HELSINGIN YLIOPISTO

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2007-2013

# Energy Positive Farm - ENPOS

## Feed and concentrates, machine manufacturing and maintenance, buildings

ENPOS Seminar - Energy use in animal production – Tartu 15 – 16 February 2010

Hannu Mikkola

# Outlines of this lesson

- Some refreshing from Otepää seminar
- Energy analysis of
  - Feed and concentrates
  - Buildings
- An Excel exampel of uncertainty analysis with Monte Carlo simulation
- Energy analysis of
  - Machine manufacturing
  - Maintenance
- Questions, discussion

# What is a system?

- 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.

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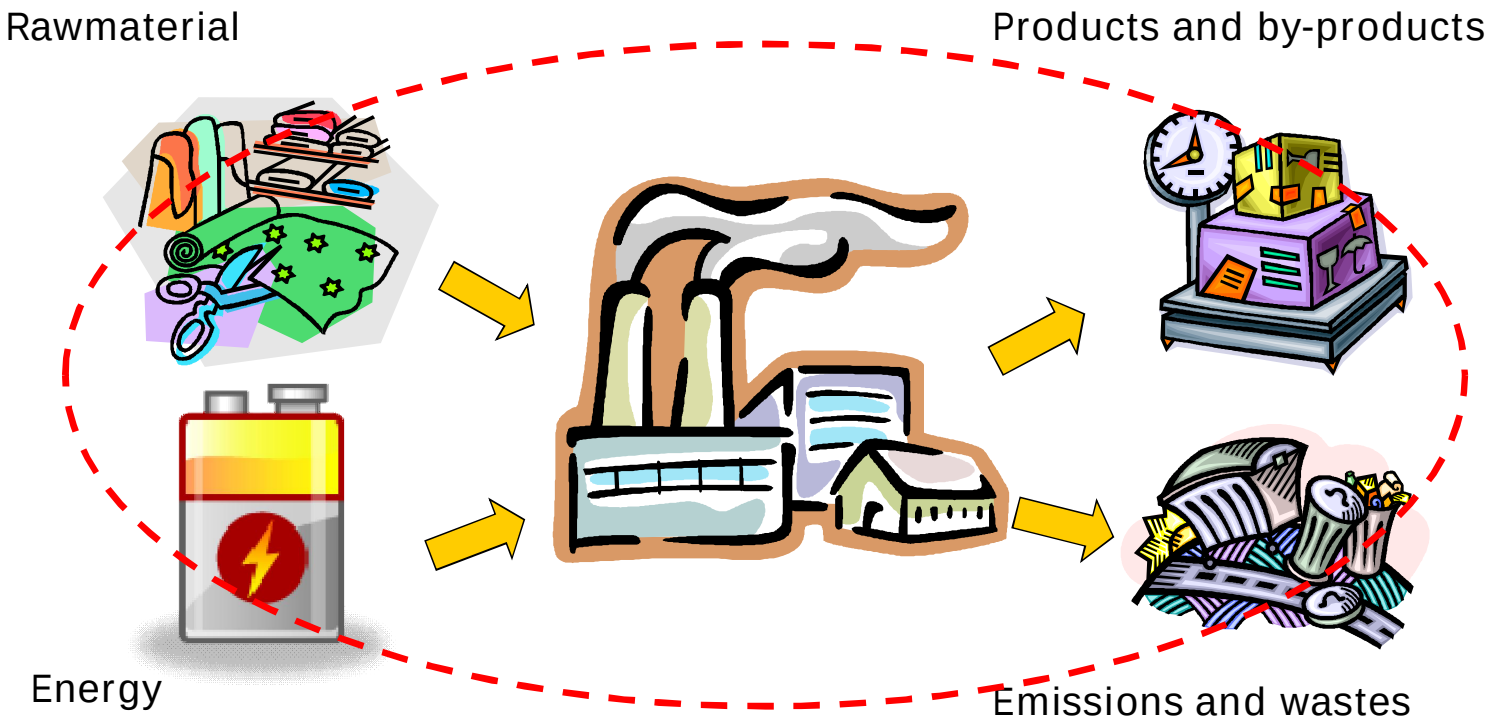
# Definition of a system



# Energy analysis is an application of systems analysis

# Energy use for producing feed and concentrates 1 (3)

Animal feeding is today sophisticated science and diets can contain numerous components. Some simplification is needed to avoid excessive work.

- Typical fodder for milking cows
  - Grass silage
  - Concentrated feed containing
    - Milled or crushed grains
    - Protein concentrate
    - Minerals
    - Vitamins
  - Hay
- On big farms total mixed ratio made with a mixing wagon

# Loading a mixing wagon

# Energy use for producing feed and concentrates 2 (3)

- Typical fodders for finishing pigs
  - Home made fodder containing
    - Milled or crushed grains
    - Protein concentrate
    - Minerals
    - Vitamins
  - Industrial fodder, which contains the same components as home made fodder + by-products from food industry (whey, molasses, DDGS = Distiller's Dried Grains with Solubles ,...)

# Energy use for producing feed and concentrates 3(3)

Principals of the energy analysis:

1. Make clear what components is used in fodder and in which ratio
2. For components produced on a farm follow the instructions for energy analysis in plant production given in Otepää seminar
3. For industrial components
   - Look from manufacturer's website
   - Make a literature review
   - Ask from manufacturer

# Importance of feed in animal production from energetic point of view

- In milk production energy for feed production and for housing are approximately as important
- In pork production energy loss with ventilation air (heating) is two times the energy for feed production

# Quidelines for an energy analysis of a building 1 (4)

1. Find construction drawings, which contain
   - Dimensions of the building
   - Constructions in detail
2. If constructions drawings are not available
   - Measure the main dimensions
   - Make a sketch, which includes windows, doors, etc.
   - Record constructions, which can be seen by naked eye
   - Consultate the farm manger to figure out hidden constructions
   - Take photos, also from details

# Quidelines for an energy analysis of a building 2 (4)

- Define construction energy for elements, which can be expressed in:
  - $m^2$ (walls, floors, roof,…)
  - Running meters (slurry canals, footings, fences, gutters, …)
  - Pieces (windows, doors, hatches, cubicle dividers, …)
- Define the area, length or number of elements
- Multiply the energy of a unit with the actual area, length or number of elements
- Sum up partial energies

# Quidelines for an energy analysis of a building 3 (4)

- Human work is normally ignored
- Excavation work can be a significant energy input but difficult to define → ignored?
- Energy for construction machines is difficult to define → ignored
- Include machines used inside the building if possible
- In the simpliest case the energy t construct a building is:

  $E_{tot} = E_1 + E_2 + E_3 + \ldots$

  where $E_1$, $E_2$, $E_3$, … are energy inputs of construction materials

# Quidelines for an energy analysis of a building 4 (4)

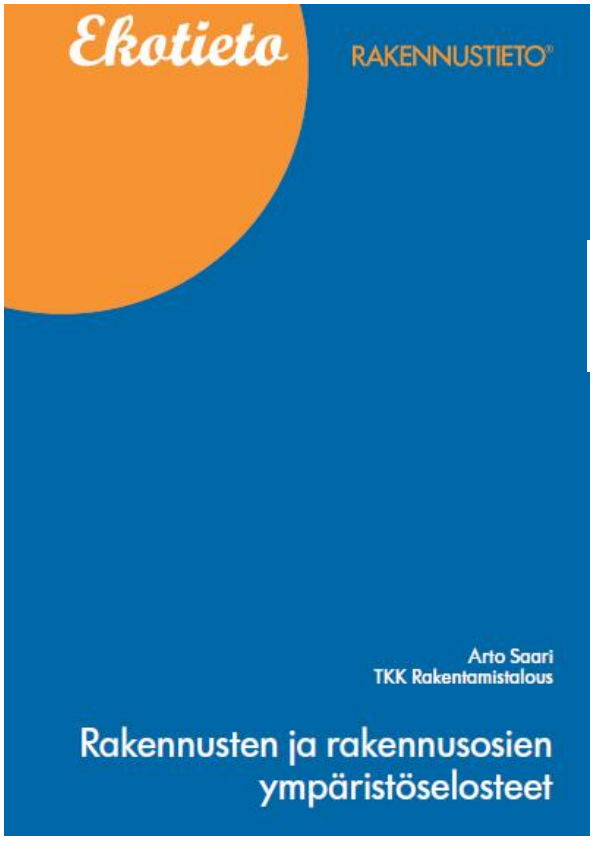
- Define the life-time of the building
- Allocate the construction energy for
  - The operational period, years
  - Animal places
  - Kilograms of milk, pork, beef, eggs,…

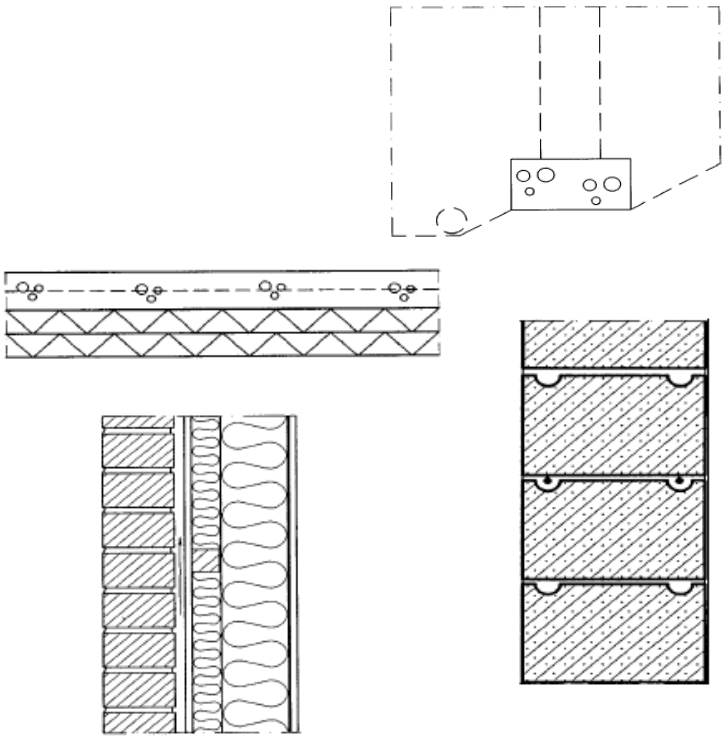
## From where to find information from energy use and emissions of construction materials

- RT Environmental Declarations
  http://www.rts.fi/ymparistoseloste/index_RTED.htm
  - All in Finnish but some also in English and Swedish
  - Gives the ”ECO-PROFILE OF THE PRODUCT”

    The eco-profile includes the life cycle stages from the acquisition of raw materials to the factory gate.
  - Gives the use of non-renewable and renewable energy
  - Gives emissions to air and water
- EKOTIETO
  - Environmental declarations for buildings and building elements

# Environmental declarations for buildings and building elements



http://www.rts.fi/Ymparistoselosteet.pdf

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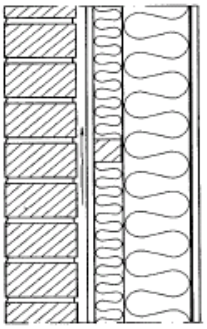
- Master thesis of Petro Tamminen and his Excel sheets

# En example, how to calculate the energy per 1 $m^2$ external wall

- Construction fom outside to inside
  - Brickwork
  - Air passage
  - Porous fibre board
  - Insulation material
  - Vapour block – a plastic film
  - Inner covering board – normally a gypsym board

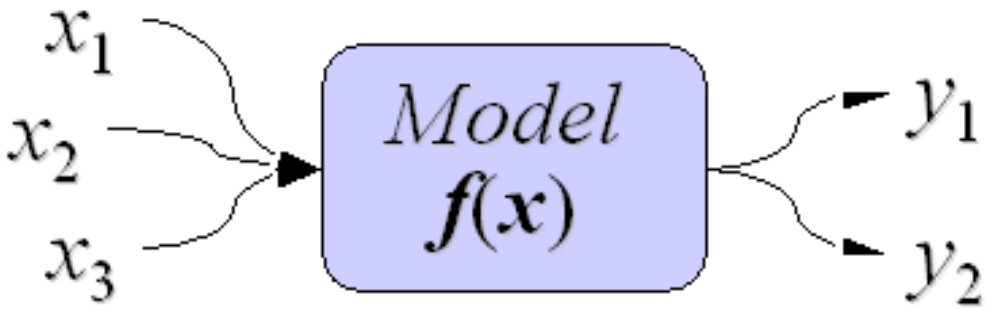


- Non-renewable energy 850 $MJ/m^2$
- Renewable energy 380 $MJ/m^2$
- Total energy 1 230 $MJ/m^2$
- Emissions 63 000 g $CO_2$ –ekv./$m^2$

# Uncertainty analysis by using Monte Carlo simulation

Input parameters $x_1$, $x_2$, $x_3$,.. have probability distributions of their own.

By means of Monte Carlo simulation we can assess their impact on output parameters.



# Finally, some remarks concerning energy analysis in animal production:

- Should human work be included? hm1
- What is the life-time of buildings? hm2
- Should recruiting be included? hm3
- At which age a building is totally written off and free from energy costs? hm4
- It is advisible to record $CO_2$ emissions at the same time as energy use.

Dia 21

hm1 Tutkitaan ylittääkö ihmistyön energiapanos cut-off-kriteerin. Haetaan kirjallisuudesta ihmisen vuotuinen energiankulutus ja se allokoidaan työtuntien suhteessa tuotannolle.
Hannu Mikkola; 15.2.2010

hm2 Elinikä lasktaan verotuksessa käytetyn poistoprosentin mukaan.
Hannu Mikkola; 15.2.2010

hm3 Kyllä pitää. Jäi vähän epäselväksi , miten?
Hannu Mikkola; 15.2.2010

hm4 Kun rakennus on verotuksellisessa mielessä poistettu.
Hannu Mikkola; 15.2.2010

# Energy for machine manufacturing and maintenance

- Energy is needed for:
  - Rawmaterials: steel, plastic, rubber, glass, …
  - To built and run factories
  - Transport
  - Service facilities
  - Spare part operations
  - Human work
  - Infrastructure
  - …

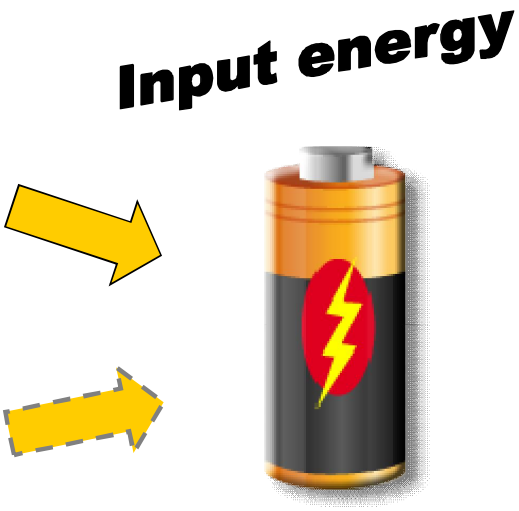
# Direct and Indirect energy

Direct energy:

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

Indirect energy:

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




A problematic, gray region in an energy analysis!

## How to manage this complexity?

- Define the system, what is included and what is exluded
- Split the system into small and understanable pieces
- Define energy need for these small pieces (they can be work operations, material, processes, ..)
- Sum up those energy needs
- Allocate the total energy for products
- Make a sensitivity analysis and uncertainty analysis

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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