CZ – AT Summer and winter school,
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Biomass – potentials, effective way of utilization

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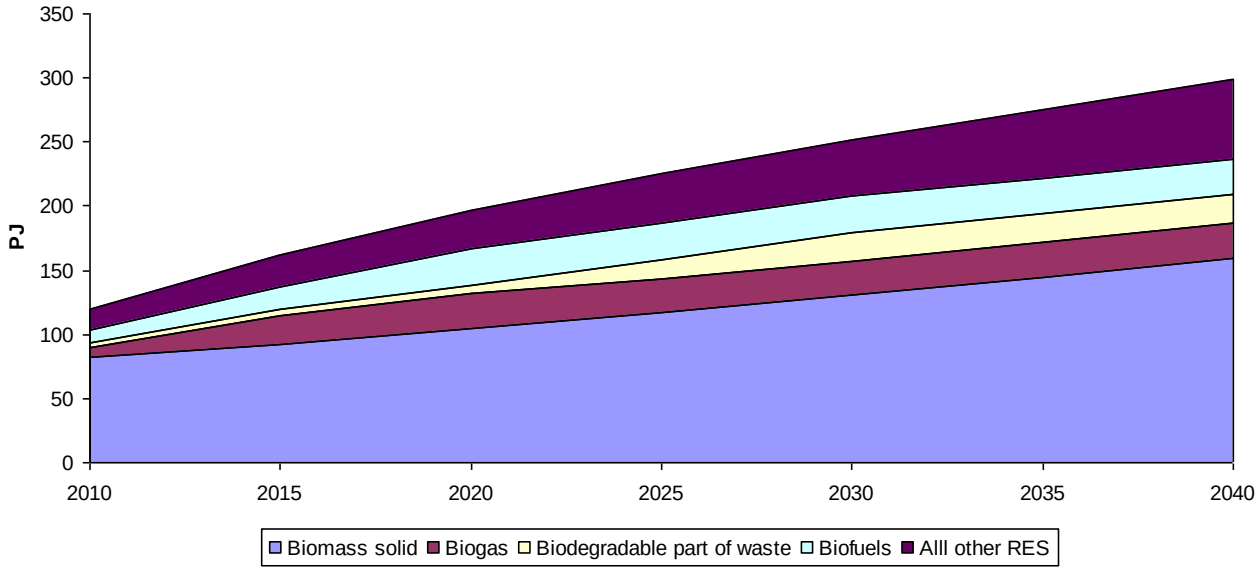
CONTENT

- Statistics on biomass in EU and CZ context
- Biomass as the unhomogenous category
- Standard and additional biomass potential methodologies
  - Demonstration of application – selected results
  - Biomass potential on agr. land as the function of land allocated for energy crop
  - Standard and additional potential around the cogeneration plant Hodonin
- Biomass fuel chains – energy effectiveness of biomass utilization

Present state – biomass plays the decisive role in RES strategies

EU28 (2012)

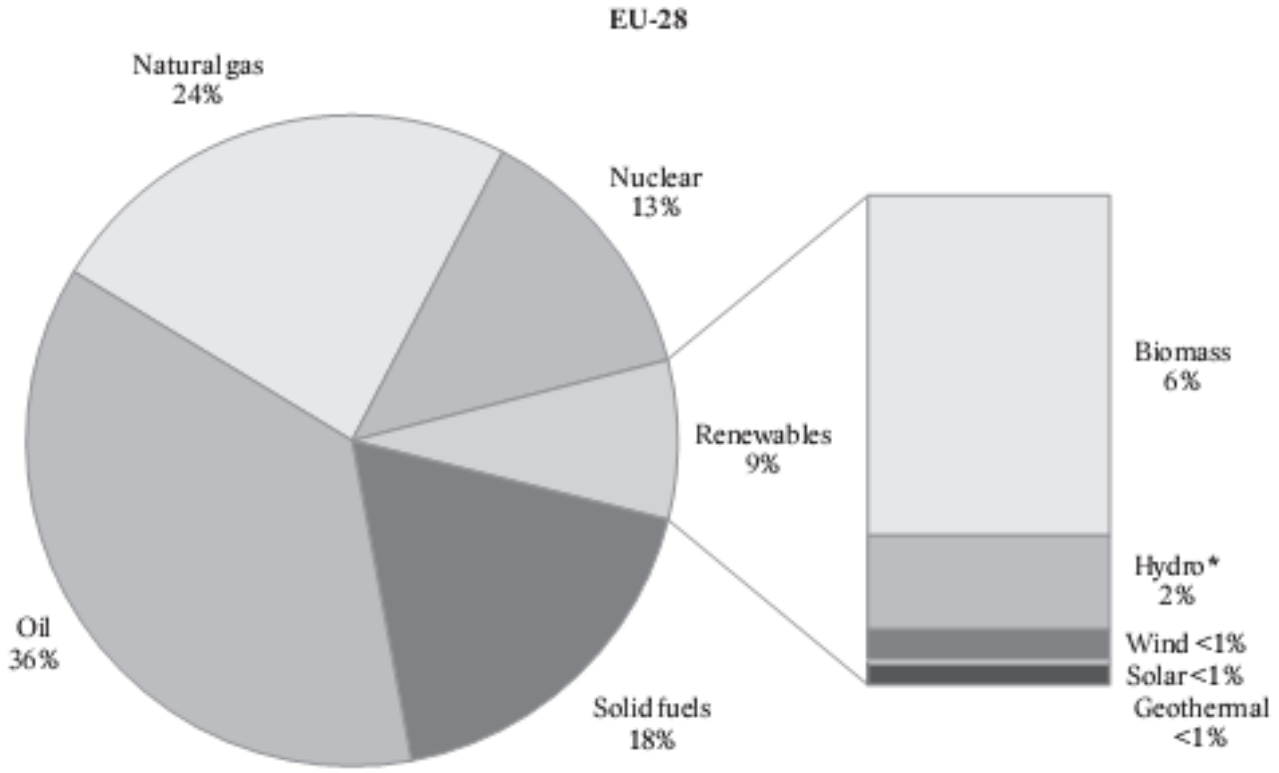
- Total production of renewable energy reached 7423 PJ
- 22,3 % of total primary energy sources
- Biomass contribution: app. by 65,5% to total sum of RES



Biomass plays even more important role in the Czech Republic

Significance of individual RES kinds

Share of RES on primary energy, EU 2012

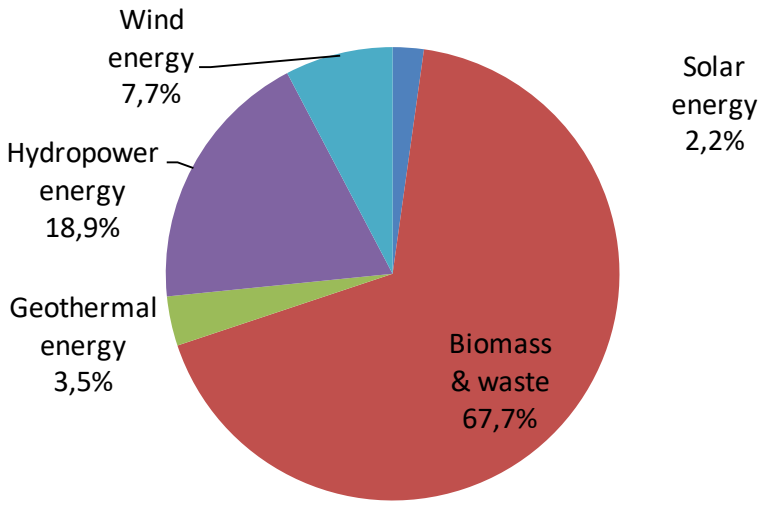


Source: EU Pocket book, 2014

Fig. 2: Primary renewable energy sources in the EU-28 in 2012 in comparison to all other energy sources

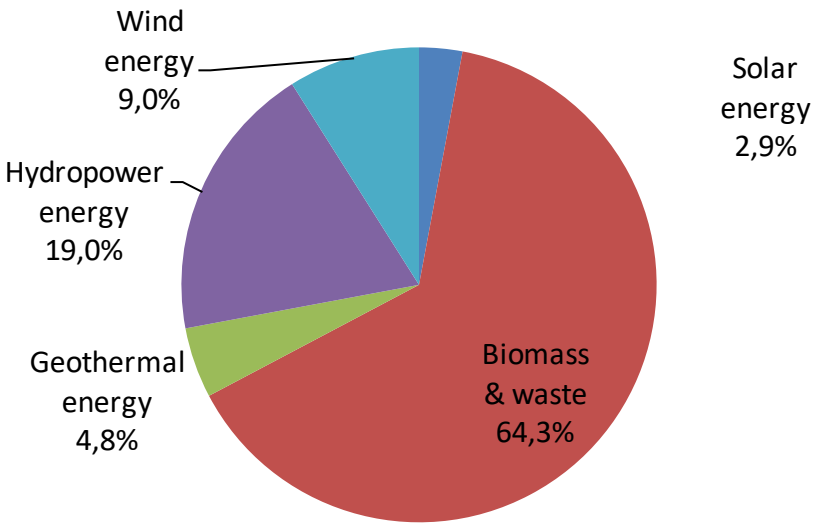
Significance of individual RES kinds, EU

Structure of primary production of rew. energy, 2000



EU 27 RES statistics RES as the primary energy

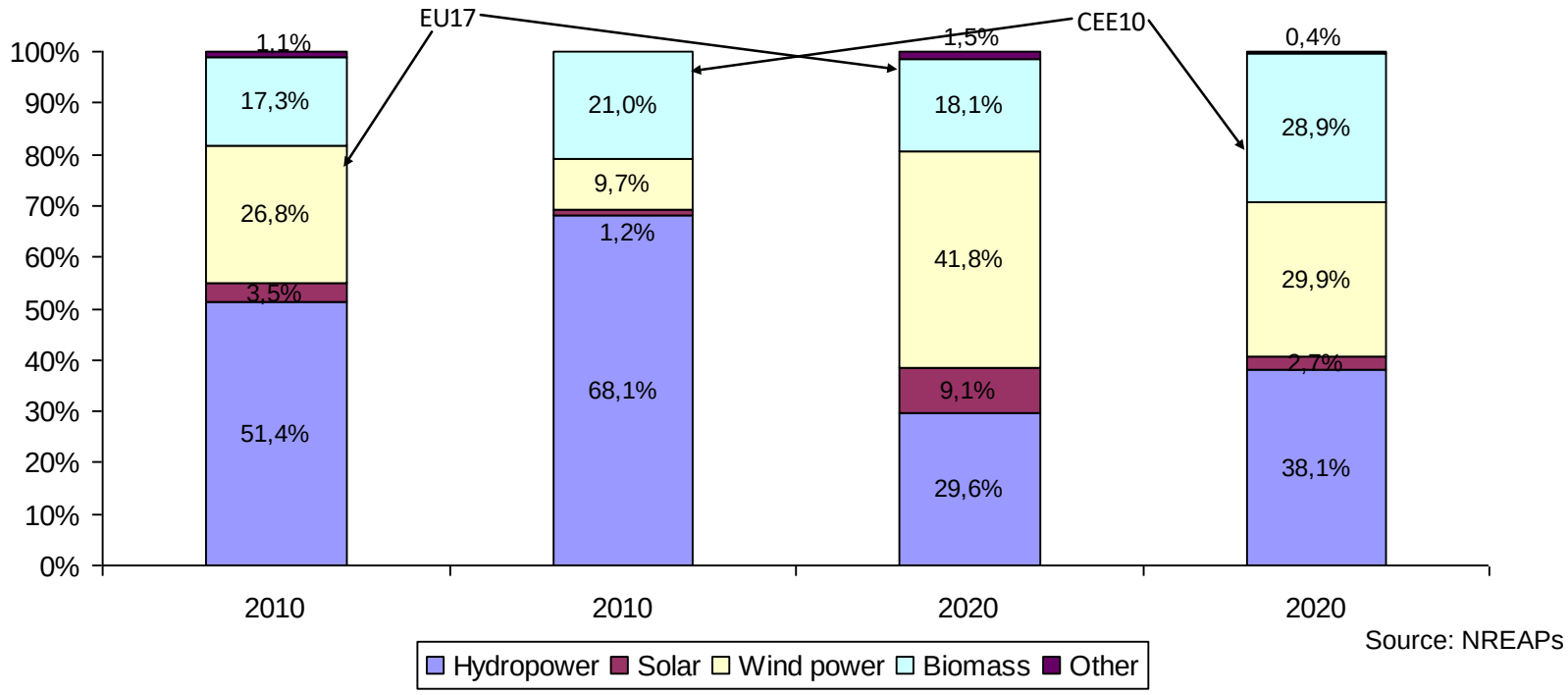
Structure of primary production of rew. energy, 2010



Biomass plays and is expected to play the decisive role

Source:Eurostat

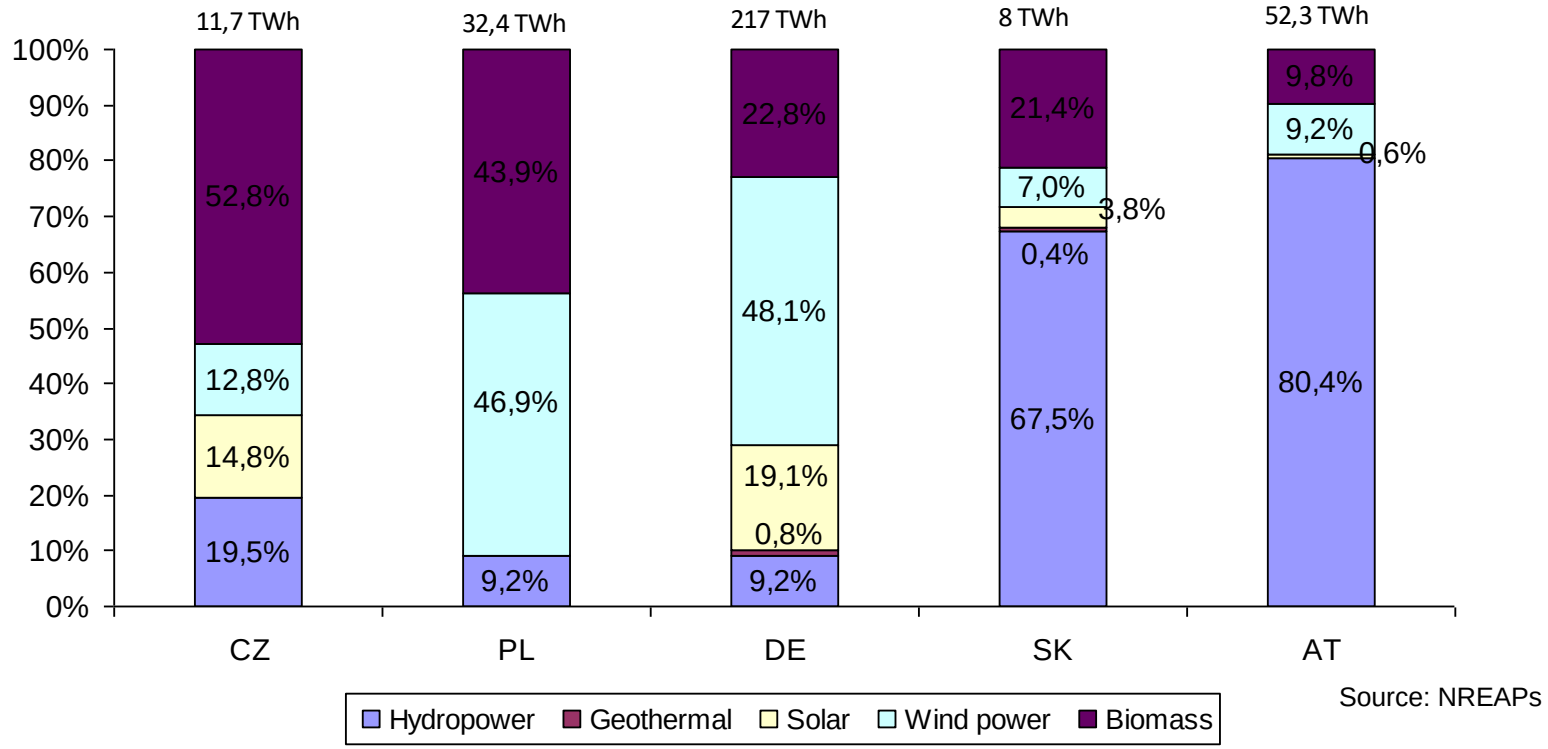
Role of biomass in different countries



Source: NREAPs

Biomass used for power generation – present state and expectation according to NREAPs

Role of biomass in different countries - 2



Biomass used for power generation – present state and expectation according to NREAPs

RES targets

2020 targets

- Directive 2009/28/EC,
  - NREAPs of EU MS
  - 20% RES share on final energy consumption (in 2005 only 8,5%)
  - 10% of renewable energies in transport
  - 20% CO2 reduction
  - 20% increase of energy efficiency (non binding)
- CZ: NAP OZE: revision 9/2012
- Action plan for biomass – APB, version 2012

RES targets

2030 targets

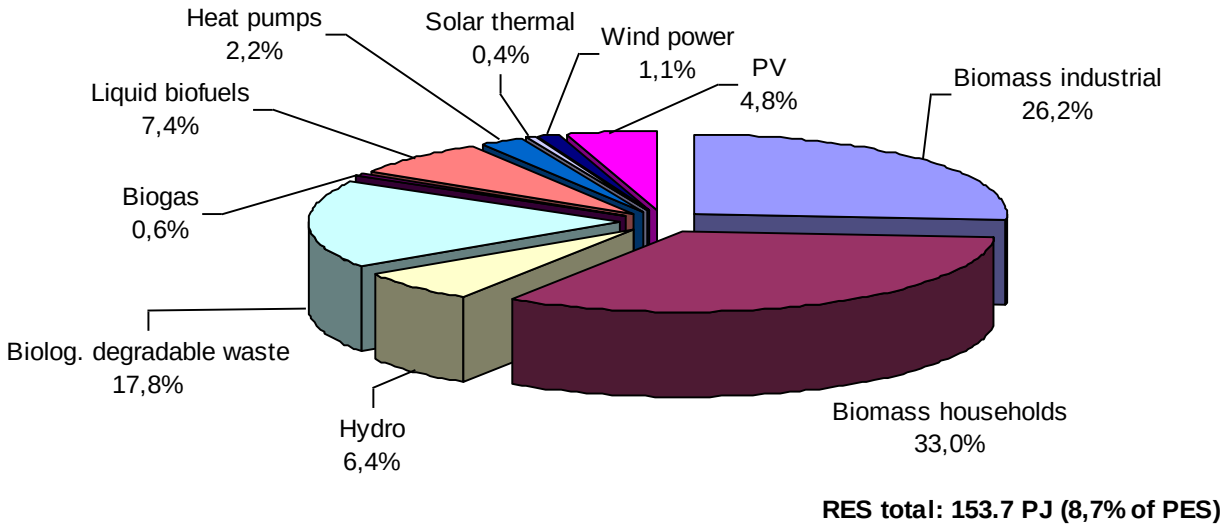
- Currently under discussion, Commission proposal January 2014
  - RES target (27%) – for EU as whole, no explicit target for MS (energy mix remains MS responsibility, MS are obliged to submit plans for competitive, secure and sustainable energy branch development)
  - CO_2 target (40% reduction against 1990)
- No specific target for energy efficiency
  - Discussion on values and the logic / one or more targets, some MS argues that there should be one target only (CO_2 reduction)

RES targets

2030 targets

- Open problems
  - Target definitions – one or more ?
  - Necessity to restart ETS and to ensure its effective functioning
  - Great distortions on power market, high uncertainty in its future development – namely thanks to the RES support
  - Asymetrix impact to the national economies from RES support

Biomass as the energy source – CZ case



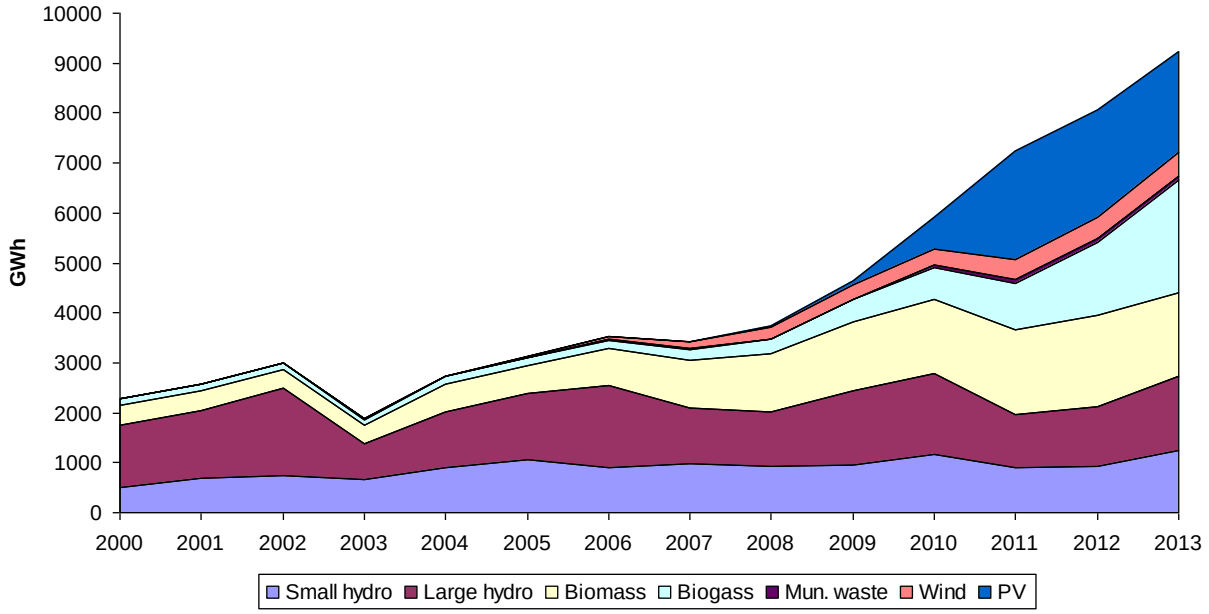
Individual RES categories contribution to the primary energy sources consumption in the Czech Republic in 2013 (Source: MPO2014)

Types of biomass used – CZ case

Biomass type	**Electricity** (mil tonnes)	**Heat** (mil tonnes)	**Total** (mil tonnes)
Wood waste	0,868	1,252	2,120
Fire wood	0,000	0,052	0,052
Plant materials	0,097	0,061	0,158
Briquettes and pellets	0,096	0,075	0,171
Pulp extracts	0,334	0,996	1,330
Households			3,897
Biomass (energy) export			0,750
Biomass (energy) total			**8,478**

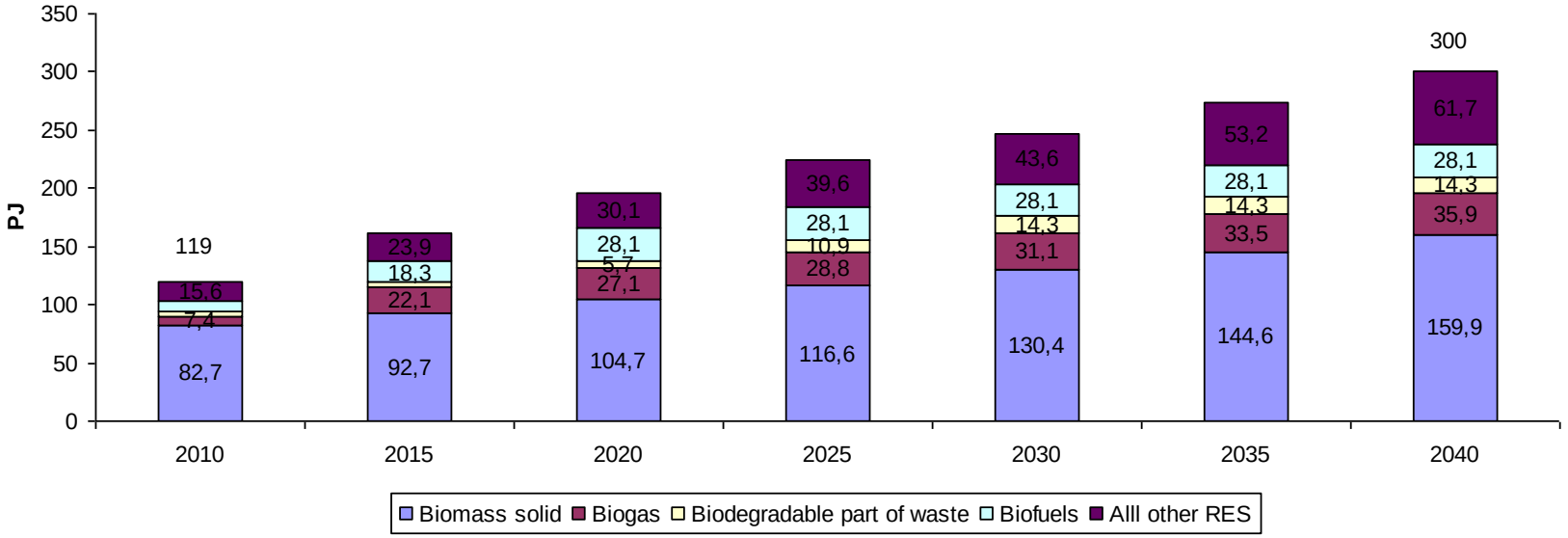
Structure of biomass consumption for energy purposes in the Czech Republic, 2013 (Source: MPO 2013)

Development of power generation using RES



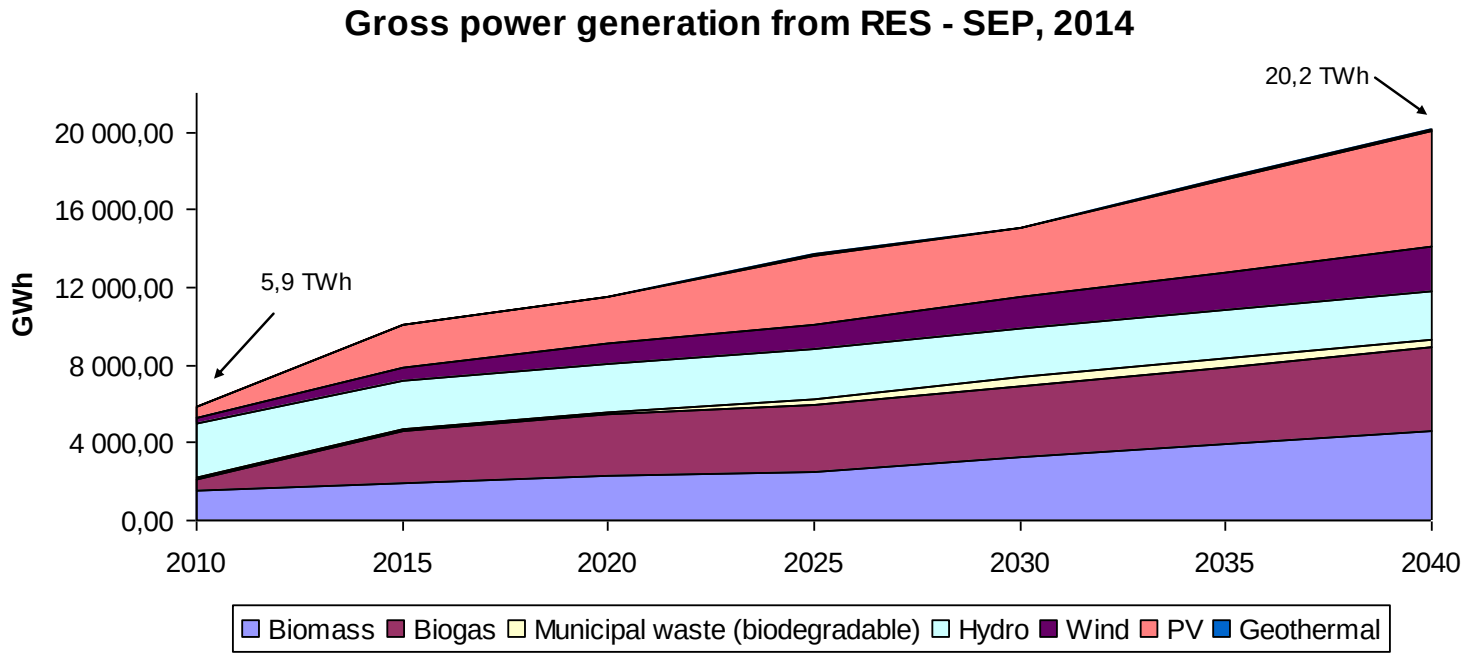
Development of power generation based on RES in the Czech Republic (Source: MPO)

Czech Energy Policy (proposal) – the role of RES



Expected development of RES contribution to primary energy consumption in the Czech Republic (State Energy Policy – 2014 update)

Czech Energy Policy (proposal) – the role of RES



Expected development of power generation from RES (Czech Energy Policy, 2014)

Biomass as the renewable energy source

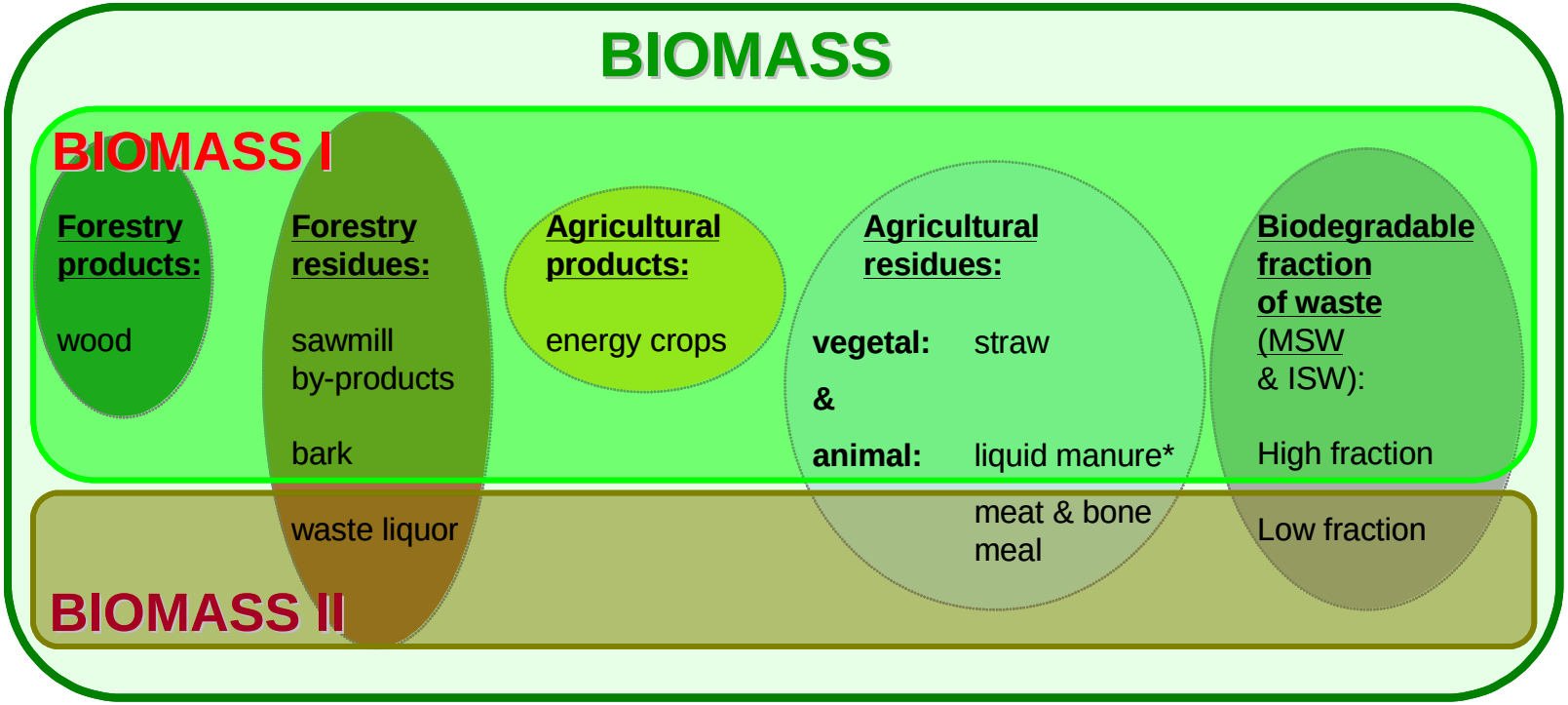
EU Directive 77/2001

“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 categories



Note: BIOMASS ... in accordance with definitions given by the *EU-Directive 2001/77/EG* (BIOMASS = BIOMASS I + II)

BIOMASS I … in accordance with definitions given by the *Renewables Act*

* liquid manure might also be used as fuel input for biogas-plants

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

Residuals from 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.)

Residuals from households and other sources

- thermal utilization
- separation of biodegradable waste
- oil from Mc Donald, etc.

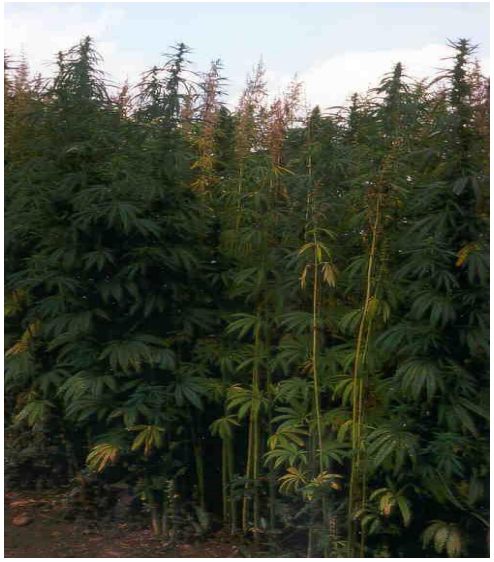
Energy crop

Intentionally planted biomass in Czech condition

Wood chips - SRC plantation
Power and heat generation

Perrenial growth
Reed grass, Sorrel (hybrid)
Power and heat generation
Solid biofuels

Annual growth
Maize, energy grass
Sugarbeet, rape, cereals
Biogas stations
Liquid biofuels



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

Advantages of perennials (energy crop)

reduce soil erosion (e.g. maze problem)

- increase soil quality (increase of humus)
- suitable for greening, increase of biodiversity
- diversification of activities

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

Biomass and biofuels

1st generation biofuels

- raw material for their production is biomass with competitive utilization for food production (incl. forage for farm animals)
  - bioethanol from corn, sugar beet, sugar cane
  - biodiesel (FAME) from rape seed
  - biofuels from palm oil
  - biogas and biomethane from maze silage

2nd generation biofuels

- non food biomass
  - residuals from forestry and from agriculture
  - biodegradable waste
  - energy crop (reed canary grass, miscathus, schavnat, etc.), but competition for the land with conventional production

Biomass availability in long run

- ***Do we have realistic plans for biomass future ?***

- ***How we can include individual constraints for biomass potential determination ?***

- ***What is the structure of biomass potential and its regional distribution ?***

- ***Can we mobilize biomass potential when needed ?***

Methodology for biomass potential determination

Specification of biomass potential

- high variability of current biomass potential estimates
- necessary to check where are the boundaries of potential
  - yields as the function of soil and climate conditions

Determination of biomass potential as the function of relevant parameters

- region selection (country, official regions, any region)
- land allocation for energy crop (relative)
- priorities for land utilization, available agrotechnologies
- environmental, legal and market limitations

Standard and additional biomass potentials

Standard biomass potential

- Biomass potential sustainable in longer run (i.e. all the legal, environmental and market constraints for biomass production and utilization are taken into account)
  - Biomass for primary energy sources balance

Additional biomass potential

- short term “boosting” of biomass potential
  - Additional biomass for periods with shortage of conventional fuels, some constraints are ineffective (period of several months up to one year - depends on season)

Biomass categories – agriculture land and forestry

Agriculture land

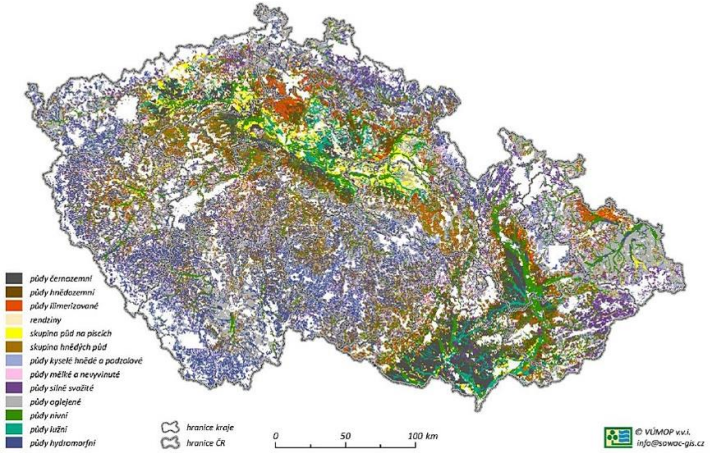
- residual biomass from conventional agricultural production (residual straw) – annual crop
- energy crop:
  - perennial (non wood) plants (reed canary grass, miscanthus, schavnat, etc.)
  - SRC plantations
- grass from permanent grasslands,

Forestry

- (fire) wood and forest residuals.

VSEU – soil and climate conditions on site

Soil types



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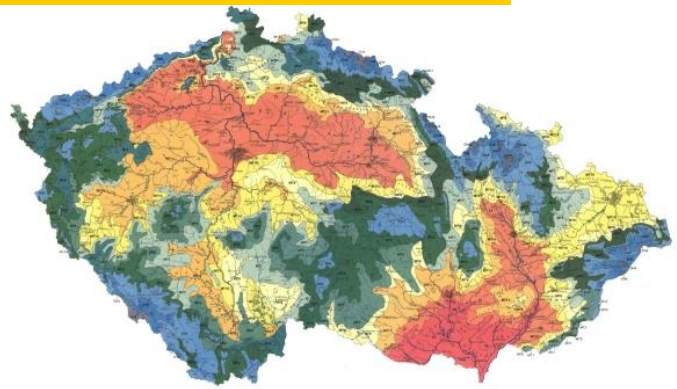
Climate regions



Bottom up approach, land plots conditions

VSEU

XYYWZ

MSCU

X:10 dif. climate regions

(similar conditions for growth of agr. crop)

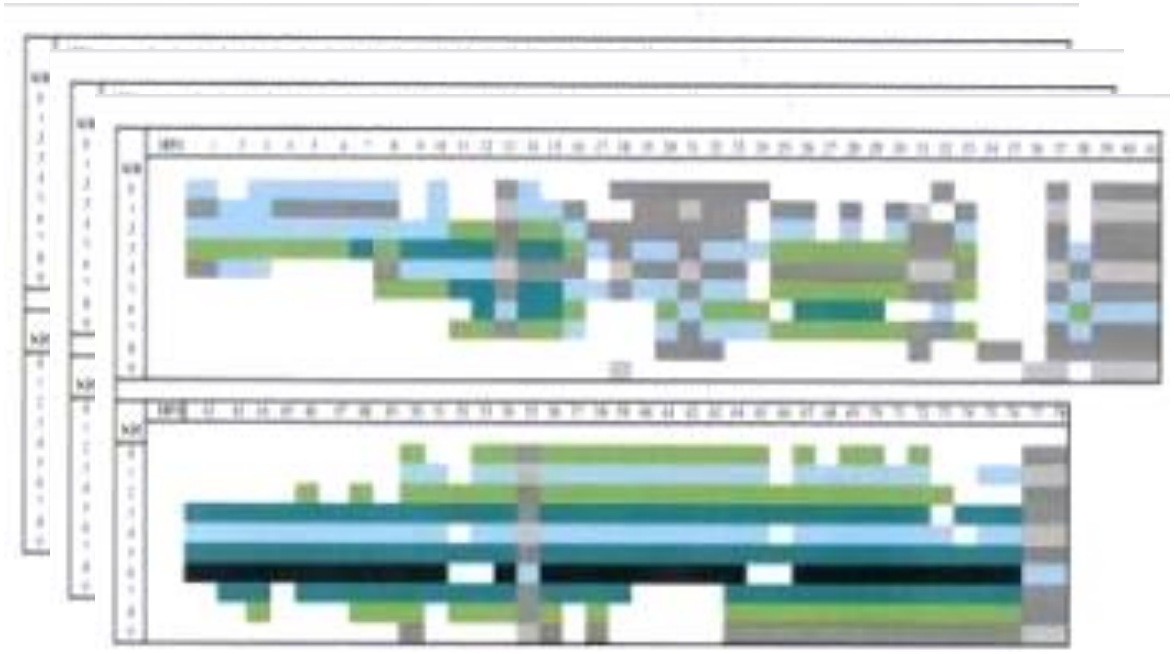
YY: main soil units

(soil type, subtype, soil matrix and the degree of hydromorphism)

W: comb. of slope and exposure

Z: depth of the soil profile and its skeleton

Typology of agricultural sites



Empirical data

Experimental plantations

Expert estimates

MSCU: Up to 550 valid combinations (climate + soil)

Identification of typical biomass yields for given conditions

Yield curves (5-7 for each conventional type of energy crop)

Typology of forests

- yields of biomass are based (as in case of agricultural land) on primary information about the soil conditions and forest type (set of forest types):

  XYZ

  X … forest vegetation levels 0-9 (e.g. 1 means oak forest up to 350 meters above the sea level)

  Y … forest soil types A-Z

  Z … index of forest type in given forest area

  Up to 170 valid combinations of forest vegetation levels and forest soil types

- age of forest (forest production plans)

Examples of yield categories

Yield cat.	**SRC** [t (DM).ha^{-1}]	**Miscanthus** [t (DM).ha^{-1}]	**Schavnat** [t (DM).ha^{-1}]	**Reed canary grass** [t (suš).ha^{-1}]
K1	< 5,01	<5,01	<2,51	<3,76
K2	5,01–7,00	5,01–9,00	2,51–5,00	3,76–5,25
K3	7,01–9,00	9,01–13,0	5,01–7,50	5,26–6,75
K4	9,0 1–11,00	>13,1	7,51–10,00	6,76–8,25
K5	11,01–13,00	-	>10,00	>8,25
K6	>13,00	-	-	-

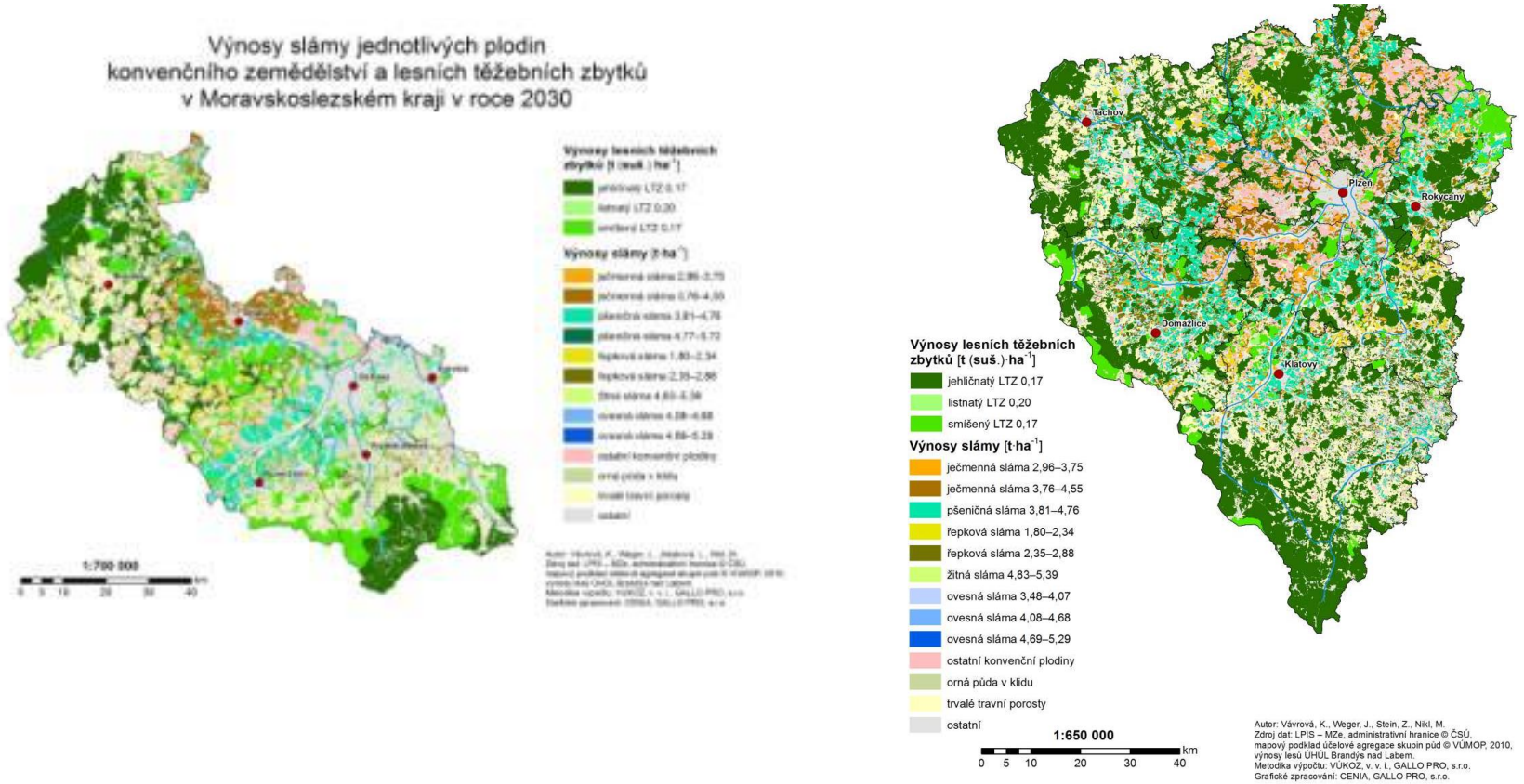
Data for conventional crop

	Straw coeff.	HV in $GJ.t^{-1}$,12 % moisture content
Wheat	0,8	15,7
Barley	0,7	15,7
Oat	1,05	15,7
Triticale	1,3	15,7
Rye	1,2	15,7
Rape seed	0,8	17,5

Order of needs for soil quality

1. Sugar beet
2. Maize for grain
3. Barley
4. Wheat
5. Rape seed
6. Maize for sillage
7. Triticale
8. Other forage
9. Rye
10. Oat
11. Other

Example - straw yields and forest residuals for two regions

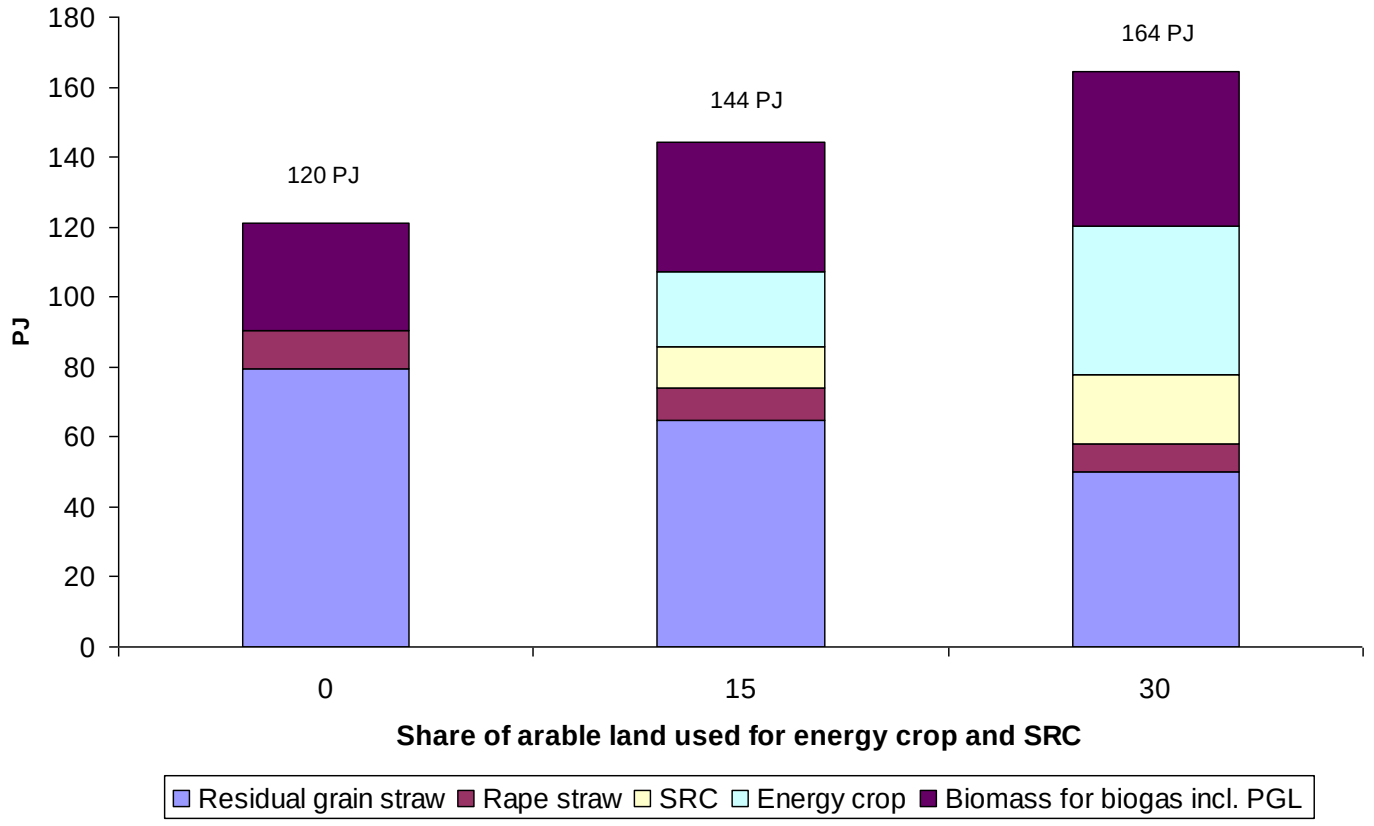


Note: GIS enable graphical presentation of biomass potential distribution in the analyzed area

Logic of algorithm

1. Information to prepare GIS model (VSEU and MSCU data for analyzed region, categorization of crop – typology of sites, plot database and other)
2. Area of arable land and distribution of the conventional crop, allocation of arable land to energy crop
3. Allocation of conventional crop to land plots according to the land parameters in the order of crop requirements for soil quality (optimum kind of crop is allocated to the given plot), yield assignment according to MSCU, application of straw to grain coefficient, correction for farm animals
4. Allocation of energy crop to land plots (similarly as above), yield assignment according to HPKJ unit (preference of conventional production)
5. Contribution from permanent grasslands (similar methodology)
6. Contribution from forestry based on forest production plans (reflecting the age and set of forest types)

Standard biomass potential as the function of land allocation for energy crop



Additional (short term) biomass potential

Sources of additional biomass potential

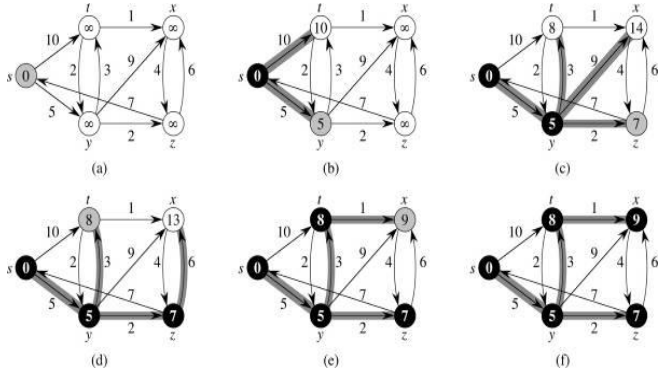
- part of straw which is ploughed into soil to keep the soil quality (changes of straw to grain coefficient),
- part of straw which is used for farm animals,
- shortening of rotation cycle o SRC plantations,
- increase of dendromass used for energy purposes (e.g. shortening of forest production cycle or change of categorization of harvested wood).

Note: “additional” means possibility of immediate reaction and strongly depend on the season, related with the growth cycle

Inclusion of logistic chains

GIS model enables solving different task

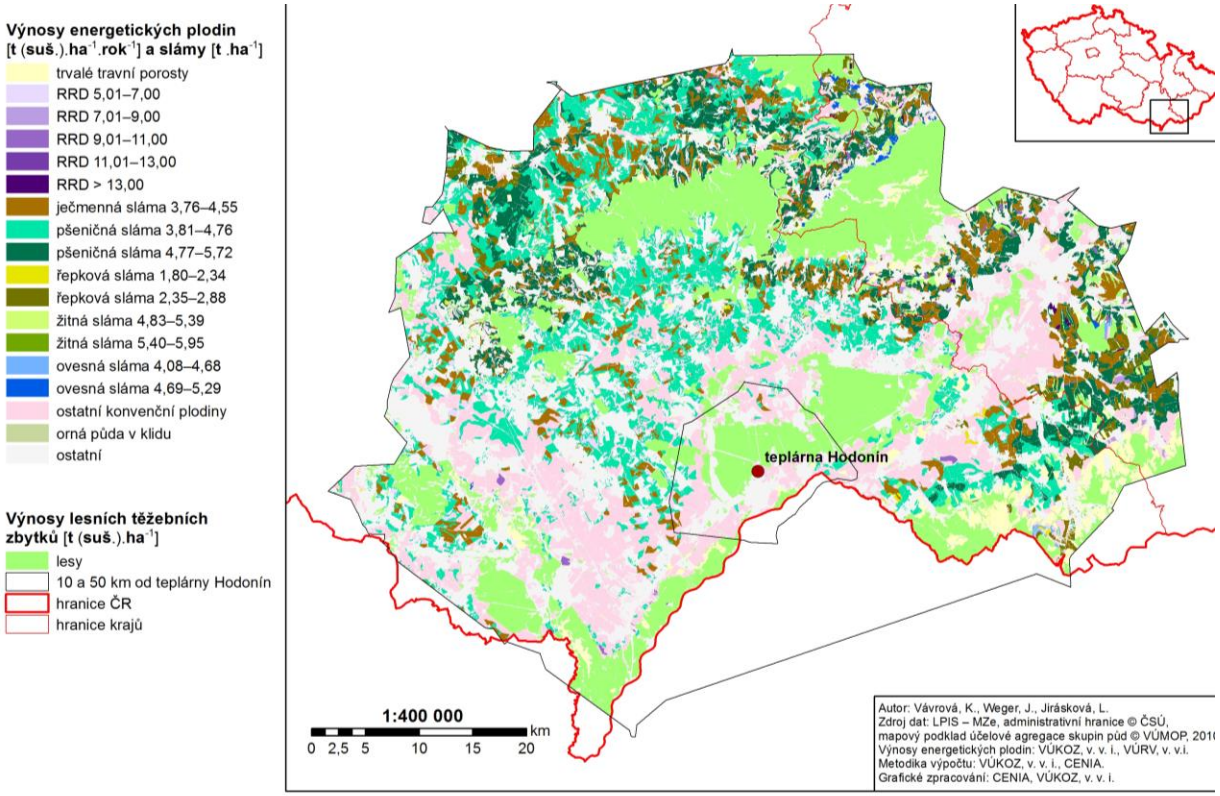
- Modeling of biomass potential as the function of land allocation for energy crop in defined region
- Determination of needed land for energy purposes to meet the biomass targets
- Biomass potential analysis around given “point on the map” and inclusion of logistic chains (storage, processing, transportation possibilities - Dijkstra's algorithm)



Additional biomass potential – Hodonin cogeneration plant case study

Hodonin: Coal / biomass power plant: 105 MW_e/30 MW_e in biomass (fluid boiler, 100% biomass)

Daily consumption: app. 1200 t of biomass (wood:straw/9:1)



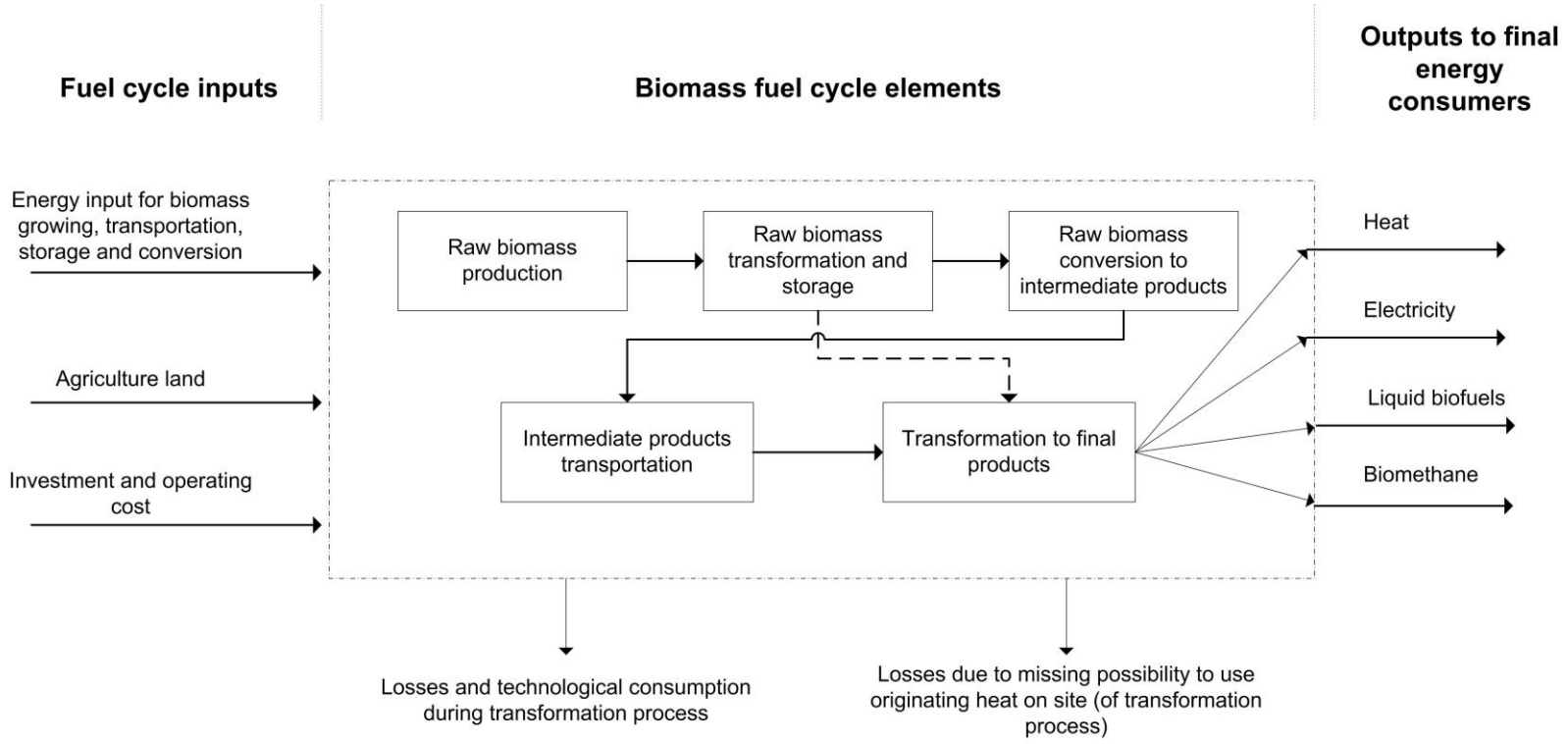
Additional biomass potential – Hodonin cogeneration plant case study - 2

	Standard potential distance 0-10 km GJ	Standard potential distance 0-50 km GJ	Standard + additional potential dist. 0-50 km GJ
Residual straw - corn	59 433	5 850 492	**7 057 257**
Straw – rape seed	0	261 772	340 303
Wood from SRC	1 829	135 673	160 546
Energy crop	9 940	419 275	419 275
Forest residuals	150 469	308 660	**1 589 612**
Total	**221 671**	**6 975 873**	**9 566 995**

Conclusions – biomass potential determination

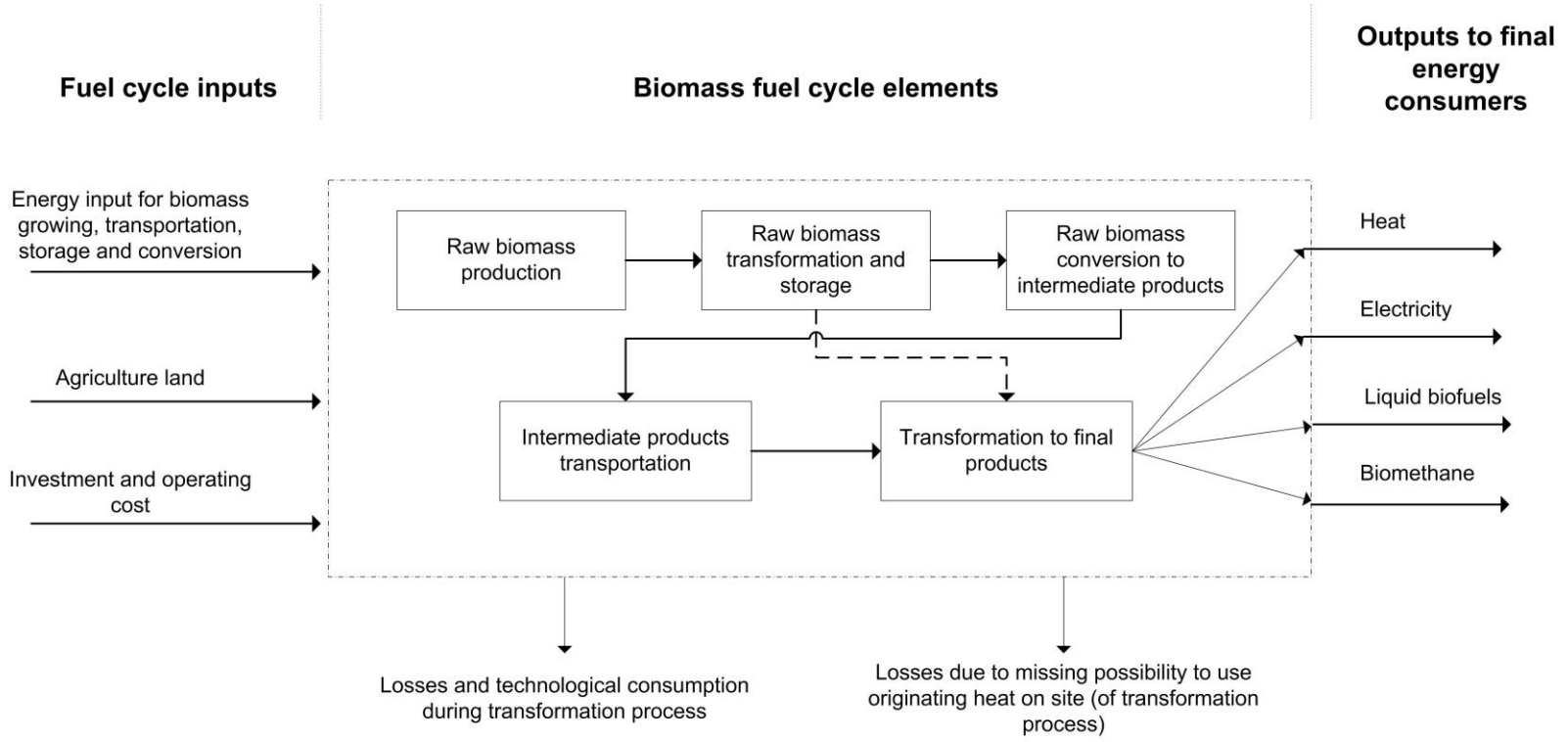
1. Derived GIS methodology respects the soil quality and climate conditions – both are influencing significantly the biomass yields
2. Methodology avoids the distortions in biomass potential calculations – the problem is not linear
3. Methodology works with arable land really used and avoids contributions from land which is not available in the reality (e.g. private gardens, parks etc.)
4. Methodology can determine biomass potential for defined area
5. Methodology can be used in the reverse order – i.e. identification of needed land area to cover biomass requirements in the given point (on the map) – logistic routes can be included in the GIS analysis
6. Methodology enables inclusion of immediate mobilization of biomass potential and inclusion of logistic chains
7. Methodology enables inclusion of different assumption on land priorities and also cost information (e.g. to derive total cost of needed support)

Effectiveness of biomass utilization



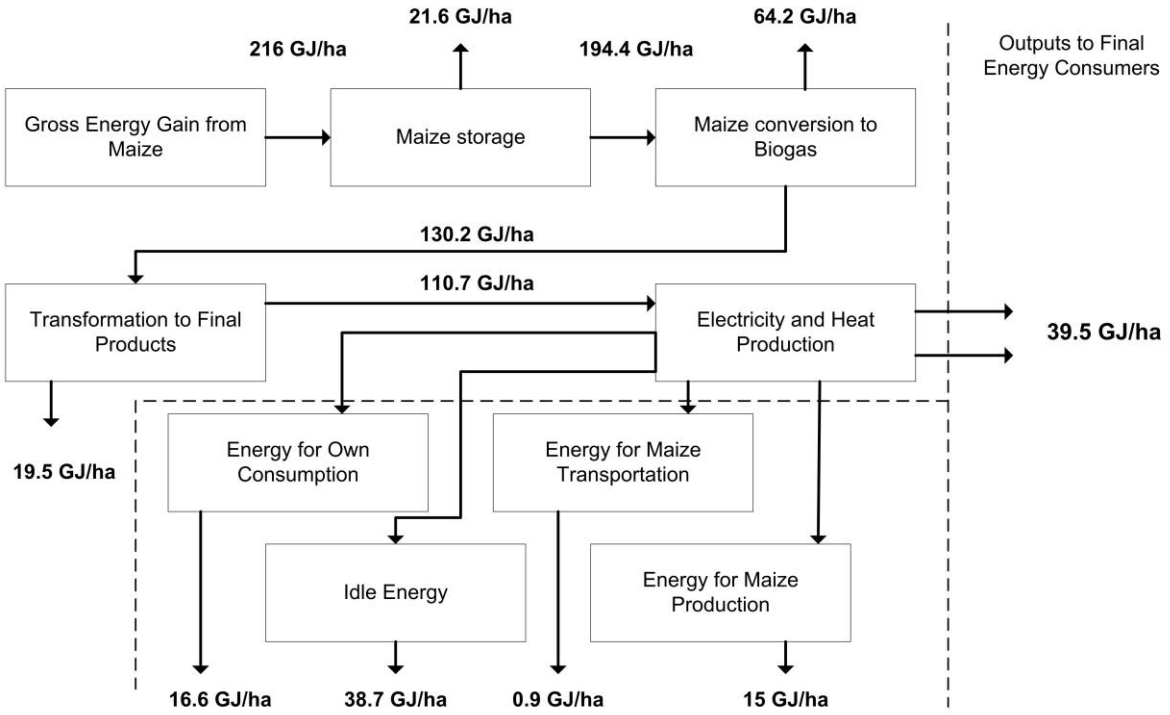
Agriculture land (forest land) is the primary limiting factor !

Effectiveness of biomass utilization



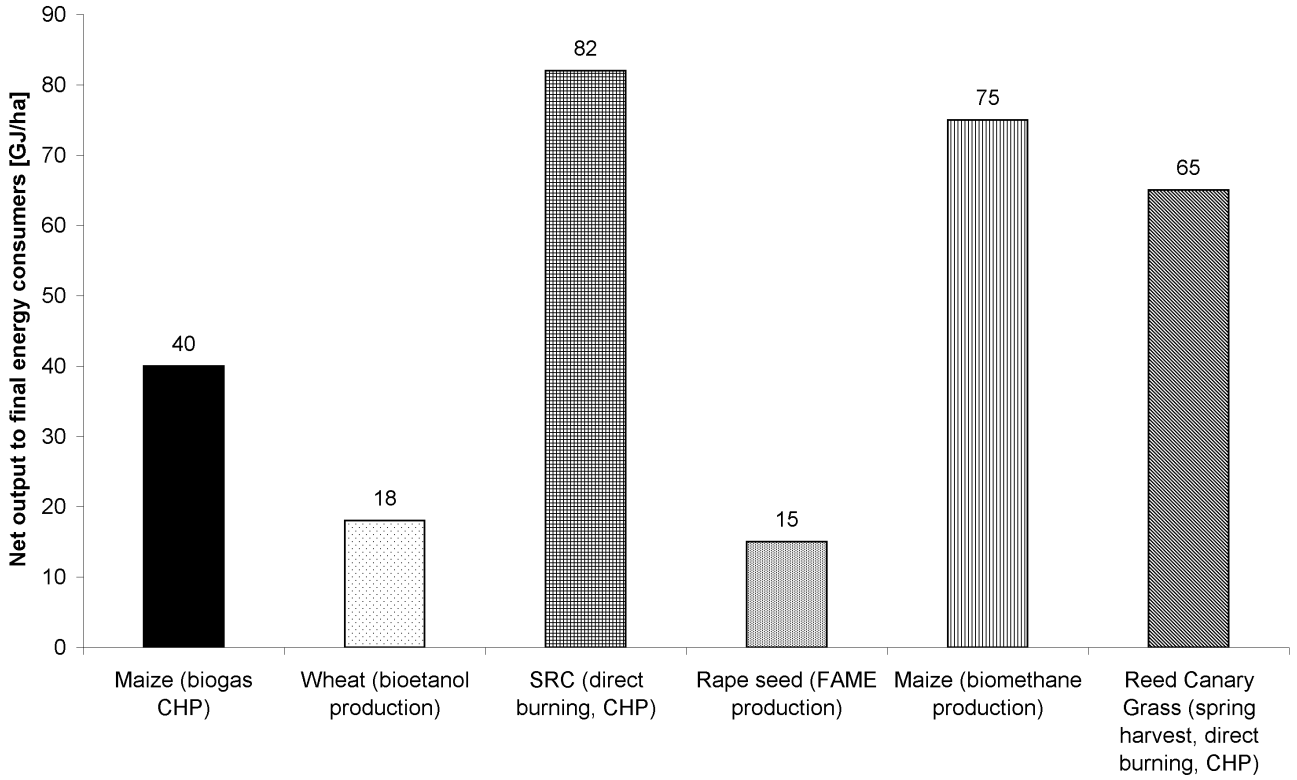
Agriculture land (forest land) is the primary limiting factor ! We have to count useful outputs and all energy losses in the given fuel chain !

Example of fuel cycle – biogas station



Looking to the useful output from biogas plant fuel cycle – is it the effective way of scarce resources utilization ?

Comparison of several biomass fuel cycles



What are the primary goals of RES utilization ? To diversify PES, to reduce CO2 and other emission, etc. It make sense to search for cost and energy effective strategies

Thanks for the attention !

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