



HELSINGIN YLIOPISTO



EUROPEAN UNION  
EUROPEAN REGIONAL DEVELOPMENT FUND  
INVESTING IN YOUR FUTURE



# Energy Positive Farm - ENPOS

## System analysis, system borders

ENPOS Seminar - Energy use in plant production - Otepää 20 - 22 January 2010

# What is a system?

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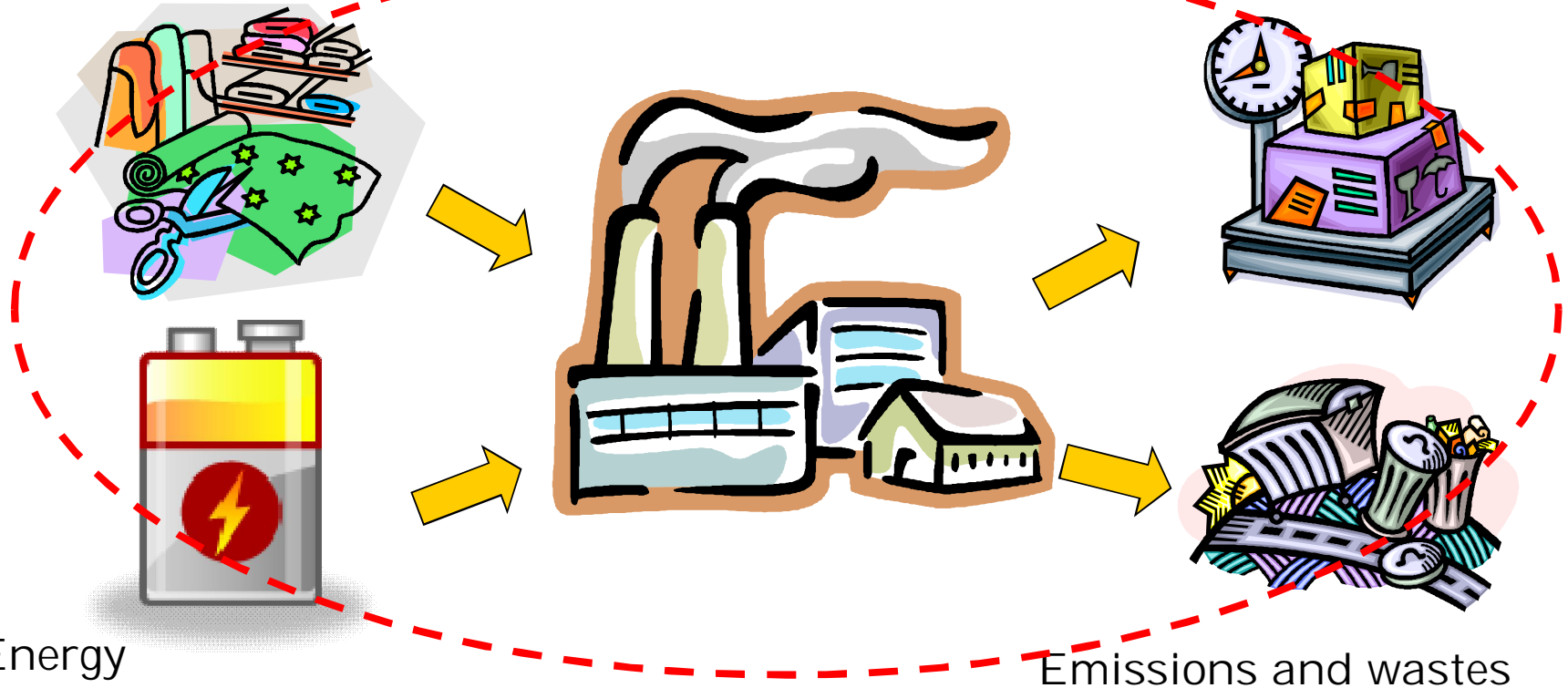
- ▶ A system consists of
  - 1) some kind of elements
  - 2) relationships between elements
- ▶ System is separated with a boundary from the rest of the world
- ▶ The rest of the world is called surroundings or environment

Source: Liljenström, H. 2008. System, modell and simulation

# Definition of a system

Rawmaterial

Products and by-products



Energy

Emissions and wastes

# Bioenergy systems are typically complex biological systems

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- ▶ A large number of components
- ▶ System includes living organisms, which behaviour is known only partially
- ▶ System is influenced by unpredictable factors e.g. weather

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Energy analysis is  
one application  
of systems analysis

# Energy Analysis

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- ▶ 2/2009 623 milj. hits with words "energy analysis" in Google
- ▶ 1/2010 923 hits with the same words
- ▶ Applications are often related to bioenergy and sustainable use of energy
- ▶ Complex systems are considered  
→ A system analytical approach is advisable

# An energy analysis? Why and for what?

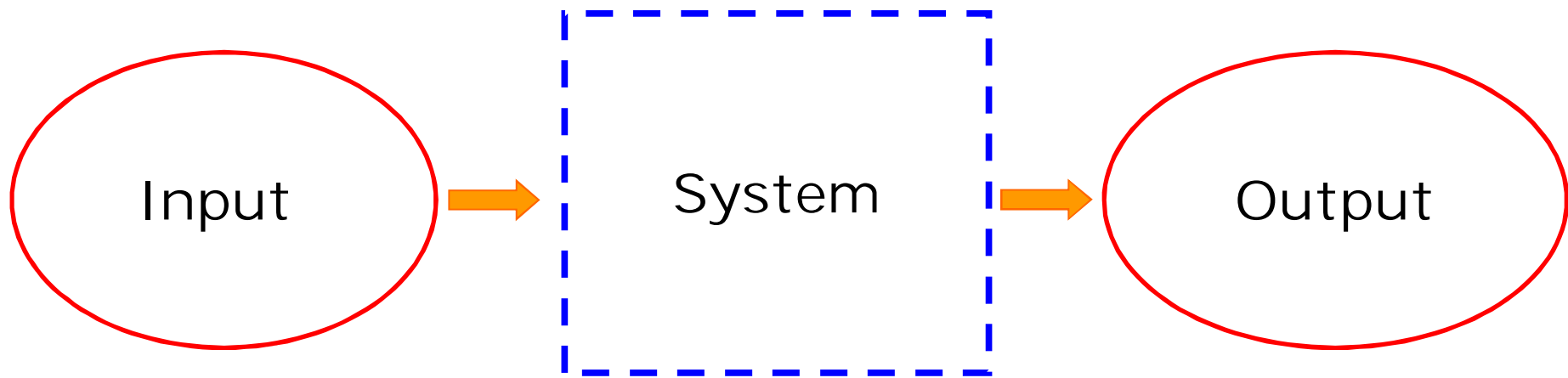
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- ▶ Decisions relating to future energy management should be based on authentic information
- ▶ Energy analysis helps to answer the question: Which energy sources are worth investing?

*E.g. in Lithuania, which energy source would be the most suitable to cover the gap left by closing the Ignalina nuclear power plant?*

# The basic idea of an energy analysis!

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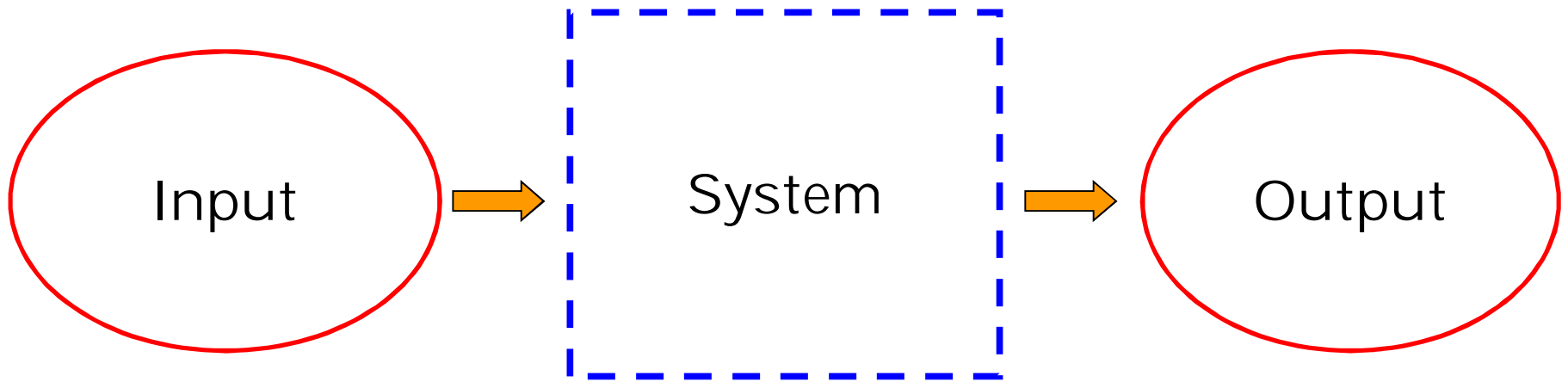




# Applications of an energy analysis!

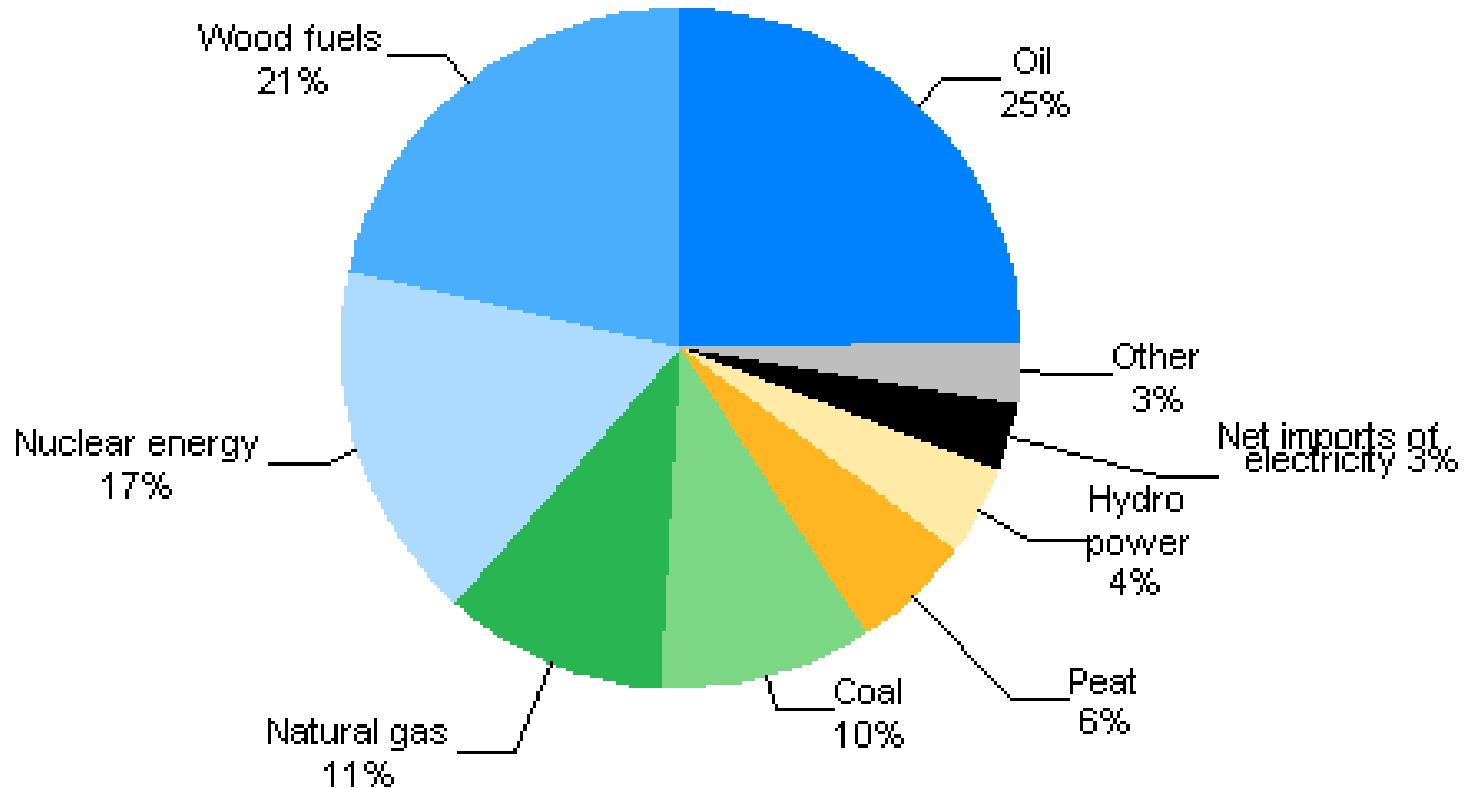
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Distribution of input energy by different energy categories or energy sources?



# Energy sources in Finland 2008

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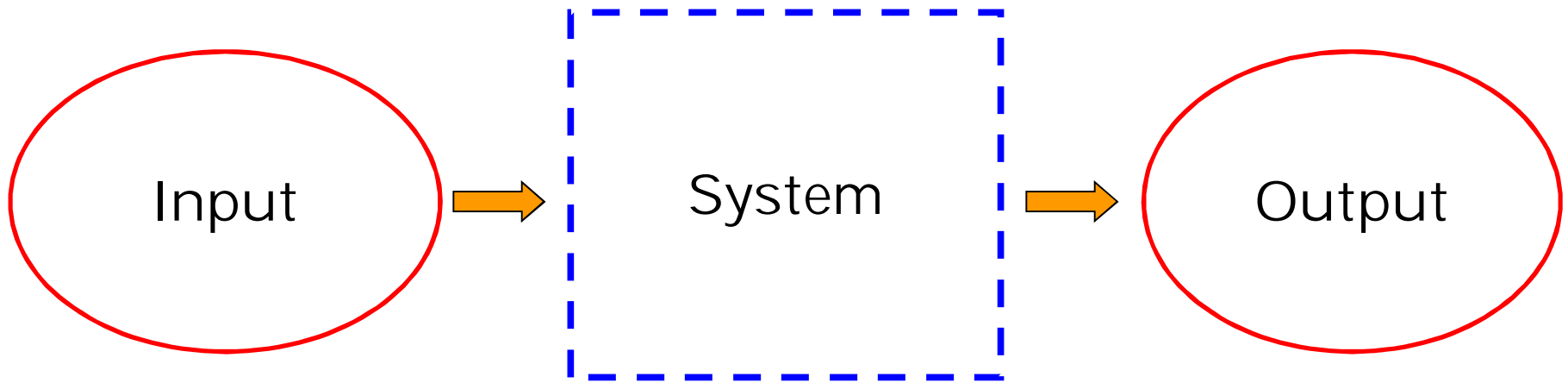


Source: Statistics Finland, [http://www.stat.fi/til/ekul/2008/ekul\\_2008\\_2009-12-14\\_kuv\\_001\\_en.html](http://www.stat.fi/til/ekul/2008/ekul_2008_2009-12-14_kuv_001_en.html)

# Applications of an energy analysis!

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Distribution of input energy for different processes of the system?



# Distribution of energy consumption on a farm

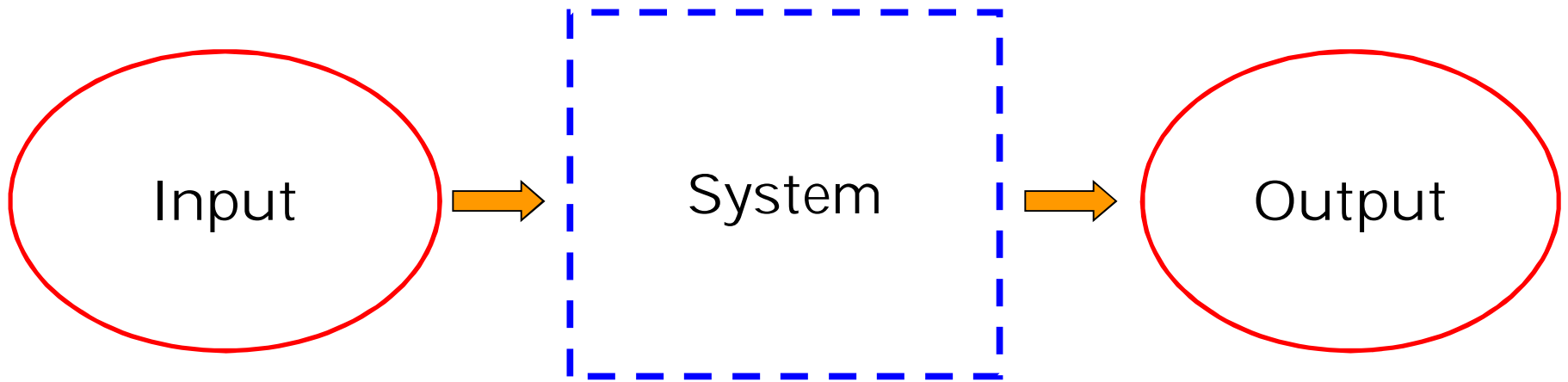
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- ▶ Plant production
- ▶ Animal production
- ▶ Forestry
- ▶ Household

# Applications of an energy analysis!

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Comparison of different production methods or parallel products?

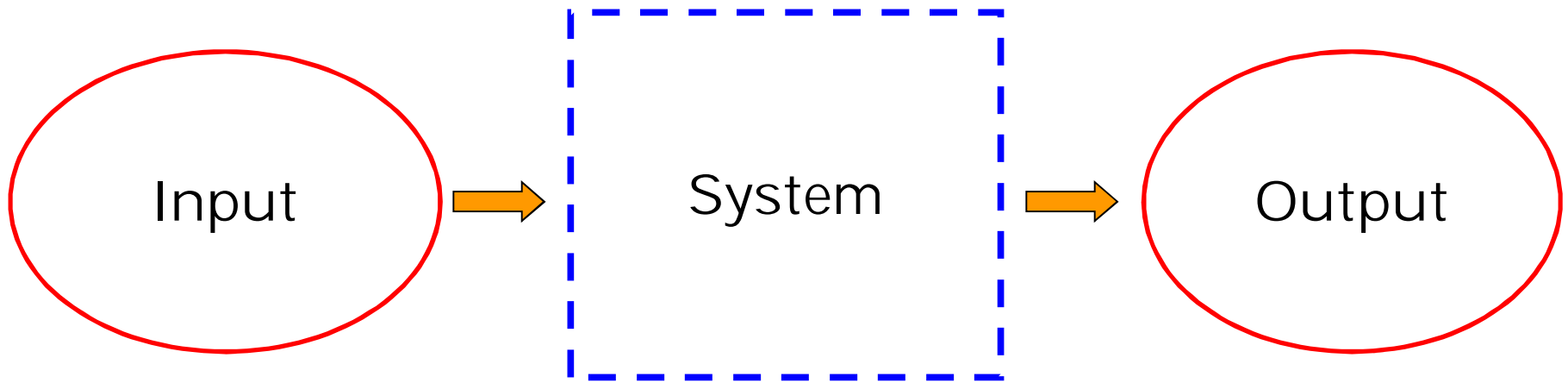


A good reference is needed!!!

# Applications of an energy analysis!

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Definition of parameters, key figures, key ratios.



Energy ratio = Energy Return of Investment (=EROI), Net Energy, Shares of fossil and renewable, ...

# Applications of an energy analysis!

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- ▶ For product developing, decision makers, politicians, citizens
- ▶ To improve energy efficiency
- ▶ To cut costs
- ▶ To guide choices of customers
- ▶ To plan taxation
- ▶ To protect environment
- ▶ To help to make a better and more sustainable world!

# Important concepts in an energy analysis

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- ▶ Defining a system and its boundaries
- ▶ Primary energy and Secondary energy
- ▶ Direct and Indirect energy
- ▶ Functional unit
- ▶ Cut-off criteria
- ▶ Allocation of energy for the main product and by-product(s)



# Instructions for defining a system

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## Include

- ▶ All relevant energy and material inputs
- ▶ Energy inputs crossing the cut-off criteria

## Possible to exclude

- ▶ Indefinite energy inputs
- ▶ Energy inputs, which are equal in the system under study and in the reference system
- ▶ Energy inputs going under the cut-off criteria

# Direct and Indirect energy

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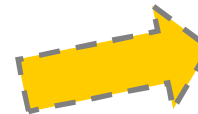
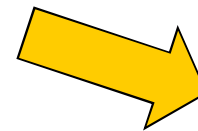
## Direct energy:

electricity, liquid fuels,  
gas, coal, firewood etc.

## Indirect energy:

embodied in material, human  
labour, infrastructure, machines,  
buildings, education, services...

**Input energy**



A problematic, gray region in an energy analysis!

# Primary energy and Secondary energy

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- ▶ Primary energy

Primary energy is energy found in nature that has not been subjected to any conversion or transformation process.

- ▶ Secondary energy

Secondary energy is primary energy which has been transformed in energy conversion processes to more convenient forms of energy, such as electrical energy or refined fuels.

# Functional unit

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- ▶ Definition in EN ISO 14040 -standard: *Quantified performance of a product system for use as a reference unit.*
- ▶ A functional unit is needed because energy analysis is often a relative approach which compares
  - 1) Same product manufactured with different ways
  - 2) Different products, which can be used for the same purpose

# Examples from the functional unit: 1(3)

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- ▶ Same product, different manufacturing technology

Diesel oil as a fuel for a passenger car:

Biomass → Gasification → F-T-synthesis → Diesel oil

Crude oil → Refining → Diesel oil

Which parameter would express quantified performance of these product systems and could be used as a reference unit?

MJ/MJ or MJ/km

# Examples from the functional unit: 2(3)

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- ▶ Different products used for same purpose

Biomass → Gasification → F-T-synthesis → Diesel oil

Crude oil → Refining → Gasoline

MJ/km

# Examples from the functional unit: 3(3)

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- ▶ You want to make an energy analysis for two different paints. How do you define the functional unit?
- ▶ Researcher X wants to make an energy analysis for a mobile phone and for 1 kg potatoes. Is this pair valid? How do you define the functional unit?

# Exercise nr 1:

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- ▶ Form teams of two persons
- ▶ Define an object for an energy analysis
- ▶ Define the functional unit
- ▶ After 10 minutes, every team presents their objects and justifies their functional unit
- ▶ The whole course assesses the validity of the objects and functional units



## Exercise nr 2:

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- ▶ Define system boundaries for one of the objects of the Exercise 1
- ▶ Suggest, which energy inputs are included and which are excluded
- ▶ Think, which definitions should be commented in the discussion of the study

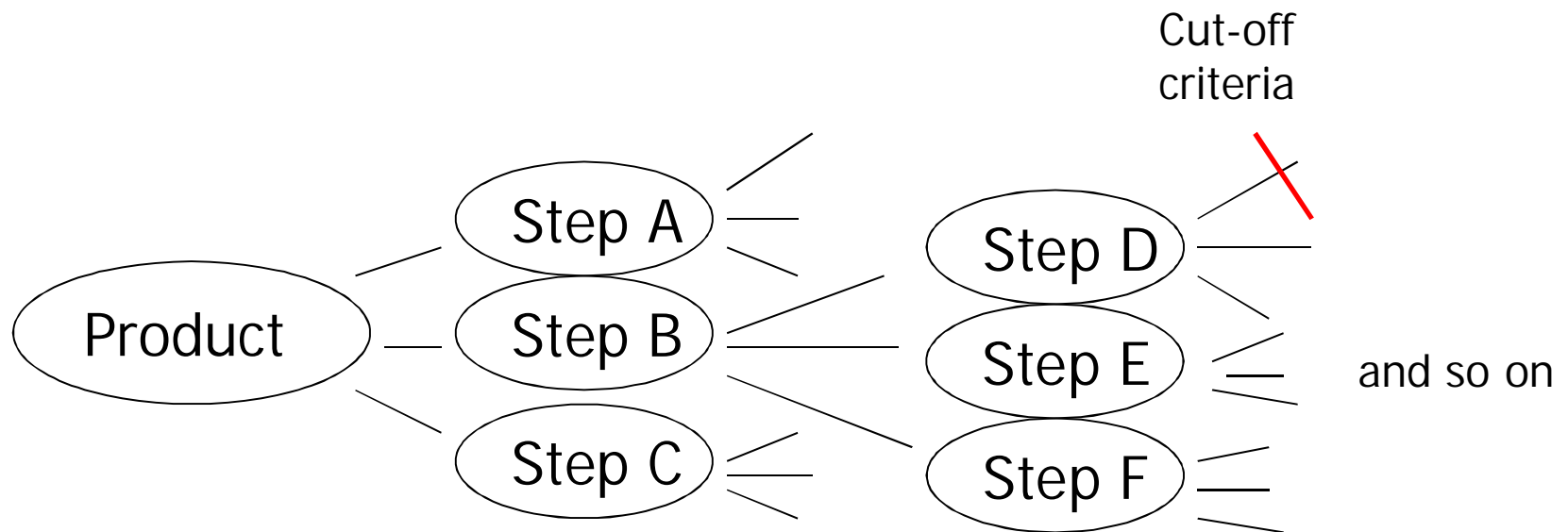
# Cut-off criteria

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- ▶ Definition in EN ISO 14040 -standard: The amount of energy flow to be excluded from a study.
- ▶ Define cut-off criteria clearly
- ▶ Cut-off criteria is a percentage of a single energy input from the total energy input e.g. 0.1%, 1%, 5%
  - ▶ an overrunning energy input is included
  - ▶ an undergoing energy input is excluded

# A sketch of the cut-off criteria in a process analysis

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# Factors affecting on the definition of the cut-off criteria

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- ▶ Accuracy of the analysis
- ▶ The purpose the analysis (for what?)
- ▶ The amount and quality of data available
- ▶ What is the reference chain and how energy inputs have been handled in the reference chain

# Important key words or concepts of this lesson:

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- ▶ System
- ▶ Definition of the system
- ▶ Direct energy and indirect energy
- ▶ Primary energy and Secondary energy
- ▶ Functional unit
- ▶ Cut-off criteria

# Handling by-products

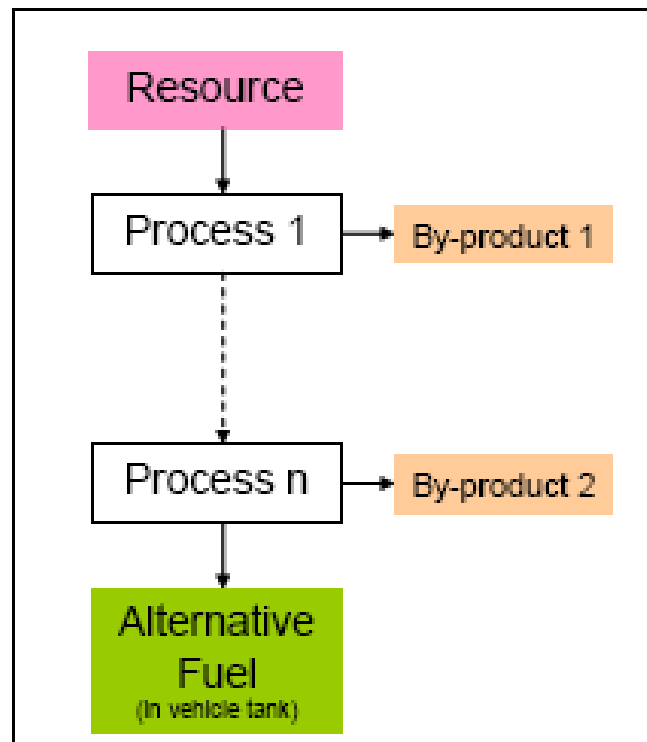
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Besides the main product, production generates often by-products

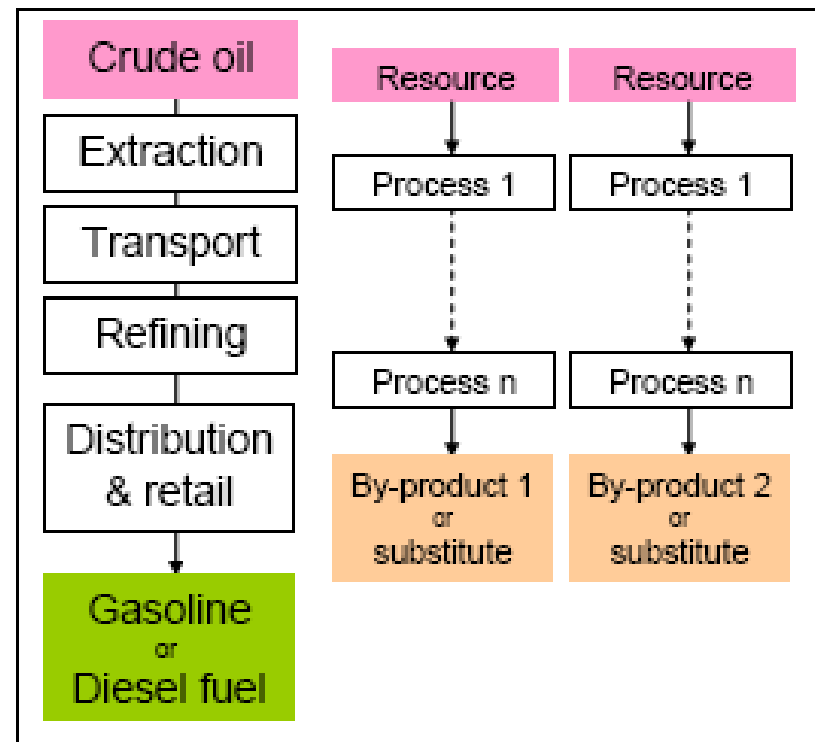
- ▶ System boundaries are expanded so that allocation of energy is unnecessary
- ▶ System is credited with energy, which is needed to produce by-products
- ▶ Energy can to be allocated to main- and by products according to the
  - ▶ mass
  - ▶ market value

# An advisable crediting methodology for a by-product

Alternative scenario



Reference scenario



Source: WTW Report, version 2b, May 2006



This material has been produced in ENPOS project. ENPOS is acronym for *Energy Positive Farm*.

The project partners are

- University of Helsinki, department of Agricultural Sciences – Agrotechnology
- MTT Agrifood Research Finland - Agricultural Engineering
- Estonian University of Life Sciences

Project home page is at <http://enpos.weebly.com/>

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