Possible scenarios and risks of Czech power industry development

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1) **Present trends and future directions**
2) **Emission-free energy sources**
3) **Successful direction to emission-free energy**
4) **Possibilities of Czechia**
5) **Update of Czech energy concept**
6) **Possible scenarios and risks**

Pchery

German solar park Neuhardenberhas 148 MW

Temelin

Present trends and future directions of power production

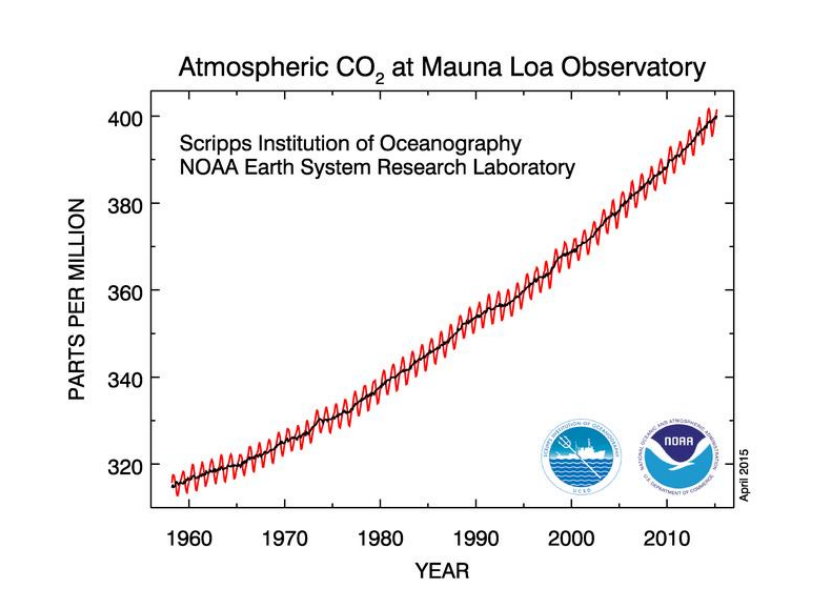
1) Live standard increasing at developing countries (China and India) – increasing of energy consumption
2) Emphasis on ecology and emission decreasing
3) Transition to electricity also at transport, industry and partly heating
4) Full of contradiction trends – decentralization: small sources, smart grid
   deepening of centralization: large wind and solar farms far away from consumption, very long power lines (even undersea) very high voltage
5) Technology progress and importance of science and knowledge

Enormous growth and polution of China cities

Wind farms are long away from consumption places

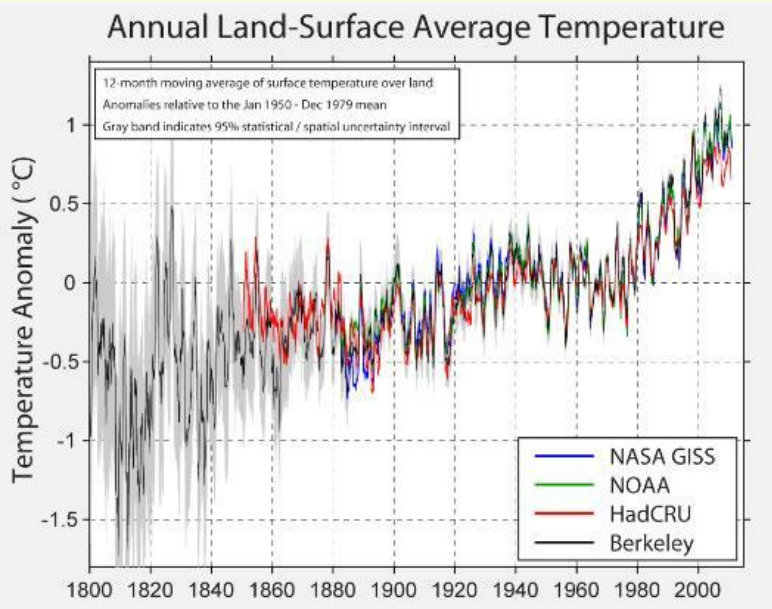
Climate Changes and their sources?

1) Increase of carbon dioxide is validated by accurate measurements
2) Its industrial origin is confirmed also by measurement of radioactive ^{14}C
3) Increasing of total temperature (global warming) is validated by measurements
4) Share of natural and industrial influences on climate change is still open
5) Future development depends on model and results have corresponding uncertainties



Measurement of CO_2 concentration on Maono Loa

Measurement of CO_2 and ^{14}C at NPI CAS



Change of global temperature

Useful measure should be wetlands and also dams

6) The measures against impacts of climatic changes (origins are not important)

7) Improvement of water management, more resistant field crops, better city architecture (more gardens, water …) …

8) The measures against CO_2 emission in power industry – only if they have not worse social impacts

9) Synergy with measures against decreasing of fossil sources (change of sources, savings and efficiency)

10) 2013 - Electricity (Overall): oil 4,4 (32,9) %, coal 41,3 (30,1) %, gas 21,7 (23,7) %, hydro 16,3 (6,7) %, nuclear 10,6 (4,4) %, wind 2,7 (1,1) %, sun 0,5 (0,2) %.

The Key Numbers:

Overall:	**fossil**	**86,7 %**
	hydro	**6,7 %**
	nuclear	**4,4 %**
	wind and sun	**1,3 %**
Electricity:	**fossil**	**67,4 %**
	hydro	**16,3 %**
	nuclear	**10,6 %**
	wind and sun	**3,2 %**

Possible Emission-Free Sources

1) **Hydro – one of the most important, Advantages: flexibility and energy storage, large but also small, decentralized**
   Disadvantages: dependency on geographical conditions
2) **Wind – Advantages: decentralized and also large**
   Disadvantages: depend on weather conditions (fluctuated), need suitable geographical conditions
3) **Solar – Advantages: thermal (large), photovoltaic also decentralized**
   Disadvantages: depends on geographical condition, depend on weather conditions (fluctuated)
4) **Biomass – Advantages: flexible, regulation, decentralized usage of waste**
   Disadvantages: combustion products, competition with food production
5) **Nuclear – Advantages: independent of weather, mostly also no geographical conditions, possible regulation**
   Disadvantages: large, complex technology, public attitude
6) **Geothermal, tidal … (mostly studies up to now)**

Successful Transitions to Emission-Free Energy

Combination of renewable and nuclear sources

Ontario 2014 - coal phase out (electricity) – upgrade of CANDU reactors for next 25 years (Year 2003 still 25 % of electricity from coal), 19 reactors with total power 13,5 GWe, nuclear 62 % of electricity

France - emission-free electricity during ten years, 58 reactors, 63 GWe, minimal emissions from nineties, still more renewables

Sweden, Switzerland – combination of nuclear and hydro electricity many years

Slovakia – nuclear and hydro 87 %, Mochovce 3 and 4 will increase share of emission-free electricity

This energy mix is prepared also at Finland and Great Britain

Off shore wind farm (Sweden)

Canadian Bruce B nuclear power plant

The Key Message

Emission-free energy mix based on nuclear and renewable sources is possible for different regions with different geographical conditions

Lot of examples work many years

Transport based on electric vehicles → emission-free power industry

Unsuccessful (for now?) Course to Emission-Free Electricity

Only renewables (necessity to use fossil sources): **German Energiewende, Denmark**

Germany – 1) Nuclear phase out (based on ideology).

2) Dominance of fossil and wind sources (share of wind depends on HV transmission lines from north to south).

3) Very intensive building of photovoltaic (big power but small share in the electricity production) massive price subsidies.

4) Import of electricity from abroad mainly in the later period (~~DESERTEC project,~~ connection to Nordic hydro sources).

Coal power plant Moorburg replaced nuclear (north Germany)

Offshore wind farm Baltik I

German „Energiewende“ (lesson)

1) Main priority – nuclear phase out
2) Next request – maximization of renewable share

Socially ecological optimum is not priority:

1) Socially acceptable energy (efficient production)
2) Environment-friendly energy production

Results:

1) Intensive deformation of market by renewable subsidies (no investments without subsidies) – huge excess of waste power
2) Intensive production from fossil sources (mainly coal by last three years)
3) High consumer electricity prices (inefficient usage of even very expensive sources)
4) Massive overflows to Poland and Czech Republic

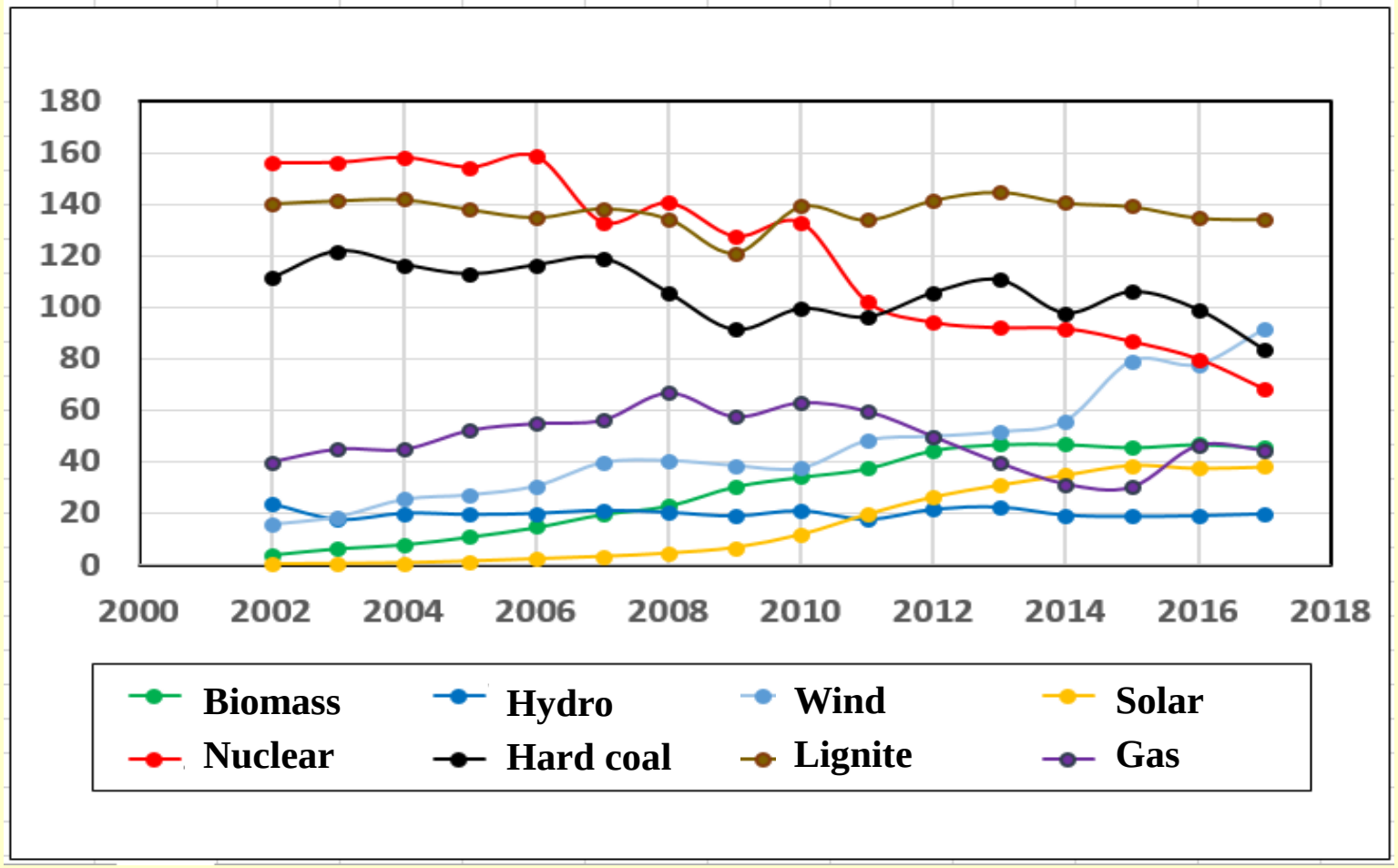
German coal power plant Neurath is the second largest at Europe

German Energiewende numbers

Hydro: still stable
Biomass: saturation last five years

Photovoltaic: increase was stopped
Wind: still increase (where is limit?)

Decrease of nuclear → and general decreasing of emission free production



Data from Fraunhofer ISE https://www.energy-charts.de/index.htm

Fundamental Problem of Energiewende in Practice

Solar and/or wind sources produce even all needed power in good weather condition – but still large part of electricity must be produced by stable flexible sources (fossil, nuclear, hydro, biomass)

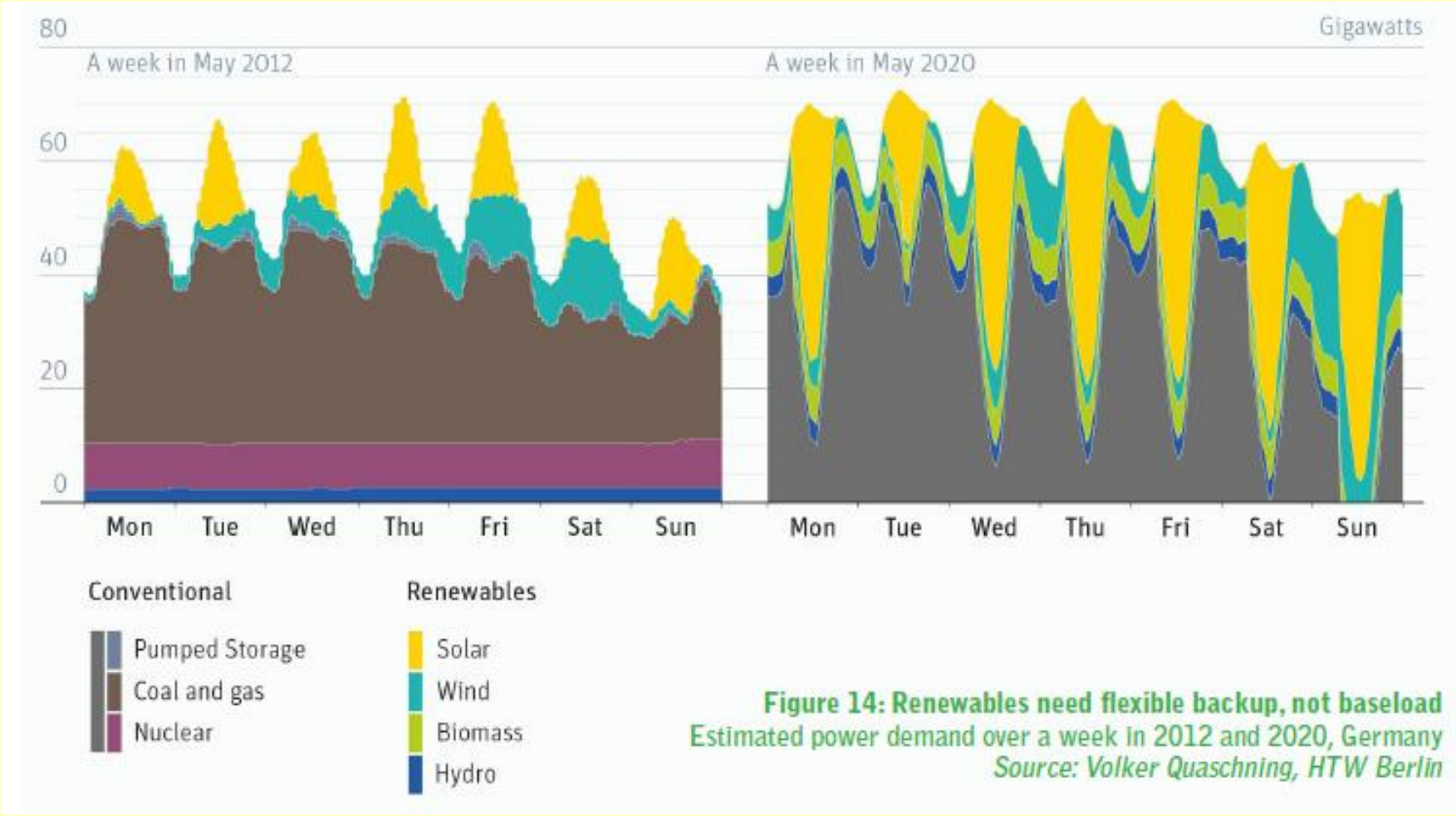
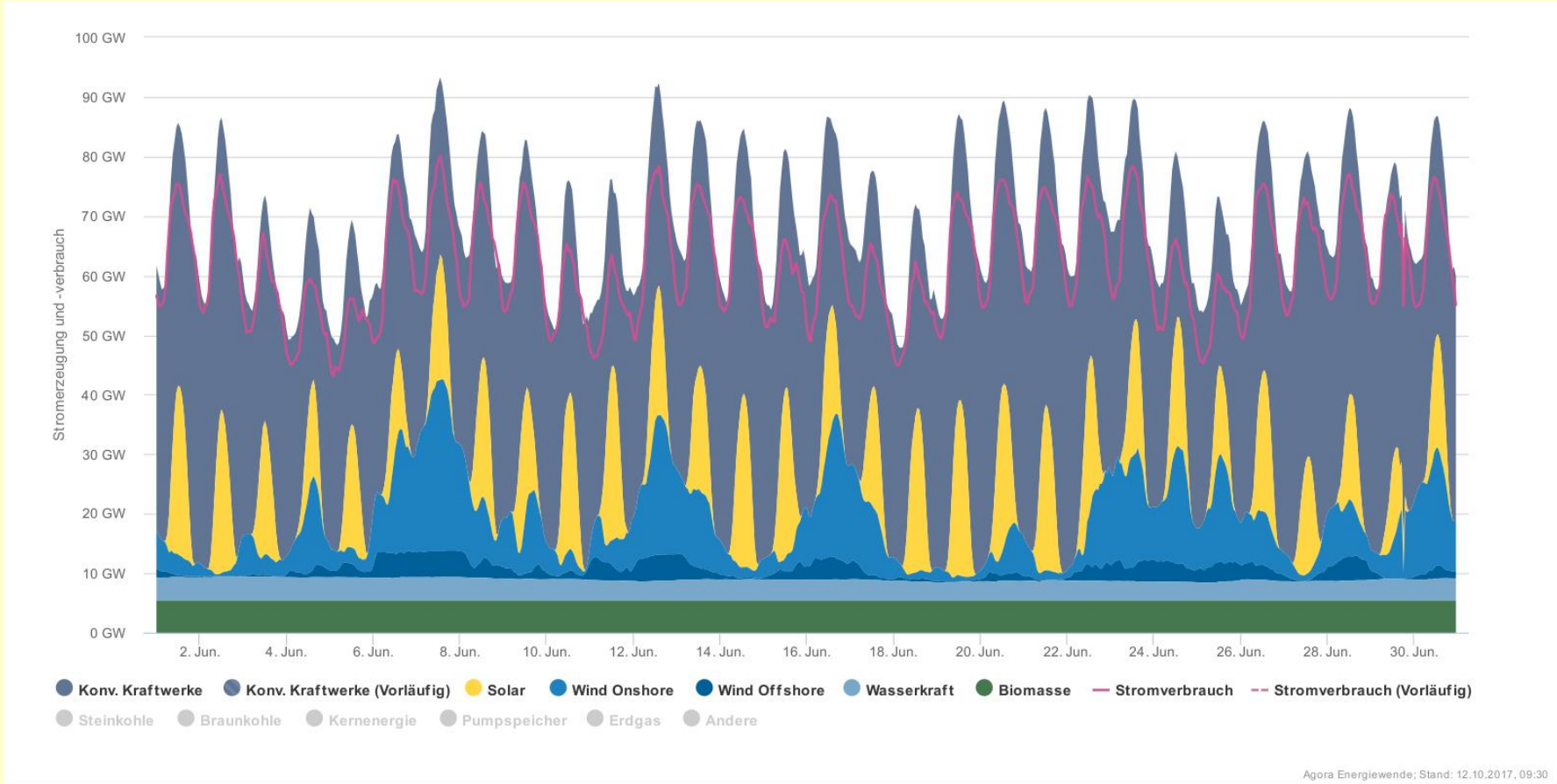


Figure 14: Renewables need flexible backup, not baseload
Estimated power demand over a week in 2012 and 2020, Germany
Source: Volker Quaschning, HTW Berlin

Present typical June situation at Germany



The Key Message

Emission-free electricity production based only on renewables was not realized up to now (exclusion are very special geographical cases (Norway, Iceland …).

Germany Energiewende lasted 18 years but share of particular sources is:
Fossil 48,1 % (coal 39,8 %), nuclear 13,2 %, renewable 38,6 % (wind 19,0 %)

A large share of fossil sources will be needed all time before solving problems with massive energy storage.

Energy Savings – Smart Grid? Smart Cities?

1) Savings are very important – realistic estimations of possibilities are necessary (energy saving bulbs - more lights are used, the same with electronic)
2) It is not possible to chase all industry to China
3) Household consumption: What is possible postpone? Cooking? Ironing? Entertainment?
4) Smart buildings, cities – increasing usage of electronic components
5) Critical is possibility of energy storage
6) Increase of computerization, smart buildings – mostly not energy saving but only status symbol now
7) Necessity of technology research and development – only prototypes at present

The Key Message:

Savings and transition to decentralization based on smart grids – significant potential, but should be realistic

Power Industry in Global Context

1) Power industry is dominated by fossil sources at present.

2) Their gradual substitution is probably possible only by intensive effective usage of all available emission-free sources and savings.

3) Energy policy should be based on geographical and other conditions.

4) Example of emission-free energy transition policy is China.

5) Substitution of coal by gas helps (USA is such example), But decreasing of CO_2 emission is only two or three times.

6) Intensive scientific studies of climate changes and their origin are necessary.

7) Scientific and technological progress is needed – in all fields (new efficient electricity production), but the energy storage is priority.

8) Very strong influence of ideological activism – necessity of rational view based on science.

Situation at Czech Republic

1) Coal reserve decreasing – decreasing of coal usage for electricity production is necessary
2) All possibilities of hydro sources are mostly used.
3) Wind map of Czechia is relatively very poor (we have not seashore).
4) Biomass – limited possibilities (production of food and ecology)
5) Czech economy is not so strong, very big dependency on industry and export, bigger social sensitivity of population to increasing of electricity price.
6) German big wind and solar power produce big excess of electricity production during proper weather conditions.
7) A lot of coal electricity production in neighborhood (Germany and Poland) – unsound emission do not know border

Present Situation at Region (2013)

State	total production [TWh]	fossil [%]	nuclear [%]	renewable [%]	wind [%]	solar [%]
Poland	148	90	0	10	3	
Germany	594	55	15,5	26	8,4	4,7
Czechia	80,8	52	35,9	11,6	0,5	2,2
Hungary	28,6	44	50,7	6	1	
Slovakia	28,2	26	51,7	20		
Austria	70,4	25	0	66	4	

Czechia, coal mining decreased by 45,4 % from 1993 to 2014

Year 2000:

Czechia coal: 70,5 %
Fossil total: 72 %

Germany coal: 50,5 %
Fossil total: 59 %

Year 2017:

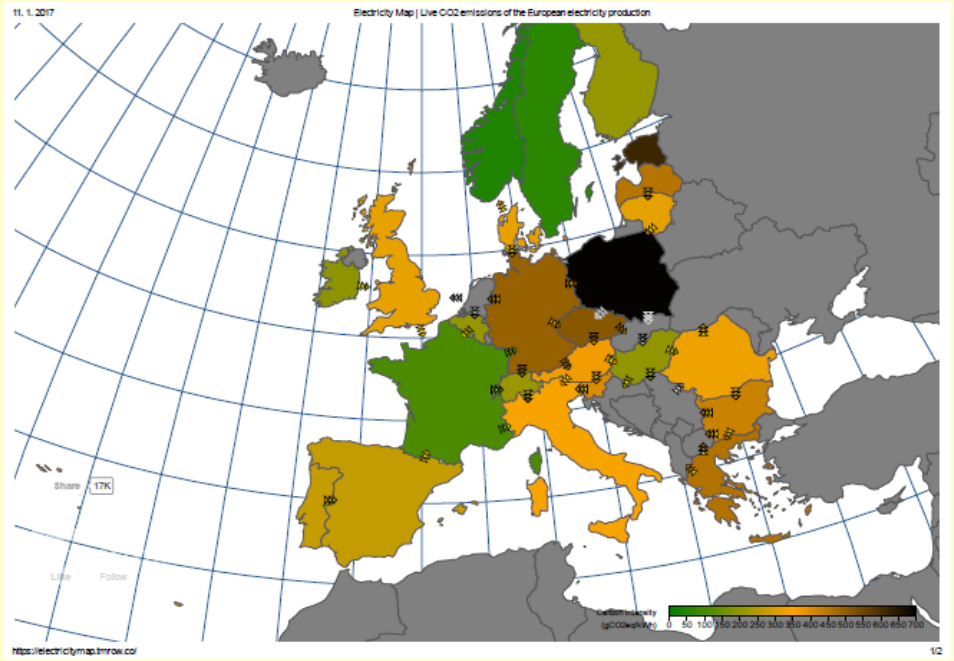
Czechia coal: 47,6 %
Fossil total: 50,5 %

Germany coal 39,8 %
Fossil total: 48,1 %
Still 13,2 % nuclear

Nuclear power plant Isar will be last at Bavaria

Influence of energy policy of EU

1) **Pressure on decreasing of emission of pollutants and carbon dioxide (increasing price of emission allowance**
2) **Pressure on coal phase-out (only Poland assumes future coal usage).**
3) **Pressure on increasing share of renewable**
4) **Pressure on electromobility and decentralization of power system**
5) **Pressure on integration of European power system**
6) **Full of contradiction stance on nuclear power**



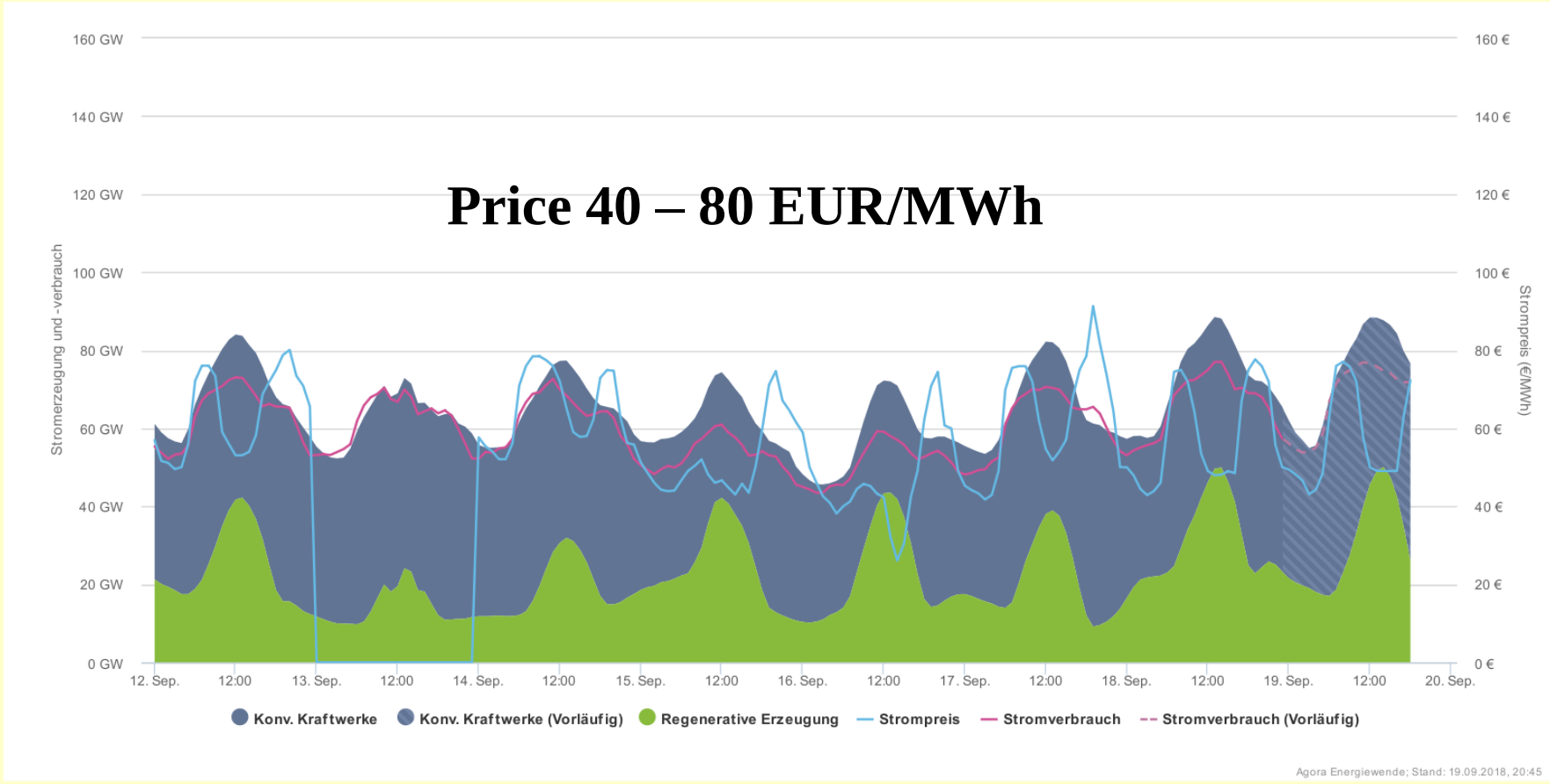
Emissions of CO_2 are possible to watch on web pages https://electricitymap.tmrow.co/

Current situation

Emission allowance price near to 25 EUR/t CO_2, 4times more, then year ago

Increasing prices of coal and gas

Close of many coal power plants at more European countries, phase out of nuclear at Germany



Czech Republic and Emission-Free Energy

Possibilities:

1) **Wind, solar – mainly small decentralized, limitation by geographical conditions and by German wind and solar electricity production excess**
2) **Biomass – small decentralized based on farming and logging waste**
3) **Not new large wind or solar parks (only small decentralized sources)**
4) **Nuclear: Dukovany possible running next 20 years, Temelin at least 35 possibility to build two new blocks at Temelin and one at Dukovany, potentially new power plant**

Current situation and necessity

1) **Nuclear sources 36 %, wind 0,5 %, photovoltaic 2,2 %**
2) **Excess of sources at present, coal phase out, Dukovany – necessary to keep and obtain substitution of coal sources,**
3) **Gas – mostly cogeneration**

Possibilities to produce emission-free energy (depend on real energy policy)

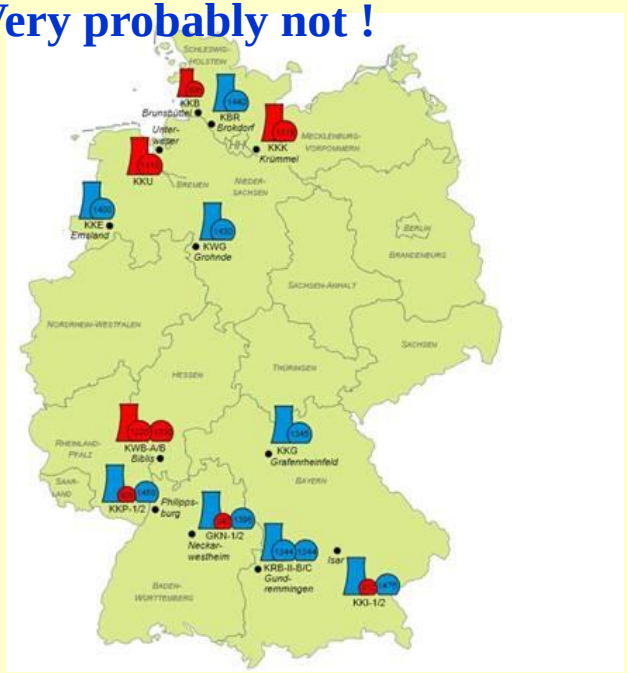
1) **Weak – continue work of Dukovany and use gas and mainly German renewable**
2) **Middle – realize accepted energy policy, preserve of self-sufficiency and export**
3) **Strong – develop nuclear sources and substitute of German and Poland coal sources**

Bavaria – model example for Czechia

1) **Bavaria - geography, size, industrial orientation similar to Czechia, had 50 % electricity from nuclear, advantage – the Alps and hydro, electricity export up to now**
2) **Nuclear will be substituted by import, gas, local photovoltaic and wind from north**
3) **At least 800 km HV line from north to south are missing – strong protests**
4) **Lower subsidy to wing and solar – stop for new Bavarian renewables, „10H“ rule – limited number of places for turbines**
5) **Still is possibility to slow Bavarian nuclear phase out? Very probably not !**
6) **Maybe import of Temelin.**

Photovoltaic really not substitute nuclear

Grafenrheinfeld is first closed large nuclear power plant at Bavaria



Bavarian nuclear phase out only started

Transitional year 2022

1) Shut down of all nuclear power plants at Germany (huge impact mainly on neighboring Bavaria)
2) Shut down of many older coal blocks in our region – new emission limits (also at Czechia and Germany)
3) The high voltage lines still will not connection of north and south of Germany
4) Wind power plant with capacity 12 GW will lose support (after 20 years)

Shut down of coal power blocks: 100 %

Decreasing of installed power 2015 - 2023 up to 62 % of present

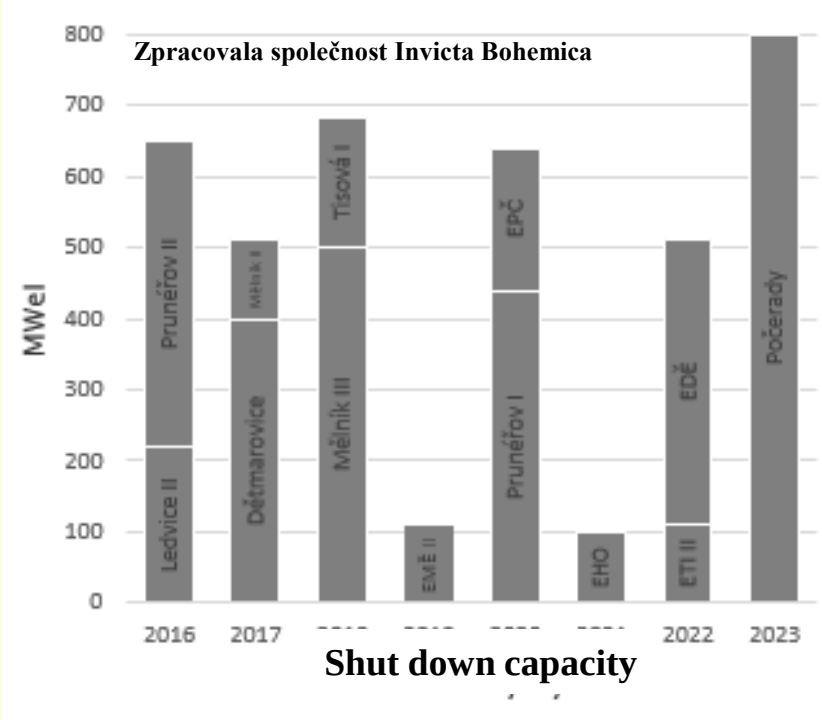
Consequences:

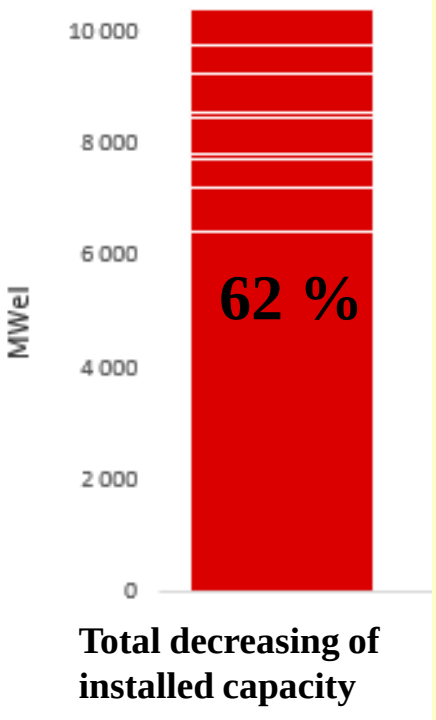
1) End of export

2) Total production OK

3) Regulation problems

We need to be ready improvement of regulation





Critical year 2035 – necessity of source replacement

1) **Gradual shut down of Dukovany power plant**
2) **Shut down of further coal power blocks**
3) **ČEZ – only three big coal blocks after year 2035**
4) **Necessity of replacement of almost all needed capacity.**

Dukovany should work hypotetically even sixty years, but political situation and attitude of Germany and Austria make very uprobable

Updated Czech Energy Policy

Approval of Czech energy policy update – May 18, 2015

Main principles:

1) Gradual fossil phase out, mainly coal
2) Transition to emission-free sources (nuclear and renewable)
3) Nuclear – large, renewable – decentralized, mainly for selfconsumption
4) Maximization of savings and efficiency increasing

What is necessary to do for realization of this policy?

1) Necessity to find way to finance emission-free sources
2) To obtain wide and stable support for this energy policy (understanding)

Year 2040 electricity production: 46 - 58 % nuclear, 18 - 25 % renewables, 11 - 21 % coal and 5 - 15 % gas).




Possible scenarios

Scenario 1: Emission free – more nuclear reactors, very intensive development of renewables and energy acumulations, help Poland with development of nuclear sources

NOT PROBABLE AT PRESENT

Scenario 2: Updated Governmental Energy Concept – relatively wide ranges – optimization on the base of condition new power reactors and renewables are needed

Scenario 3: Second Bavaria – decreasing capacity of nuclear and coal sources, their replacement by gas sources and wind sources from north of Germany Bavaria will show us results of such scenario.

Scenario 4: Second Bavaria very quickly - shut down of Dukovany before year 2025 – under political pressure from Germany and Austria,

Principle question – Gas or Nuclear?

We need smart regulation, smart grid and smart energy producers and users

Summary

1) Increasing of CO_2 amount and its industrial origin are clearly confirmed, increasing of global temperature also, share of antropogenic influence is open

2) Different geographical, geological and climate conditions need different energy policy and energy mix.

3) Many examples show, that emission-free power industry based on combination of nuclear and rewenable sources is possible.

4) No example of emission free electricity production based only on renewable

5) Czechia needs to replace coal sources. Wind and sun have not sufficient potential.. Nuclear power plants are necessary.

6) There are four possible scenarios in principle. 1) Very green – very low emissions 2) Updated Governmental Energy Concept 3) Second Bavaria 4) Second Bavaria very quickly.

7) Two critical dates: year 2022 – coal sources will be closed, nuclear at Germany

year 2035 – probable shut down of Dukovany and other coal sources

8) Regulation and smart grid, smart elements will be very useful