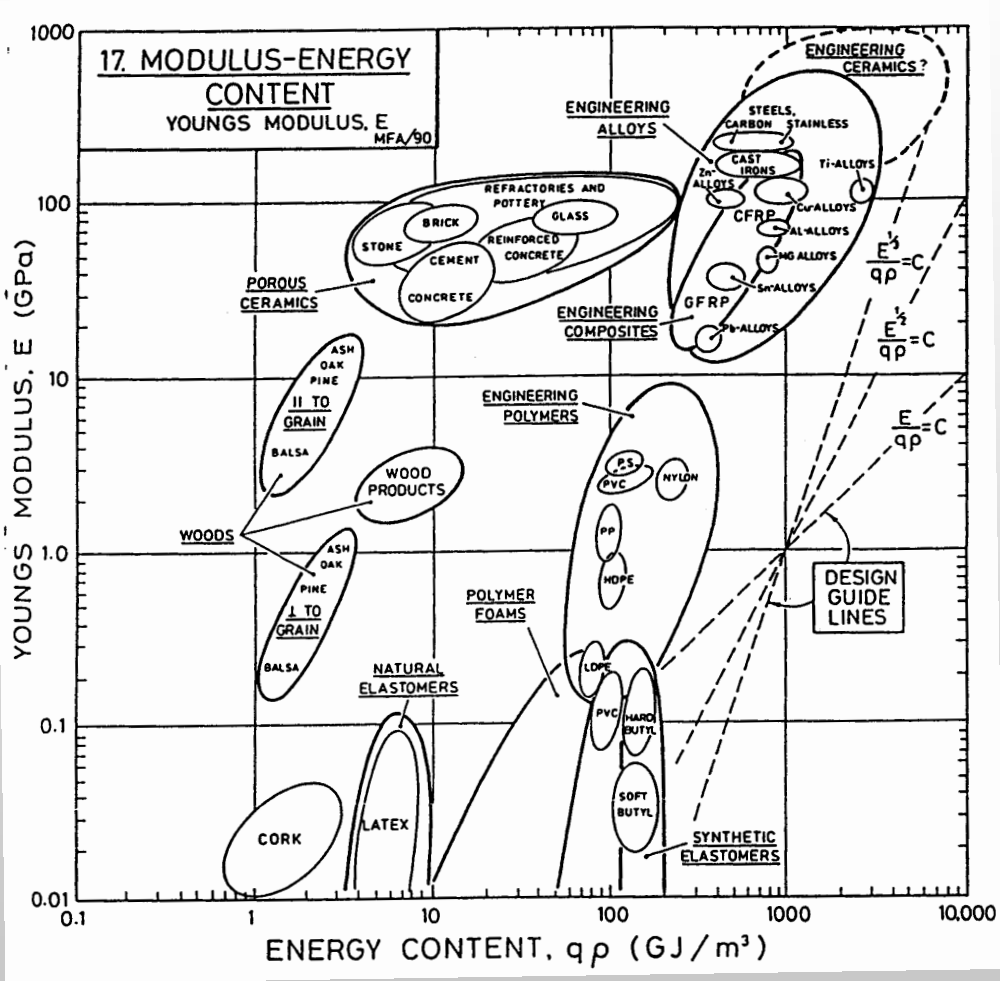
Youngs modulus - describes material's resistance to compression or extension



Creation phase: Evaluation of elementary flows

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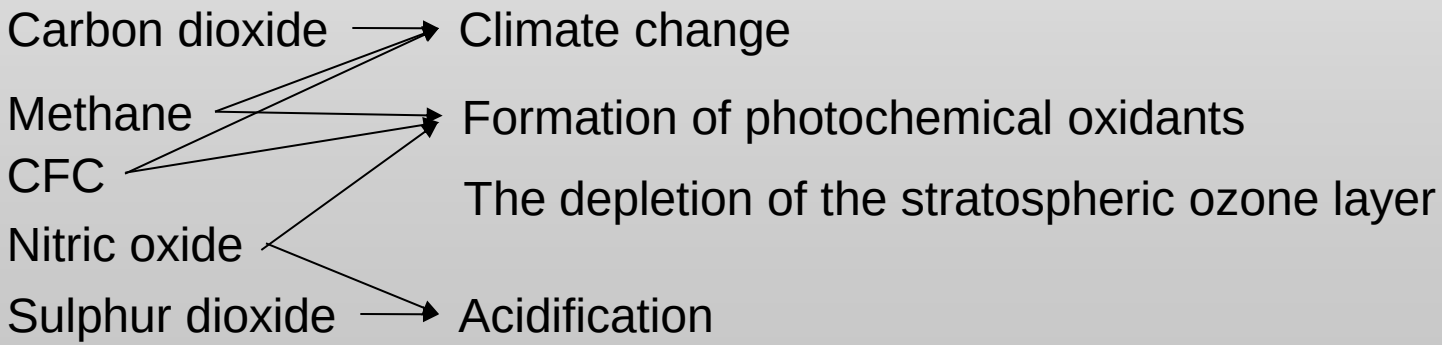
Impact assessment

- **Determination of impact categories** (only ecological evaluation according ISO methodology):
  - ✓ climate change;
  - ✓ the depletion of the ozone layer;
  - ✓ formation of photochemical oxidant;
  - ✓ acidification;
  - ✓ eutrophication;
  - ✓ toxic impact on human being;
  - ✓ toxic impact on environment.
- **Classification** – categorization of emission pending on selected impact categories (pending on selected model of environment protection)

e.c.:



Creation phase: Evaluation of elementary flows

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Impact assessment

Calculation (converting into indexes of impact categories)

e.c.: Climate change IPCC modelis GWP_{100} kg CO_2 ekv./kg išmetalų

Emission:	Quantity (kg)		Index		Result (kg CO_2 ekv.)
Carbon dioxide	50	×	1	=	50
Methane	76	×	21	=	1596
CFC-11	0,5	×	4000	=	2000
CFC-13	0,04	×	11700	=	468
HCFC-123	1,5	×	93	=	140
HCFC-142b	0,1	×	2000	=	200
				∑	**4454**

Exploitation phase: Assessment of the energy need

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Goal and scope determination

During the exploitation phase elementary flows have to be evaluated relative to security of a building's microclimate and maintenance of a building's elements.
Researching **microclimate security**, energy requirement is evaluated. The main problems to solve are:

- ✓ Operation **mode setting** of the system and it's separate elements**:**
- Capacity?
- Period?
- Under what external conditions?
- ✓ **Influence of** operation **modes** on **efficiency** of the system and it's separate elements:
- Efficiency dependence on the load
- Efficiency dependence on other parameters (e.c.: temperature)

Researching **maintenance**, energy requirement is evaluated.

- Repeatability of maintenance works?
- Requirement of material (raw material)?
- Transportation?

Exploitation phase: Assessment of the energy need

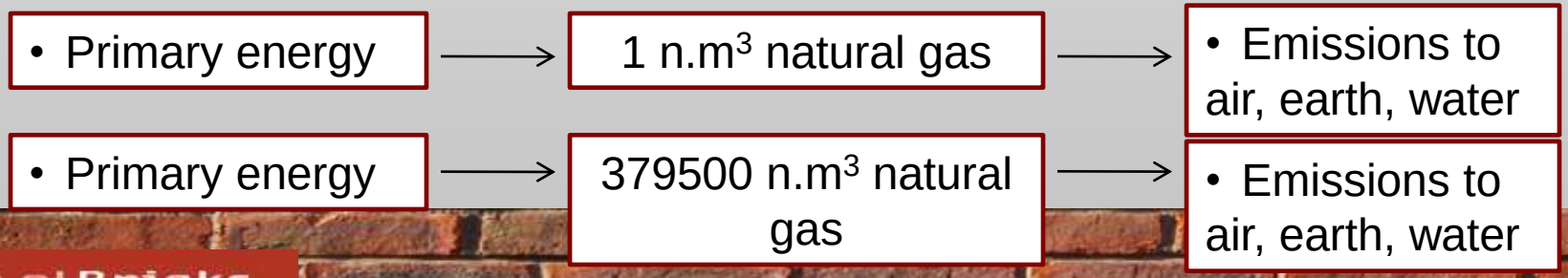
Inventory analysis

At inventory analysis stage, considering the goal and scope requirements, all **main elementary flows** are calculated (material (raw material), primary energy and emissions) necessary/nascent for security and maintenance of a building's microclimate.

e.c.:

1. **Security of a microclimate system.**

Heat needful for a building's **heating** 30 MWh/year.
Fuel – natural gas ($Q_{ž}$=9,3 kWh/n.m^3) → 3226 n.m^3/year.
Boiler efficiency (seasonal) 0,85 → 3795 n.m^3/year.
Building's life cycle – 100 years → 379500 n.m^3.



Exploitation phase : Maintenance evaluation

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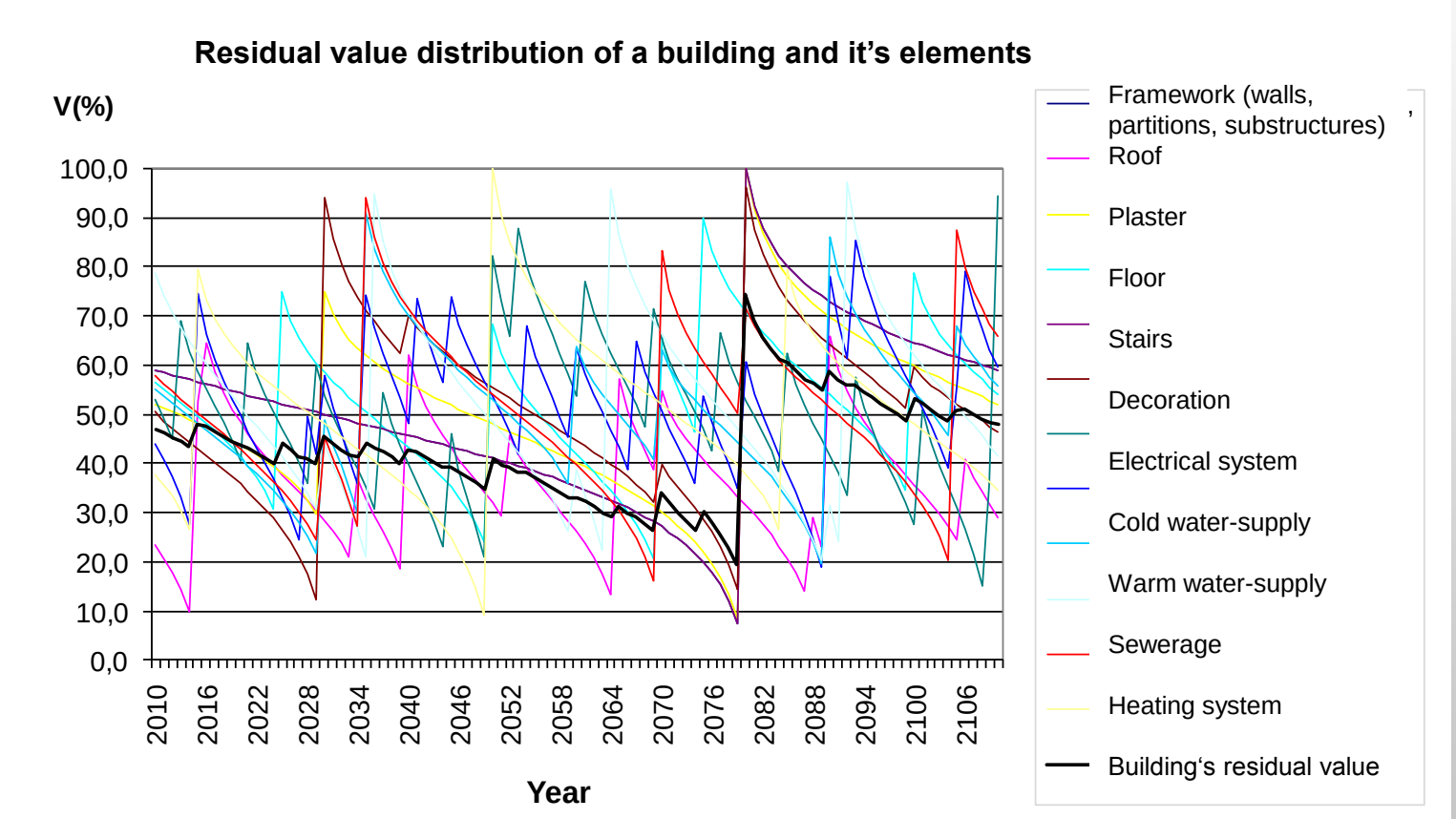
Inventory analysis

The need for repeatable maintenance work is usually determined considering existence duration of separate building's elements:

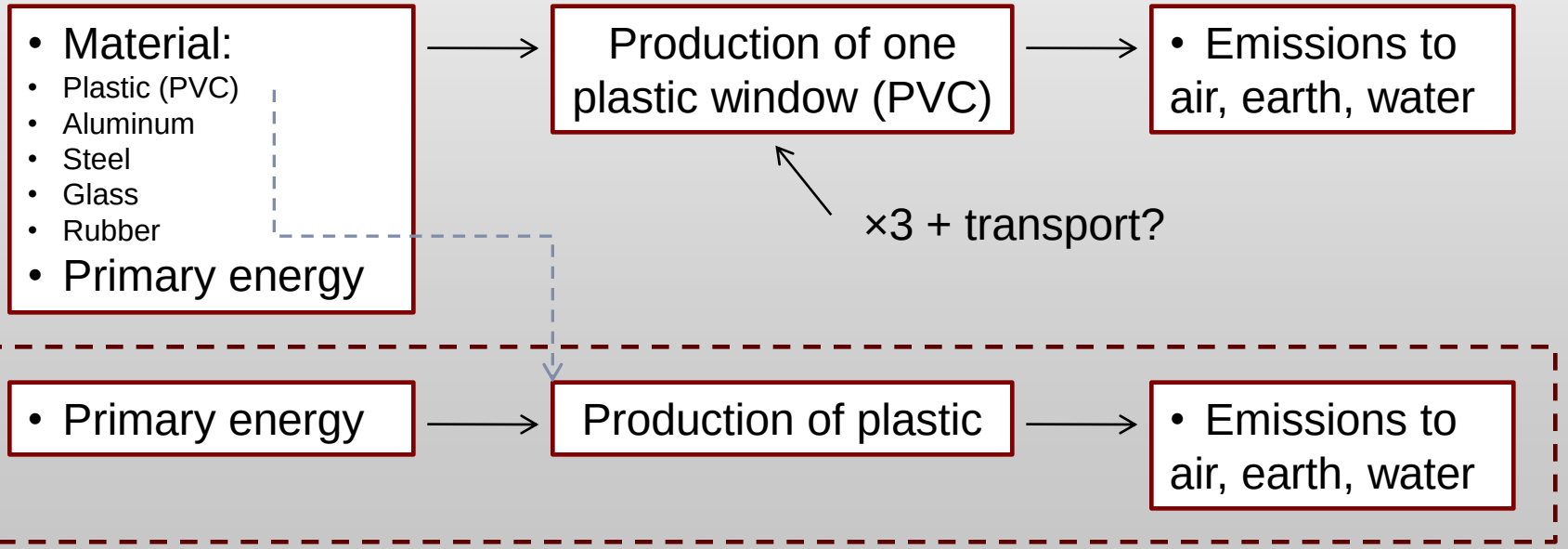


Exploitation phase : Maintenance evaluation

e.c.:

2. **Maintenance**

Replacement of windows :
Existence duration: 30 years
Existence duration of a building: 100 years
Number of replacements: →30 →60 →90 = 3 times



Destruction phase: Evaluation of recycling

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Goal and scope

There are two problems to be solved at destruction stage:

1. **Expenditures** for destruction/recycling
2. **Savings** as a result of recycling/reuse

- Which material can be recycled on order to use them again?
- Which part of a material can be recycled/used?
- Should savings be included in the bounds of the system?
- Were materials from recycled material evaluated at creation phase?

Reuse

Recycling

Destruction

Destruction phase: Evaluation of recycling

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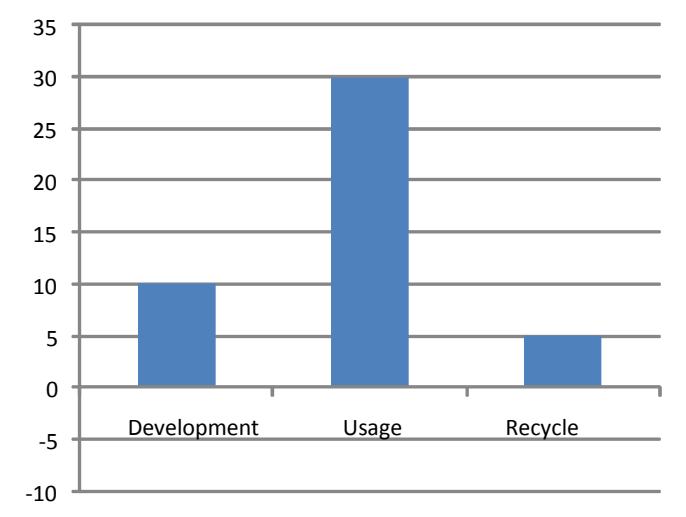
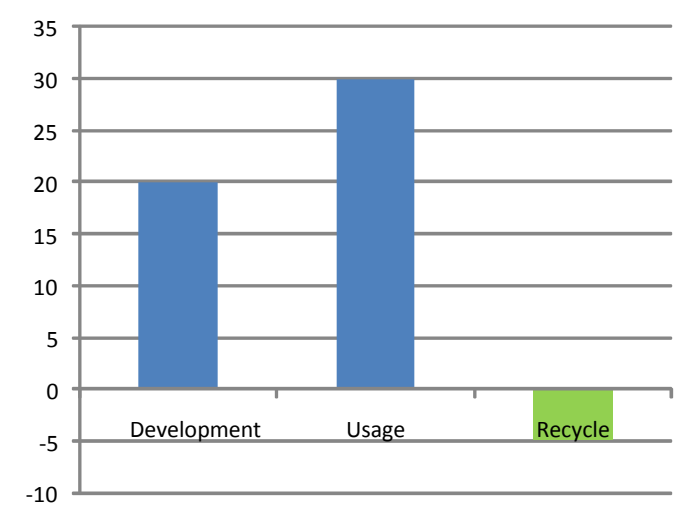
Inventory analysis

1. **Expenditures** destruction/recycling (principle “from the cradle to the cradle”)

According to critics in some cases the whole recycling process can exceed energy expenditures for material’s ultimate destruction (biodegradation), however everyone agrees that the common effect (evaluating creation phase) is good – the need of primary energy is reduced as well as pollution, there is a job-creation in recycling industry.

2. **Savings** as a result of recycle/reuse





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Interpretation

Goals:

- **Determination of relevant problems** on the ground of inventory analysis and results of influence at evaluation stages.
- Finish, responsiveness and adequacy **review**.
- **Conclusions, restrictions** and **recommendations**.

Principles:

Information (results) are presented in a way (tables, graphs, percentages, etc.) which would increase the understanding of results without simplifying them.

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Thank you for your attention!