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# Field Bioenergy in Finland, possibilities and challenges

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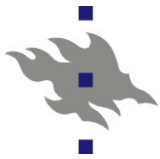
## Function of the field

### Original function

- Food production
- Feed production
- Fibre production, flax, hemp, cotton

### Modified function

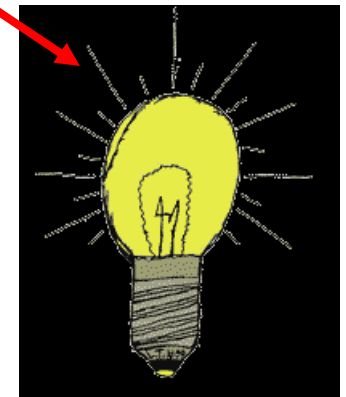
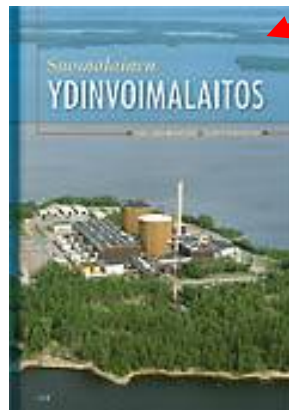
- Bioenergy

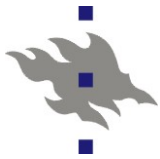


## Food energy need in Finland

**Human being needs 10 MJ energy in a day**

Population	5300000	
Energy need	10 MJ/day	
Food energy amount needed in Finland in one day		
	53000000 MJ/day	
Corresponding mean power	613 MW	
	116 W/human	

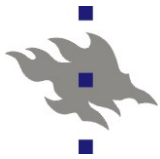




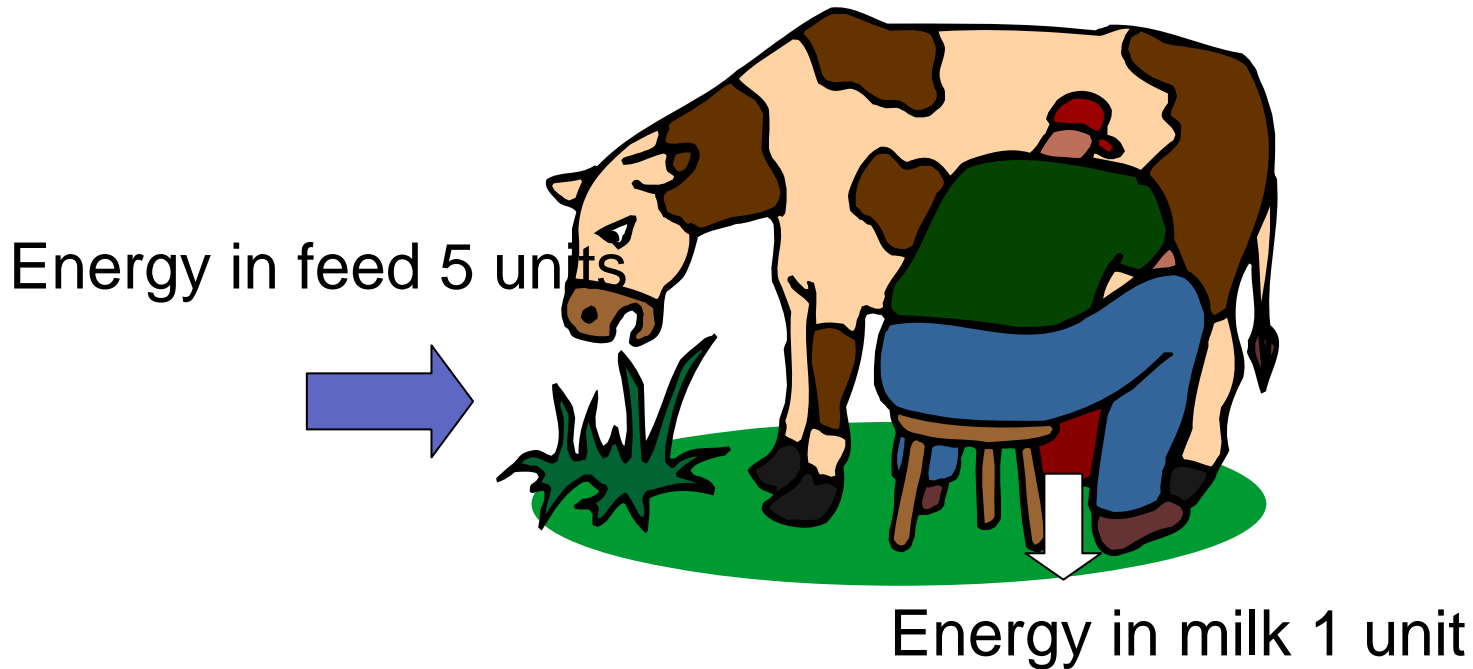
## Need for dark bread

Energy in bread	8400	kJ/kg			
Bread need in a day in Finland	6309524	kg/day			
Bread need in a year in Finland	2302976	t/year			
Amount of flours needed for baking	1681173	t/year	Bread includes 78 % flours		
Amount of rye needed for making flours	2241563	t/year	75 % of the rye is converted to flour		
Rye yield	2300	kg/ha			
Area needed for rye production	730945	ha			

***If only dark bread was eaten we would need about 730 000 ha of fields***



# Milk factory



The milk factory inside a cow can produce milk with 20 % efficiency !

## Field area needed for milk production

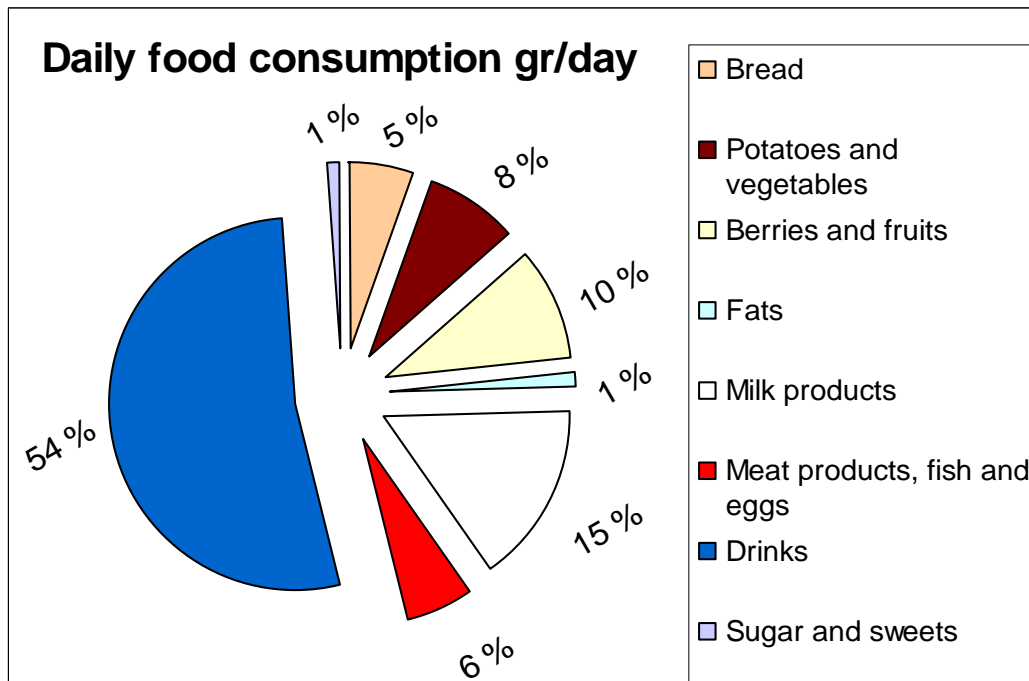
<b>Population</b>				5300000	
Food energy amount needed in Finland in one day				53000000	MJ/day
Energy amount needed in one year				19345000000	MJ/year
Milk needed (only milk is drunk)				7440384615	kg/year
				20384615	kg/day
<b>Number of cows needed</b>				978998	cows
- heath power of a cow				0,8	kW/cow
- heath power of all cows				783	MW
<b>Field area</b>					
- energy needed to feed cows				9.67E+10	MJ/year
- field are needed for hay production (only hay for cows)				1087776	ha/year

***If only milk was drinken we would need about 1 100 000 ha of fields***



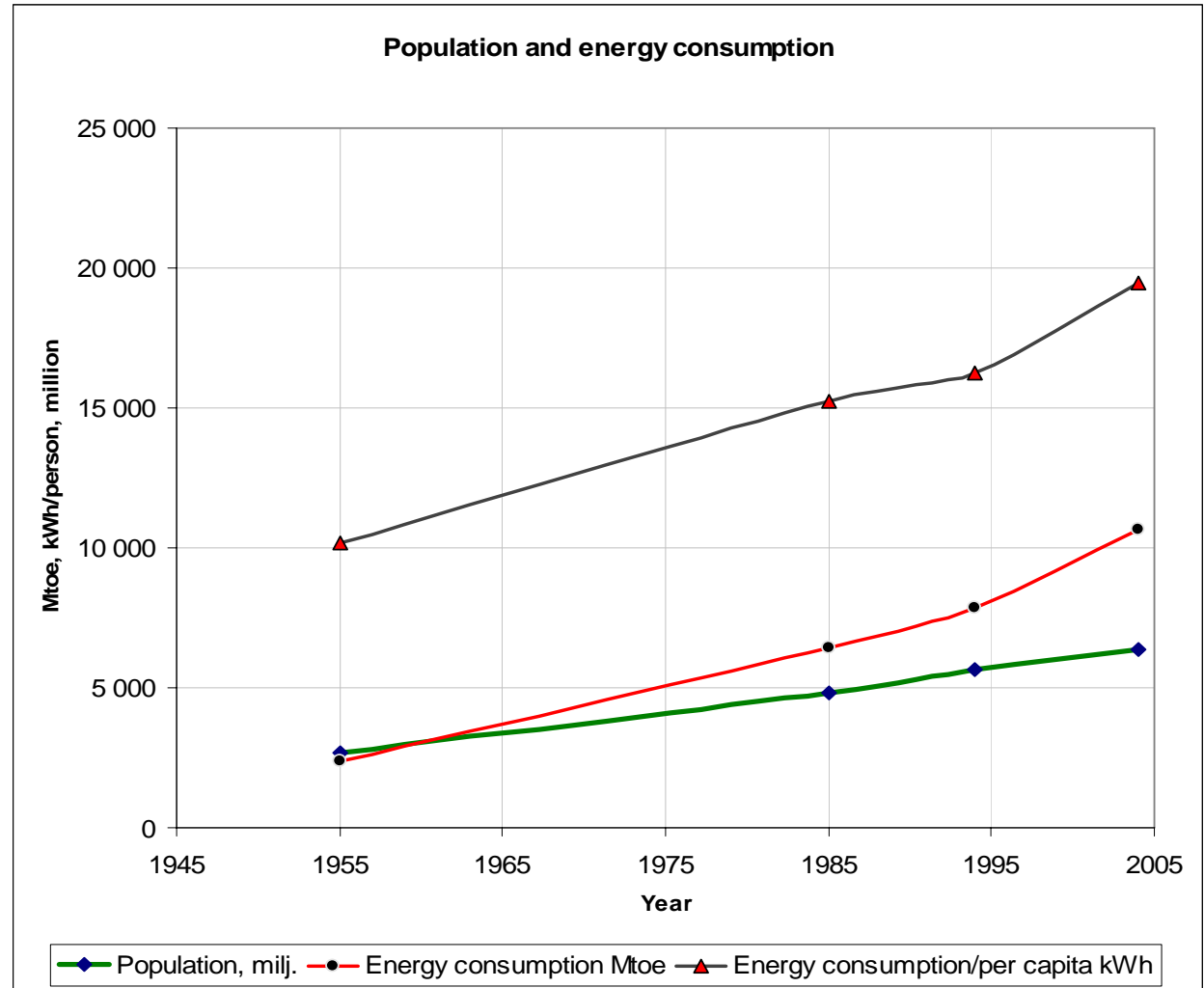
## What does a human being eat?

- Human being eats also other food than bread
- Food from animal production always decreases production efficiency => more hectares are needed for food production
- On the other hand for instance cows can exploit hay, which human beings cannot eat
- Finnish Ministry of Agriculture and Forestry suggests that 0,5 million hectares could be used for other than food or feed production



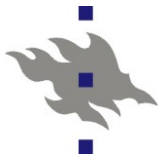


# World population and energy consumption

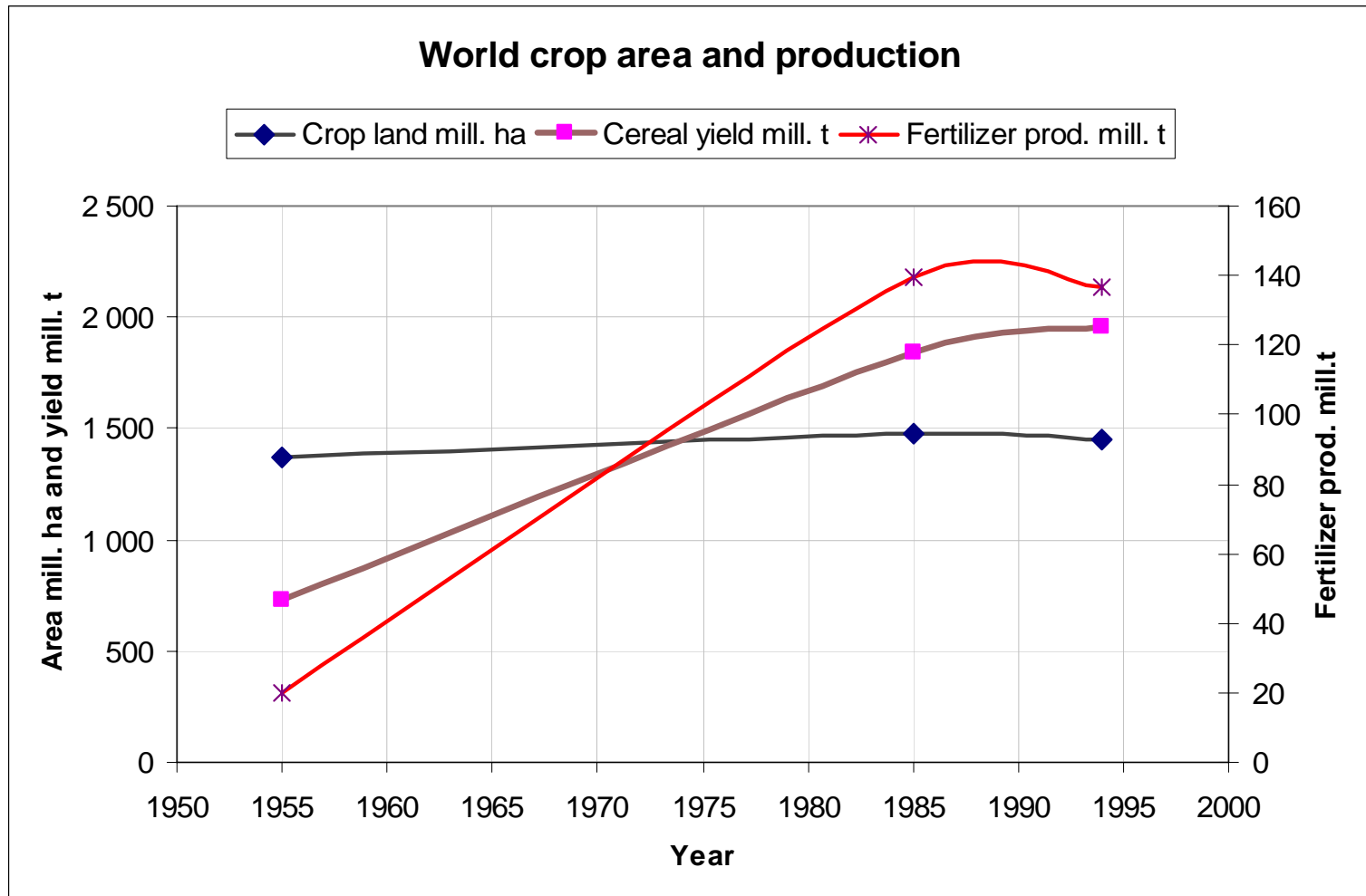


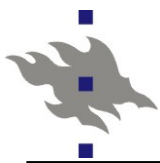
Source: <http://www.eia.doe.gov/emeu/iea/popgdp.html>, Kitani O. Natural Energy and Biomass. CIGR Handbook of Agricultural Engineering, Volume V. ASAE 1999





# World food production





# Population and food 1955 - 1995

## ■ Conclusions

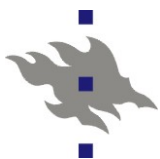
- World population has doubled
- Cereal area is about the same
- Cereal production has almost tripled
- Fertilizer usage has increased 7-times

If population increases more area is needed for agricultural production

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

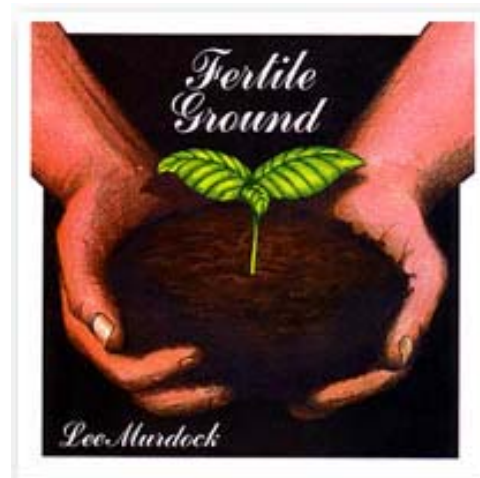
What happens if we will have an energy crisis?





## If energy shortage occurs

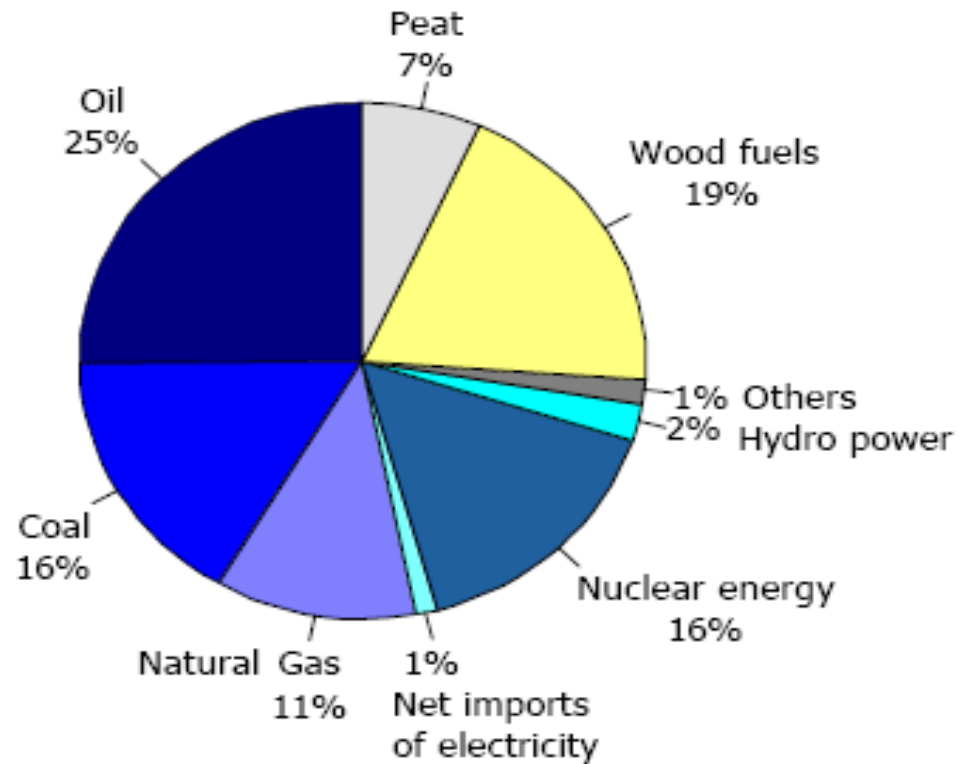
- Fertilizer prices will increase and fertilizer supply will decrease
  - Fertilizer usage will decrease
  - Yields will decrease
  - More area is needed for food production
  - Supply of field bioenergy will decline
- If agricultural production does not get enough oil
  - More human and animal labour will be needed
  - Animals and machines 'eat' part of the production



# Energy consumption in Finland

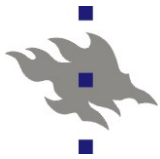


## Total energy consumption 2003



Energy Statistics 2003

*Field bioenergy is in the Others 1 % category*



## Energy scenario in Finland

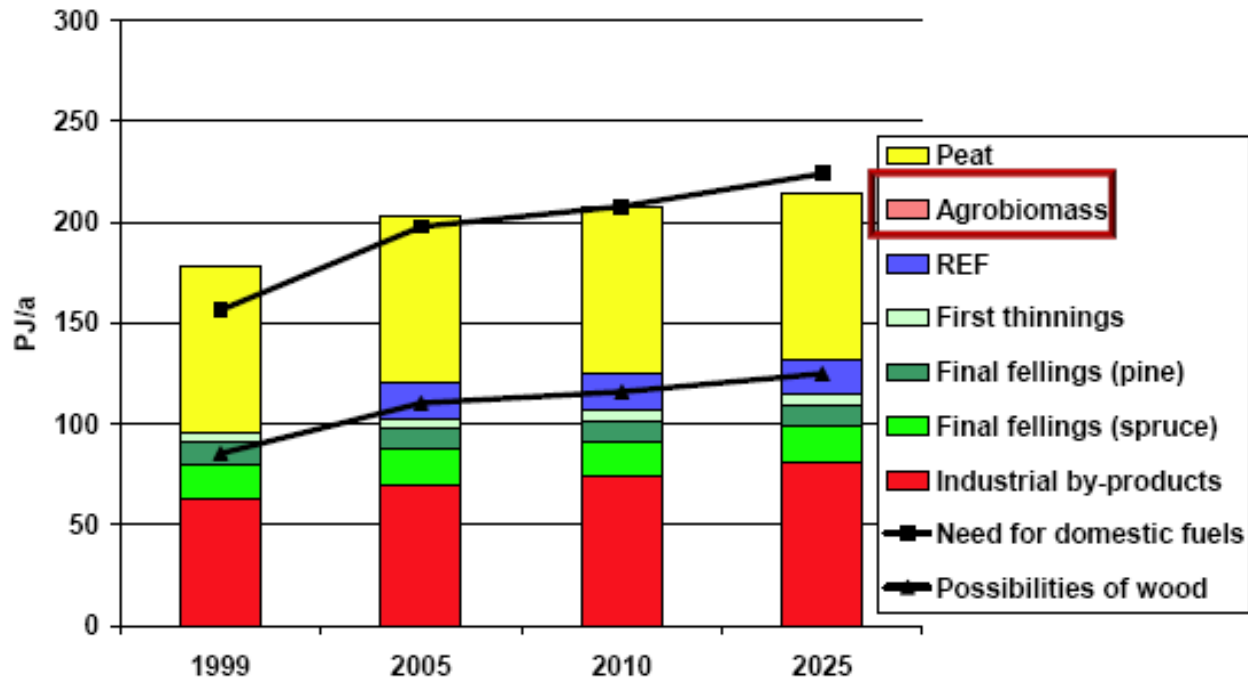
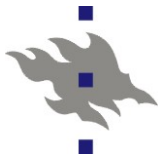


Figure 8. Availability of wood and peat fuels by employing conventional technology and based excluding black liquor and firewood on Basic Scenario /28/.

Helynen, S, Flyktman, M., Mäkinen, T., Sipilä, K. & Vesterinen, P. 2002. Bioenergian mahdollisuudet kasviuonepäästöjen vähentämisessä. [The possibilities of bioenergy in reducing greenhouse gases. In Finnish, with English abstract]. Technical Research Centre of Finland, Espoo. VTT Research Notes 2145. 110 p. + app. 2 p.



## Wood – Field energy

- Bioenergy production in Finland is based on wood and especially on industrial waste or thinning wood
- The future of field bioenergy is seen marginal
- Reason for this
  - Long tradition in wood usage
  - Wood material is easier to handle
  - Energy balance is better for wood energy
    - Forrest produces yield with minimal fossile energy usage



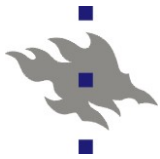


## Energy and emission analyses

### Results of analyses

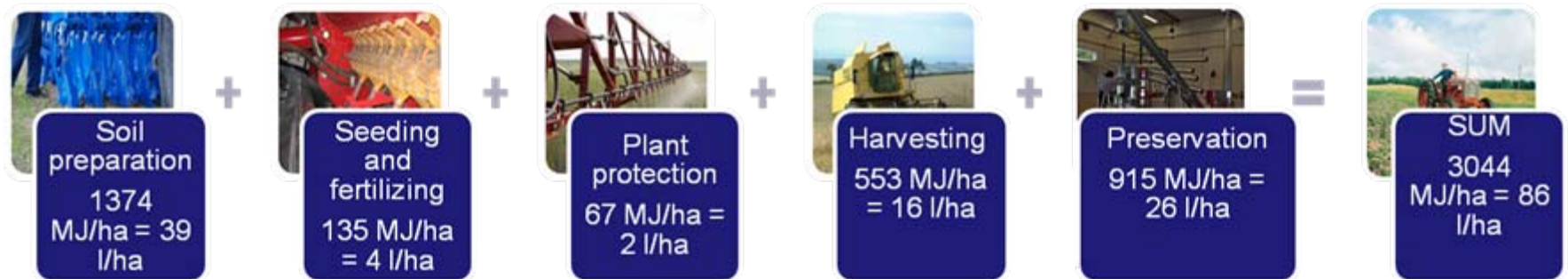
- Is more fossil energy used in the production than what the product contains ?
- Is more emissions produced during the production than for instance direct fossil energy produces ?
- Analyses reveals:
  - Production sense
  - Weakest points in the production chain



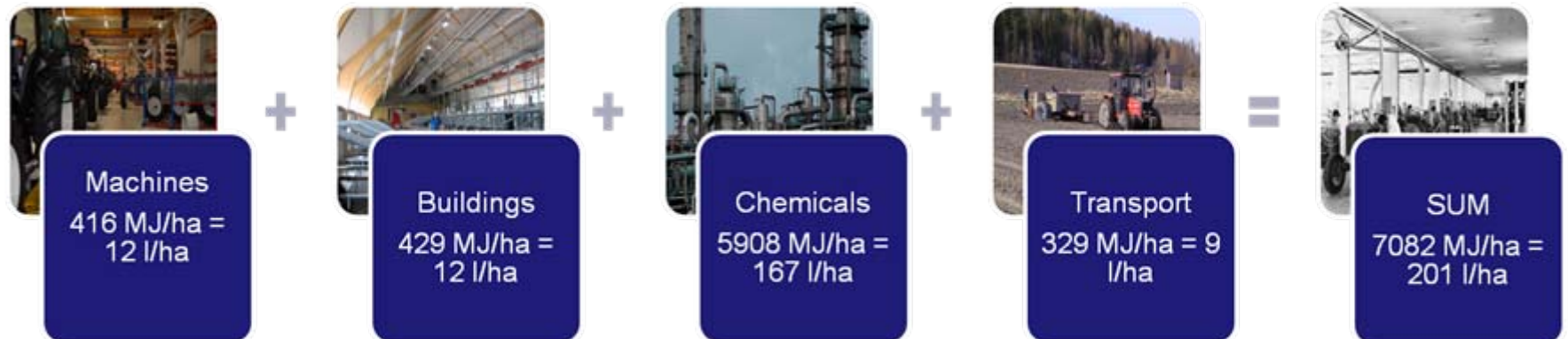


# Energy usage in plant production

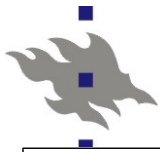
## Direct energy usage



## Indirect energy usage

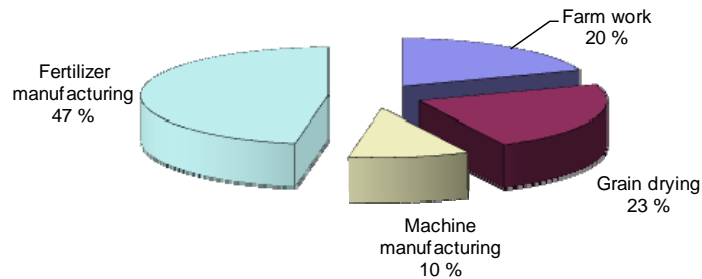






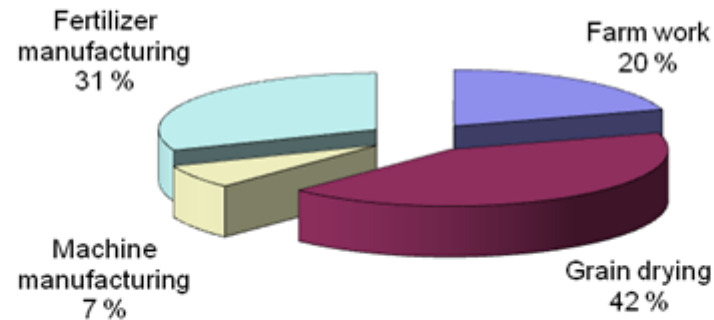
# Example of Energy usage in plant production

Energy usage in barley production in Finnish conditions  
total energy demand 9780 MJ/ha (274 l/ha diesel oil)  
Favourable climate conditions



> 50 % more

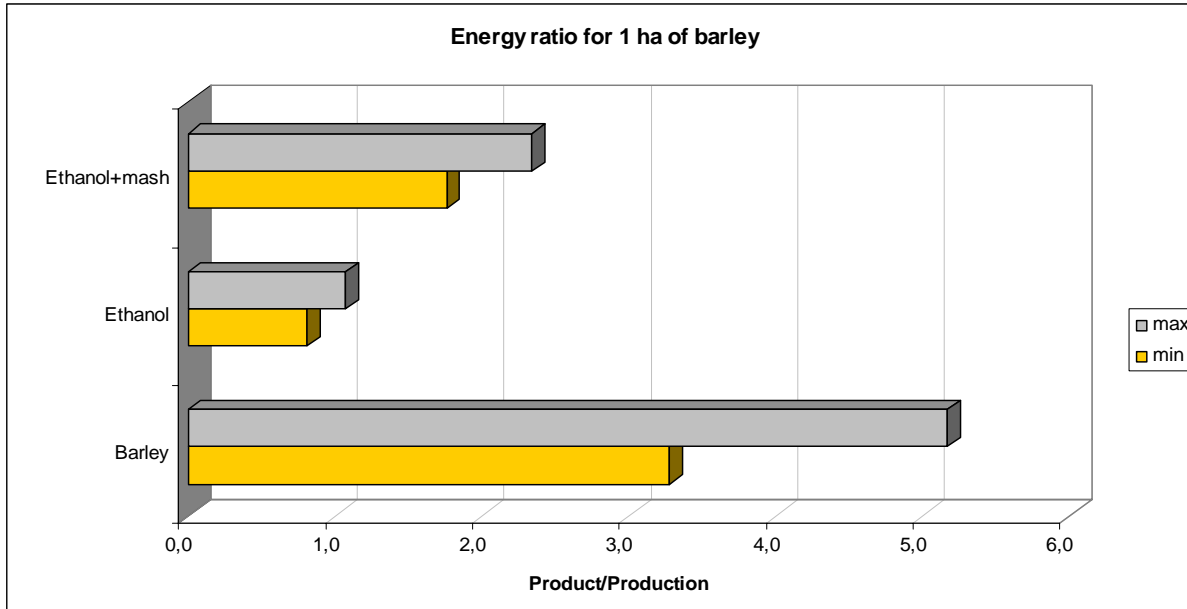
Energy usage in barley production in Finnish conditions  
Total energy demand 14880 MJ/ha (417 l/ha diesel oil)  
Poor climate conditions



# Energy balance

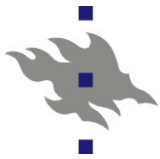


Grain could be used as a fuel  
*It is immoral to burn grain!*

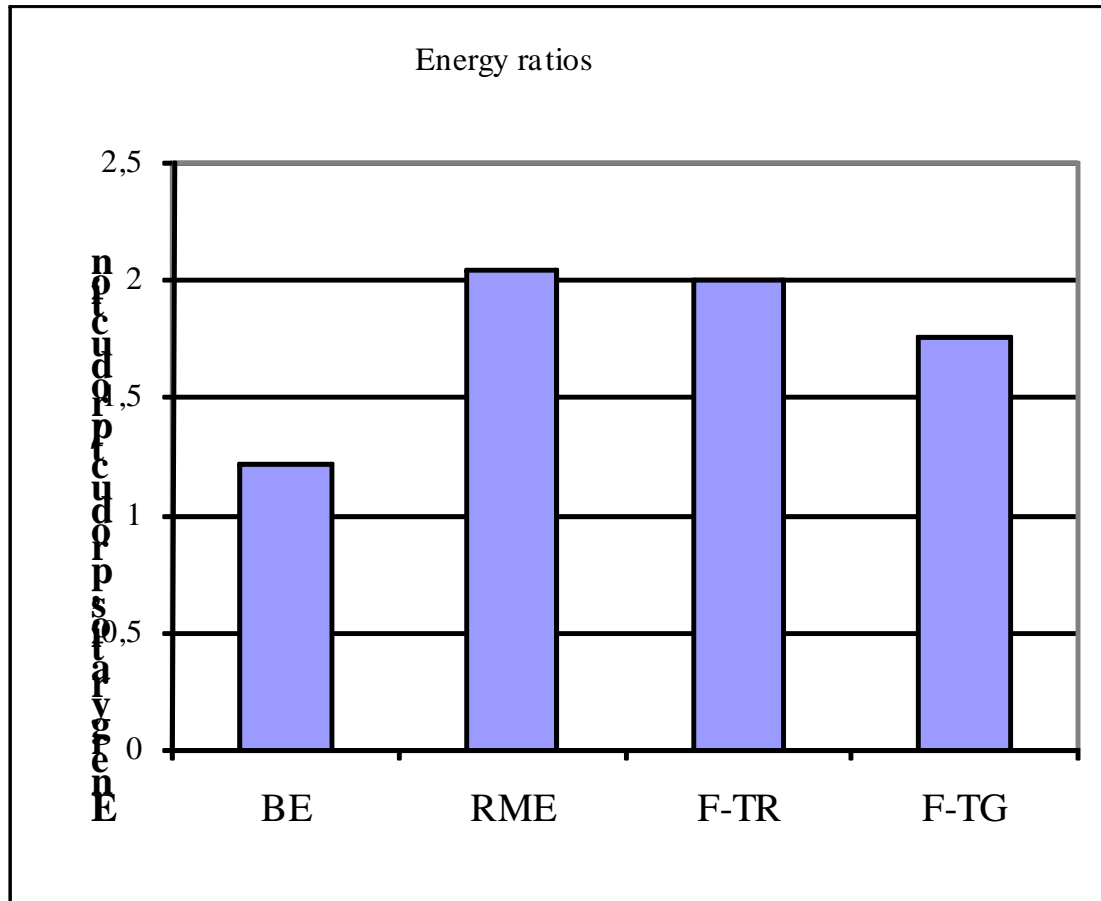


Is it moral to use ethanol as a fuel?

**In ethanol production more energy can be used in production than what is got from ethanol**

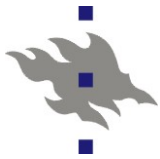


## Energy balance



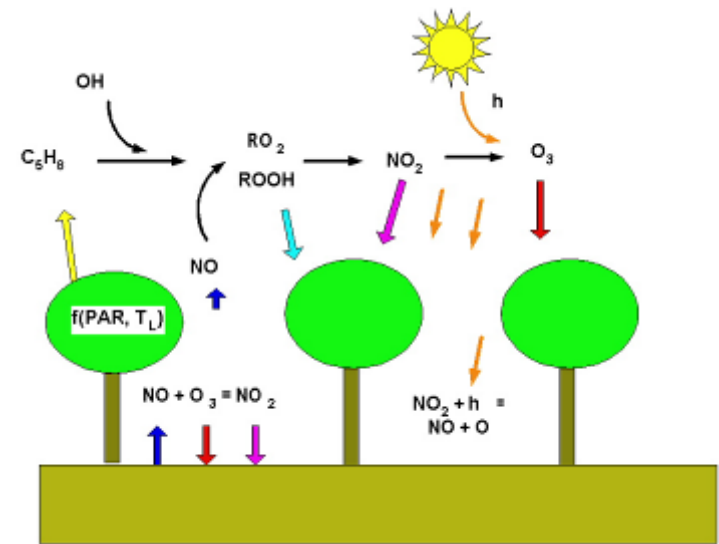
BE = Barley Ethanol, RME = Rape seed Methyl Esther, F-TR = Fischer-Tropsch diesel from Forest Residues, F-TG= Fischer-Tropsch diesel from Reed Canary Grass

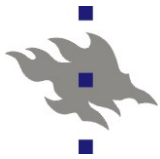
Source: Mäkinen et al. Liikenteen biopolttoaineiden ja peltoenergian kasvihuonekaasutaseet ja uudet liiketoimintakonseptit. VTT tiedotteita 2357, Espoo 2006



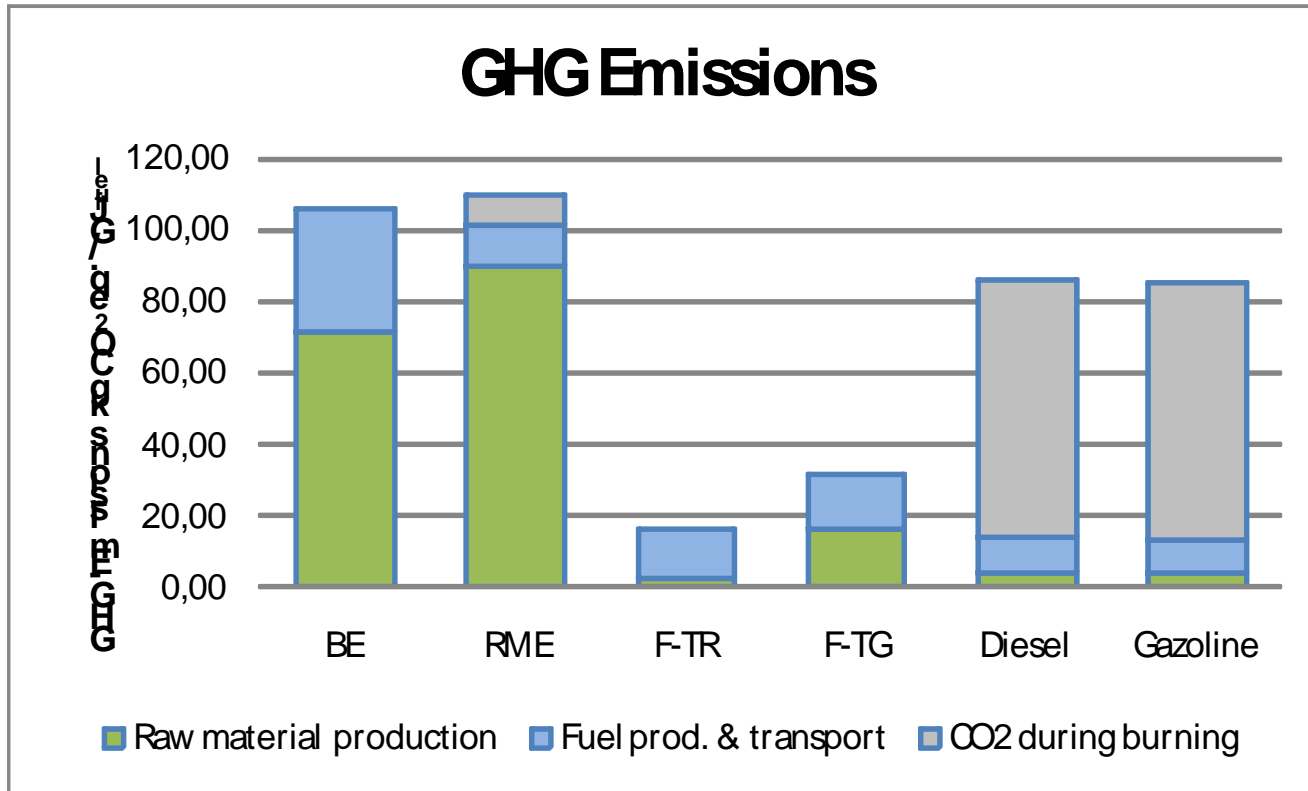
## Bioenergy – GHG analyses

- Fossil energy is used for bioenergy production => also emissions are produced during production
- Fertilizer usage makes changes to field emissions =>  $N_2O$  from soils is a problem for field bioenergy production
- GHG (Green House Gas) analyse takes into account the production emissions
- Normally IPCC (Intergovernmental Panel on Climate Change) GHG analyse is done for bioenergy production
  - GWP (Global Warming Potential) indexes for 100 year time period:  $CO_2 = 1$ ,  $CH_4 = 24,5$  and  $N_2O = 320$





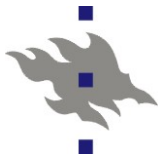
# Bioenergy and GHG effect



BE = Barley Ethanol, RME = Rape seed Methyl Ester, F-TR = Fischer-Tropsch diesel from Forest Residues, F-TG= Fischer-Tropsch diesel from Reed Canary Grass

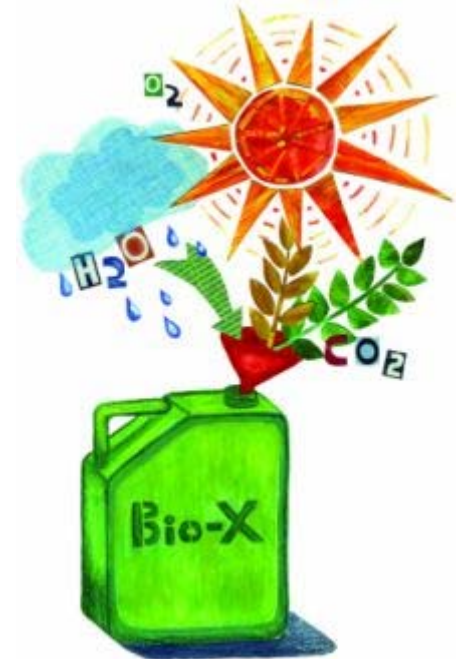
***Ethanol and biodiesel have stronger GHG effect than fossil fuels***

Source: Mäkinen et al. Liikenteen biopoltoaineiden ja peltoenergian kasvihuonekaasutaseet ja uudet liiketoimintakonseptit. VTT tiedotteita 2357, Espoo 2006



## Future of field bioenergy

- At the moment some amount of field area can be taken to bioenergy production
  - 500 000 ha at the moment seems to be available
  - marginal soils and 'waste' fertilizers could be used on these fields
- Agricultural, industrial and municipals wastes could be be used more for biofuel production





# Evaluation of bioenergy



**Economically profitable**



**Political reasons**



**High energy ratio**



**Emission reduction**



# Challenges for field bioenergy research

- Analysis methods
  - common background for analysis is missing
- Decrease of fossil energy consumption
  - Decrease of fertilizer usage by
    - Better nutrient recycling
    - Using nitrogen fixing plants in production
  - Improving grain drying efficiency and storage methods
  - Improving efficiency in biomass usage, all parts of the plant must be utilized
- If energy plants are used
  - Present plants are selected and developed by their food or feed production capability => new species must be developed
  - Harvest and storage methods must be developed
  - Plant rotation must be developed







# Challenges for field bioenergy research

## ■ 'Waste' utilization

- Agricultural (industrial, municipal) waste exploitation must be improved
  - straw
  - manure

- Minor and problematic soils could be reserved for biomass production

## ■ Cultivation method

- Biomass production must be integrated to normal agricultural production (rotation)
- Biomass production needs own production systems





# Challenges for field bioenergy research

- Biofuel or biofuel raw material production on farms
  - Fuel properties must be standardized (biodiesel)
- Changes in agricultural product prices and markets
  - Field biofuels should not decrease food production
- New fuels
  - New fuels , we must not stay in the traditional fuels but also look at other fuels

