CZ AT spring-summer school
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Biomass as a major RE carrier versus Biomass within the concept of changing energy markets – part 2

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Content

1. General context – update

2. Biogas/Biomethane

3. New trends in biomass – selected examples

5. Perennials and ecosystem services

6. Economic competition between conventional and energy crop – opportunity cost point of view

RES development context

RES development including biomass should be understood within the context of changing energy and other markets, EU strategic policies and global context

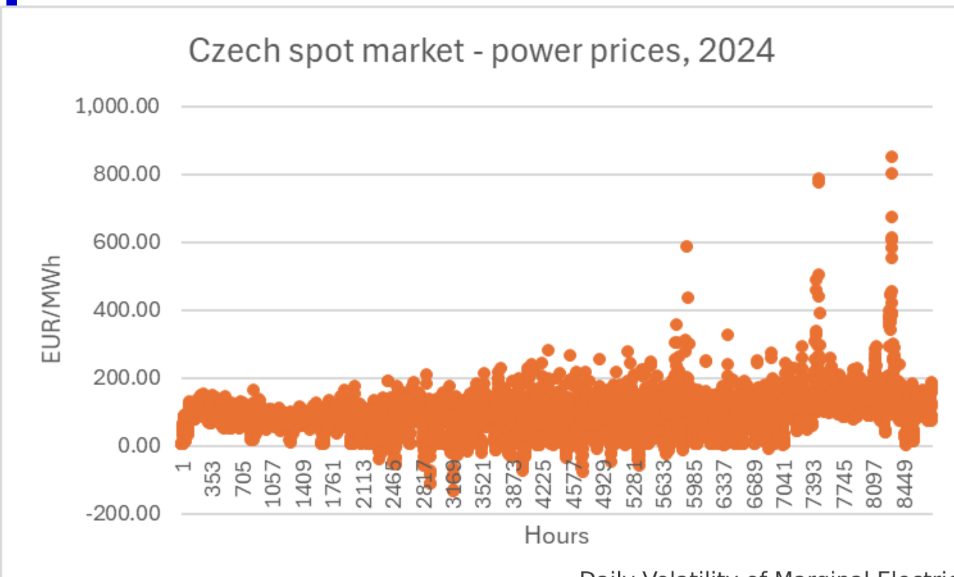
Combination of energy branch transformation tasks:

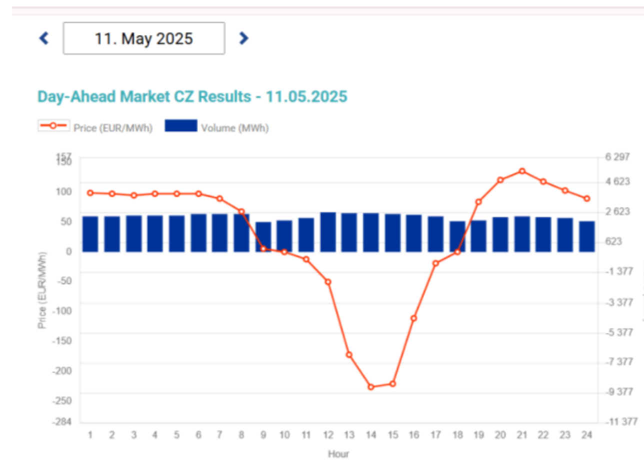
- Short term goals („to manage current needs")
- Long term goals (transformation pathways taking into account rest of globalized world)

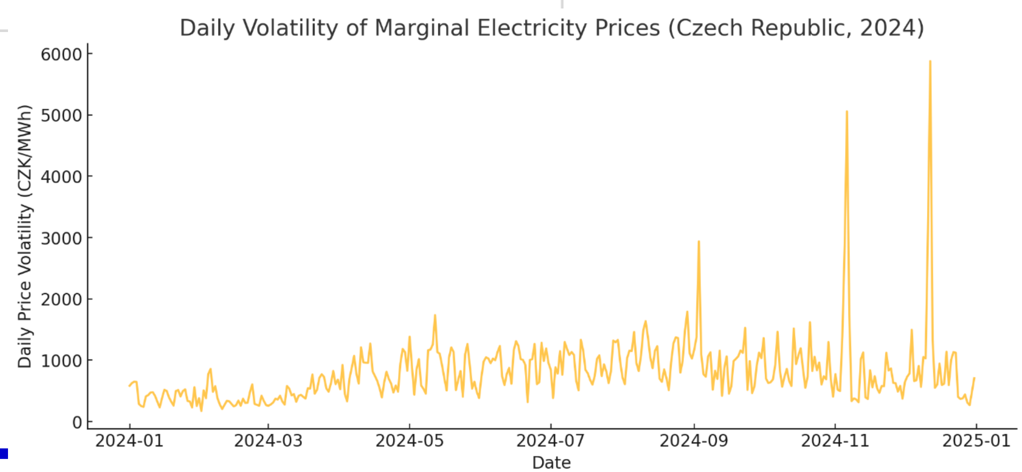
Safety, reliability and competitiveness

What lessons can we learn from the recent blackout in Spain and Portugal?

High fluctuation of power prices on spot market



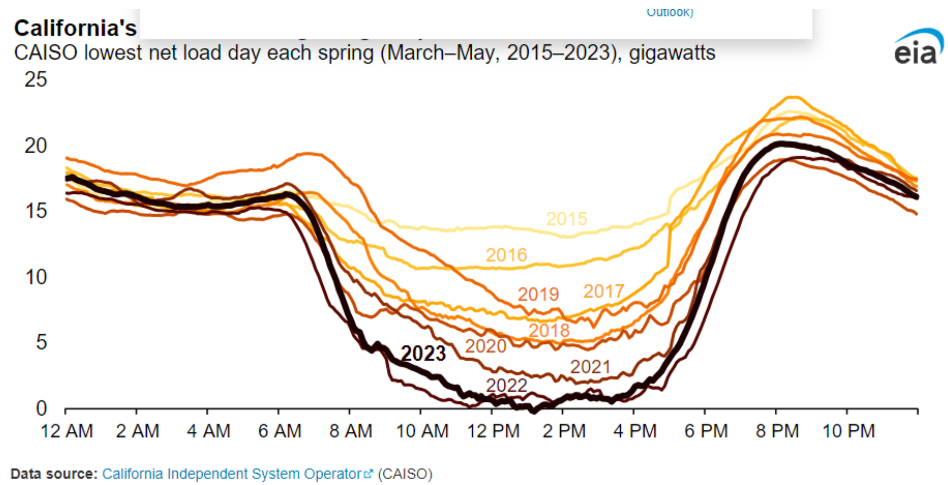




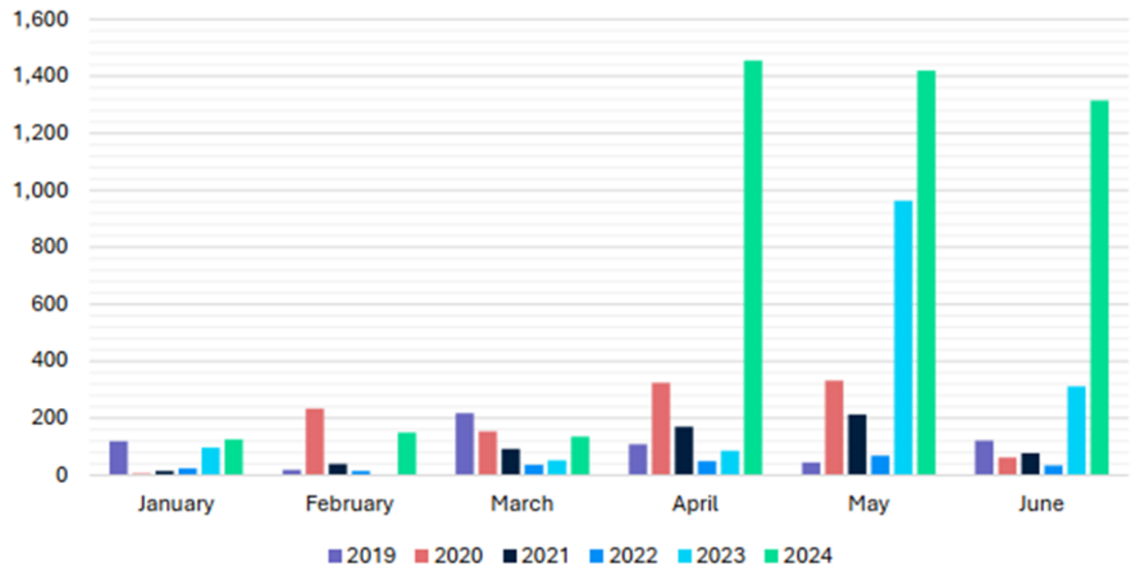
Increasing frequency of negative prices

Czech Republic, 2024

	Hours with negative price
January	2
February	0
March	4
April	47
May	72
June	57
July	60
August	38
September	12
October	22
November	0
December	1
TOTAL	315



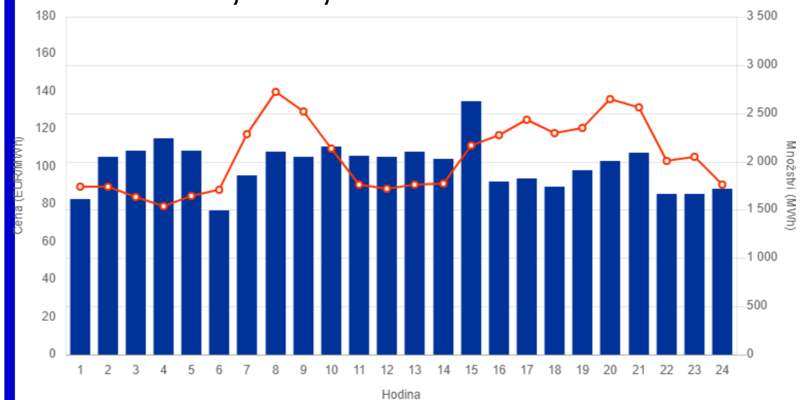
Increasing frequency of negative prices



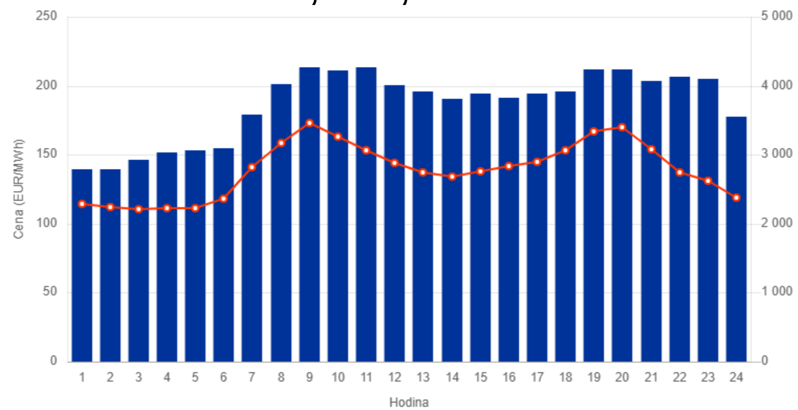
Frequency of negative electricity prices in each month of the first half of the year between 2019 and 2024 (40 EU bidding zones including the UK and Norway)

Changes of power prices

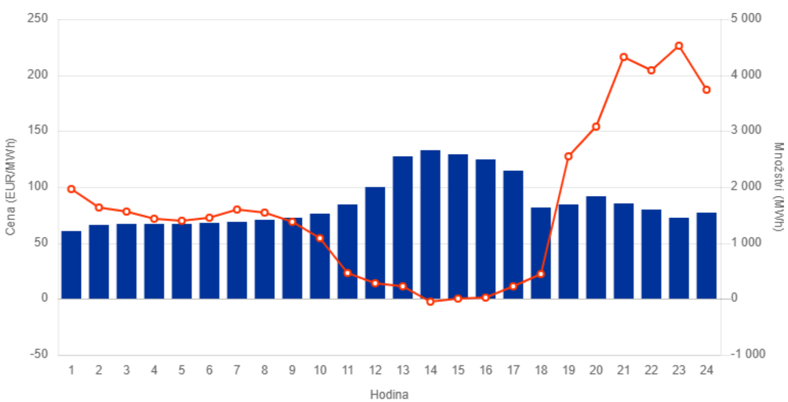
DAM, CZ, 30.3.2023



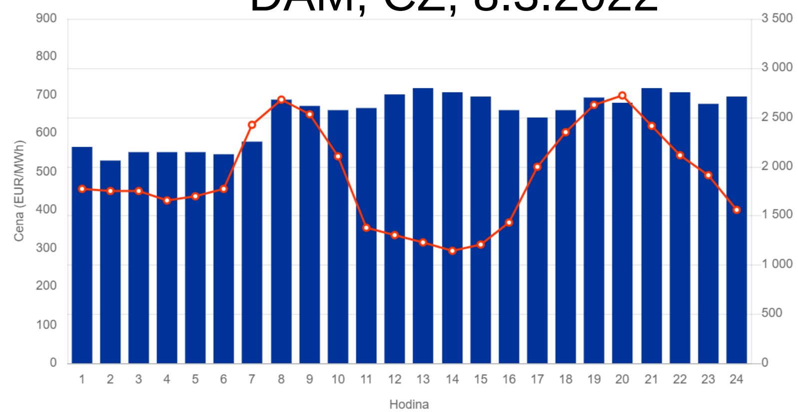
DAM, CZ, 8.3.2023



DAM, CZ, 10.4.2023



DAM, CZ, 8.3.2022



Why has the price of electricity in March 2023 fallen compared to March 2022? What factors are influencing this? Where can electricity prices fall? What will be the next development? And what happened on 10.4.2023 ?

EU energy policy – Other news

EU ETS: (emission allowances) applies to sources above 20 MWt (defined technologies)

EU ETS II introduces a carbon price for other sectors and technologies not yet covered - from 2027

- transport (defacto carbon tax on petrol and diesel, albeit through the purchase of emission allowances by suppliers

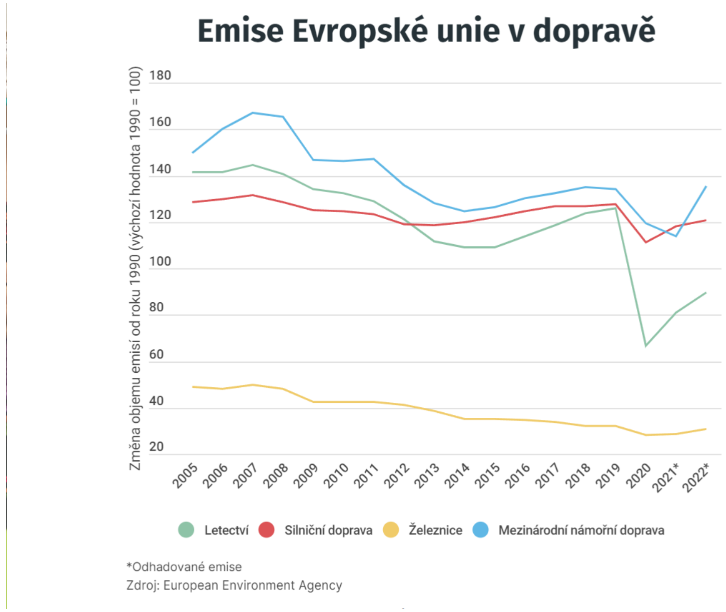
- heating of buildings (including local sources), similar principle to liquid fuels
- removing the asymmetry of the ETS impact on sources above and below 20 MWt

- ending free allocation of allowances by 2034 (especially heavy industry), aviation from 2026

- Introduction of carbon tariff (to prevent "carbon leakage" by shifting production to other countries outside the EU) This will apply to steel, cement, aluminium, fertiliser, electricity or hydrogen production.

EU energy policy – Other news

A separate new ETS II will be created for road transport fuels and buildings. This will put a price on greenhouse gas emissions from these sectors in 2027 (or 2028 if energy prices are exceptionally high). A new price stability mechanism will be established to ensure that 20 million additional allowances will be made available if the ETS II allowance price rises above €45.



EU energy policy – Other news

- Rapid development of LNG terminals.
- Natural gas spot price has reached the level of more than 3 years ago.

BUT

- Problem with payback period for LNG terminals (Taxonomy assumes natural gas only as the transient fuel/technology), but we need it right now
- Similar problem with duration of the contract for natural gas delivery

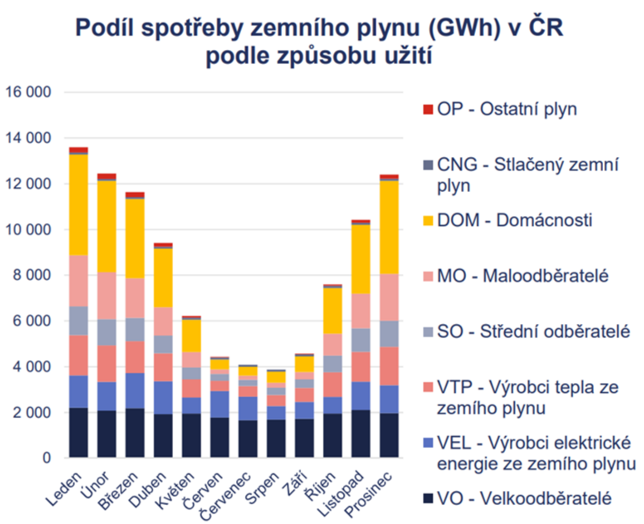
(producers require typically 15 year contracts)

- Transformation of energy systems needs time

Other context

- High seasonal profile of natural gas consumption (problem either for its assurance or substitution)

- Demostrated on the example of the Czech republic seasonal profil of natural gas consumption

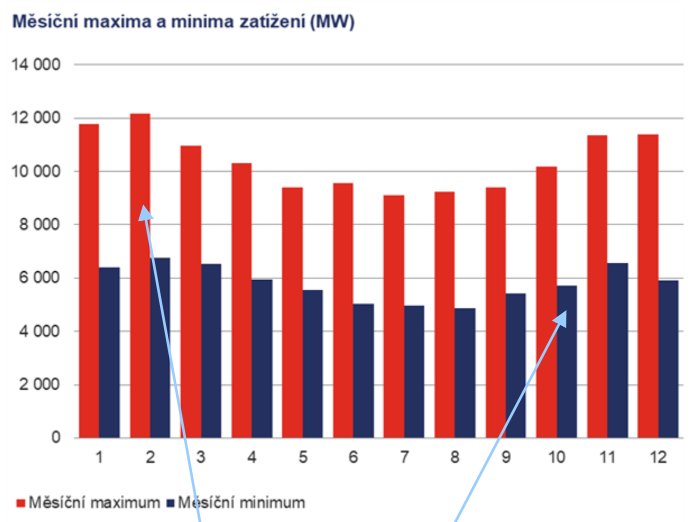


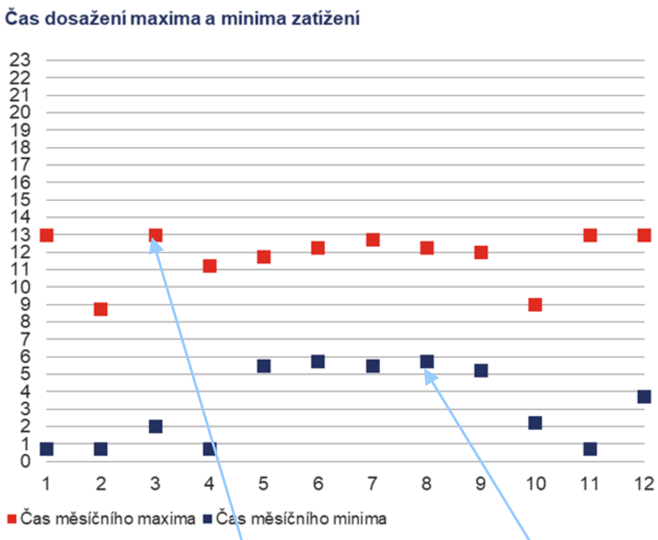
Kategorie	Spotřeba [GWh]
DOM – Domácnosti	26 899
VO – Velkoodběratelé	23 259
MO – Maloodběratelé	13 377
VEL - Výrobci elektrické energie ze zemního plynu	13 067
VTP - Výrobci tepla ze zemního plynu	12 830
SO - Střední odběratelé	8 904
OP - Ostatní plyn	1 344
CNG - Stlačený zemní plyn	1 057
CELKEM	**100 737**

DOM- households
VO-industrial consumers
MO- small consumers
VEL- power genration from gas
VTP- heat producefs from gas
SO- middle size consumers
OP- other gases
CNG- compressed natural gas

Other context

- Substitution of conventinal power generation capacities with intermitent RES – example of the Czech rep.

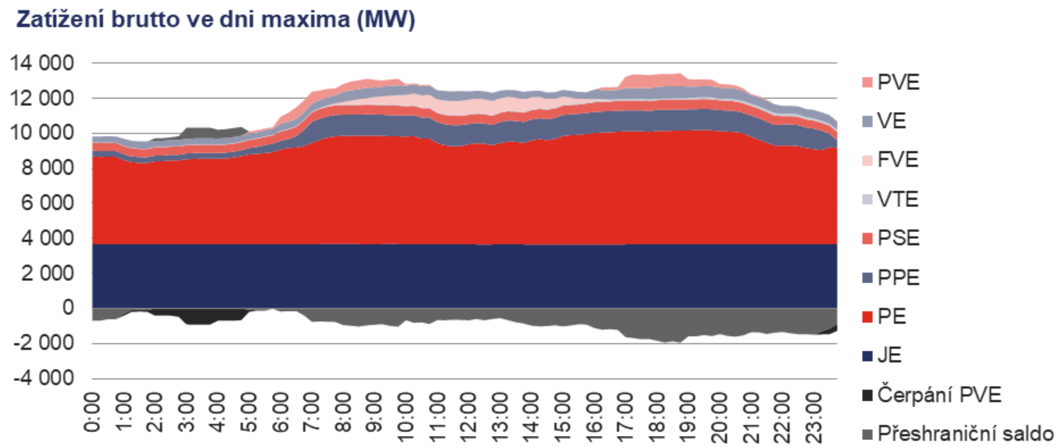




Monthly maximum, monthly minimum

Hour of monthly maximum and monthly minimum

Other context



Maximum load demand – CZ 2021

Structure of meeting load demand
JE – nuclear power plant (PP)
PE – steam PP
PPE – gas fired PP
VE – hydro PP
PVE-pump storage PP
FVE – PV PP
VTE – Wind PP

Struktura pokrytí denního maxima zatížení (15. 2. 2021 08:45)	[MW]	
Zatížení brutto	**12 159,0**	**100%**
Jaderné elektrárny (JE)	3 678,9	30%
Parní elektrárny (PE)	6 201,1	51%
Paroplynové elektrárny (PPE)	1 206,0	10%
Plynové a spalovací elektrárny (PSE)	554,3	5%
Vodní elektrárny (VE)	581,1	5%
Přečerpávací vodní elektrárny (PVE)	514,5	4%
Fotovoltaické elektrárny (FVE)	330,9	3%
Větrné elektrárny (VTE)	54,7	0%
Přeshraniční saldo	-962,6	-8%
Čerpání PVE	0,0	0%

ČEPS – TSO outlook for the Czch republic

PROGRESIVNÍ SCÉNÁŘ

Instalovaný výkon	Progresivní 2025	Progresivní 2030	Progresivní 2035	Progresivní 2040
Nedodávka	0 GWh	1 GWh	305 GWh	798 GWh
Saldo dovozu a vývozu	2 121 GWh	15 218 GWh	19 981 GWh	19 961 GWh
Palivové články	0 GWh	0 GWh	16 GWh	42 GWh
Bateriová akumulace	36 GWh	256 GWh	718 GWh	1 401 GWh
Vodní a přečerpávací elektrárny	2 605 GWh	3 452 GWh	3 495 GWh	3 554 GWh
Fotovoltaické elektrárny	5 658 GWh	12 469 GWh	13 782 GWh	14 518 GWh
Větrné elektrárny	1 484 GWh	2 349 GWh	5 258 GWh	7 280 GWh
Ostatní OZE	3 374 GWh	3 109 GWh	2 605 GWh	2 784 GWh
Plynové zdroje	3 273 GWh	9 298 GWh	18 195 GWh	15 437 GWh
Uhelné zdroje	24 961 GWh	9 039 GWh	0 GWh	0 GWh
Jaderné elektrárny	27 883 GWh	28 381 GWh	27 921 GWh	36 326 GWh

The Czech Republic is becoming an importer of electricity from an exporter (from where?) + the question of importing electricity at a time when production in PV and wind power plants is limited

- The open question of the operation of coal-fired power plants and the related extraction of coal for thermal power plants
- Rapid growth of electricity from RES places increased demands on flexibility services and electricity storage (will it be available in 2030?)
- What to do with surplus electricity from PV ?

DEKARBONIZAČNÍ SCÉNÁŘ

Instalovaný výkon	Dekarbonizační 2025	Dekarbonizační 2030	Dekarbonizační 2035	Dekarbonizační 2040
Nedodávka	0 GWh	83 GWh	985 GWh	2 676 GWh
Saldo dovozu a vývozu	2 377 GWh	19 989 GWh	20 008 GWh	19 990 GWh
Palivové články	0 GWh	20 GWh	383 GWh	585 GWh
Bateriová akumulace	42 GWh	283 GWh	861 GWh	1 575 GWh
Vodní a přečerpávací elektrárny	2 652 GWh	3 598 GWh	3 737 GWh	3 905 GWh
Fotovoltaické elektrárny	7 366 GWh	16 274 GWh	19 000 GWh	21 715 GWh
Větrné elektrárny	1 484 GWh	2 354 GWh	5 258 GWh	7 280 GWh
Ostatní OZE	3 374 GWh	3 431 GWh	2 605 GWh	2 783 GWh
Plynové zdroje	3 310 GWh	15 190 GWh	21 627 GWh	19 673 GWh
Uhelné zdroje	25 179 GWh	0 GWh	0 GWh	0 GWh
Jaderné elektrárny	27 883 GWh	28 370 GWh	28 071 GWh	36 265 GWh

Balance import - export

Other context

The current situation is accelerating processes already underway

- Development of RES (but care must be taken to ensure a balanced production mix with regard to the reliability of electricity supply, including in the RES segment)
- Decarbonisation of the energy sector
- Diversification of imports of primary sources
- Increased perception of the risk of asymmetric impacts on national economies (e.g. due to massive domestic support for their industries)
- Increased perception of the risk of social instability and associated energy poverty

Search for new market mechanisms (what it all involves?)

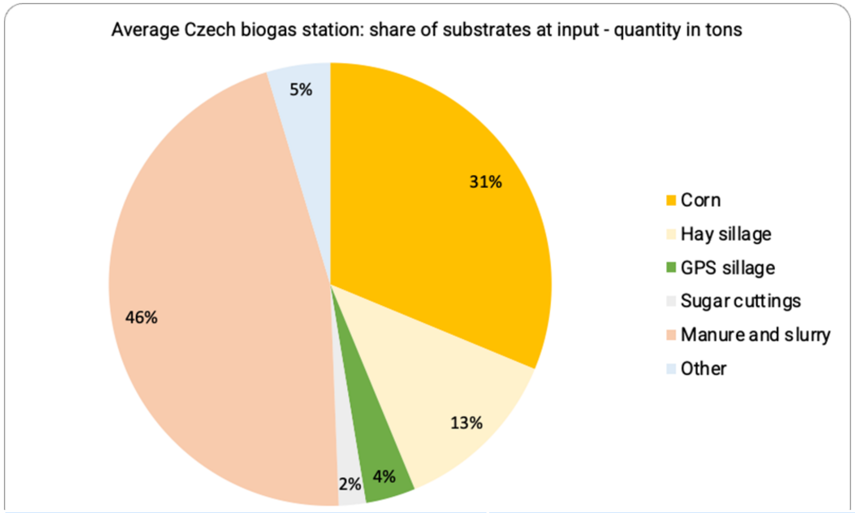
Biogas plant/Biomethane plants

How to find well balanced, effective and long-term stable policy?

Questions:

- **What do we really prefer ?**
  - ☐ **Electricity plus flexibility**
  - ☐ **Biomethane**
  - ☐ **Heat**
  - ☐ **All**

Biomass fuel cycle - effectiveness



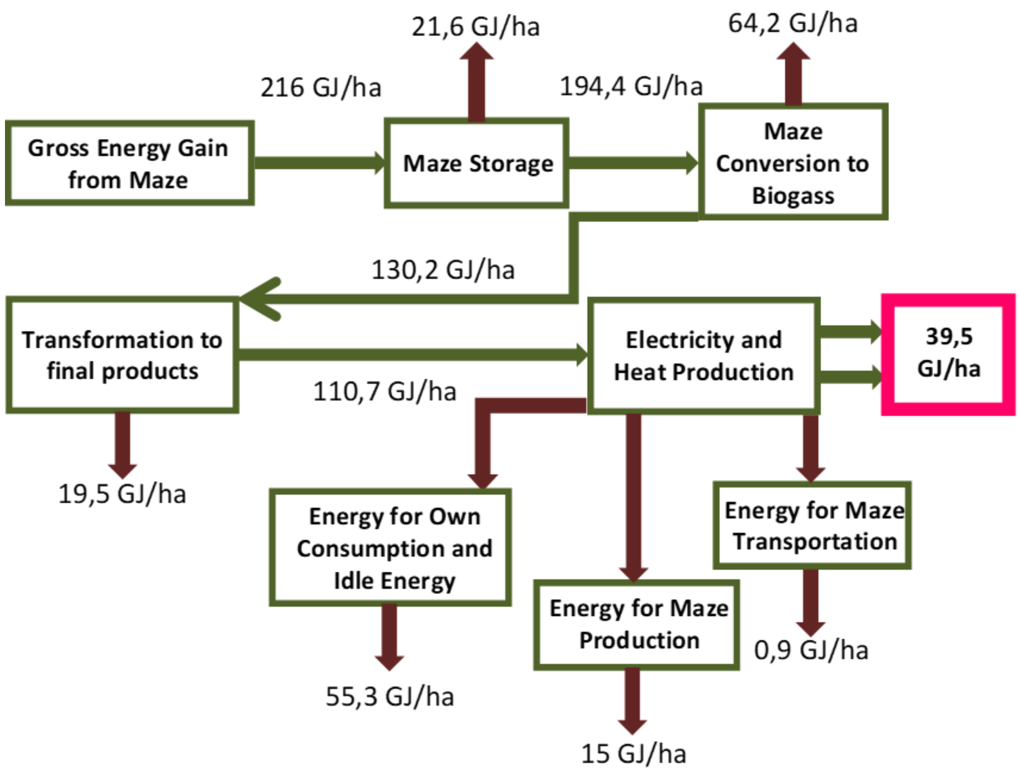
Current composition of input substrate

Biogas: 55-70% CH_4

Substrate	Input [tons]	Share [%]
Maize	2 852 607	31%
Haylage	1 142 449	13%
GPS	332 717	4%
Beet pulp	180 386	2%
Manure	895 673	10%
Slurry (cattle)	1 850 204	20%
Slurry (pig)	1 449 829	16%
Other (biowaste, agri residues etc.)	424 569	5%
Total	9 128 433	100%

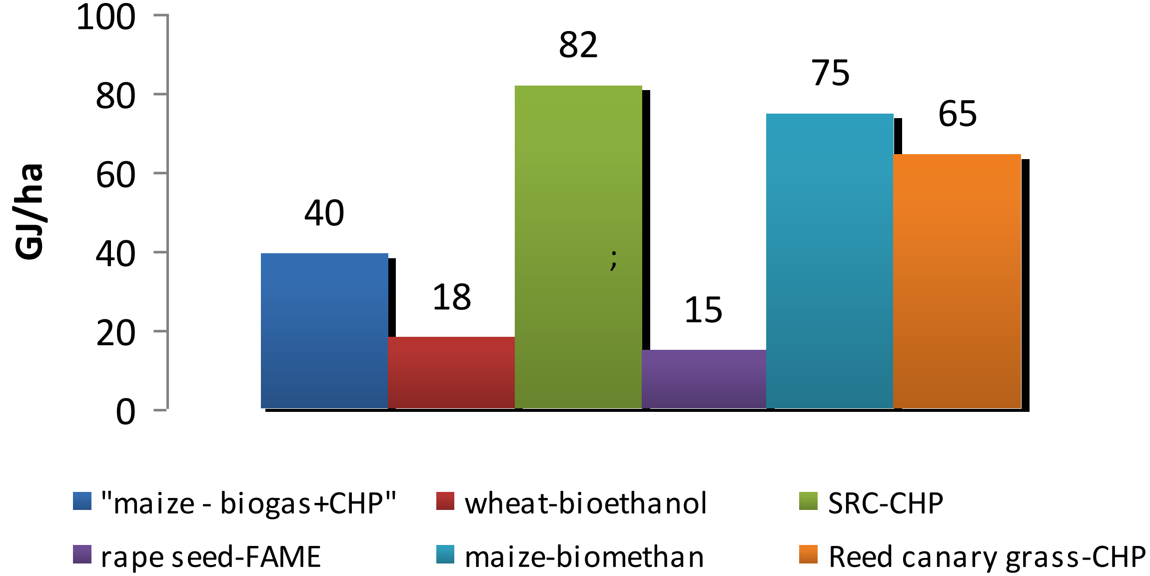
Biomass fuel cycle – biogas plant effectiveness

Effectiveness of RES utilization – example of energy balance for biogas station

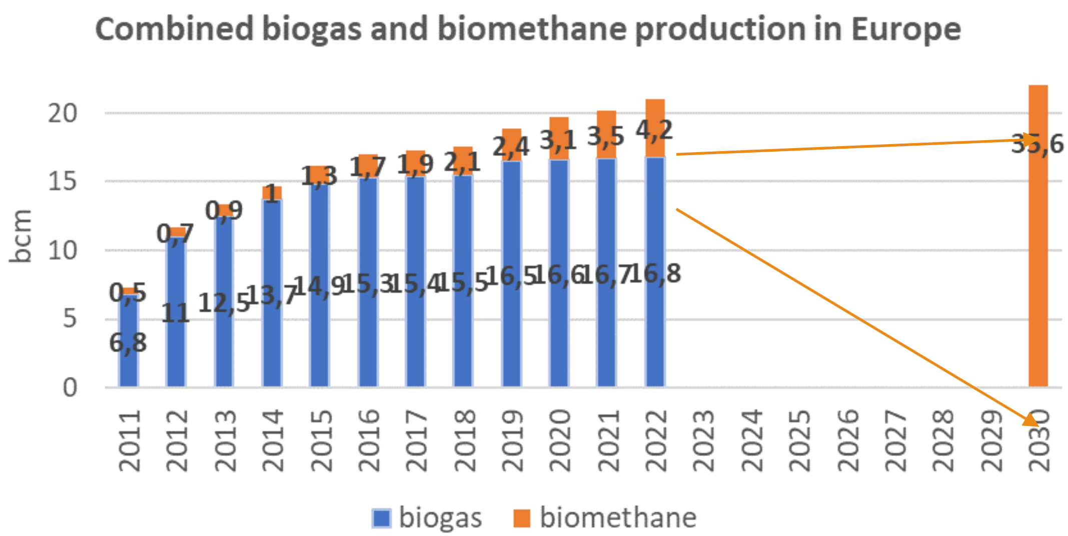


Biomass fuel cycle - effectiveness

Effectiveness of RES utilization – comparison of net yields for different biomass cycles



Biogas and biomethane production – present state and projections - Europe



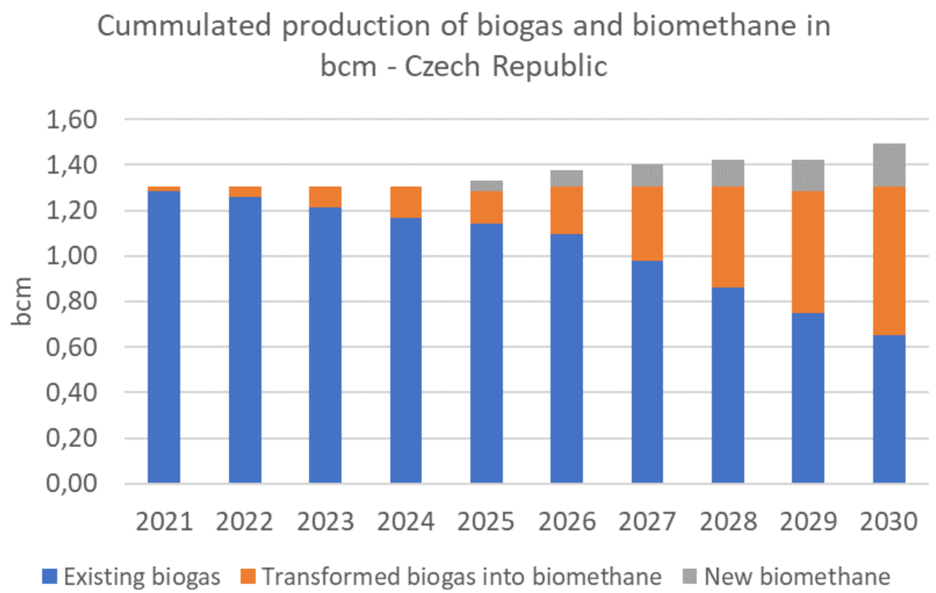
To reach 2030 targets for biomethane requires app. 30% annual growth rate !

2022:

- 19,491 biogas plants (70 TWh_{el}, 2,2% of total EU power consumption, 6% of electricity from RES)
- 1323 biomethane plants (4,2 bcm)

REPowerEU: 2030 target for biomethane 35,6 bcm

Biogas and biomethane production – present state and projections - CZ



CZ 2022:

- Biogas plants: 2,59 TWh_{el}, 24,2% of total CZ RES power generation
- FIT and FIP support schemes lead to high load factor (7489 hours in 2021 on net production), no use for flexibility services
- Biomethane targets significantly assumes transformation of existing biogas plants

Biomethane development strategies

Transformation of existing biogas plants into biomethane plants:

+ Higher efficiency in the use of processed biomass (1.8-2 times)
+ Substitution of fossil fuel – natural gas: already existing infrastructure and end consumers technologies (incl. transportation)
− Loss of green electricity generation (base load character)
− Loss of ability to provide flexibility services in the electricity market

- Biogas plants have the ability to accumulate biogas (optimization of the production diagram, ability to provide + and - services)
- **Increasing frequency of hours with negative prices of electricity and requirements for flexibility services**

Construction of new biomethane stations

- Potential risk of competition for feedstock (biomass) with biogas plants

Rapid expected development of biogas/biomethane branch requires systematic solution to optimize functioning of biogas/biomethane plants

Transformation of existing biogas plant into biomethane

To develop a model to assess the realistic capability of a biogas plant or combined biogas plant technology supplemented with a biomethane upgrading unit to provide flexibility services.

→ Efficiency of flexibility service provision and efficiency of biogas plant transformation for flexibility service provision and biomethane production

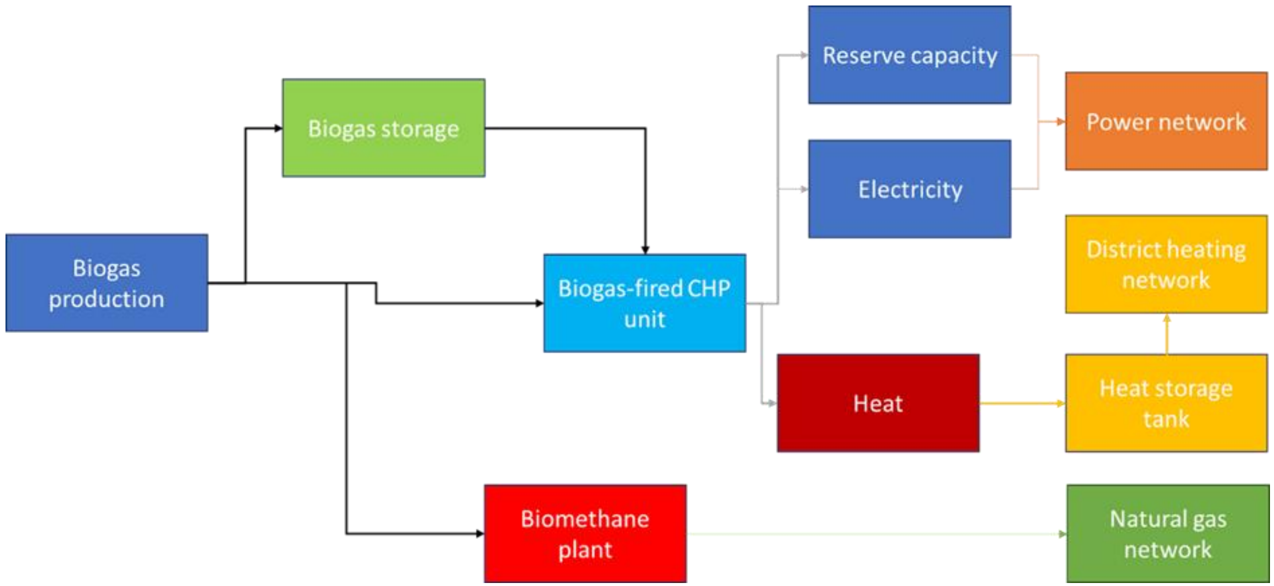
→ Optimization of the operation of a combined biogas/biomethane plant in relation to the output products (power generation, power balance services, biomethane and heat production)

Design of the model

↳ Case study for the Czech Republic / real data 2022 and 2023

↳ Recommendation for the biogas/biomethane development strategy

CZ – biomethane targets to 2030 /3



Complex solution for BMS/BGS stations

Source: own figure

Biogas/biomethane strategy

The combination of a biogas CHP plant with a biomethane production unit can be an effective option for the development of the biogas/biomethane sector from the point of view of both investors and the electricity system.

- The participation of the biogas-fired CHP unit in ancillary services markets enhances its profitability. **Automatic Frequency Restoration Reserve** (aFRR) seems the most promising service.

- The existence of the biomethane plant provides **additional flexibility** in the utilization of the biogas. High natural gas prices can make the operation of the biomethane plant profitable even without incentives.

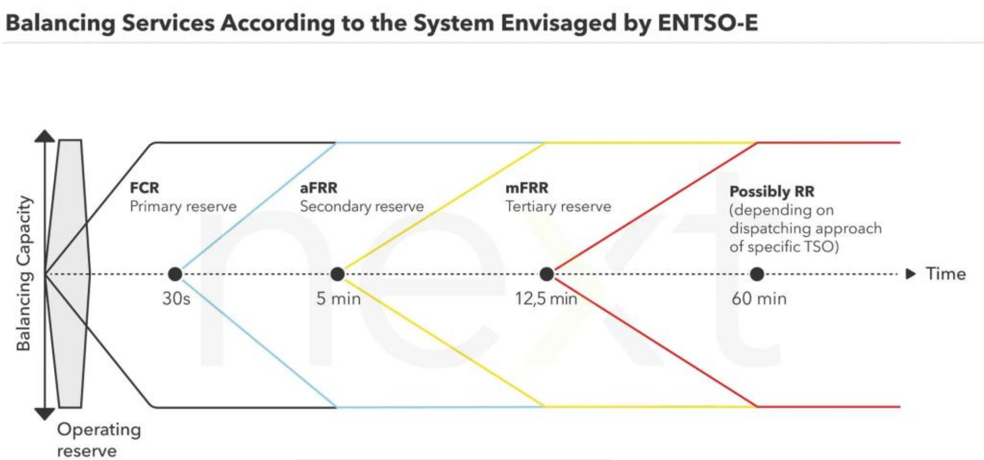
- The existence of the **biogas storage facility** is key for the optimal management of the biogas between CHP operation and biomethane production.

- The consideration of **higher CO_2 emission avoidance costs** due to biomethane generation can further enhance the profitability of biomethane plants.

CZ – biomethane targets to 2030 /2

CZ National energy climate plan – goal to 2030: 0.5 bcm of biomethane

- Mainly through conversion of existing BGS into BMS (cleaning technology added – typically membrane technology for separation of CO2)
- BGS in this case should solve heat source (for fermenter, technology, etc.)
- BGS has accumulation capacity – gas accumulation typically for 1-3 hours
    - Possibility to offer flexibility services
    - Conversion of BGS into BMS results in loss of flexibility services



Source: Next Kraftwerke GmbH, https://www.next-kraftwerke.com/products

BUT: Quick increase of RES in power generation mix will require additional sources of flexibility services.

Development of BMS should be based on system strategy

Biogas plants – open questions

Today: support by green bonus scheme, specific case of CfD régime

- Green bonus is the difference between reference price ensuring rate of return (6,21% for the Czech republic) and market price:
  - If market price is higher then reference price: operator gets difference back
  - If market price is lower than reference price: operator gets the difference
  - If market price is negative: operator gets nothing

Todays support scheme (Czech rep.) is assuming constant operation of biogas plants: 24/7 régime (load factor brutto significantly above 8000 hours)

Does it make sense to operate biogas plants e.g. In periods with electricity surplus from PV?

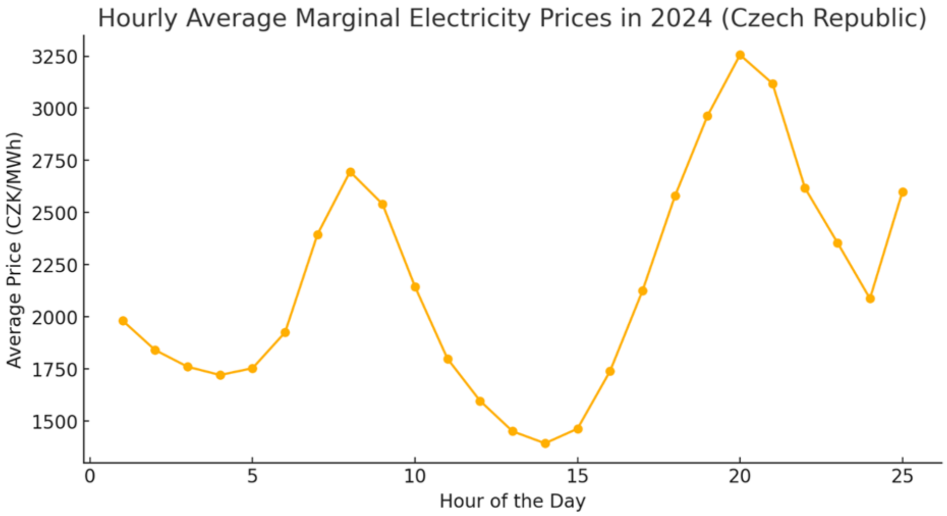
Biogas plants – flexibility

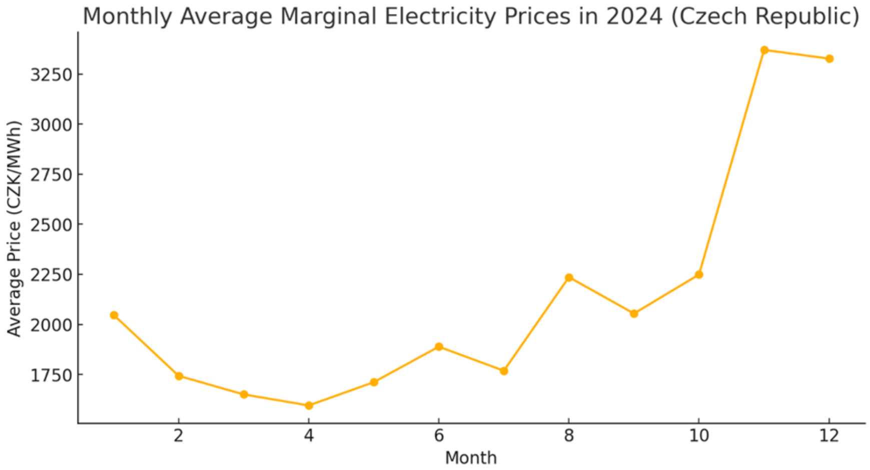
Biogas plants have typically up to 3 hours accumulation capacity for biogas

- **Can offer negative service, but what to do with accumulated biogas when fermenter works on nominal output?**
    - **Loss of power generated (and money from green bonus)**

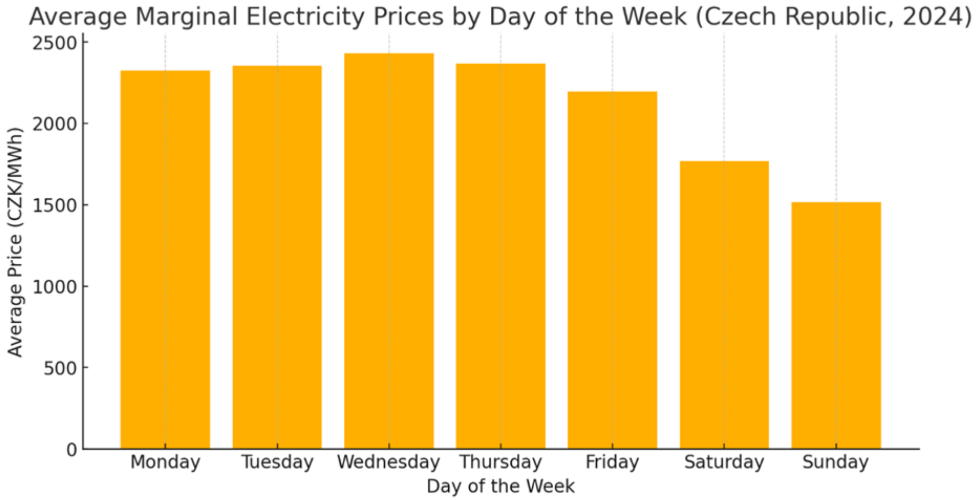
- Biogas plants can reduce output from fermenter (e.g. to 50%) and to operate on reduced time on nominal capacity of cogeneration unit (e.g. 2x6 hours/day)
    - Better suits with load diagram
    - Frees up space for cheaper electricity from PV

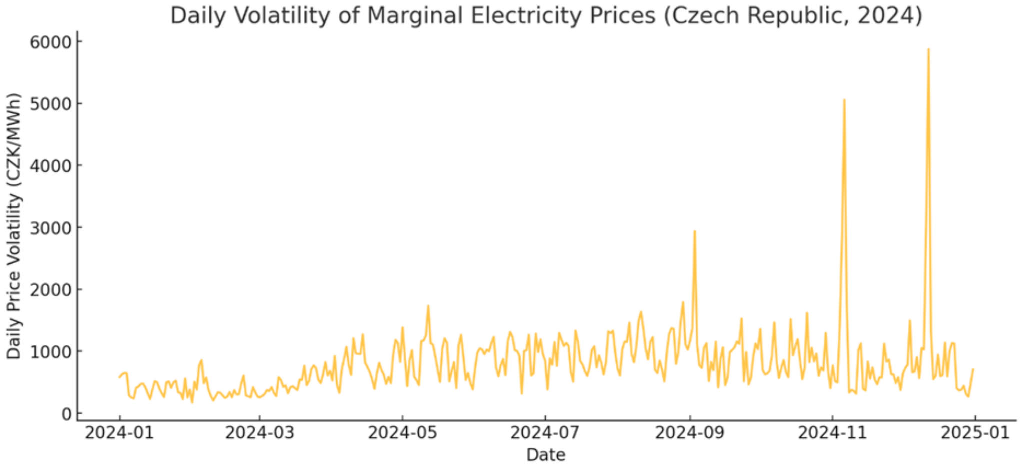
Biogas plants – flexibility





Biogas plants – flexibility





Biogas plants – flexibility

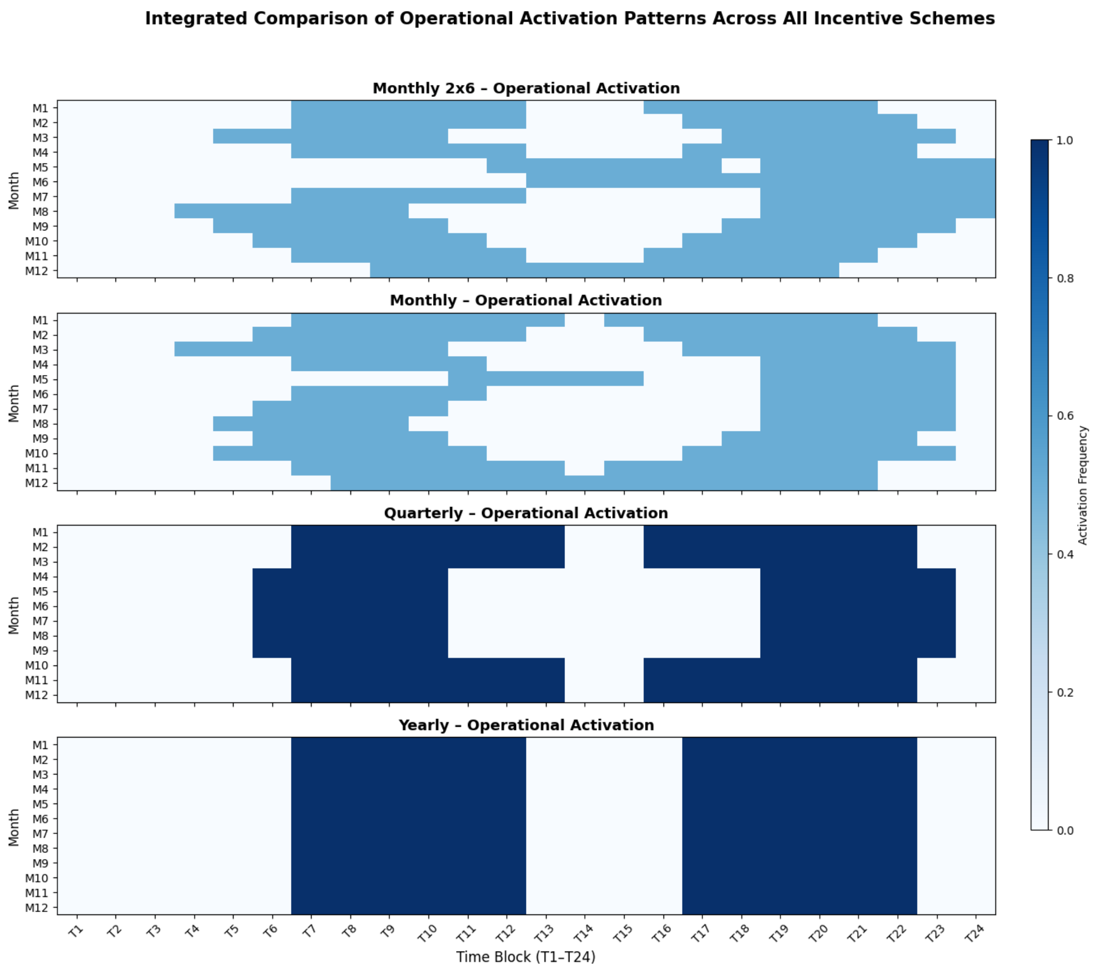
Biogas plants can directly contribute to the flexibility services, but:

- When operating on nominal capacity, what to do with accumulated biogas (negative service)
- No rational possibility to offer positive service

Solution can be abandoning régime 24/7 and concentration to hours with high prices

- Biogas surplus (fermenter is operating at constant level) can be used for transformation in biomethane
- Fermenter out is reduced to 50% and biogas plants is operated in time periods with highest prices on spot market

Biogas plants – flexibility



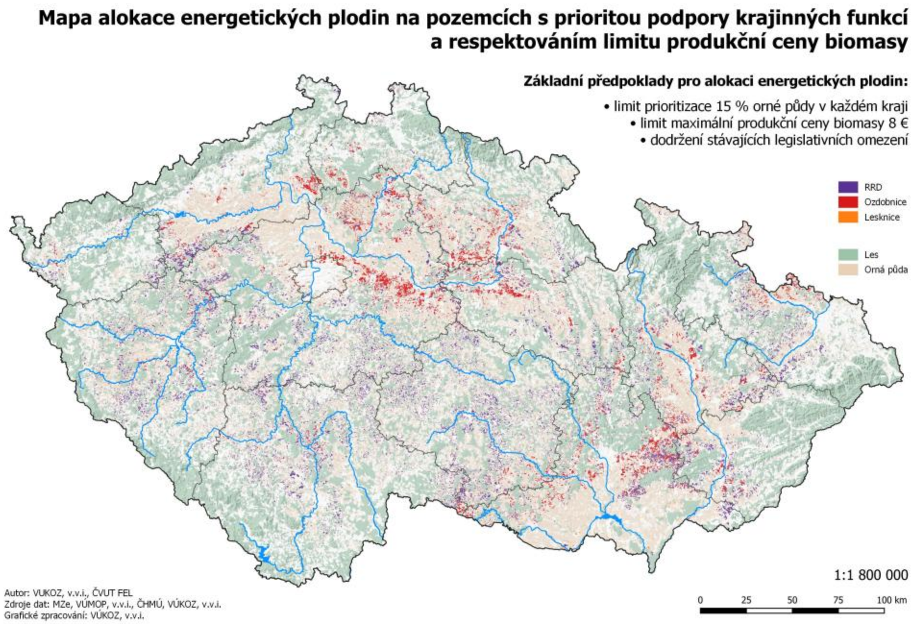
Biomass – New Trends

Preference of utilization of waste and residual biomass

- But limited potential
- Intentionally planted biomass will remain, but sustainability criteria has significant impact (e.g. on maize)
- Focus on ecological aspects of agriculture land and forest land utilization
- Ecosystem services related with perennial energy crop
- How to introduce logic of fallow land (part of land which is not currently utilized for intensive agriculture – e.g. Grass, wildflowers, perennials etc.
- Agroforestry, agrivoltaics

Biomass – New Trends 2

- Plantations of perennial energy crops can serve as a suitable tool for reducing the ecological impacts of conventional agriculture



Classification system for evaluation of level of risk associated with conventional agriculture:

- Landscape connectivity - support of migration and dispersion possibilities of organisms
- Landscape heterogeneity - the size of soil blocks directly affecting habitat and species diversity
- Drought threat to land
- Threat to land from water erosion
- Threat to land from wind erosion

Perennial energy crops can significantly help reduce these risks

Biomass – New Trends 2

- Plantations of perennial energy crops can serve as a suitable tool for reducing the ecological impacts of conventional agriculture
- 2021: preparation of the European Forestry Strategy
- Effective afforestation, protection and restoration of forests, as well as their resilience. All of this is intended to contribute to increasing the capacity of forests to absorb and store carbon dioxide
- Wood (see European Parliament resolution, 2021) is not to be used primarily as biomass to replace heat from fossil sources, but "wood should, where possible, be prioritized for longer-life uses to increase global carbon storage".
- All of the above factors will influence and limit the potential of biomass for energy in the future

Biomass – New Trends 3

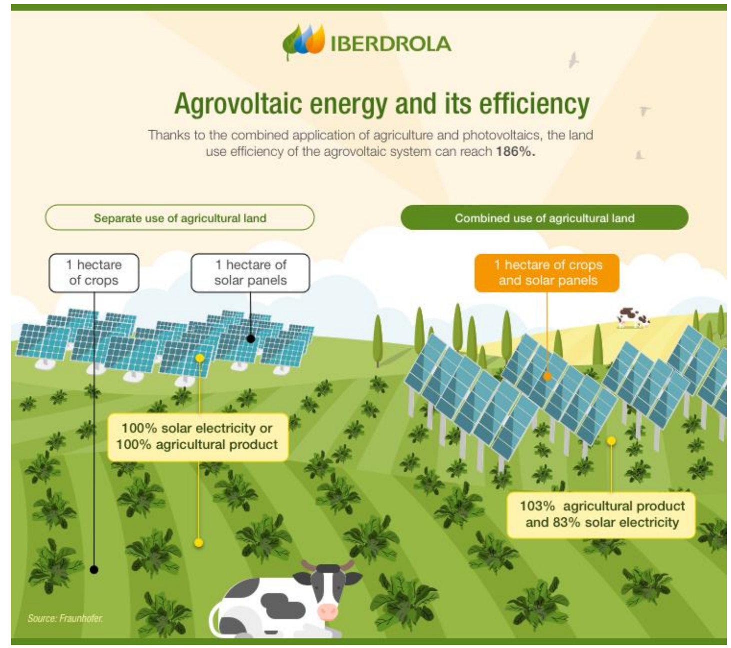
Biobelts with fruit trees on erosion-prone slopes (left; Šardice, Moravian Tuscany) and alternating belts of erosion-resistant and anti-erosion crops (right: maize - barley, Němčičky

Biomass – New Trends 4

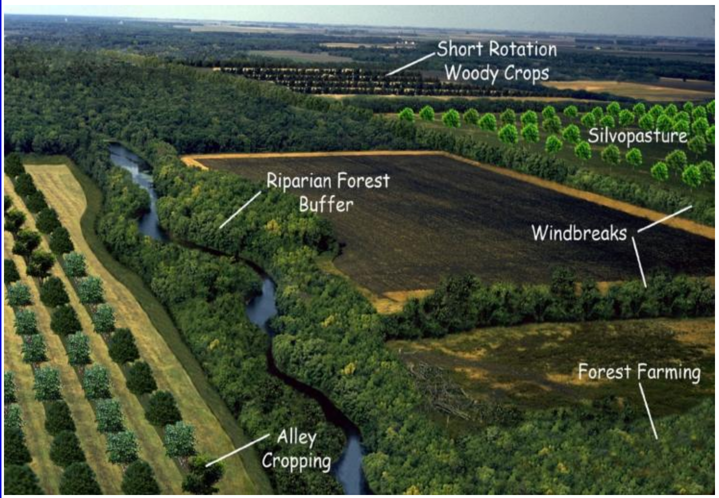
Plantations of energy crops perform important productive and non-productive functions in the landscape (on the left - harvesting of the RRD plantation for Plzeňská teplárenská a.s., on the right - plantation of ornamental plants in the summer season performing the function of permanent greenery even after harvesting monocultures of annual crops in Vysočina)

Biomass – Agrovoltaic, example of the new trend

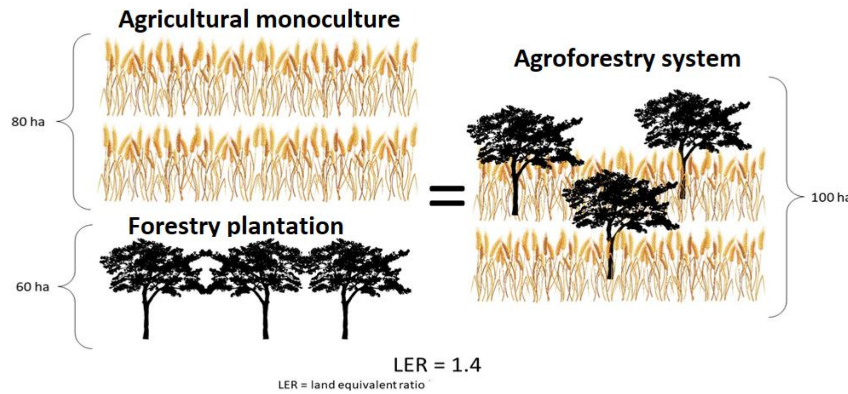
www.univergysolar.com



Biomass – Agroforestry, example of the new trend



Main types of agroforestry systems USDA, 2010

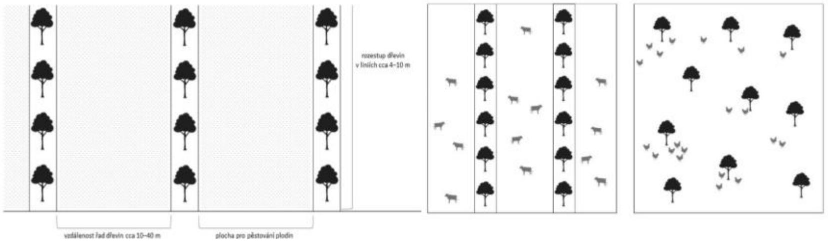


LER (*land equivivalent ratio.*) of value 1,4 means that 100 ha of AFS produces the same yields as 140 ha of trees and agricultural crops when grown separatelly. (Mead, Willey, 1990)

Agroforestry systems (ASF) means land use systems in which trees are grown in combination with agriculture on the same land (**EU regulation no. 1305/2013**)

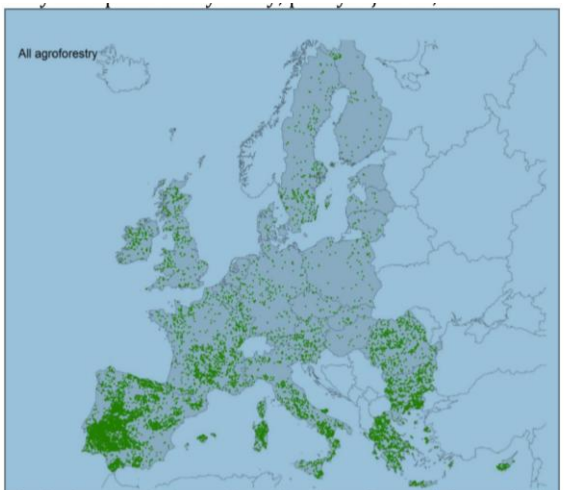
- very innovative and flexible (for task - conditions)
- allows stable production with strong eco-services
- mitigation and adaptation measures

Biomass – Agroforestry, example of the new trend



Obrázek 3.4 Ukázky silvopastevního agrolesnictví – stromy na pastvinách

Biomass – Agroforestry, example of the new trend



Obrázek 3.5 Odhadované rozšíření agrolesnických systémů v Evropě (den Herder a kol. 2017)

Obr. 3.8 Výsadba dřevitých (nezakořeněných) řízků RRD do výmladkových pásů se provádí ručně mechanizovaně sazečem do kvalitně připravené a odplevelené půdy.

Obr. 3.-11 Polní pokusy s pěstováním pšenice a brambor v ALS-1 Michovky a odběr vzorků pšenice pro analýzy z kontrolního pole

Biomass from energy crop – different points of view on its price / cost of cultivation

Perennial energy crops – plantation lifetime:

- ❑ 10 years (e.g. Miscanthus), 20-24 years (SRC plantations)
- ❑ the decision to grow energy crops can be evaluated using investment evaluation methods - NPV of project cash flows (CF)

Biomass price - energy crop, perennials, two points of view

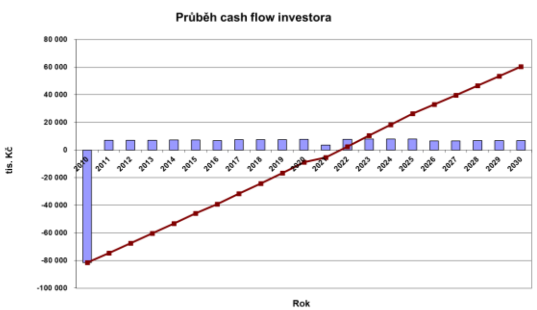
Minimum price to get required rate of return	Opportunity use of soil for conventional crops
C_{min}: $NPV_{enercrop}=0$	C_{alt}: $NPV_{enercrop}=NPV_{convcrop}$
rate of return is equal to discount rate used for NPV calculation	to get the same economic effect as from growing of conventional crop

Limit of biomass price from the consumers point of view – competition with other energies

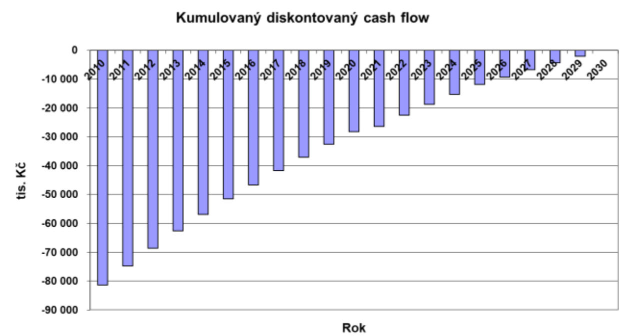
Biomass from energy crop – minimum price modelling 2

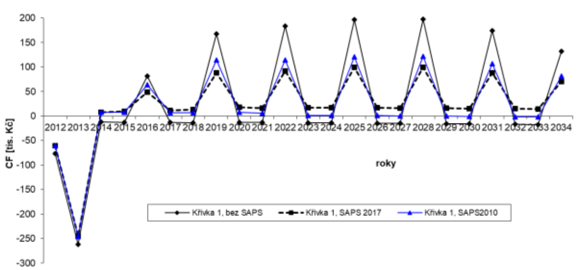
Minimum – price

- ❑ Sum of discounted CF at the end of the project equals to zero
- ❑ Example of CF and DCF profiles for



PV Power plant





SRC plantation CF profile

- ❑ Minimum price methodology is widely used e.g. to define FIR for electricity from renewables, for waste disposal, etc.
- ❑ To derive price of commodity from supplier point of view

Opportunity use of soil for conventional crops

C_{alt} calculation - equality of CF generated from the production of conventional crop for the duration of the energy crop plantation

$$NPV(\text{energy}) = \sum_{t=1}^{T_h} [c_{alt,1} \cdot Q_t \cdot (1+i)^{(t-1)} + S_t - E_t] \cdot (1 + r_{n,d})^{-t}$$

$$NPV(conv) = \sum_{t=1}^{T_h} (R_{t,q} - C_{t,q}) \cdot (1-d) \cdot (1 + r_{n,1})^{-t}$$

$$c_{alt,1}: \quad NPV(\text{energy}) = NPV(\text{conv})$$

C_{alt} . Q + S: revenues from energy biomass plus subsidy

$r_{n,d}$,$r_{n,1}$: discount rates

T_h: energy crop plantation lifetime,

10, 24 years

rotation of conv. crop according to site conditions

R_q-C_q: market price of crop and cost of q conv. crop

Opportunity use of soil for conventional crops - 2

$$NPV(\text{energy}) = \sum_{t=1}^{T_h} [c_{alt,1} \cdot Q_t \cdot (1+i)^{(t-1)} + S_t - \mathrm{E}_t] \cdot (1+r_{n,d})^{-t}$$

$$NPV(conv) = \sum_{t=1}^{T_h} (R_{t,q} - C_{t,q}) \cdot (1-d) \cdot (1+r_{n,1})^{-t}$$

$$c_{alt,1}: \quad NPV(\text{energy}) = NPV(\text{conv})$$

Key role of risk inclusion into calculation – discount values $r_{n,d}$,$r_{n,1}$

Higher risk for perennials:

: (1) high one-off costs of plantation (approx. 1440 EUR / ha for SRC, approx. 1500 EUR / ha for Miscanthus); present value of the plantation-related costs is about 50% for SRC plantations. If, due to bad weather conditions (e.g., due to drought), the established plantation is damaged or destroyed, the farmer realizes a high loss,

(2) SRC or Miscanthus plantation do not reach the maximum yield of biomass in the first year, but only with a delay, e.g., for SRC the maximum yield is attained between 8 and 12 years, the income from the sale of biomass has a significant distance from the investment in the plantation (future income is thus more uncertain than current expenditures for plantations establishment). **RISK INCREASE.**

Energy crop: price modelling – case example of the Czech republic 2

Methodology: biomass yields of energy and conventional crops are allocated according to soil and climate conditions on given land plot

- Soil valuation system used: 10 climate regions, 78 different soil types, app. 570 valid combinations
- Expected yield of crop for each combination of climate region and soil type (long term field experiments, expert estimates, etc.
- Arable land divided into agricultural production area - APA
  - affects production costs
  - APA determines the recommended crop rotation
  - a total of 92.3% (2,287 th. hectares) of the total arable land area included in the analysis
  - 7 year rotation cycle of conventional crop – different for each APA
  - Comparison period – based on lifetime of energy crop plantation

Year1	Year 2	Year3	Year4	Year5	Year6	Year7	Year8	…….	Year20	Year21	Year22
Crop1	Crop2	Crop3	Crop4	Crop5	Crop6	Crop7	**Crop1**	…….	Crop6	Crop7	**Crop1**

Energy crop: price modelling – case example of the Czech republic 3

Input data:

- Conventional crop price: average market prices in period 2014-2018
- Production cost of conventional crop: average cost for each APA and type of crop, year 2018 (the differences in the rated costs per hectare among the zones differ by 10% (silage maize) to 25% (winter wheat)
- Subsidy 210.6 EUR/ha
- Production cost of SRC and Miscanthus plantations: economic models based on results of experimental plantations
- Cost and revenues escalation: 2%
- Income tax rate: 19%
- Discount rates: $r_{n,d}=r_{n,1}=10\%$ (nominal)
- Land: LPIS - Land Parcel Identification System
  - Each land plot registered in LPIS is assigned to given APA and c_{alt} is calculated simulating rotation of conventional crop

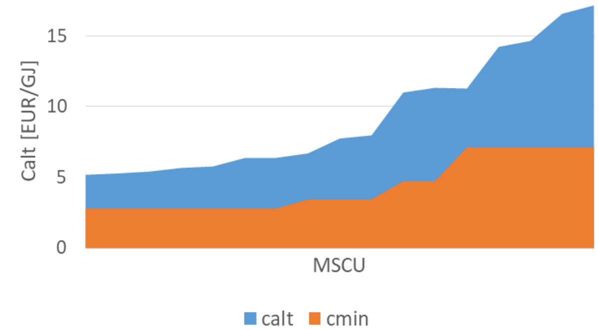
Price modelling results

High profitability of conventional crops pushes the c_{alt} price up

SRC plantation

Region/APA	Average		Weighted average	
	C_{min} [EUR/GJ]	C_{alt} [EUR/GJ]	C_{min} [EUR/GJ]	C_{alt} [EUR/GJ]
Maize-growing	4.4	9.3	5.2	11.4
Beet-growing	3.4	6.5	3.2	6.7
Potato-growing	3.4	6.3	3.0	5.8

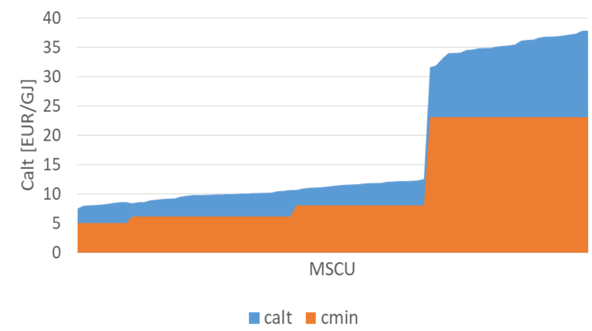
SRC, maize growing APA



Miscathus plantation

Region/APA	Average		Weighted average	
	C_{min} [EUR/GJ]	C_{alt} [EUR/GJ]	C_{min} [EUR/GJ]	C_{alt} [EUR/GJ]
Maize-growing	7.9	10.9	7.2	10.6
Beet-growing	7.1	9.6	6.4	9.3
Potato-growing	11.9	18.2	11.2	17.3

Miscanthus, potato growing APA

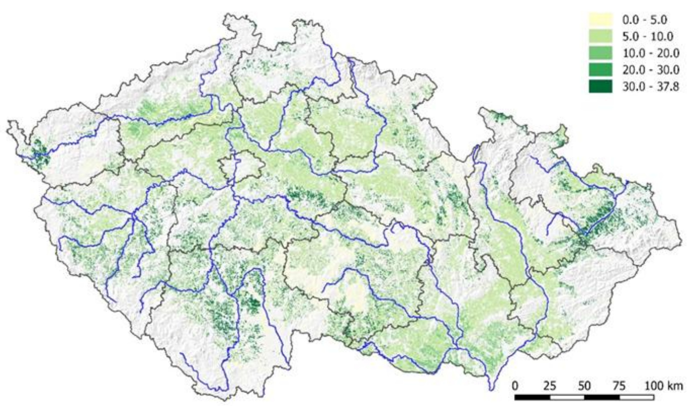


Note: prices of raw biomass without storage and transportation to final consumer

Price modelling results - 2

Factors influencing calt price:

- Suitability of given APA for energy crop – e.g. potato production area is not suitable for Miscathus – typical yields app. 2,5 t(FM)/ha,year
- High yields of conventional crop at given land plot – high profit that must be compensated by a higher c_{alt}
- Higher risk related with energy crop compared with conventional crop – higher discount rate and higher c_{min} and c_{alt} prices



c_{alt} price has high variability according to the specific conditions of the area

Example of c_{alt} price distribution for Miscanthus on the territory of the Czech Republic

Policy implication

Areas with c_{alt} lower than given maximum limit

SRC plantations

Maize-growing zone		Beet-growing zone		Potato-growing zone	
EUR/GJ	Area	EUR/GJ	Area	EUR/GJ	Area
<6	10.1%	<6	41.5%	<6	78.2%
<8	20.5%	<8	79.8%	<8	92.6%
<10	20.5%	<10	87.9%	<10	92.7%
<12	73.0%	<12	97.1%	<12	99.9%

Miscathus plantations

Maize-growing zone		Beet-growing zone		Potato-growing zone	
EUR/GJ	Area	EUR/GJ	Area	EUR/GJ	Area
<6	0.0%	<6	0.0%	<6	0.0%
<8	0,0%	<8	47.2%	<8	0.7%
<10	53.8%	<10	88.5%	<10	56.5%
<12	80.4%	<12	94.5%	<12	70.0%

Based on competition with other fuels and technologies - maximum competitive c_{alt} price limit is 6-8 EUR/GJ

Competition with conventional crop significantly reduces economic potential of energy crop

Expectations of an increase in targeted biomass may not be met!

Note: growing areas: maize: 140 th. ha, potato: 880 th. ha, beat: 972 th. ha (areas where yield of energy crop are defined, some unsuitable areas are excluded from the analysis)

Thank you for your attention !