What Is Energy?

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HY

Agroteknologia

Energy

What is energy?

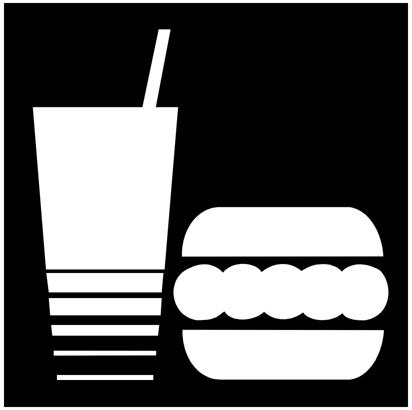
- Energy is ability to do work

Energy can be:

- In material
  - •Food, feed, oil, wood, gas
- Potential energy
  - Waterfalls
- Kinematic energy
  - •Wind, waves

•Radiation energy

- Sun

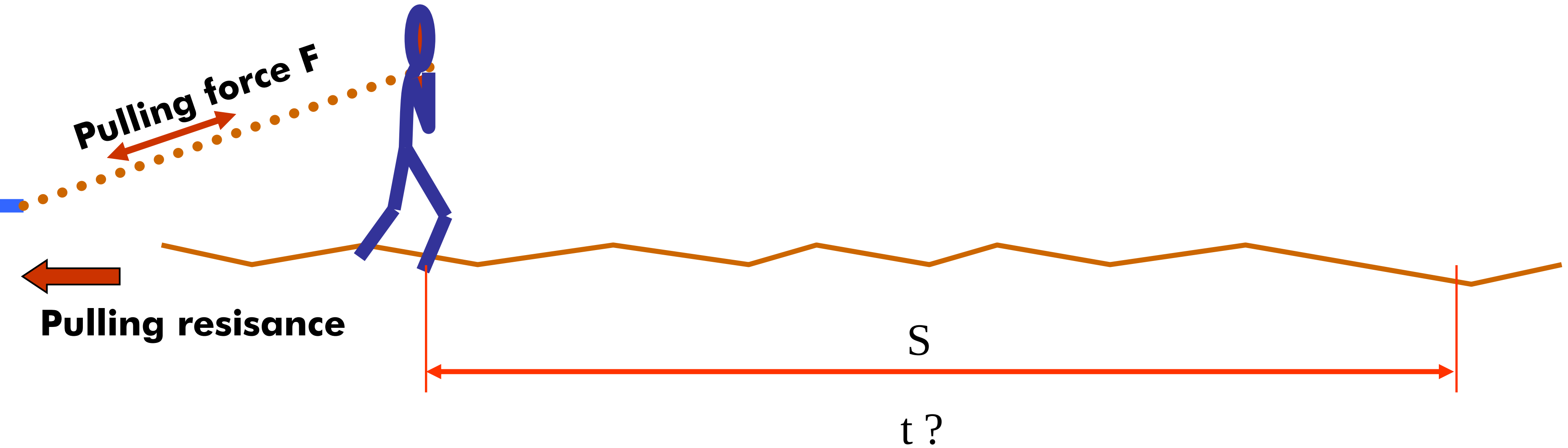


Energy - Work

$$W = F \cdot s$$

$$P = \frac{W}{t}$$

W = work
F = force
s = distance
P = power
t = time



Energy enables work!

Energy consumption

- Energy is valuable and we must pay for the consumption
- Depending on energy type we buy it as liters, cubic meters, kWh
- The unit depends also how much we buy or consume, liters - barrells
- Energy consumption is often measured with the same units as it is sold => to compare or to add different energy sources we must make conversation from one unit to another unit

Energy units

- Energy is not sold with basic unit J (joule)
- Electricity and heat is sold with kWh
- Oil products are sold with liters and barrells
- Wood is sold with cubic meters (m^3)
- In statistics different units are used
  - Earlier toe was often used , toe = equivalent oil ton
  - Nowadays J (MJ, GJ, TJ) and different ?Wh (kWh, MWh, TWh) are used

	MJ	kWh	toe	kcal
MJ	1,00	0,27778	0,00002388	238,89
kWh	3,6	1,00	0,00008598	860
toe	41990	11630	1,00	10000000
kcal	0,004199	0,001163	0,0000001	1,00

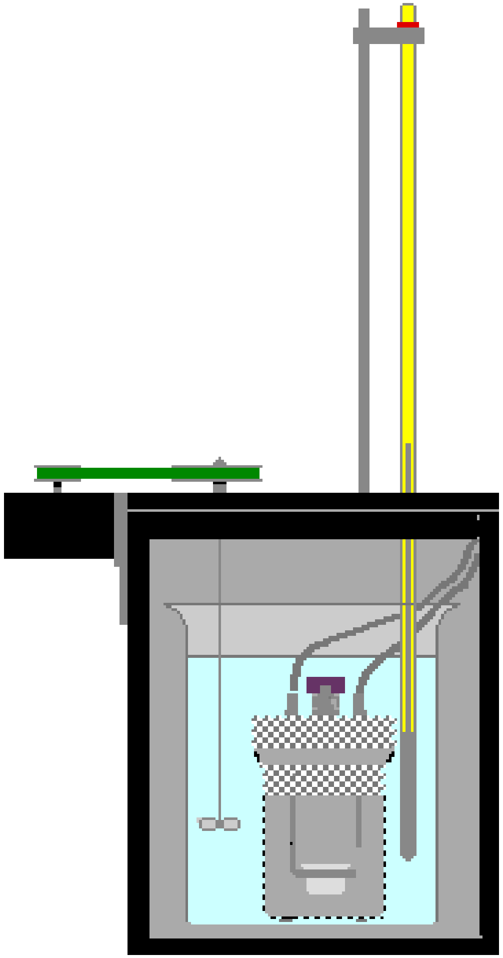
Name	Abbreviation	Magnitude
Kilo	k	10^3
Mega	M	10^6
Giga	G	10^9
Tera	T	10^{12}
Peta	P	10^{15}
Exa	E	10^{18}

Example

- A small house uses typically 20 MWh for heating in a year. How much is this in other units?

Energy content

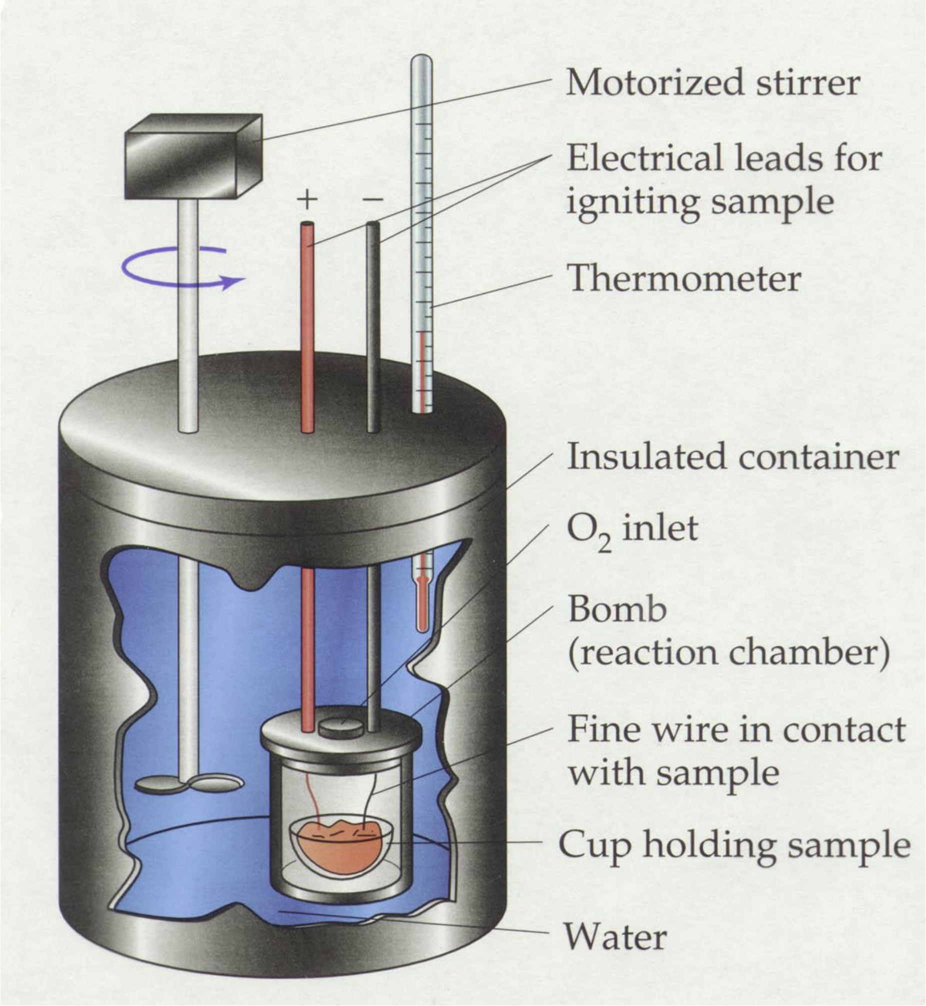
- Energy content of a material is determined by burning the materia in very efficient way and recording the freed energy amount (bomb calorimeter)
- This the maximum amount of energy which we can get from materia and it is called calorimetric value or heat value
- Heat values are quite constant and they can be determined at the species level: birch, spruce, wheat, rape
- In practice efficiency is never 100 %, the usable energy is always lower than the calorimetric value



Bomb calorimeter

- A small portion of the material is put in the calorimeter and this amount is burned and the energy released during burning is recorded.
- Bomb calorimeter gives the maximum energy (heating value), which can be released from a material.
- Three different heating values can be determined for material
  - **Higher heating value** (HHV, gross caloric value, upper heating value). During combustion the flue gases and vapour are also heated up and the heating of these are included in the upper heating value.
  - **Lower heating value** (LHV, net calorific value). The heating of flue gases and vapour are not included in the upper heating value.
  - **Gross heating value**. Many materials such as biomasses include besides the dry part also water. This has to be taken into account when the heating value of moisture material is defined.

Bomb calorimeter



http://chemistry.umeche.maine.edu/~amar/fall2007/bomb.html

www.chem.hope.edu/~polik/Chem/bombcalorimetry.htm

Gross heating value

- Some materials and especially biomaterials have different amounts of water (moisture)
- Water is already burned material, its share must be subtracted
- Water in material is evaporated and this phenomena engages heat

$$H_g = H_{LHV} \cdot (1 - w) - 2,443 \cdot w$$

H_g gross heating value at the consumption moisture content
H_{LHV} lower heating value
w material water content

Heating values

Material	Lower heating value H_{LHV} MJ/kg
Crops	20
Straw	19
Rape seed	37
Wood	19

Wood species	Part of wood	H_{LHV} MJ/kg
Pine	Whole tree	19.6 – 20.4
	Woody material	18.7 – 19.3
	Husk	18.4 – 20.7
	Branches	19.4 – 20.5
Spruce	Whole tree	19.2 – 19.6
Birch	Whole tree	19.1 – 19.6
Alder	Whole tree	18.7
Aspen	Whole tree	18.5

Example

- Firewood moisture content after one year storage in a shelter is about 15%. What is the gross heating value?

Power and energy

- Fuel includes energy, which depend on fuel type, moisture content and amount of fuel
- Power reveales how fast the energy is released from the fuel amount

$$P = \frac{E}{t}$$

P power
E Energy amount released
t time used in release of energy

Example

- Armful of firewood is burned in 5 min, 15 min or 1 hour. What is the fuel power?

Energy consumption

- Used amount of energy can be achieved by multiplying the power with time.
  - This method is used in electricity and heat trade.
- If energy is produced from fuels, then energy consumption can be derived from the amount of fuel used
  - This can be converted to other energy units when the fuel gross heating value is known

$$E = q \cdot H_g$$

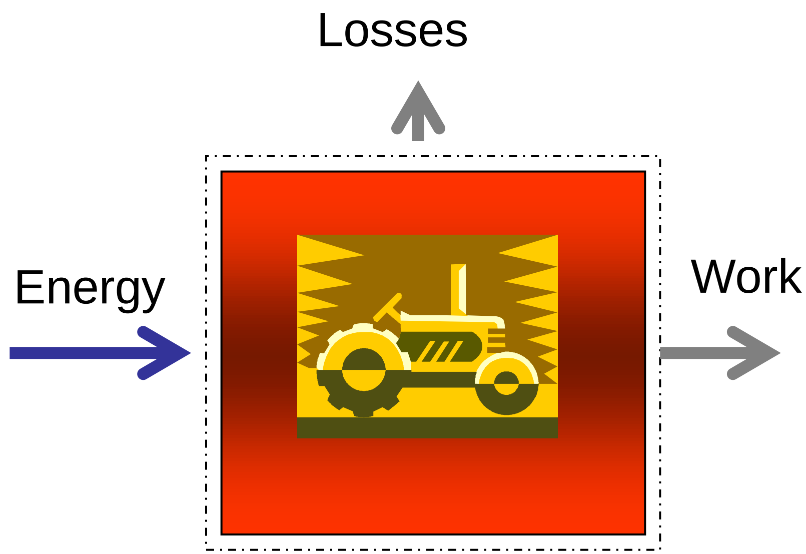
E = energy
q = fuel consumption
H_g = fuel gross heating value

Example

- The mean heating power of a small house is during one hour 3.6 kW. How much energy did the house consume?
- A diesel car consumes 5,3 l/100 km when driving 80 km/h. How much energyh does the car consume in one hour?

Efficiency

- During energy conversation part of the energy goes to losses
- Efficiency is used to report the gained part
- The losses transform to heat or not all the energy was converted and then we will produce emissions
- Efficiency can be calculated either with energy or power



$$\eta = \frac{E_{utilised}}{E_{total}} = \frac{P_{utilised}}{P_{total}}$$

η = efficiency

$E_{utilised}$ = utilised energy amount

E_{total} = total used energy amount

$P_{utilised}$ = utilised power amount

P_{total} = total power

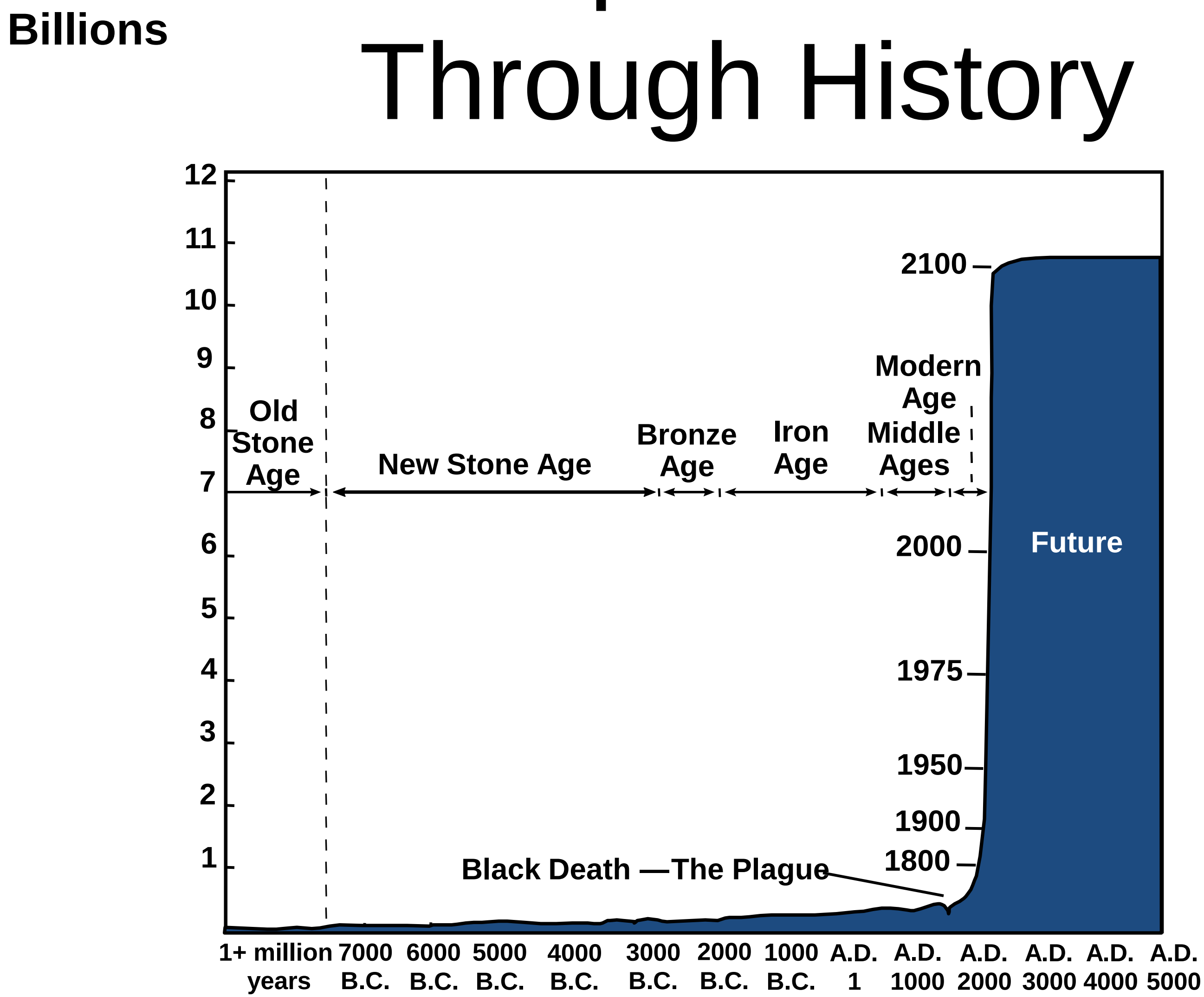
Example

- In wood firing the fuel consumption is 2 kg/h and the heating power is 7 kW. What is the efficiency of the heating system?

Energy storage

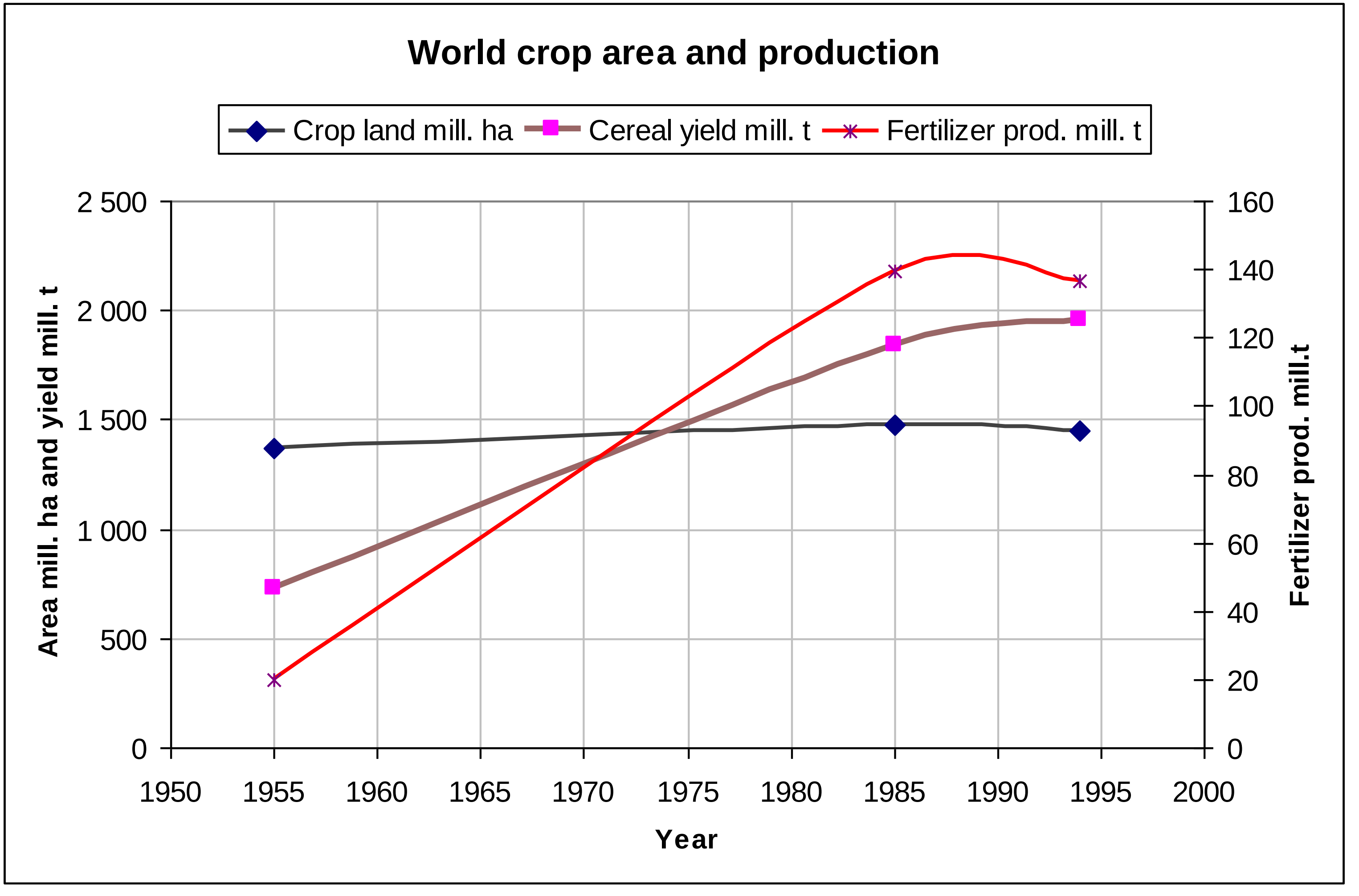
- Energy is hard to store
- Liquid fuels are good because they are easy to store, their density is high and the heating value is high
- 'Natural' energies are hard to store. Sun and wind energies can be converted to heat or electricity but the storage of these energies is not easy
- Storage of electricity in batteries is not efficient
- Plants use sun radiation energy in photosynthesis and store ’this energy’ in stems, seeds or roots. Plants are good in storing sun energy

World Population Growth Through History



Source: Population Reference Bureau; and United Nations, *World Population Projections to 2100* (1998).

World food production



Population and food 1955 - 1995

- Conclusions
  - World population has doubled
  - Cereal area is about the same
  - Cereal production has almost tripled
  - Fertilizer usage has increased 7-times

If population increases more area is needed for agricultural production

Production increase is achieved with fertilizers, which is mainly produced with oil

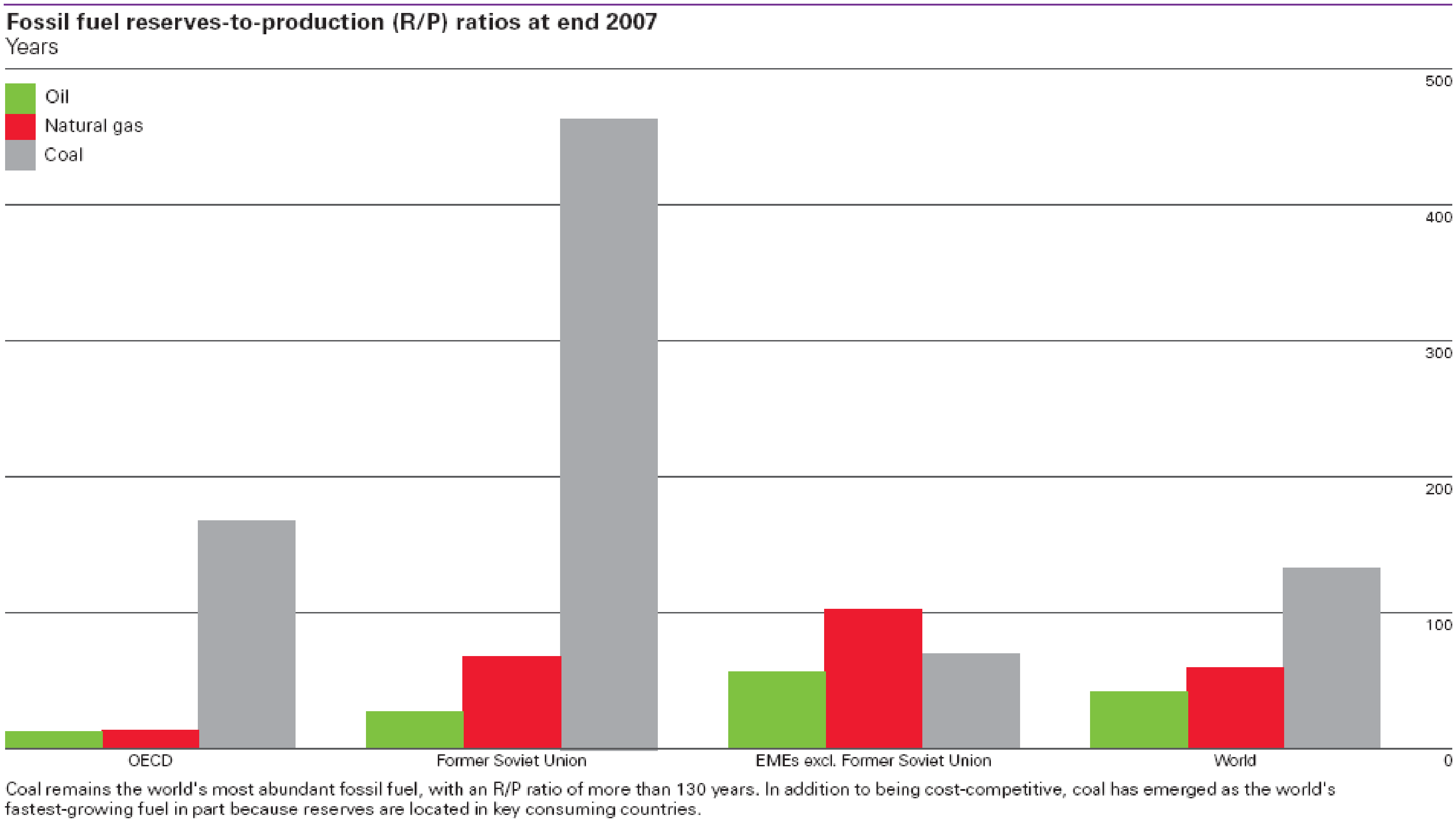
What happens if we will have an energy crisis?

Agriculture and energy

Energy usage in agriculture has increased significantly. The reason for this is:

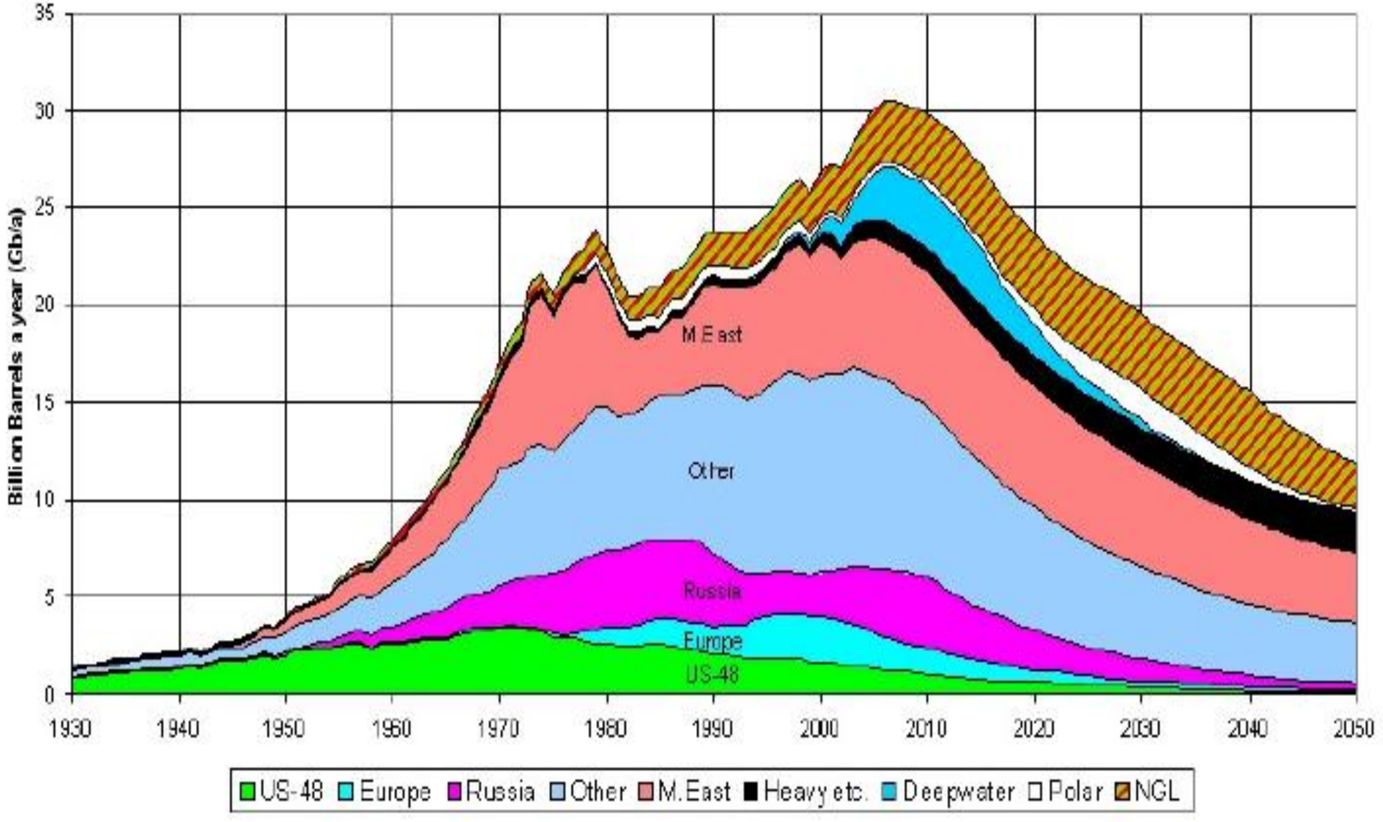
- Increase of world population
- Workers movement to cities
- New production technologies, great part of production energy is used in fertilizers and fuels

Energy resources



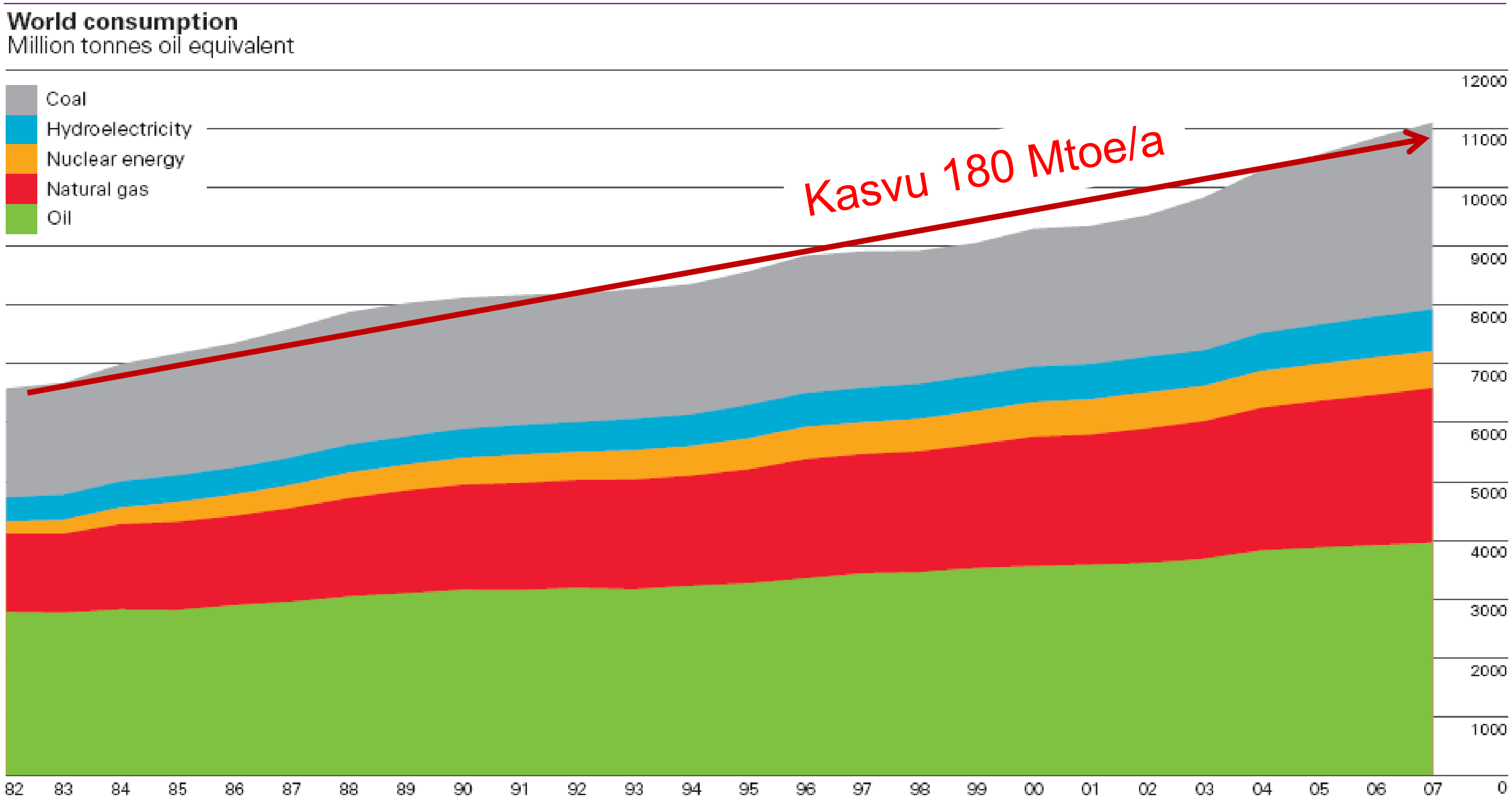
http://www.bp.com/productlanding.do?categoryId=6929&contentId=7044622

Oil production



Kuva 10. Öljyn tuotanto eri lähteistä (lähde: Aleklett et.al., www.peakoil.org)

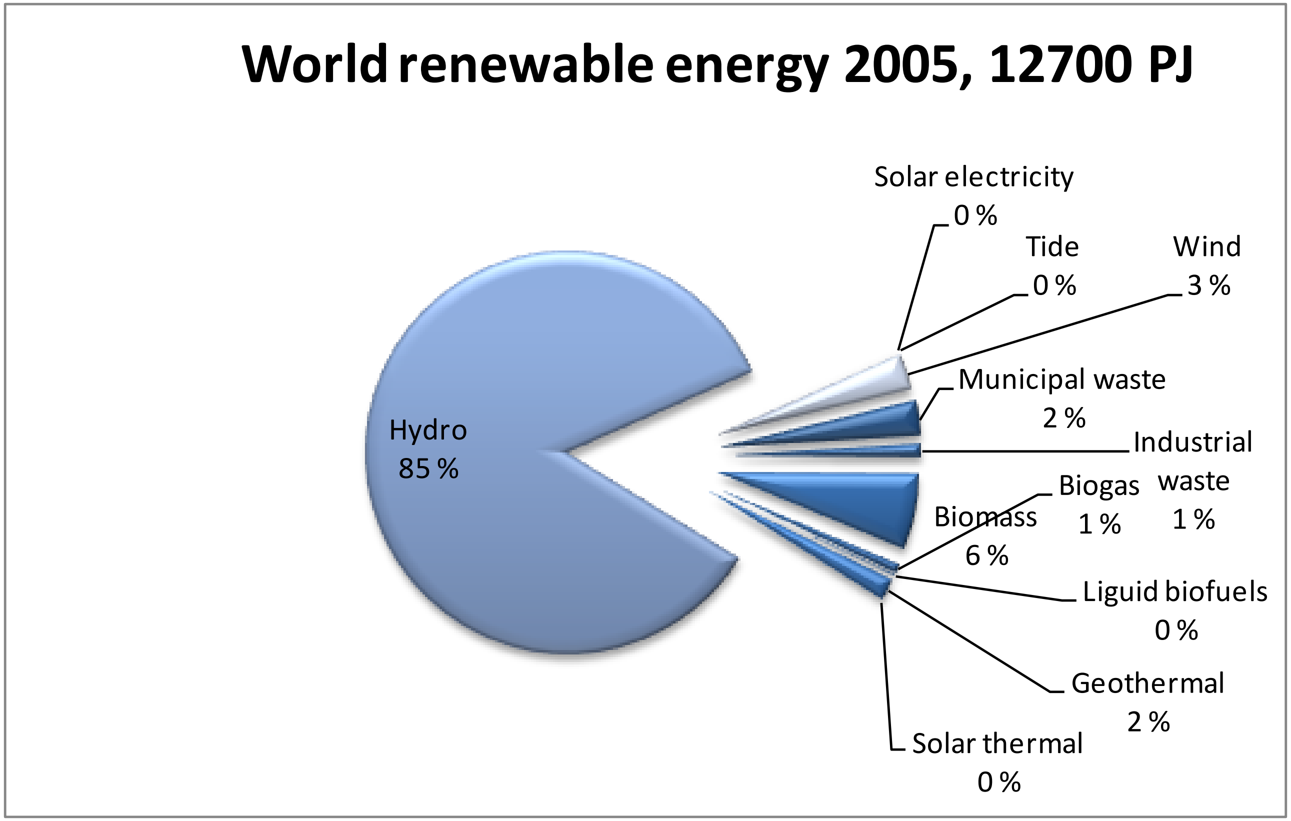
World energy consumption



World primary energy consumption slowed in 2007, but growth of 2.4% was still above the 10-year average. Coal remained the fastest-growing fuel, but oil consumption grew slowly. Oil is still the world's leading fuel, but has lost global market share for six consecutive years, while coal has gained market share for six years.

http://www.bp.com/productlanding.do?categoryId=6929&contentId=7044622

Renewable energy

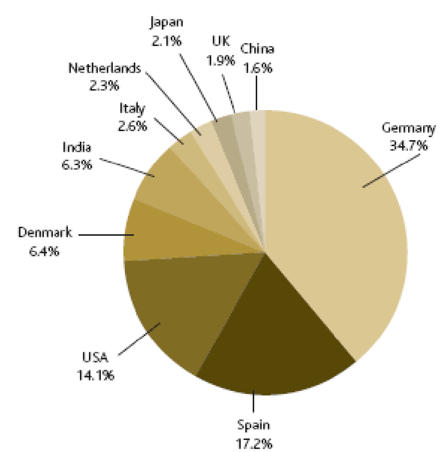


http://www.iea.org/Textbase/stats/prodresult.asp?PRODUCT=Renewables

Likely energy resources

- Solar energy
  - Finland and Estonia: during summer 400 – 700 W/m^{2}during winter and nights 0 W/m^2
  - 0.02 % of solar energy is enough for the whole world energy demand (100 % efficiency)
  - The prices of solar panels are high and the energy demand and supply occur in different times
  - Fastest growing energy form, annual growth rate is 35%
- Wind energy
  - 5% of worl wind energy could produce the energy needs of the world
  - Problems are same as with solar energy, expensive and the energy demand and supply occur in different times
  - P ~ v^3

TOP TEN WIND POWER MARKETS 2004: CUMULATIVE MW INSTALLED



Country	Total capacity End 2004 (MW)
Germany	16,649
Spain	8,263
USA	6,750
Denmark	3,083
India	3,000
Italy	1,261
Netherlands	1,081
Japan	991
UK	889
China	769
Total	**42,735**

Source : GWEC

Information

http://www.worldenergy.org/wec-geis

http://www.weea.org

http://www.worldenergynews.com

http://www.worldenergy.net

http://www.energia.fi

http://www.peakoil.org

http://www.iea.org

www.finbioenergy.fi

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

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• MTT Agrifood Research Finland - Agricultural Engineering
• Estonian University of Life Sciences

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

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ENPOS Energy Positive Farm

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