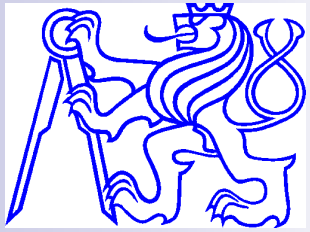
CZ-AT Summer School
Vienna, May 2013

Progress in research on biomass



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Content

1. Biomass definition, CE and EU statistics
2. Biomass and the Czech Republic – basic figures
3. Biomass – sources of origin
4. Biomass advantages compared with the other RES
5. Biomass utilization
6. Liquid biofuels as the controversial option
7. Energy efficiency of biomass fuel cycle
8. Selected opened questions

Biomass as the renewable energy source

EU Directive 77/2001

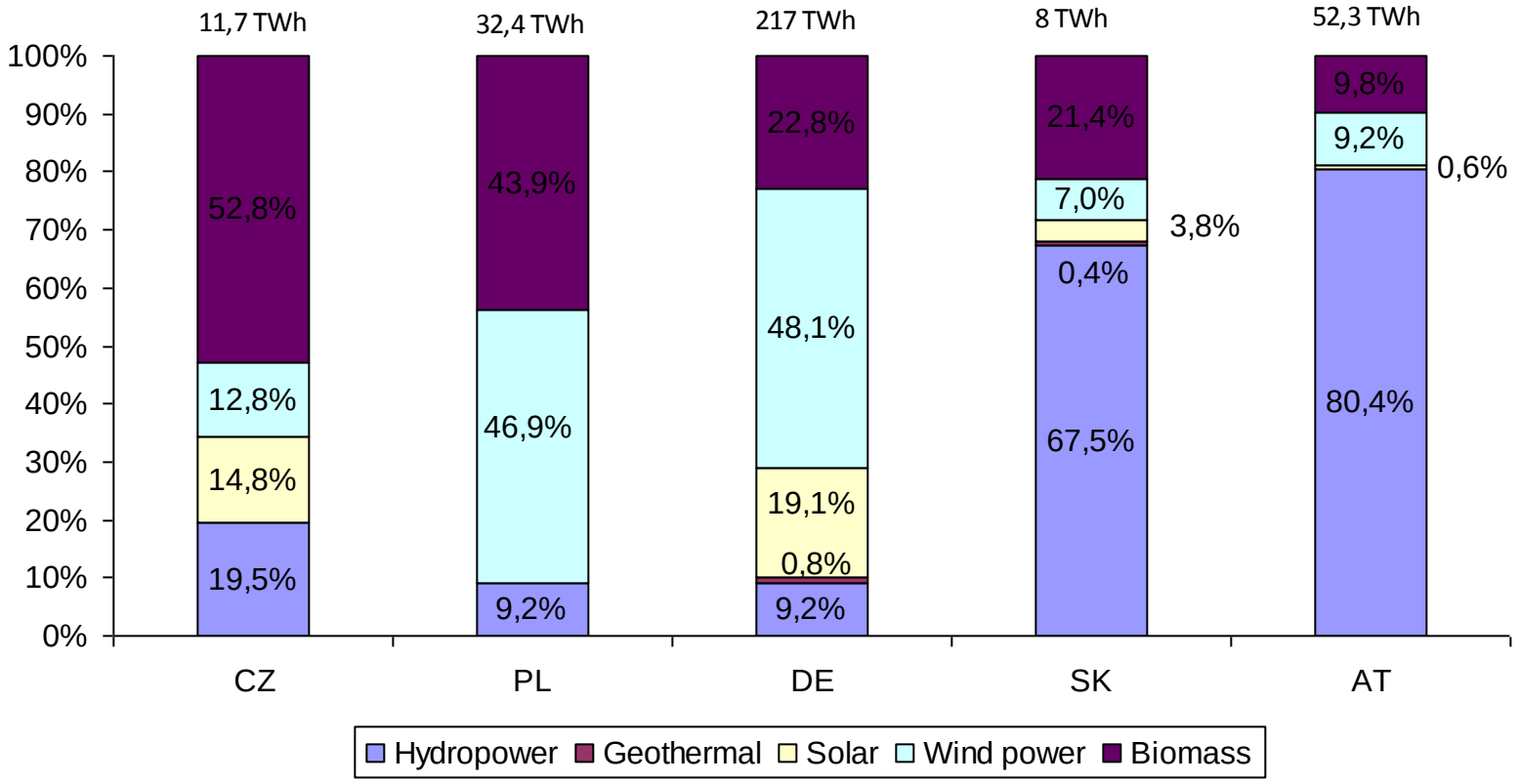
“biomass’ shall mean the biodegradable fraction of products, waste and residues from agriculture (including vegetal and animal substances), forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste”

Biomass as supported RES:

- sustainability criteria
- biodiversity and soil quality protection

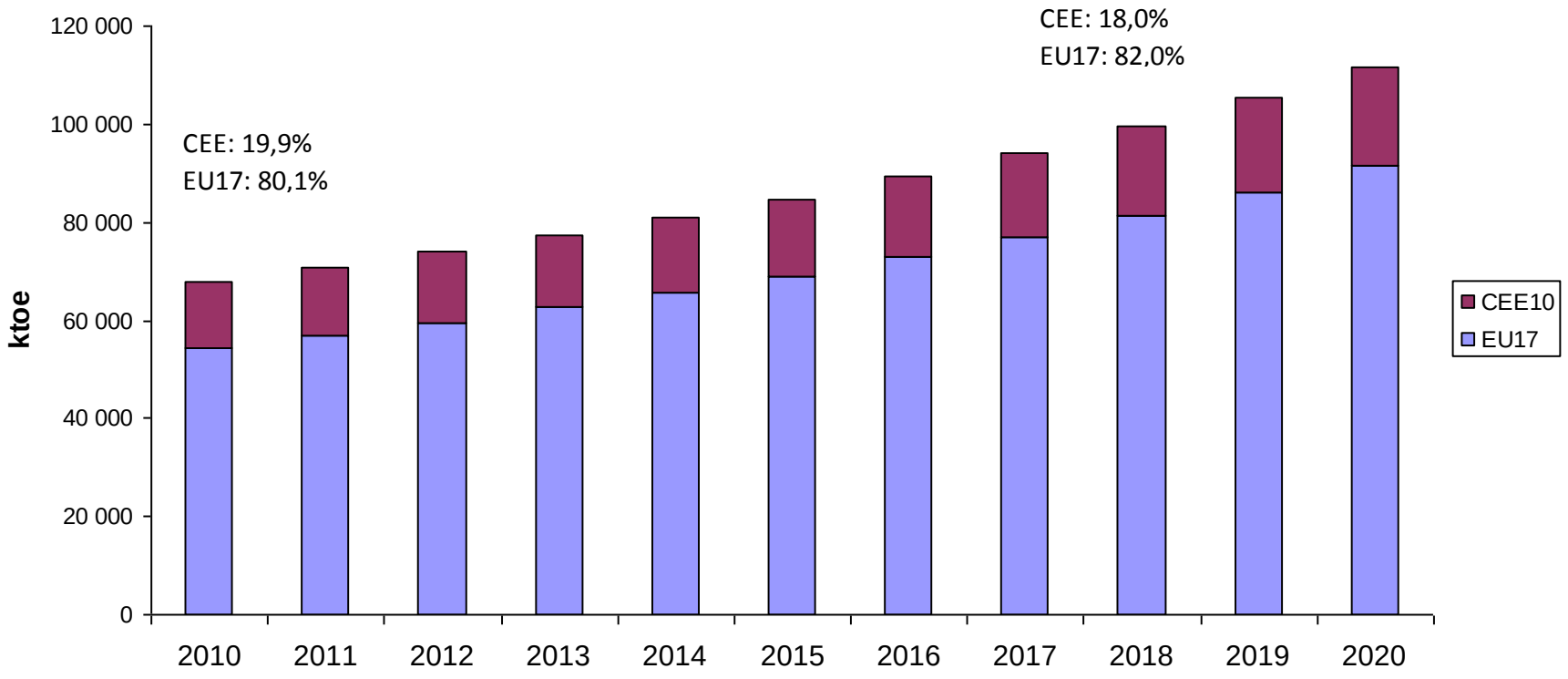
Biomass potential and utilization reflects specific conditions of given country

Power generation in 2020 (NREAPs)



Biomass potential and utilization reflects specific conditions of given country

RES for heating and cooling (NREAPs)



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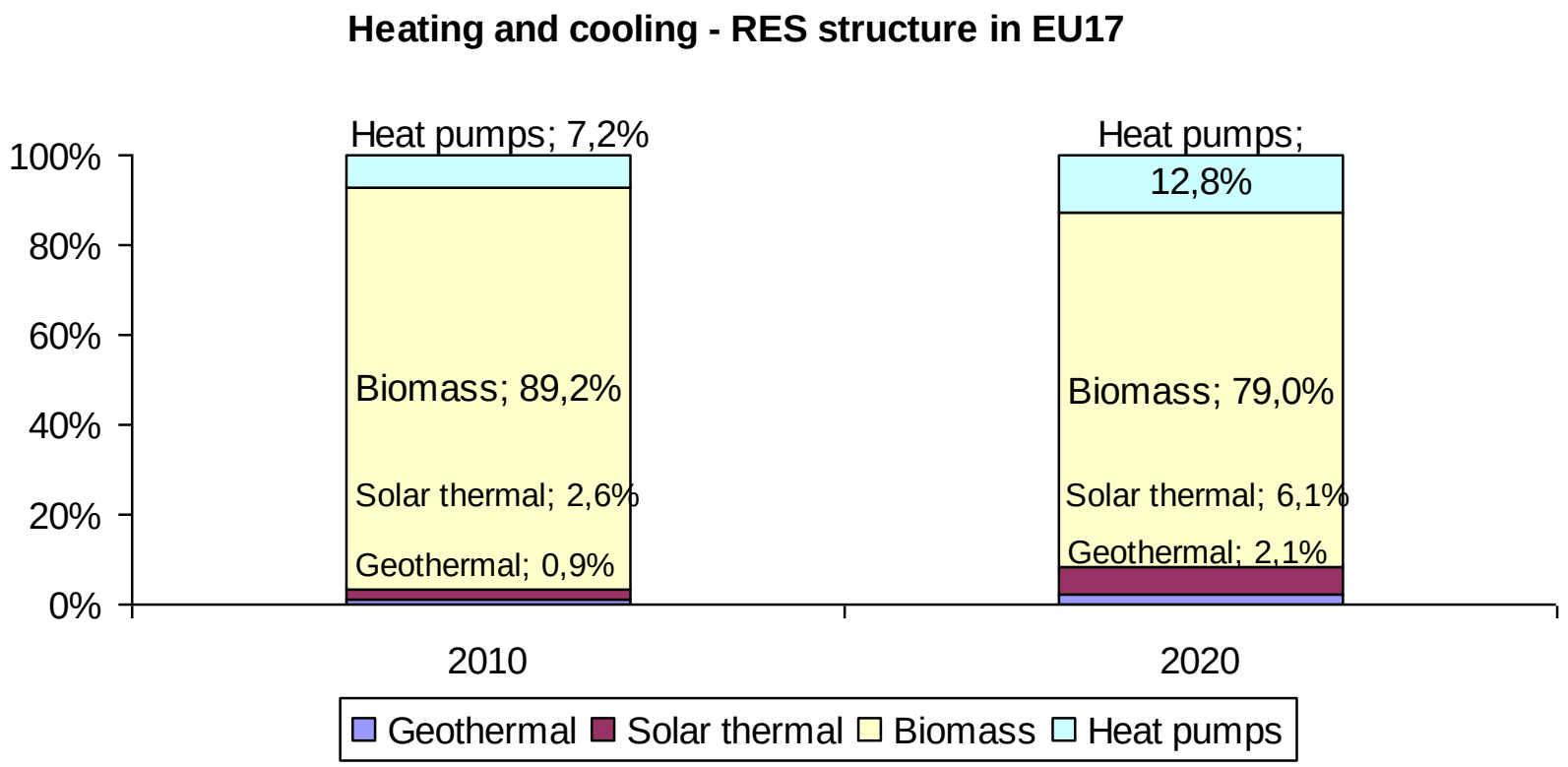

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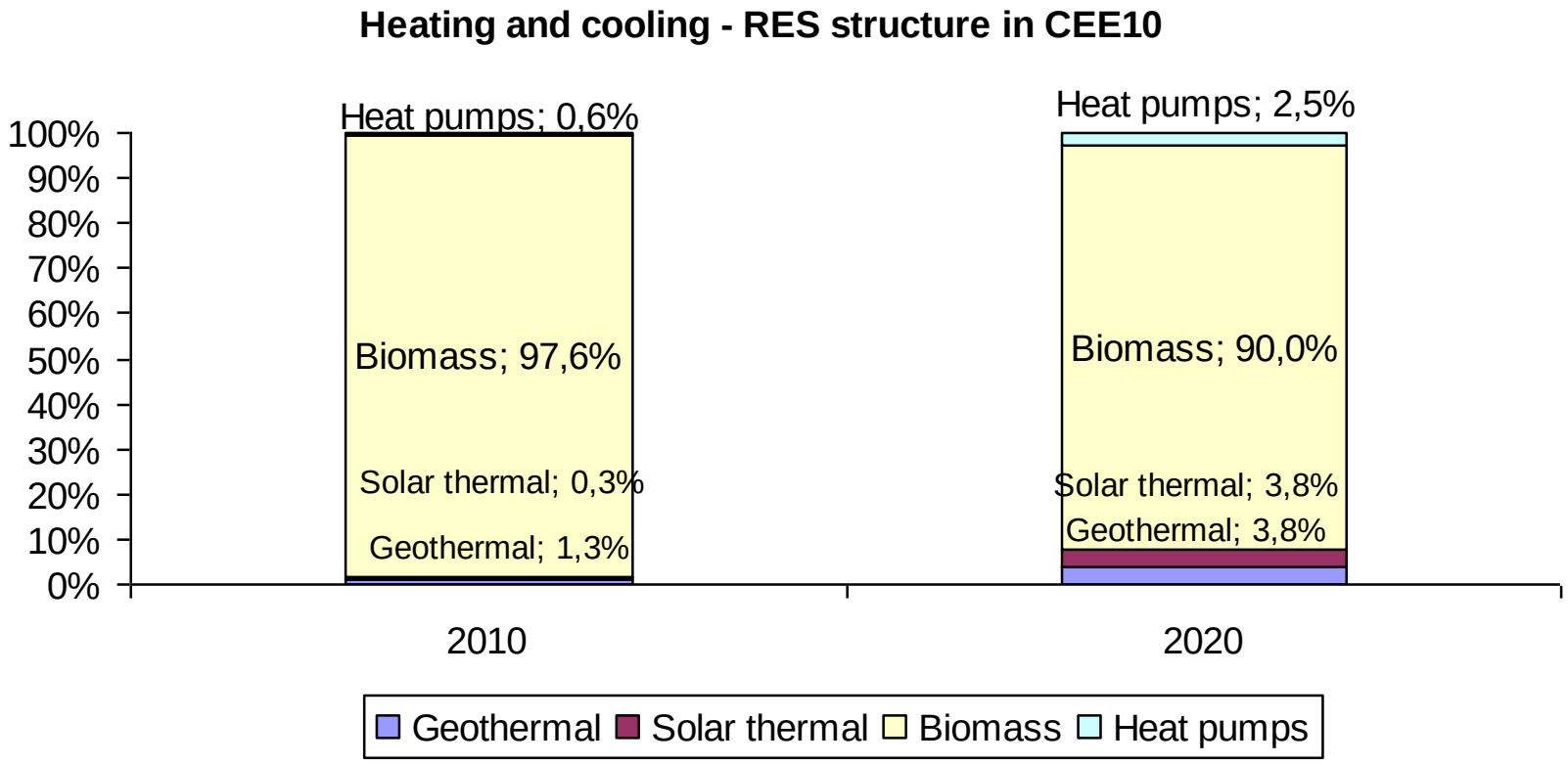


Biomass and the Czech Republic

- Biomass is by far the most important renewable energy source (RES) in the Czech Republic.
- Biomass share on total RES contribution on primary energy sources (128 PJ of the total RES contribution to PES) was app. 85,3% (including biogas – 8,1%, liquid biofuels – 9,8% and biodegradable waste – 3,3%) in the year 2011.
- The total contribution of RES to PES reached app. 7% in the year 2011.

Biomass – various sources of origin

Fire wood – competition with the material utilization (paper production, furniture, passive houses, etc)

Forest residuals – app. 15% of biomass is left on site - small branches (to diameter 7 cm), bark, etc.

- ❑ processing to the wood chip
- ❑ moisture content: 50-55% in winter period
- ❑ limited by the requirements for soil protection (risk of increase acidy in some regions, in CZ reduced potential by 33-50%)

Agriculture residuals

- ❑ straw (utilization depends on the number of farm animals)
  - ❑ pressed bundles
  - ❑ raw material for pellets and briquettes production
  - ❑ or direct burning (whole bundles or cut bundles)

Biomass – various sources of origin

Agriculture residuals

- grass from permanent grasslands
  - grass is the side product in many cases, if not used by farm animals causes problems

- manure (pigs, cows, etc.)
  - valuable input to biogas stations

Wood processing industry

- paper production residuals (pulp extracts, etc) – currently significant item in the statistics

- saw dust, wood waste – wood processing industry (furniture, construction elements, cask, items of daily use, etc.)

Biomass as the special RES

Several advantages of biomass compared with the other RES:

- long term experience with utilization
- can be easily stored or delivered to the point of consumption
- low dependency on immediate weather conditions - no quick fluctuation of its availability (in contrary to PV or wind), but its yield (from agriculture land fluctuate according to the given year conditions)
- can be (easily) transformed into (higher quality) biofuels
- can serve as fuel both for decentralized or centralized heat production

Biomass as the special RES

Several advantages of biomass compared with the other RES:

- can be easily added into coal and burnt with it – co-combustion (substitutes part of coal)
- can help to solve diversification of activities in rural areas
- can be the option for the excess arable land
- domestic source contributing to the energy security

Biomass as the special RES

But biomass has (as the other RES) relatively low energy density – large land areas are needed to substitute the significant portion of currently used PES

Question: Comparison of energy gain from one hectare of land used for PV and for biomass (e.g. plantations of short rotations coppice).

Assuming just energy equivalent and total sum of energy per one (average) hectare and (average) year what option brings higher contribution ?

What other factors have to be taken into account doing such comparison ?

Grown biomass

Intentionally grown biomass on agriculture land has by far the highest contribution to total biomass potential in longer run (e.g. case of the Czech Republic)

- Sources of waste and residual biomass are quickly depleting
- Increasing efficiency of agriculture production results in reduction of needed acreage
- Arable land cannot be left without care
  - permanent grasslands
  - reforestation
  - intentionally grown biomass for energy purposes

Significant portion of land can be used for energy purposes

Grown biomass

Land availability for energy purposes in the Czech Republic

Biomass type	2010 [ha]	2020 potential [ha]
Maize (biogas)	22052	150000
Wheat (bioethanol)	22474	24000
Rapeseed (FAME)	96841	200000
Sugar beat (bioethanol)	11237	126000
SRC plantations	760	120000
Permanent grasslands	2400	370000
Perennials (reed canary grass, etc)	892	85000
Other	5600	45000
TOTAL	**162256**	**1120000**

Biomass and biofuels utilization

Power generation

- RES-E support resulted in quick development of biomass utilization
  - Easily accessible sources of residual and waste biomass (competition of other branches for biomass, e.g. start of biomass support for power generation in 2004 resulted in jump increase of biomass prices for heating plants
  - "If some commodity started to be market commodity – even in local scale – it is no more waste for negligible price" – e.g. case of residual straw
- Preference of cogeneration
- Wood and other biomass residuals, wood pellets, liquid biofuels
- Biogas stations using waste and residual biomass or intentionally planted biomass

Biomass and biofuels utilization

Heating (and cooling)

- decentralized (local) heating – firewood, wood residuals, (bio)pellets and briquettes
  - possibility of (biomass) fuel preparation for municipal projects (both heating plants and briquettes/pellets production
  - “local solution”

- centralized – district heating systems (substitute of fossil fuels, in the Czech Republic substitute of domestic brown coal)
  - heating plants
  - cogeneration plants

Biomass and biofuels utilization

Substitute of natural gas

- upgrade of biogas into quality of natural gas
- substitute of natural gas for cooking, heating and industrial purposes
- fuel for vehicles

“wood gas” used during the war as the substitute of gasoline

Biomass and biofuels utilization

Substitute of liquid fuels for transportation

- EU target to 2020 - 10% of the final consumption of energy in transport in the EU and each of its MS should come from renewable sources
  - Two options:
    - **electric vehicle** + RES electricity (seems at the moment that there will no significant contribution), liquid (or gaseous) biofuels (from biomass)
    - **Bioethanol and biodiesel –** E85, obligatory share of bioethanol in gasoline and of FAME in diesel

Biomass and biofuels utilization

Bioethanol and FAME adding change fuel parameters

- possible problems when not operating diesel car during winter time
  - (average) percentage of biocomponent is the balance fiction – percentage should be fulfilled as the year avaerage

- **do not forget gasoline in lawn mowers and esp. do not used in at spring without filling it with the fresh gasoline / esp. two stroke types**
  - threat of engine damage
  - bioethanol in gasoline absorbs water which influence of machine lubrication (water vapors blocks oil lubricant)

Liquid biofuels as the controversial option

Quick development of biofuels raised many questions and caused many problems:

- real contribution to the (EU) climate policy – seems have no significant effect (if not negative even)
- impact to the biodiversity
  - e.g. large monoculture plantations of palms for palm oil production – problem of tropic jungles damage, e.g. large areas of rape seed in the Czech republic (app. 16,2% of sowed land),
  - related impacts to the ecosystems and soil quality (e.g. enormous increase of wild boars (pigs) which cases big damages to parks, gardens, etc.)
  - soil erosion – case of maize planted for biogas stations in sloped fields

Liquid biofuels as the controversial option

Quick development of biofuels raised many questions and caused many problems:

- sustainability criteria
- political and economic problem
  - defined as the (political?) target – hardly to change it
  - huge investments already done (under “promised” conditions) – problems with stranded cost – who should bear these cost ?
  - and even – do we need these biofuels ? What do we really need ?
    - contribution to GHGs reduction
    - substitute of liquid fossil fuels
    - diversification of sources and reduction of import dependency (but majority of biofuels is imported from regions out of EU)

Liquid biofuels generations

First generation (liquid) biofuels:

- raw material for the production have utilization for food production (bioethanol from corn, sugar beet, sugar cane, biofuels from palm oils, FAME from rape seed etc.)
    - in general (out of narrow definition): everything grown on agriculture land which can be utilized for food production

Second generation (liquid) biofuels:

- raw material is non food biomass: forest and agriculture residuals, straw, energy crop etc.

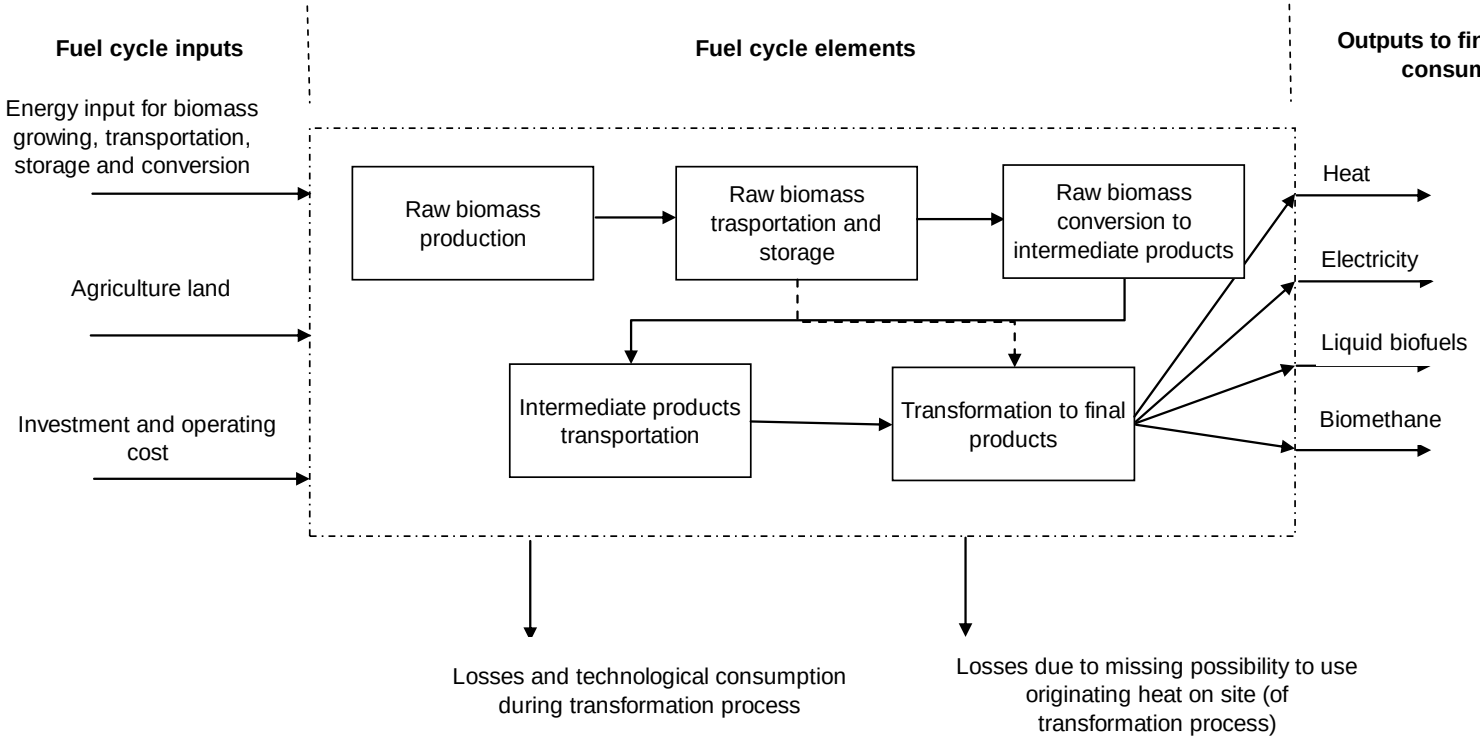
Energy efficiency of land utilization for “energy biomass”

Fuel cycle approach has to be applied

- losses in the fuel cycle should be taken into account (storage, transformation losses etc.)
- energy to the final consumers (out of energy branch consumers) plays role only !
- each biomass fuel cycle is unique – reflects conditions of biomass growing in given country and technologies used
  - coil and climate conditions in each country are unique – only limited possibility of results transfer to other countries

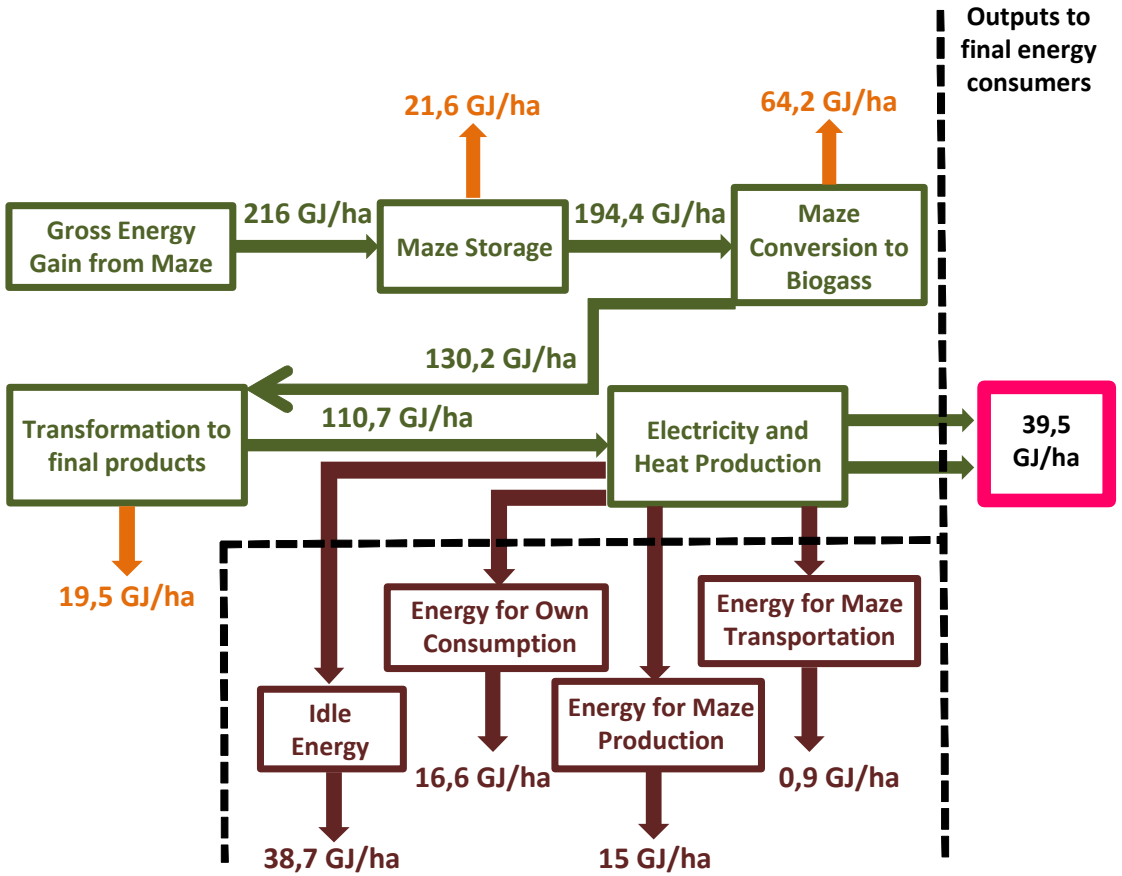
Energy efficiency of land utilization for “energy biomass”

Fuel cycle approach has to be applied



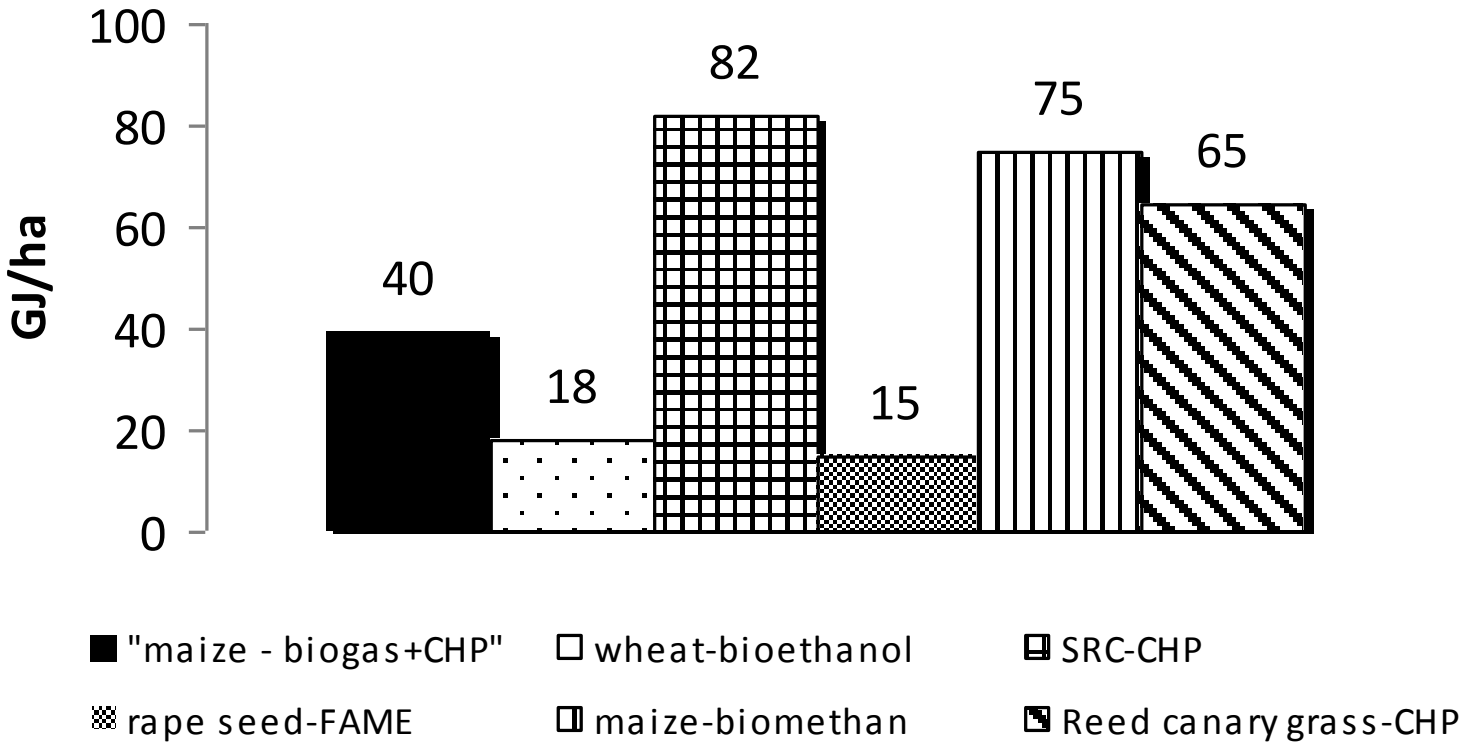
Energy efficiency of land utilization for “energy biomass”

Example of biogas station fuel cycle and energy losses



Energy efficiency of land utilization for “energy biomass”

Example of energy efficiency for six fuel cycles



Energy efficiency of land utilization for “energy biomass”

Example of energy efficiency for six fuel cycles

$$BEGnetto_{l,k,i} = BEG_i \cdot (1 - CELts_i) \cdot (1 - CELcip_{k,i}) \cdot$$
$$\cdot (1 - CELtp_{k,i}) \cdot (1 - CELtfp_{l,k,i}) \cdot (1 - CELnufp_{l,k,i}) -$$
$$- ECBEG_i - ECts_i - ECcip_{k,i} - ECtp_{k,i} - ESCtfp_{l,k,i}$$

Energy efficiency of land utilization for “energy biomass”

Agriculture land is the (only real) scarce resource !

- necessity to define “optimum” strategy of biomass development – not all the options are reasonable from the energy efficiency point of view

- **“cannibal” effect**
  - land used for food production cannot be used for energy purposes and vice versa
  - increased prices of conventional crop push prices of grown biomass for energy purposes up – rule of the same economic effect not depending on who is customer – biomass is not and esp. will not be cheap source

Opened questions

- Biomass potential (short and long term) assuming all the limitations (food security, biodiversity protection, soil protection, etc., sustainability criteria
- Optimized agrotechnologies for energy crop (still at the beginning)
- Role of liquid biofuels, also with respects to development of shale gas (it seems that NG reserves should be significantly increased) – possible impact to biomethane
- Role of GMOs
- Development of burning technologies
- **Impact of energy crop on soil quality and positive/negative impacts to ecosystems**

Thank you for your attention !

Děkuji za pozornost!