Power markets
Recent development

Jaroslav Knápek

Interdisciplinary Summer School 2020 on "The Future of Energy Systems in Austria and the Czech Republic"

Content

1. Electricity as the comodity, time constants, black out
2. Power market, power grid
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10. CZ position

Electricity as the commodity

- balance between supply and demand at any instant
  - NO BALANCE FICTION (in energy)!
  - Limited accumulation ability
- electricity: active and reactive power
  - necessity to keep the balance
  - to respect distribution profiles
  - to keep voltage (and frequency)
- power flows: according to the physical flows
  - physical flows versus traded flows

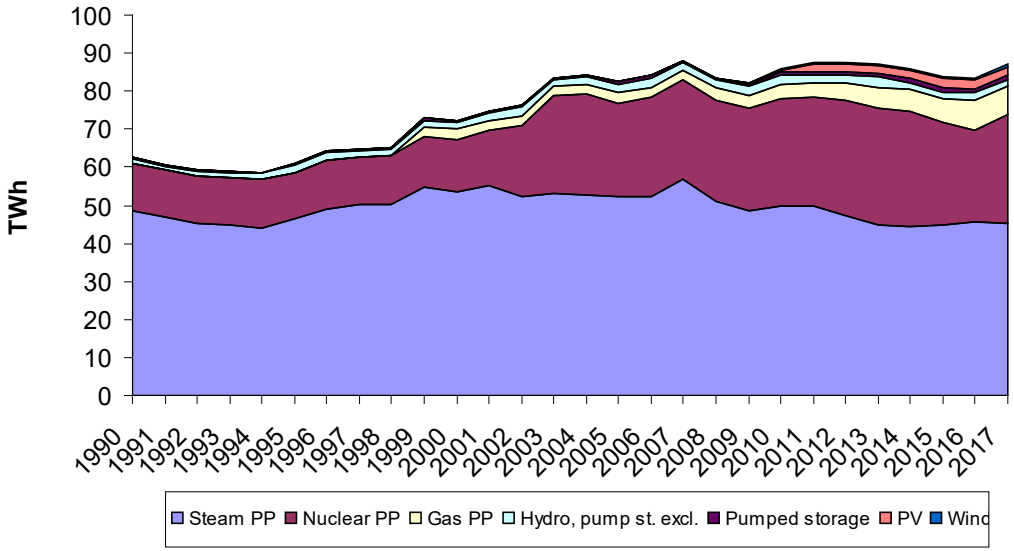
Time constants

- **Seconds**: if demand is not covered with supply
  - BLACK OUT: Restoration of the grid from the blackout need hours (days) blackouts: 11/2006 (Northern Germany, France, Italy, Spain, Belgium) – 12 mil. affected
  - See: https://www.youtube.com/watch?v=A30DdnsICuw
- **One or two decades**:
  - Preparation and construction of power plants
- **40-60 years:** investment horizon for conventional power plants

Blackouts

- Italy 2003, Sept. 28, 56 mil., night
- Sweden, Denmark 2003, 4 mil., 7 hours
- Turkey 2015: 70 mil., 10 hours
- New York: 1977, 25 hours, 9 mil., Looting and vandalism, 1 bil. USD damages
- CZ analysis: after 72 hours completely collapse

Czech Republic – example of th grid



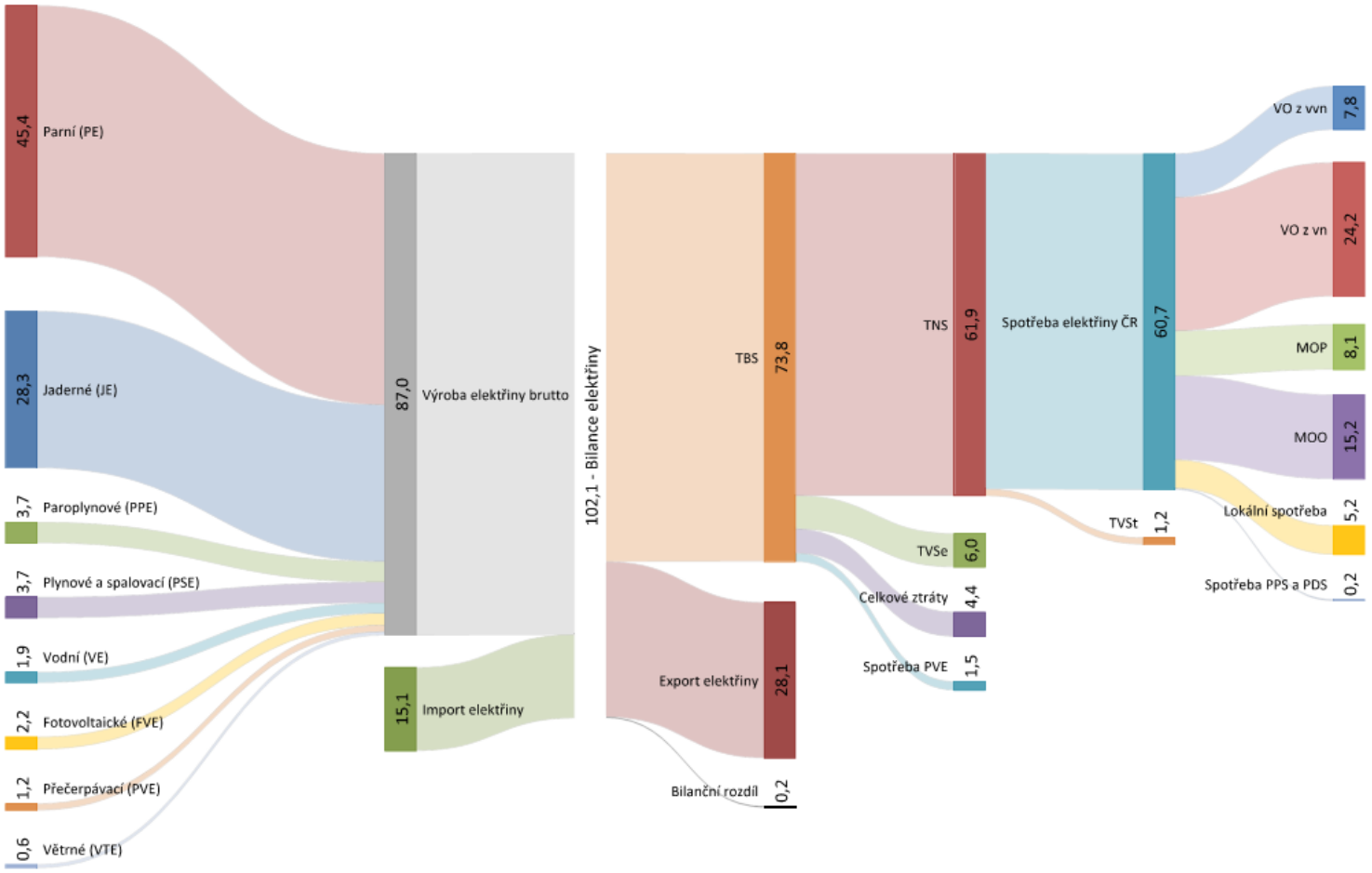
Balance 2017 - TWh

2017	
Gross	**87,039**
Tech. own con.E	-6,1
Generation netto	**80,939**
Saldo Imp-Exp	-13,037
Losses TS	-1,212
Losses DS	-3,163
Pump storage	-1,531
Total	**61,9**

+losses TS and DS	4,4
=gross domestic consumption	**73,9**
- tech. own cons. E	-6,1
- pump storage	-1,5
- losses TS and DS	-4,4
=netto domestic consumption	**61,9**

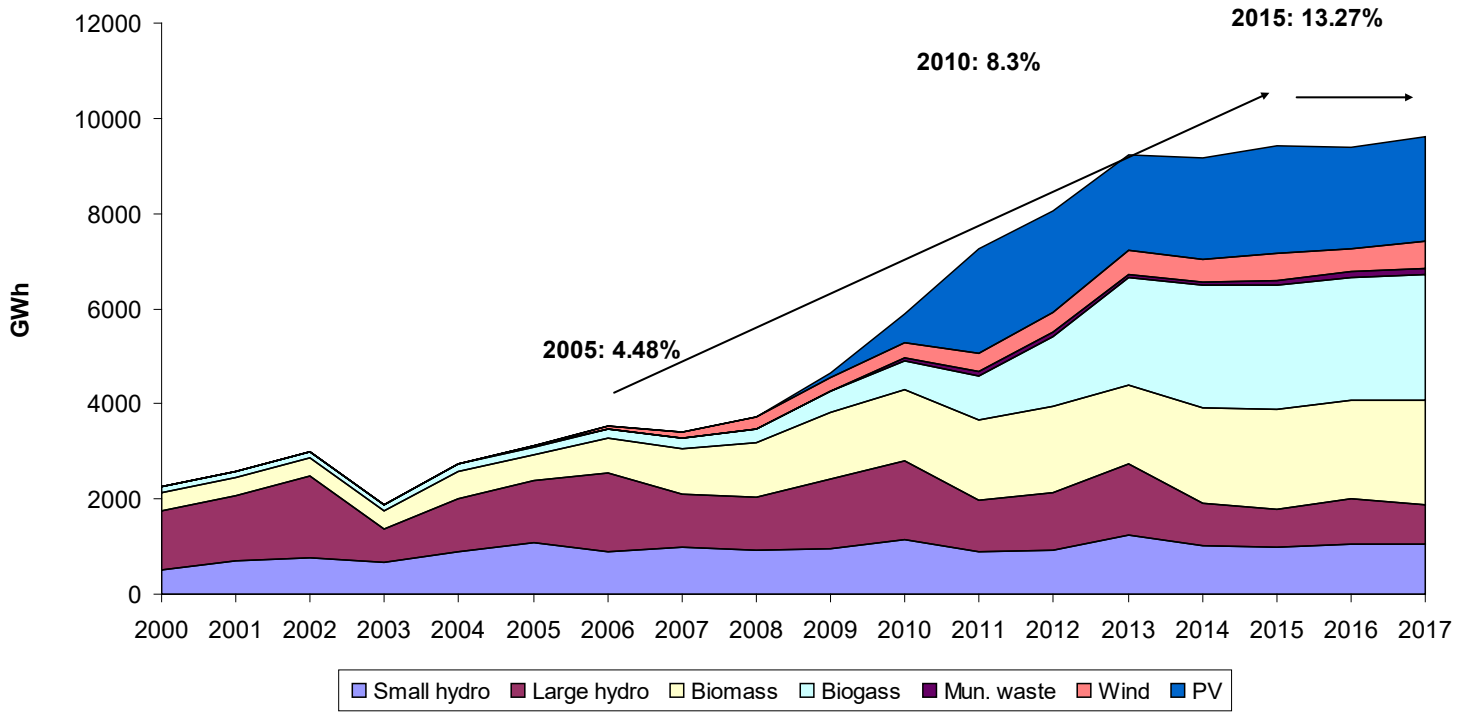
Consumers	TWh
Business vhv	7,8
Business hv	24,2
Small business lv	8,1
Households	15,2
Consumption TS and DS	0,2
Local consump.	5,2
Tech. own consE	6,1
Tech. own cons.Q	1,2
Pump storage	1,5
Total	**69,5**

Electricity balance 2017
Czech Republic, TWh



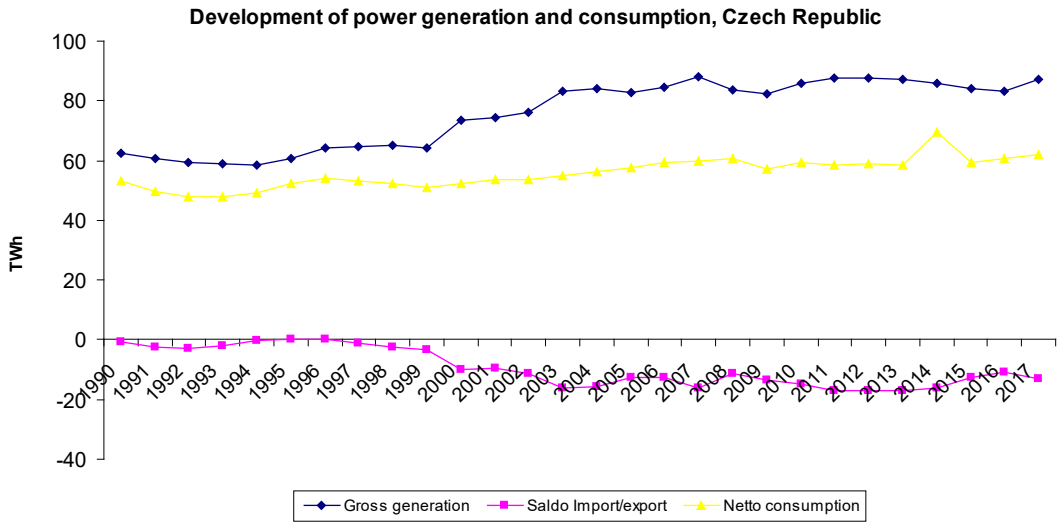
http://www.eru.cz/documents/10540/462820/Rocni_zprava_provoz_ES_2017.pdf/521bff99-fdcf-4c86-8922-3a346af0bb88

RES power generation- ČR



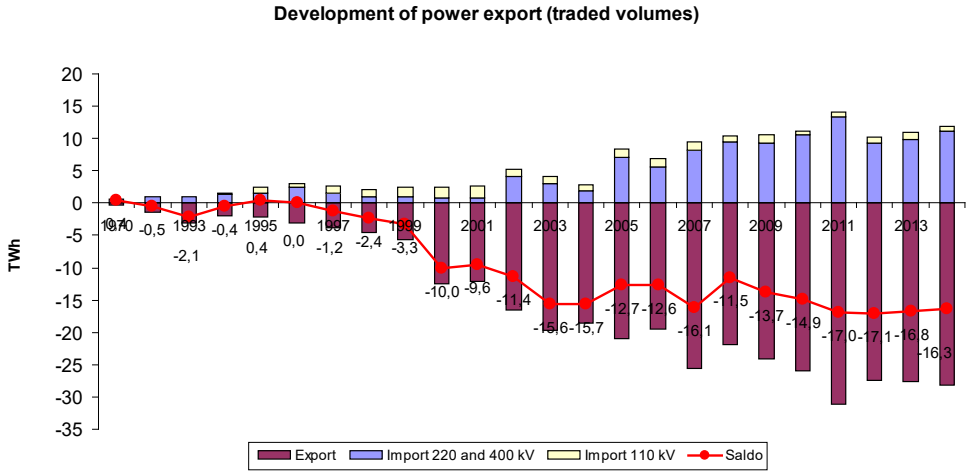
Boom 2006-2013: result of systematic support – FIT a FIP, Act. 180/2005 Col.

Development of power generation and consumption. Czech rep.

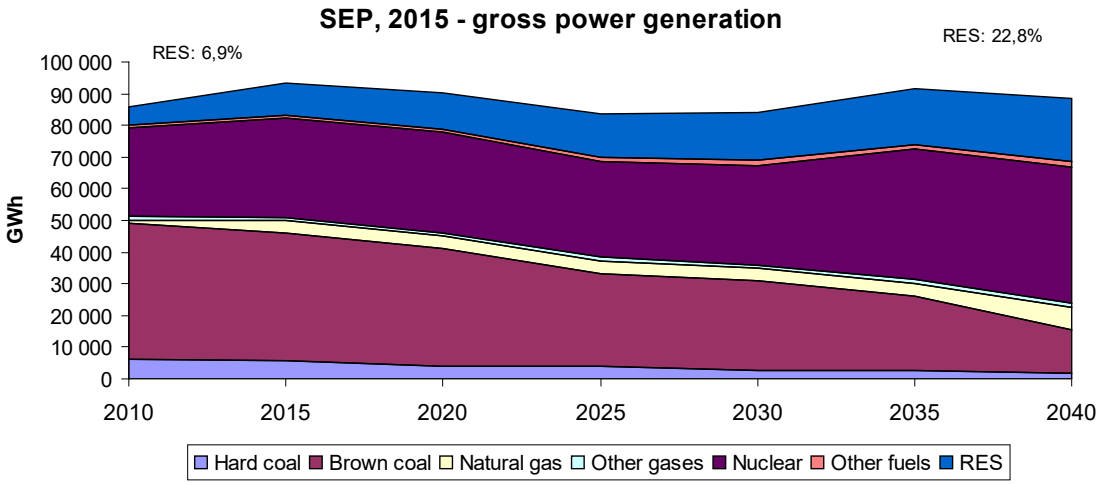


Zdroj: ERU, roční zprávy o provozu ES

Max. export: 2012: 17,1 TWh



ČR - power generation outlook according to SEP

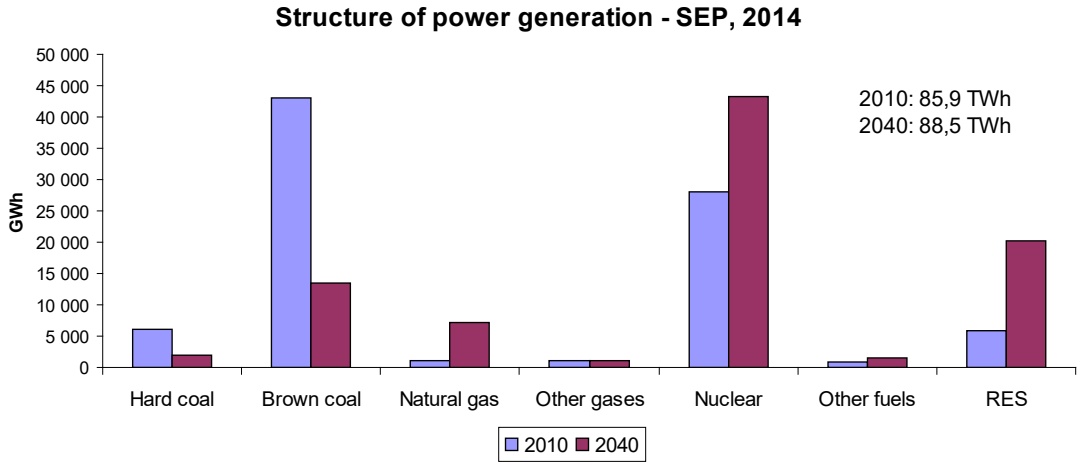


Target: meeting domestic consumption by own production

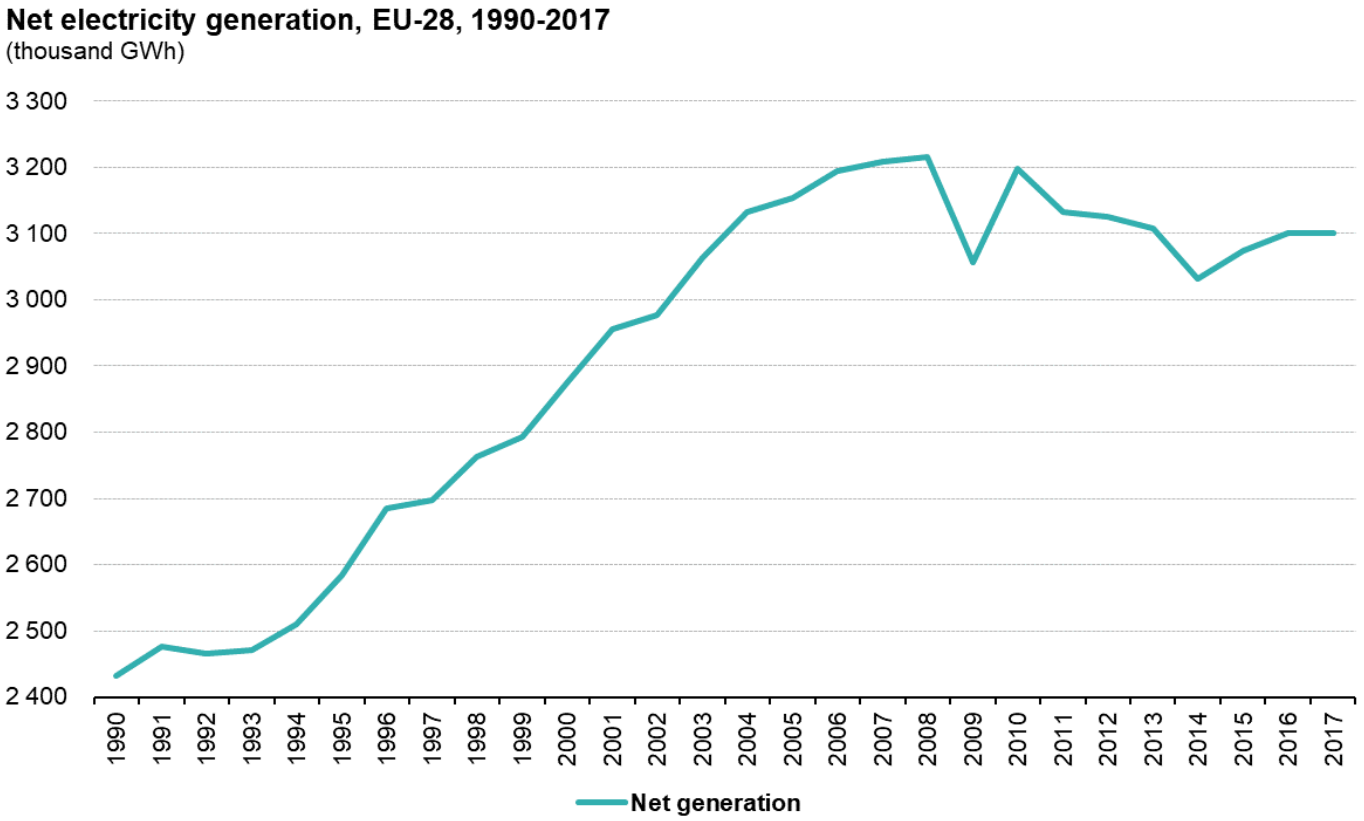
Zdroj: SEK, https://www.mpo.cz/assets/dokumenty/52841/60959/636207/priloha006.pdf

Decline of power generation from coal:

- Quick depletion of available coal
- Decarbonization

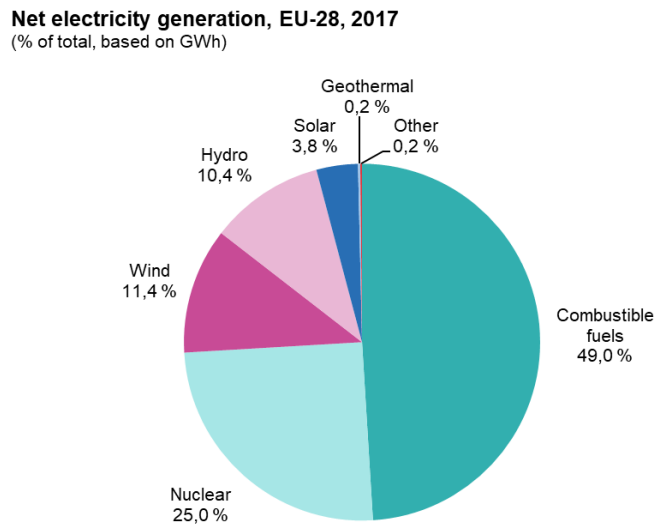


Electricity generation in EU since 1990



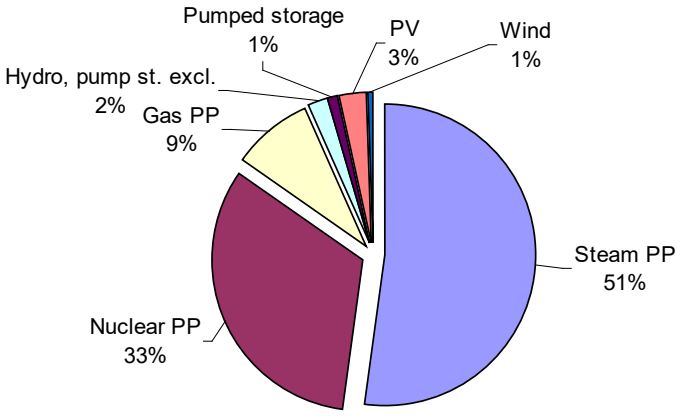
Source: Eurostat, https://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_production,_consumption_and_market_overview

Power generation in EU according to PES



https://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_production,_consumption_and_market_overview

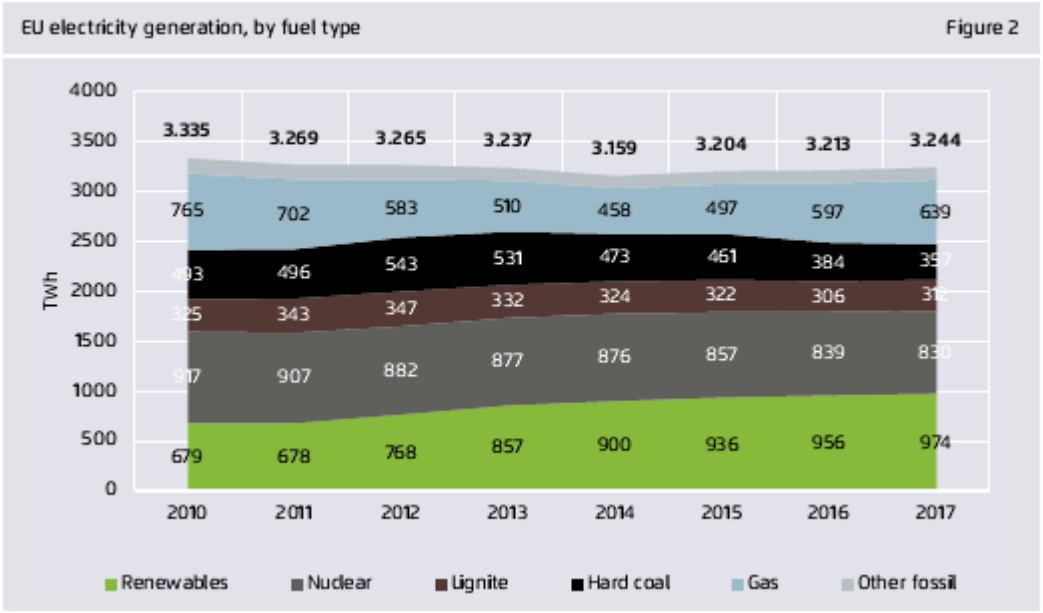
Power generation structure – CZ, 2017



EU28: much higher share of RES compared with CZ

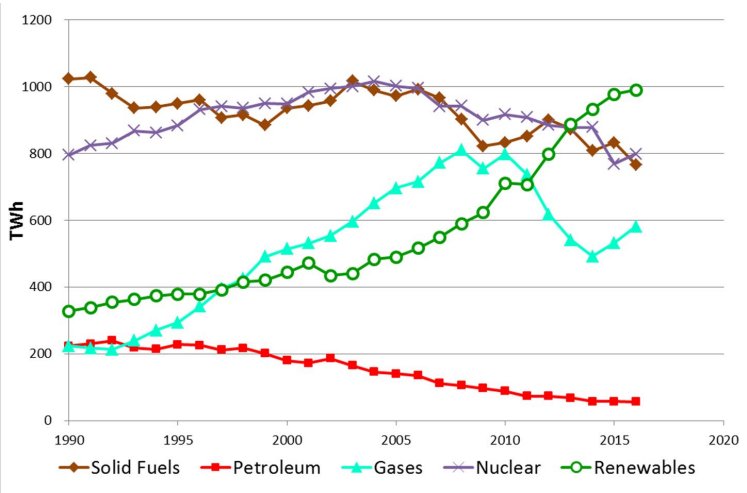
Source: http://www.eru.cz/cs/zpravy-o-provozu-elektrizacni-soustavy

Power generation in EU according to PES

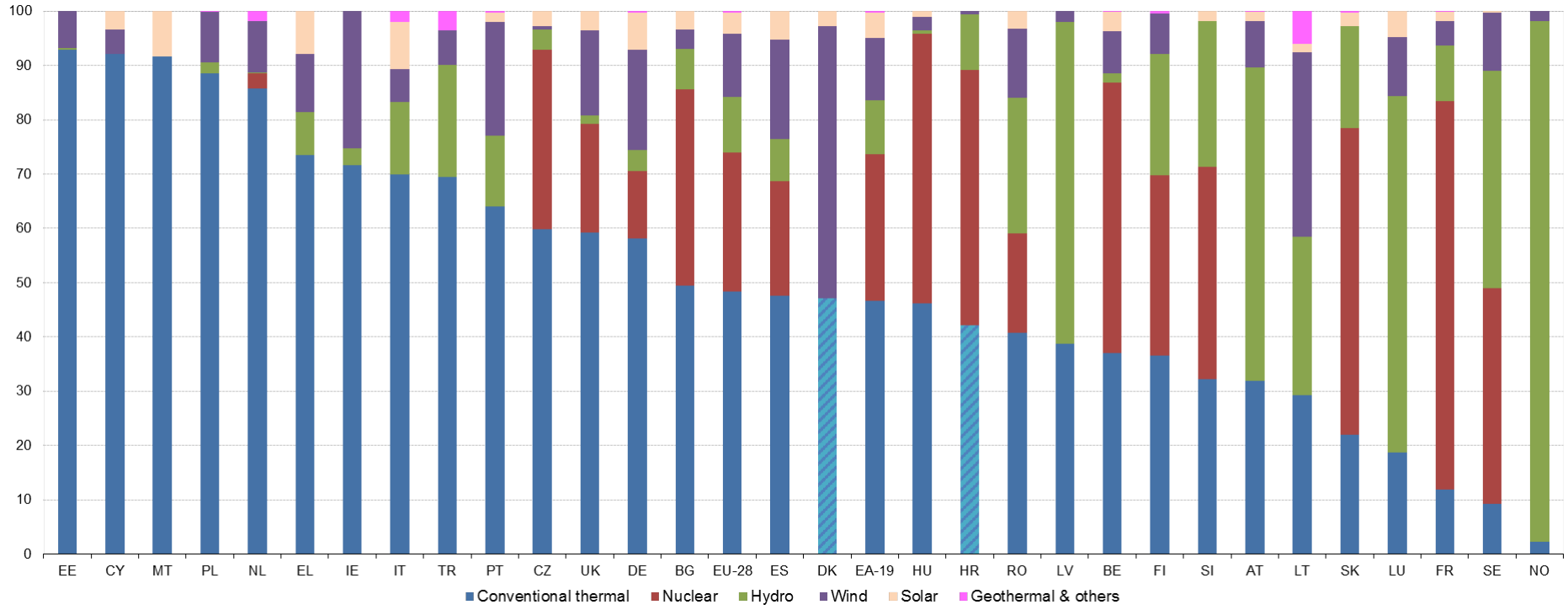


Source: The european Power Sector in 2017, https://sandbag.org.uk/wp-content/uploads/2018/01/EU-power-sector-report-2017.pdf

Continuos growth of RES electricity



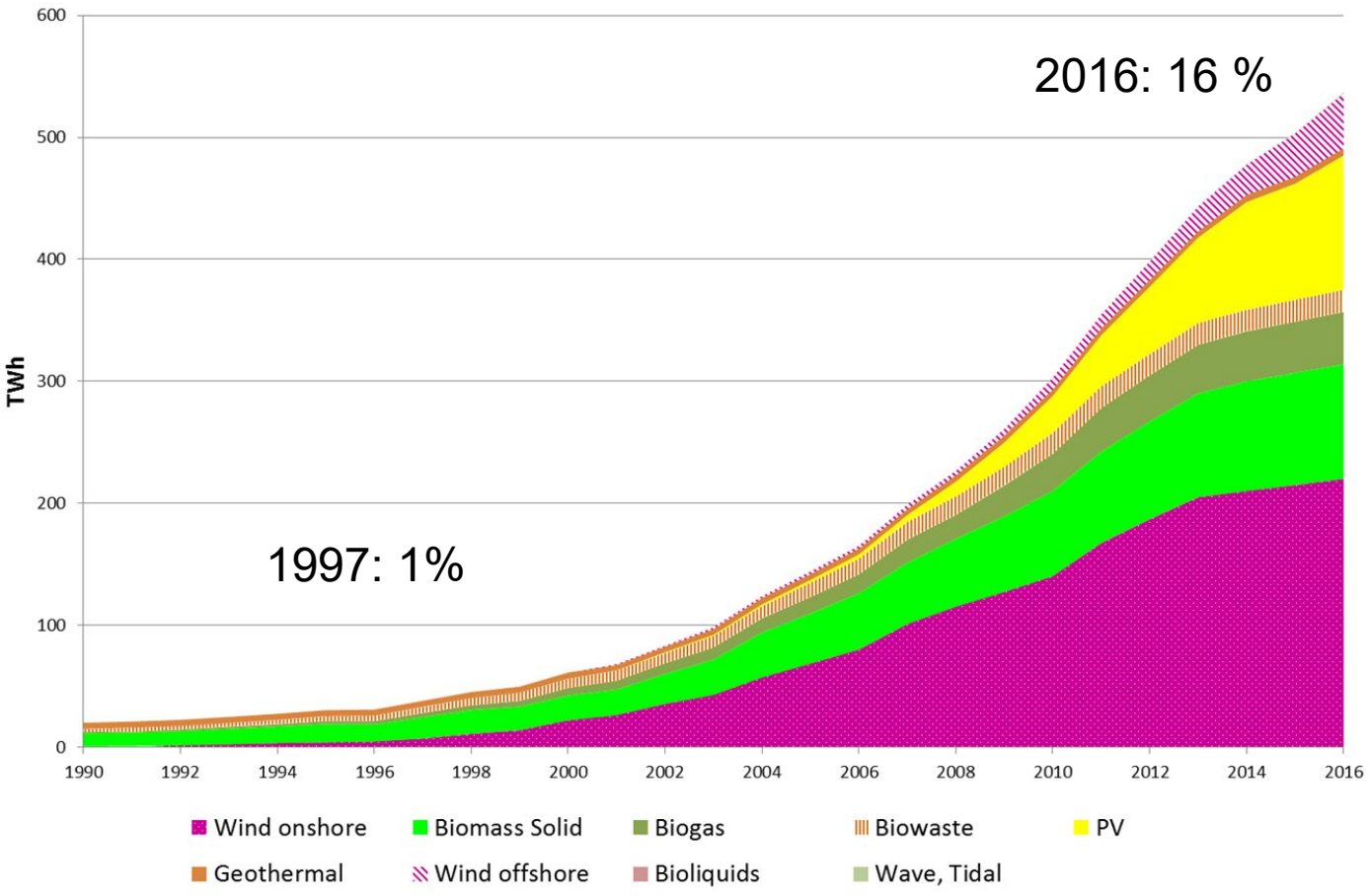
Power generation in EU according to PES



https://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_generation_statistics_%E2%80%93_first_results#Production_of_electricity

Fuel mix: country condition, history, economic power, struture of industry and economy, etc

Quick growth of RES (New)



Zdroj: R. Haas, Eurostat

Rapid increase in the share of intermittent sources of electricity
- displacement of conventional power plants

Power market liberalization

- till mid of 90ies: vertically integrated power companies (monopolies)
- basis of liberalization of power market were founded by the EU Directive 96/92/EC (only minimum opening and liberalization)
- second energy package", EU Directive 2003/54/EC – **legal and functional splitting of power companies** (2004-2007 market liberalized for all consumers)
- third liberalization package", 2009, full liberalization, separation of TSO (3 models), energy only market
- Winter package (proposed 2016, passed 2018): Energy Union

EU energy policy – New targets to 2030

Winter package

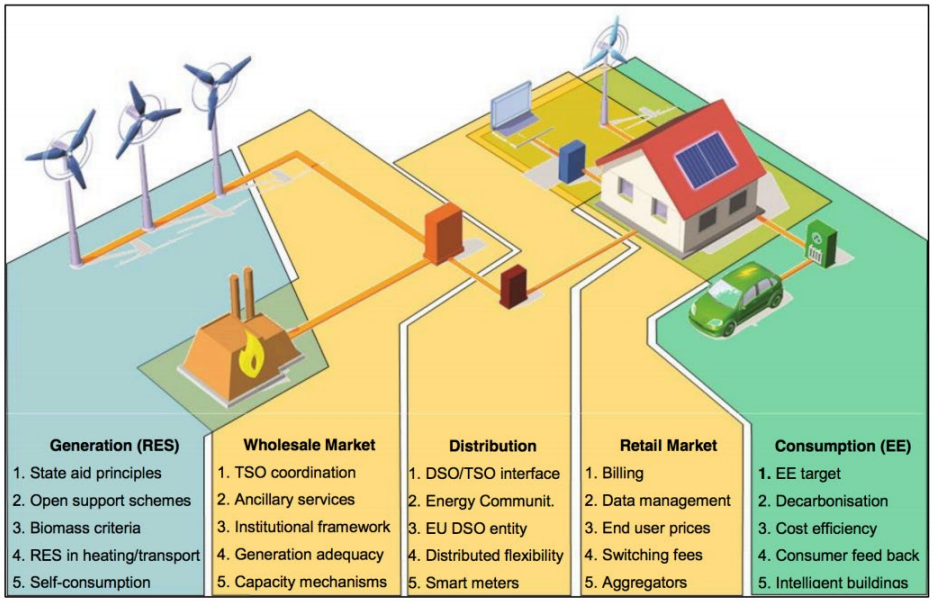
- Energy Union – Regulation 2018/1999 of European Parliament and of the Council … on the Governance of the Energy Union and Climate Action
- Goals to 2030
  - CO_2 reduction by 40% (annual reduction of emission roof for branches under ETS by 2,2 % after 2020, increase from current 1,74%)
  - 32 % RES share on final energy consumption (which means up to > 50% on power consumption)
  - increase of energy efficiency (at least by 32.5%)

EU winter package

ENERGY UNION

- path to energy union, reliable energy (electricity) delivery
- low emitting sources, better functioning of power markets
- decline of coal use for power generation, higher importance of energy savings (+increasing role of consumers)

Main priorities and their place in the energy value chain



8 legislative proposals and many other nonlegislative documents - impacts to buildings, transpartation, heating sector, biomass origin, etc

EU winter package

ENERGY UNION – 5 Dimensions

- Energy security
- Internal energy market (incl. energy poverty aspect)
- Energy efficiency
- Decarbonizaton (GHG reduction + RES)
- Ressearch, innovation and competitiveness

All plays the same role!

Energy security (external + internal):

- diversification of energy sources, reduction of import dependency
- energy storage
- ability to react to temporary failur of energy delivery from given source
- demand side response

EU winter package

Internal energy market

- Level of connectivity of national power grid (conditions for enhanced power market, Energy Union)
- Key infrastructural projects (power transmission and gas transportation)
- Increase of market flexibility
- Market integration (coupling), smart grids, aggregation of demand, distributed power generation, etc.

Energy efficiency

- PES consumption reduction
- Energy savings (buildings, etc)

Decarbonizaton

- GHG emissions reduction (not only CO2)
- Share of RES on gross final energy consumption

EU winter package

Ressearch, innovation and competitiveness

- emphasis on research
- EU aggregate competitiveness
- Innovative technologies

NECPs – (Integrated National Energy Climate Plans)

- One roof for currently separate actions plans (e.g. for RES, energy efficiency, etc.)
- Defines concrete targets for individual MS, in early 2019 submitted to Commission, 2019 negotiation
- Periodical reporting of the progress

Electricity as the product

Consumers point of view: one product – reliable, (economically acceptable) electricity delivery

But it means:

- electricity as the commodity
- system services (TSOs are responsible for the grid stability – purchase of various ancilliary services)
  - systems services: power quality, power balance, restoration of the power supply, dispatch control
  - Viz https://ceps.cz/cs/systemove-sluzby
- OTE – power market operator (statistics)

Electricity as the product

Ancilliary services:

- *Balancing services (BS) – used for securing balance between production and consumption*
- *Other ancillary services (non-frequency services) – used for securing quality of voltage and working of power system (PS)*

https://ceps.cz/cs/podpurne-sluzby

Electricity as the product

Balancing services purchased on a free market through day-ahead market with AnS or through long-term auctions

- Frequency Containment Process (FCP) - The frequency containment process (FCP) is a local automatic process provided by primary control circuits
- Automatic Frequency Restoration Process (aFRP) - Automatic Frequency Restoration Process (aFRP) of a unit concerns a change in the power output of a regulated unit as requested by the load frequency controller.
- Manual Frequency Restoration Process within 5 minutes (MFRP5), 15 minutes positive (MFRP15+), 15 minutes negative (MFRP15-)

❑*https://ceps.cz/cs/podpurne-sluzby*

Electricity as the product

Ancillary services purchased via a direct contract with an AnS provider:

- Secondary Voltage and Reactive Power Control - Secondary voltage and reactive power control (SVQC) is an automatic control for which the entire regulating range of unit reactive power is used to maintain the set voltage value at pilot nodes within the power system
- Island operation capability
- Black start capability

Energy only market

Energy only electricity markets recovery of costs comes from energy (and operating reserves) and not capacity

Trade with electricity as the commodity

- Market with futures (month, quarter, year, all in baseload and peakload) – Energy exchanges (long term market)
- Day-A-Head Market (spot market)
- Intra-Day-Market (spot market)
- Bilateral (direct) Contracts

Energy only market

Price of electricity:

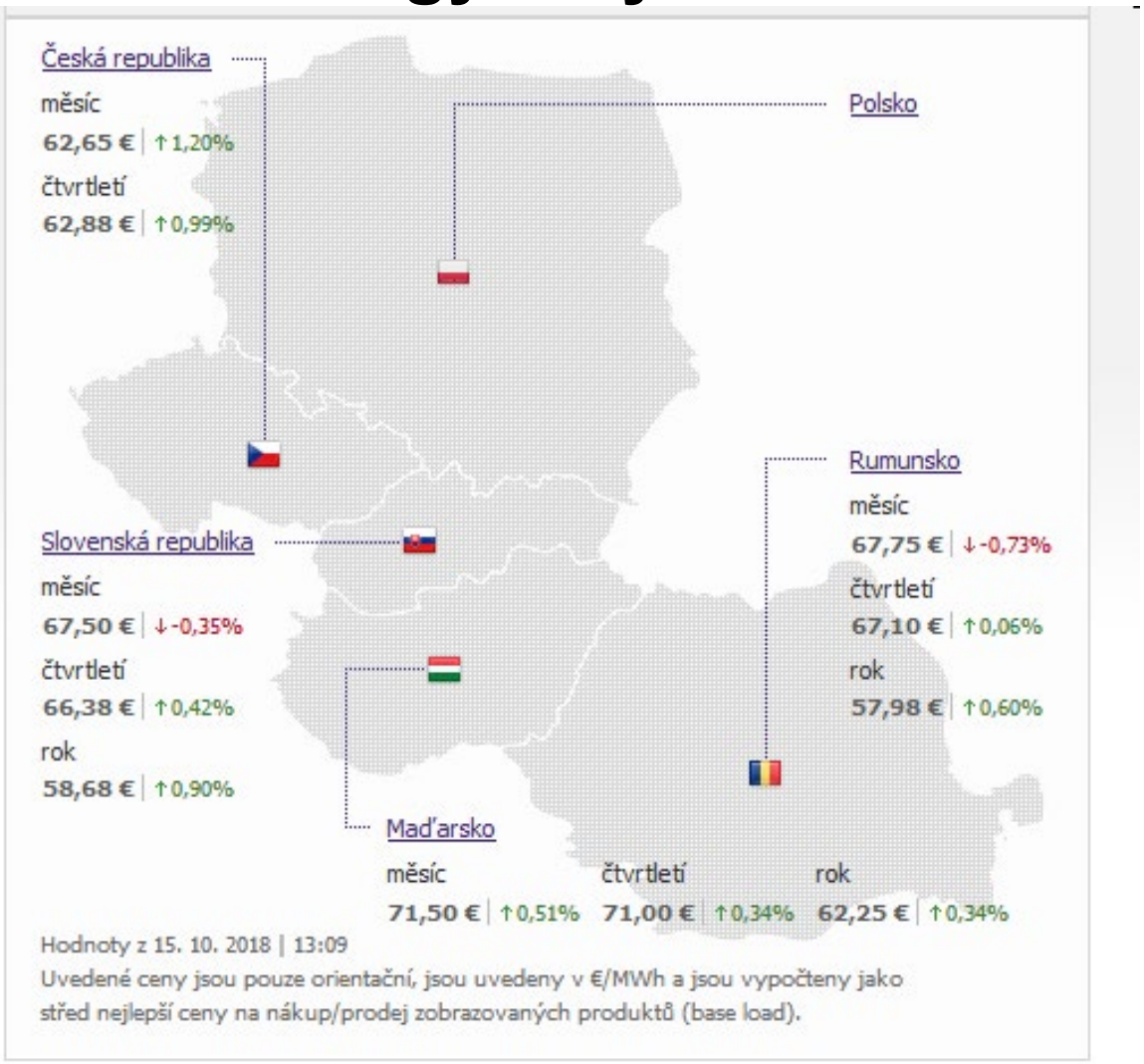
- defined (at all markets) based on the balance between the supply and demand.
- power producers are placing their bids (e.g. for DAM they place amount of offered electricity for each hour of the day)
- bids of all participating producers are sorted from the cheapest offer to the most expensive one, the resulting diagram of cumulated power offers is called “merit order” – the diagram starts with the cheapest bids (i.e. cheapest power producers in terms of variable cost) and ends with the most expensive ones.

Energy only market

Energy exchanges started to play important role with the liberalization of the energy markets

- http://www.eex.com/en/ (European Energy Exchange in Leipzig)
- https://www.pxe.cz/ (Power Exchange Central Europe)

Energy only market



PXE.CZ, state as of 15.10.2018

Energy only market

Energy only electricity markets recovery of costs comes from energy (and operating reserves) and not capacity

Present state

- effective functioning of short term (energy markets) – but from one point of view only
- *power branch is living at the expense of the future*
- no investment into new generation capacities instead of RES
- no proper investment signals, only political decisions
- real threat of missing installed power in conventional PP in next decade
- great troubles of gas fired PP – operational loss due to low power prices

Example of market distortions consequences

Development of clean spark spread for gas fired PP

(CCGT, 58% efficiency, market prices of NG)

source: P. Cyrani, Jak skončí krize jednotného trhu, 2014

Example of market distortions consequences 2

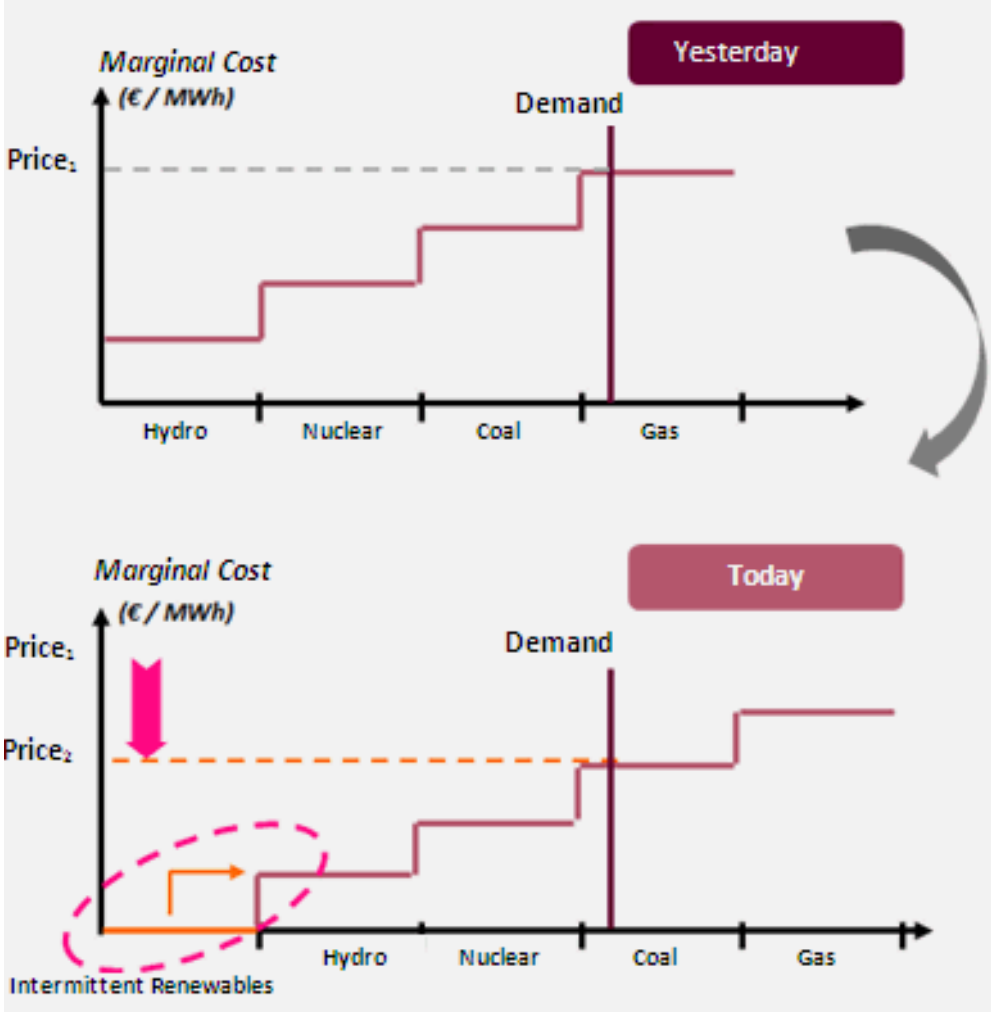
Troubles of gas fired PPs result from:

- quick decrease of power prices
- lower ration between peak/base load prices
- E.g. case of new CCGT power plant Pocerady – 840 MW installed capacity (app. 600 mil EUR investment cost)

Merit order effect

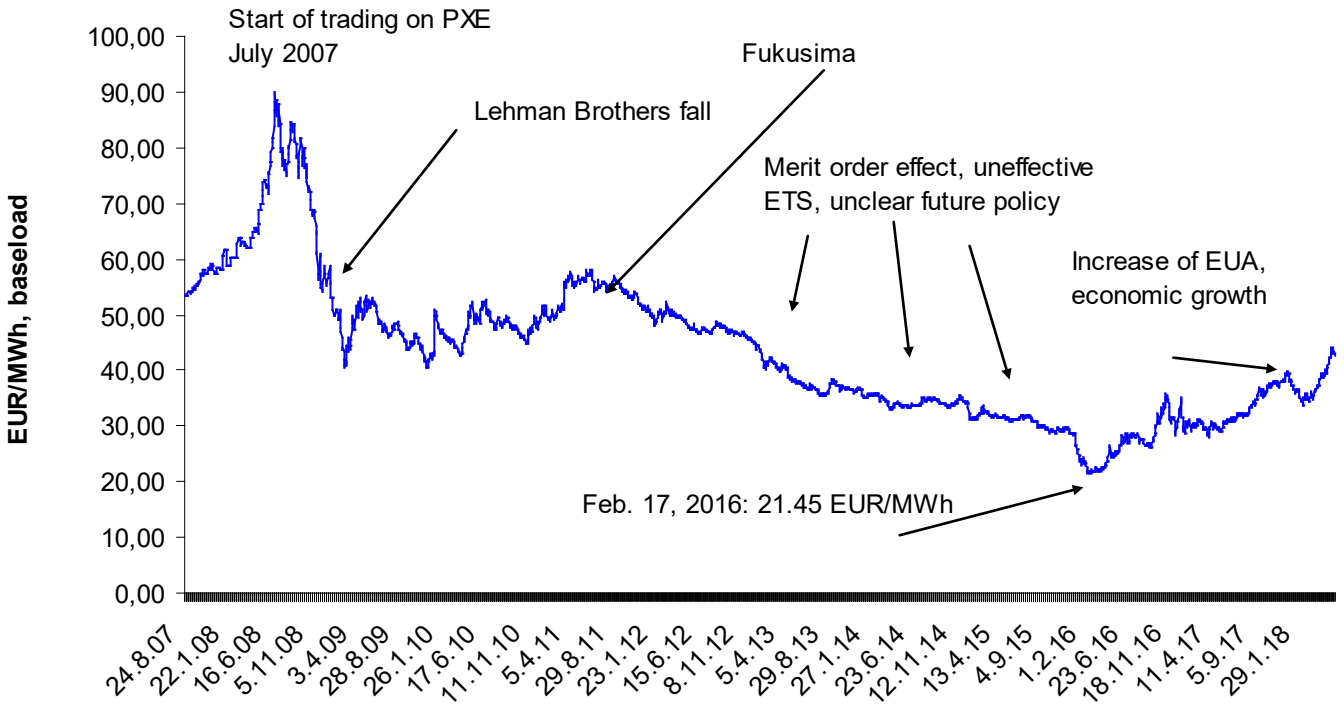
- RES power generation has (thanks to subsidies) short run marginal cost close to zero (wind, PV)
- reduced load factor of conventional PP – problems in recovery of fixed cost

Merit order effect



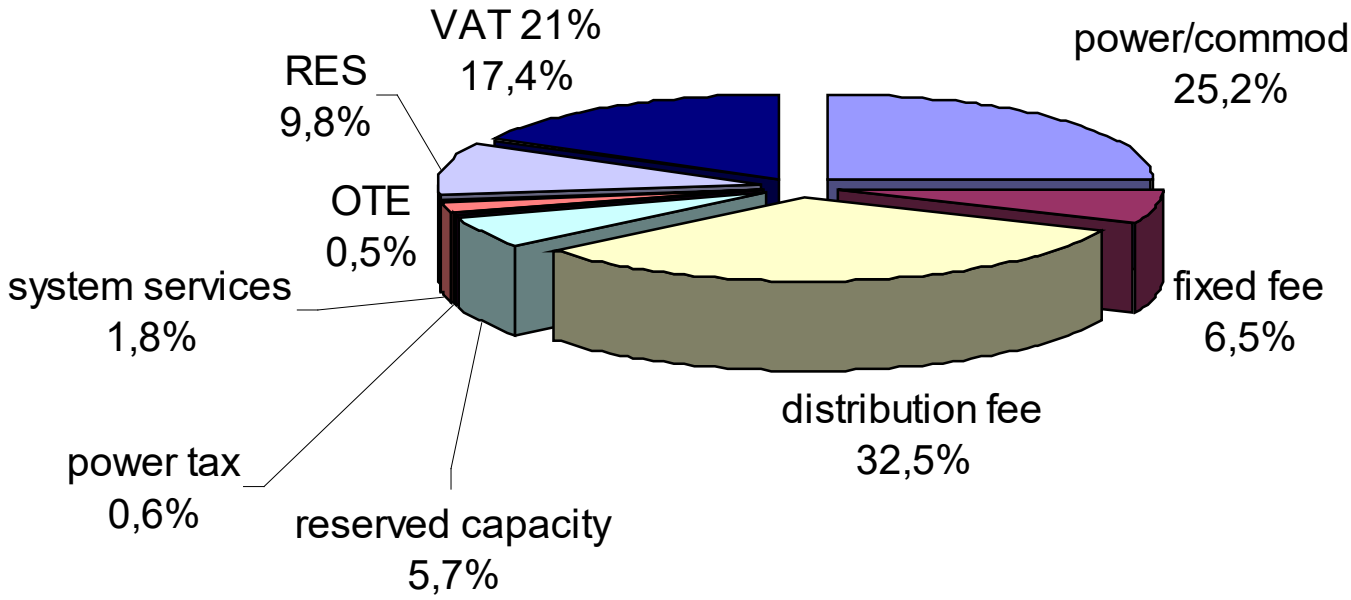
Source: http://energy.sia-partners.com/files/2013/07/Image2.png

Development of electricity price on PXE



Development of electricity price on PXE – Base load, year ahead

Price of electricity for final consumers

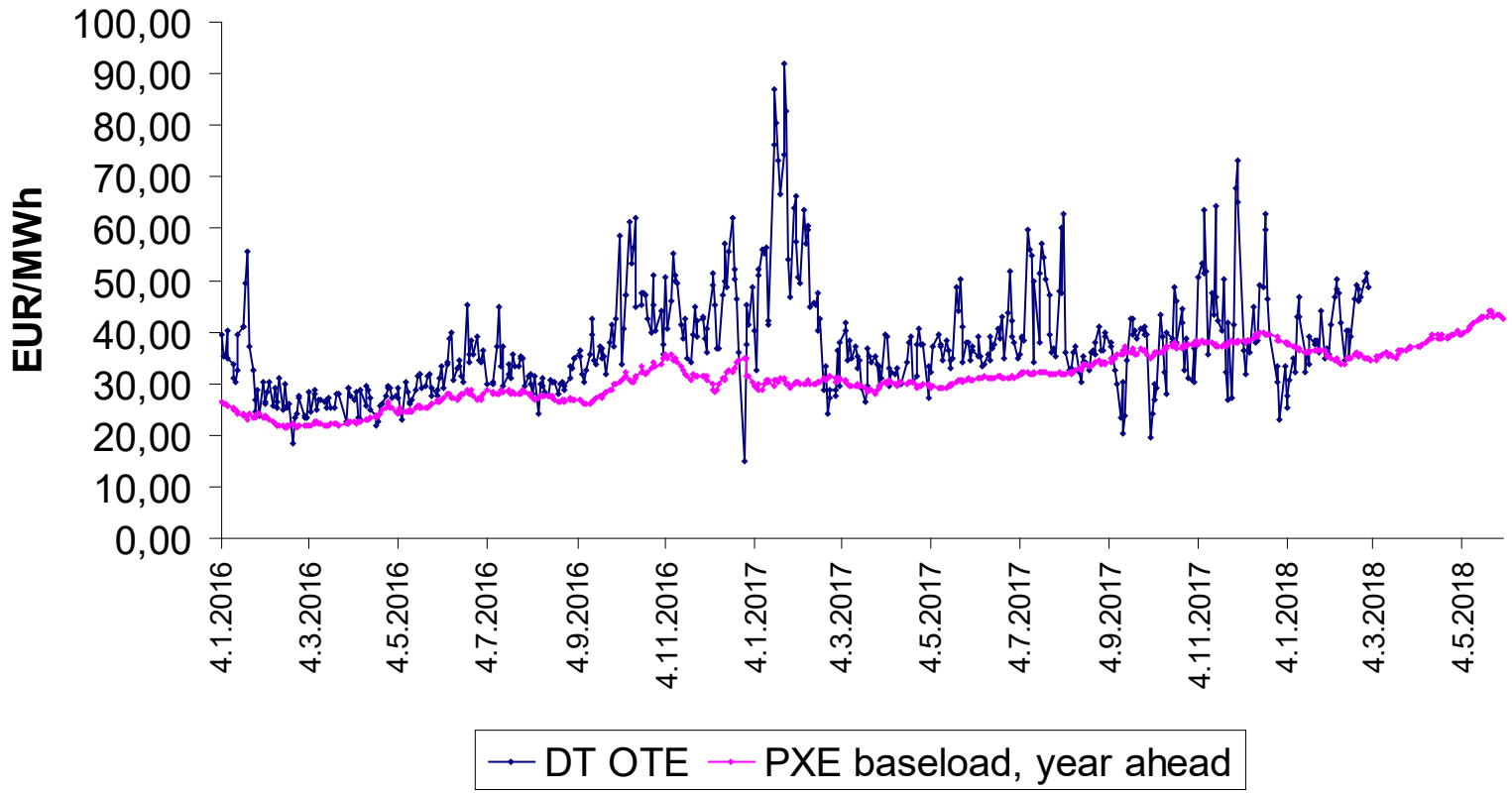


CZ, 2018: tariff D02d, 2,5 MWh/year

Cost recovery

commodity - MWh	79,4%
distribution - MWh	85,1%

Development of electricity price on PXE



Development of electricity price> Short term and long term market

Tariff problem

Currently major part of fixed power generation and grid cost is transferred to final consumers via power consumption

- power generation cost – e.g. coal fired: app. 50% fixed cost, nuclear much higher, CCGT major role of fuel cost
- grid cost: > 85% of distribution grid cost is fixed cost
  - but see example of CR: price at LV has 85% variable component
  - does not correspond with the grid cost strucuture

Tariff problem II

Electricity savings – power (kW) versus energy (kWh)

Recovery of fixed cost via variable component:

• do not motivate to power (kW) savings, distribution companies should guarantee “purchased” power, impact to grid development planning

• prosumers concept: e.g. small PV on the roof – leads to the energy savings but not to power savings, might results in transfer part of cost to households having no PV

Recovery of fixed cost via fixed component

• reduce motivation to energy savings

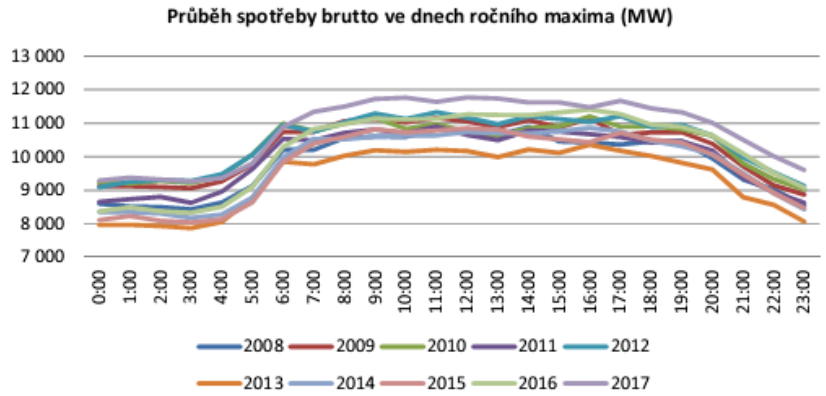
• results in electricity price increase of low consuming households

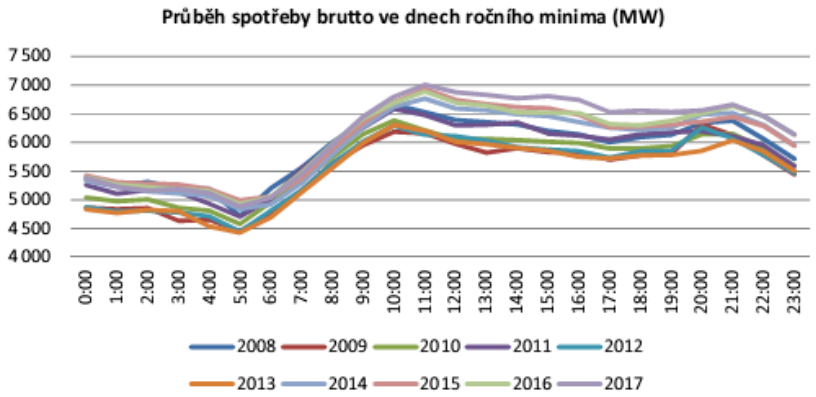
Past, present, future

- **Present -** thanks to the massive supply of electricity from RES, the position of the supply curve is changing:
- so-called "merit order effect" - displacement of conventional sources (ie reducing the use of installed capacity)
- "Energy only market" is based on the payment of fixed and variable costs of electricity production through a variable component (production in MWh)
  - this leads to a reduction in the efficiency of operating conventional resources (the investor does not cover fixed / capital costs)
  - high uncertainty of investors = (almost) zero investments in new and in the renewal of existing conventional plants = potential problem with backup sources, with the provision of support services, etc.

Past, present, future

- Conventional sources may then be missing to cover the load diagram - see examples of consumption during the annual minimum and maximum, ES CR





Pas, present, future

Can the price of electricity be zero or negative? Or, on the contrary, extremely high?

Den	Hodina	Nákup (MWh)	Prodej (MWh)	Export ČR->SR (MW)	Import ČR<-SR (MW)	Množství - vč. Exp a Imp (MWh)	Marginální cena ČR (EUR/MWh)	Marginální cena ČR (Kč/MWh)
26.12.2016	23	2 520,6	1 927,5	0,0	593,1	2 520,6	6,50	175,63
26.12.2016	24	2 594,4	2 041,2	0,0	553,2	2 594,4	-6,00	-162,12
27.12.2016	1	2 733,4	2 225,8	0,0	507,6	2 733,4	-3,33	-89,98
27.12.2016	2	3 026,3	2 425,3	0,0	601,0	3 026,3	-1,46	-39,45
27.12.2016	3	2 962,0	2 666,6	0,0	295,4	2 962,0	-2,00	-54,04
27.12.2016	4	2 842,8	2 662,8	0,0	180,0	2 842,8	-4,46	-120,51
27.12.2016	5	2 719,9	2 617,9	0,0	102,0	2 719,9	-0,77	-20,81
27.12.2016	6	2 387,9	2 246,7	0,0	141,2	2 387,9	-2,00	-54,04
27.12.2016	7	2 714,8	2 118,0	0,0	596,8	2 714,8	2,51	67,82
21.01.2016	17	2 307,0	3 128,0	821,0	0,0	3 128,0	75,78	2 050,99
21.01.2016	18	2 539,7	3 708,1	1 168,4	0,0	3 708,1	101,70	2 752,51
21.01.2016	19	2 797,2	3 715,6	918,4	0,0	3 715,6	91,00	2 462,92
21.01.2016	20	2 874,3	3 710,3	836,0	0,0	3 710,3	79,00	2 138,14

Source: roční zpráva o trhu, 2016, OTE ČR

http://www.ote-cr.cz/statistika/rocni-zprava/page_report_62_162

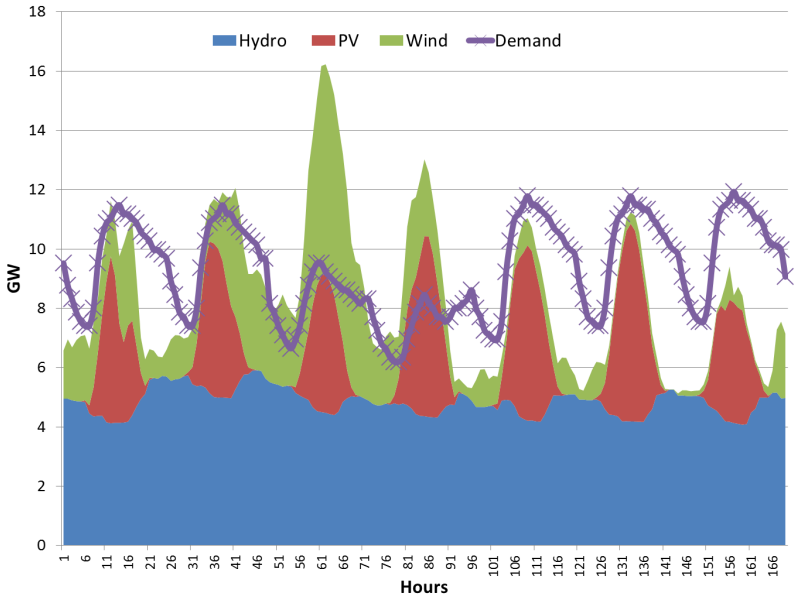
cold start of the year,

warm end of the year + VE

why are manufacturers willing to sell at negative prices?

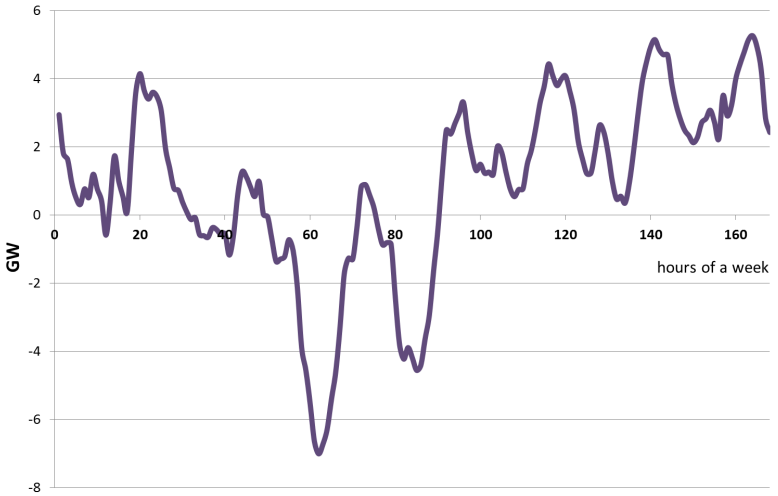
Past, present, future

There are major changes in the coverage of the load diagram - see the AT example



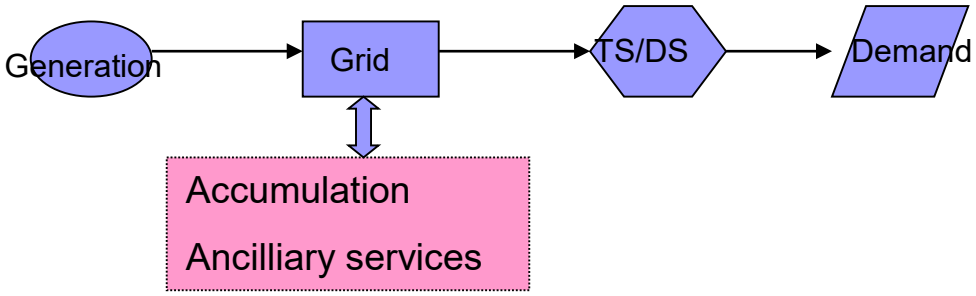
Sourcej: R. Haas

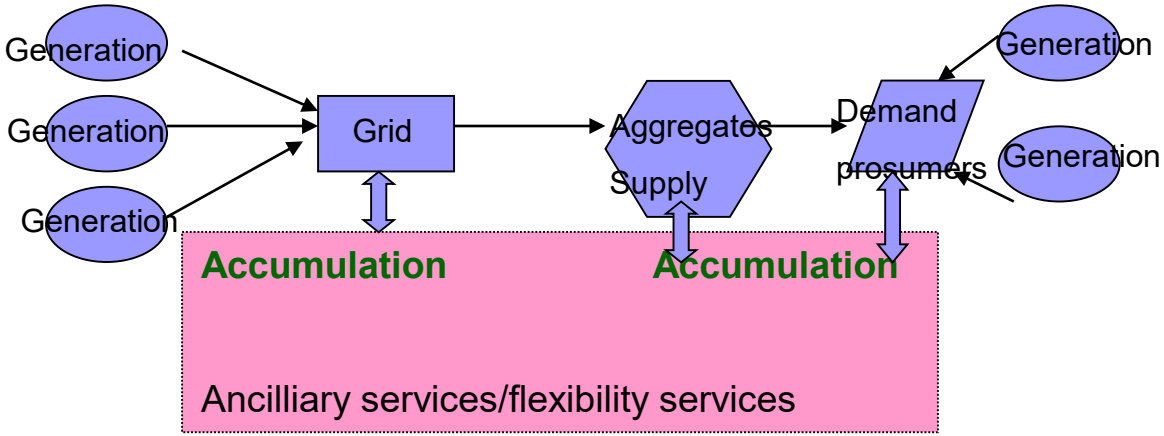
Rezidual diagram



Past, present, future

Changing thinking and functioning of the market: present x future





Czech power market - EEX

EEX: Power Exchange Central Europe, a.s.

- start of trading: July 17, 2007
- October 2008: trading with power from Slovakia
- March 2009: trading with power from Hungary
- December 2013: trading with CZ natural gas
- September 2014: Polish and Romanian power included
- November 2014: E-auction of power for final consumers
- Electricity futures - physical delivery or financial settlement including the physical fulfilment

Czech power market – OTE

among other:

- the Czech electricity and gas market operator (estab. 2001)
  - day-ahead electricity market (since 2002)
  - the intra-day and block electricity markets

Day-ahead market - CZ

- 15,11 TWh (2014) – av.price: 33 EUR/MWh, 12,99 TWh (2013)
- intra-day market: 443 GWh
- 105 registered players (producers, wholesalers, big consumers)

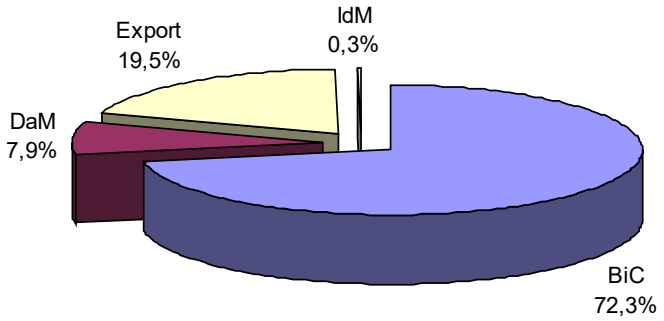
Czech power market – OTE2

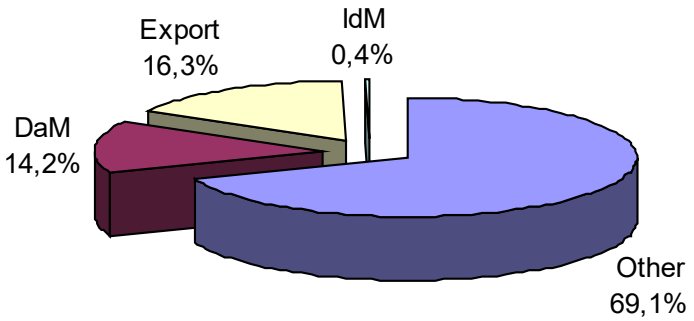
Market coupling:

- Sept. 2009: start of Czech-Slovak Market Coupling
- May 2011: CZ, SK, HUN signed Memor. of Understanding
  - Sept. 2012: start of CZ-SK-HUN coupled market operation
  - July 2011: Memor. of Understanding with ROM and POL
  - Nov. 2014: ROM joined market, POL observing member
  - agreed close cooperation with NEW region

CZ power market – 2013/2017

Source: OTE annual market, 2013,2017





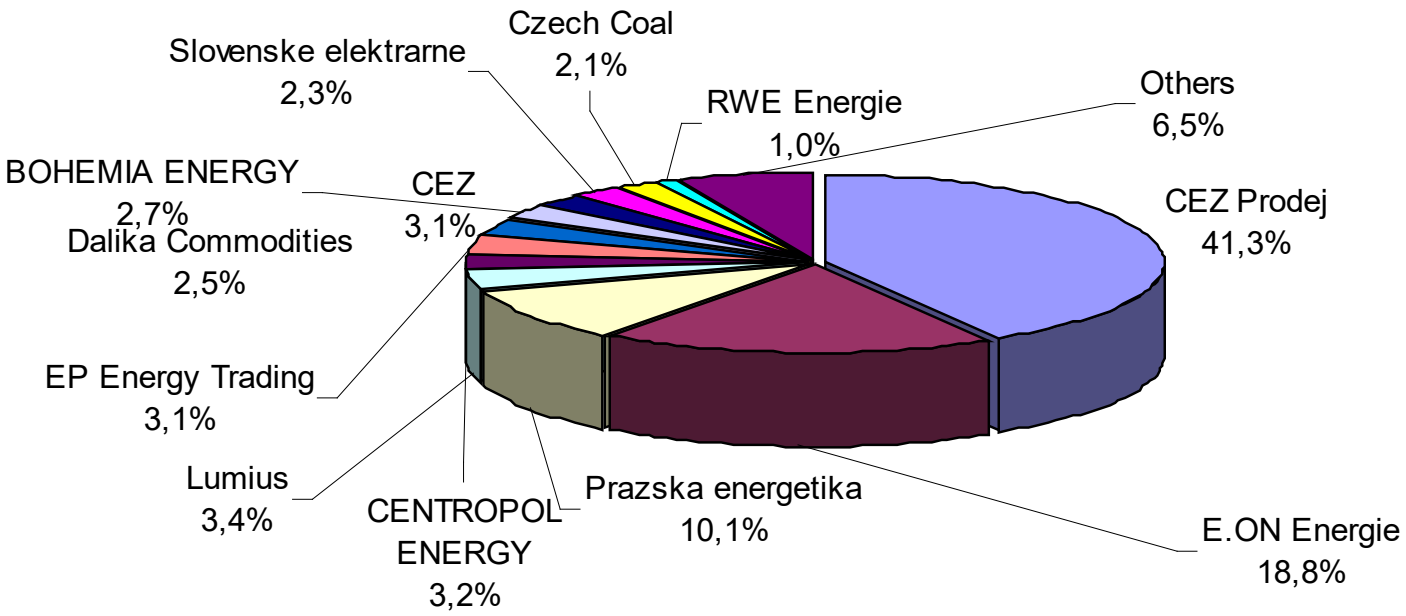
Other: Bilateral intrastate contracts (EEX, direct contracts), bilateral export and import contracts

DaM: spot market

2013: 147 TWh

2017: 144,6 TWh

CZ power market - players



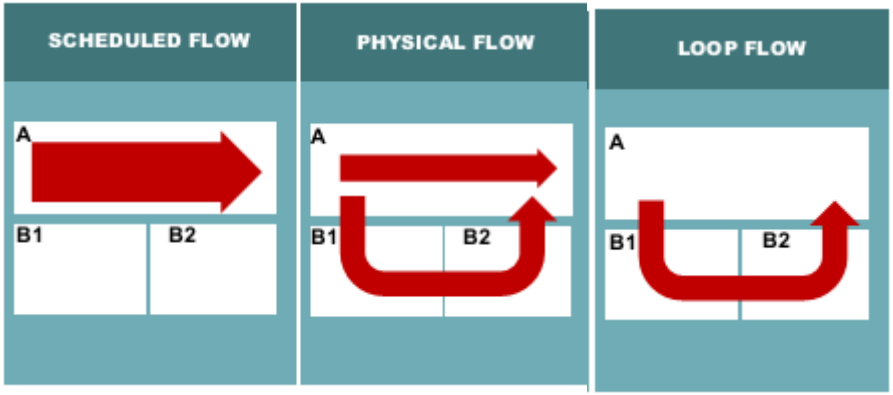
Source: OTE

Shares of specific BRPs in electricity consumption in CR in 2013

Market participants – balance responsible poarties

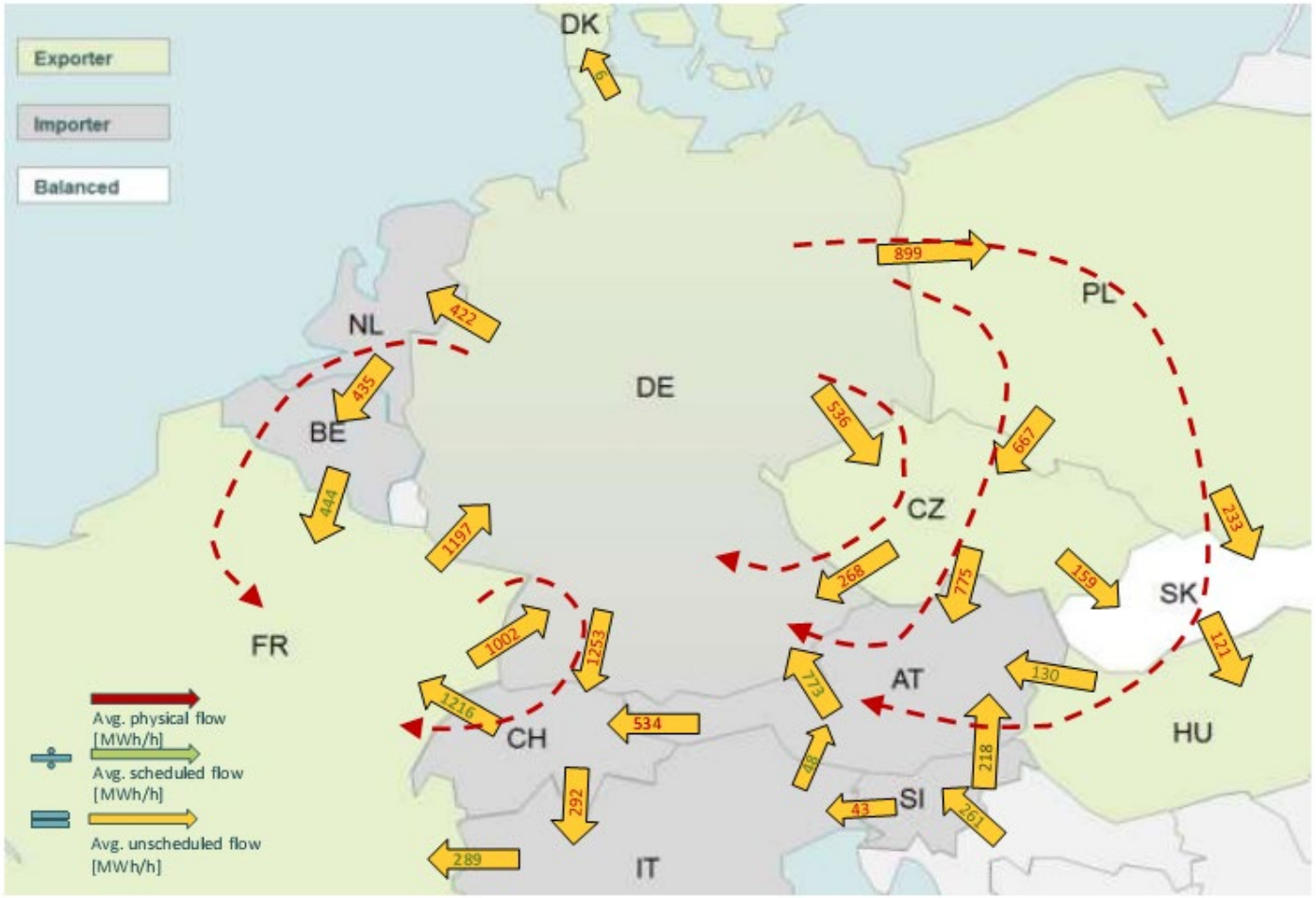
Power flows

- market (scheduled) flows: result of commercial transaction (seller to buyer)
- physical flows (measured): real flows in the grid of according to Kirchhoff's 1st law
- loop flows: physical flows occurring in external (i.e. host) area as the result of congestions in primary control area



Source: http://ec.europa.eu/energy/gas_electricity/studies/doc/electricity/201310_loop-flows_study.pdf

Loop flows

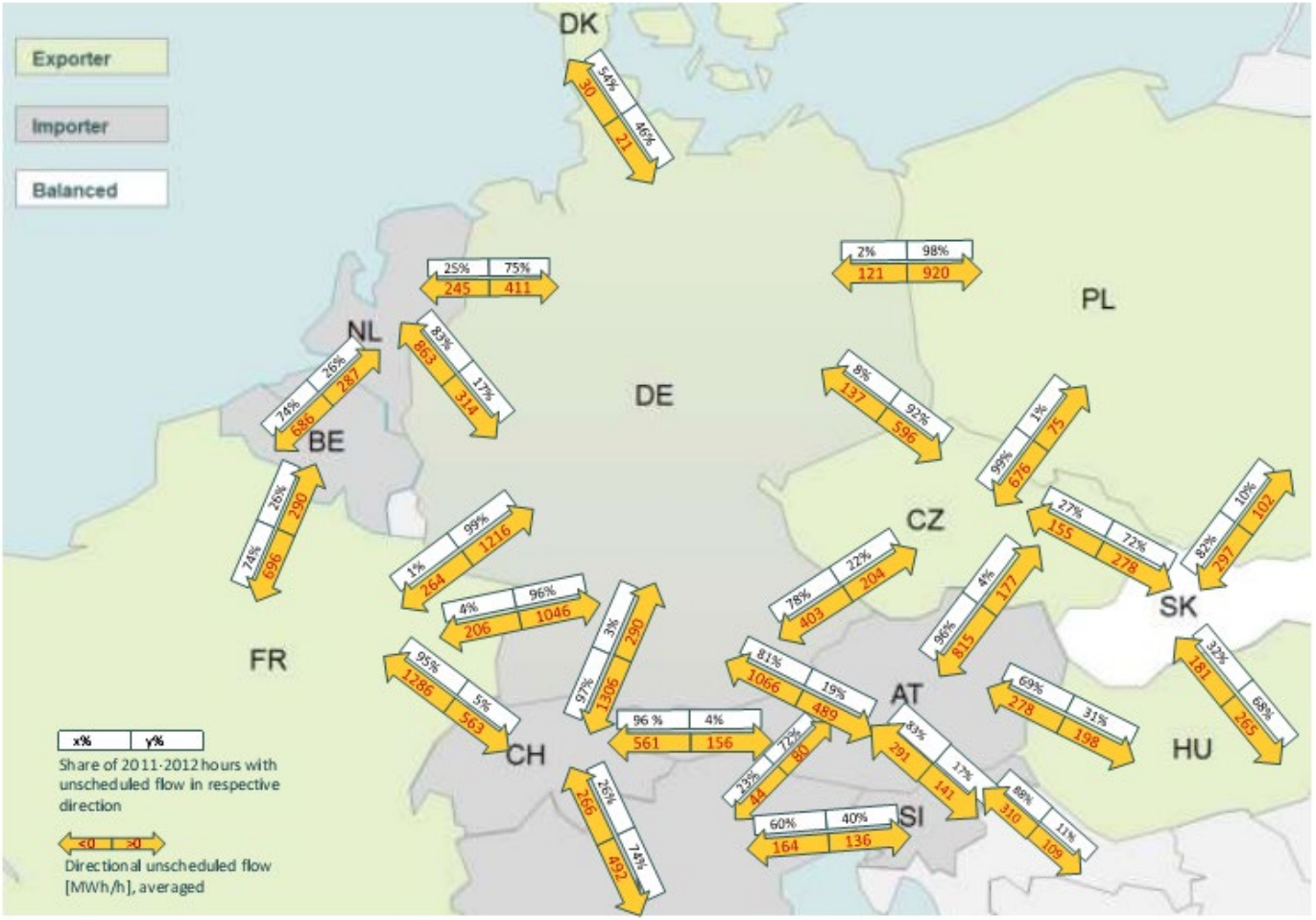


Source: THEMA Consulting Group, based on data from 16 TSOs

Average unscheduled flows (2011-2) in MWh/h

Source: http://ec.europa.eu/energy/gas_electricity/studies/doc/electricity/201310_loop-flows_study.pdf

Loop flows 2

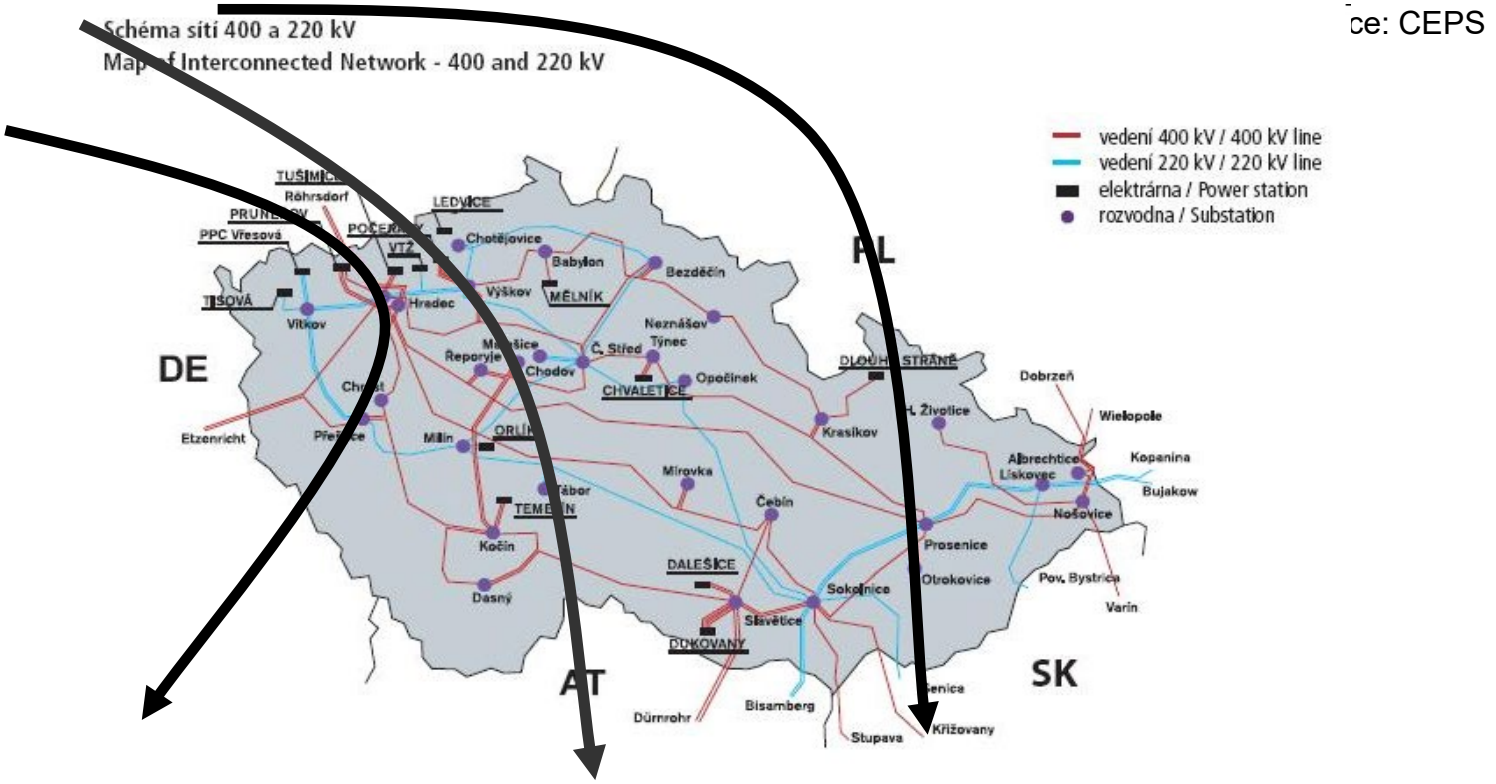


Source: THEMA Consulting Group, based on data from 16 TSOs

Average unscheduled flows (2011-2) in MWh/h and share of hours with unscheduled flows

Source: http://ec.europa.eu/energy/gas_electricity/studies/doc/electricity/201310_loop-flows_study.pdf

Czech Rep. – loop flows



Source: CEPS

Problem: Loop flows from N. Germany to S. Germany and Austria, end of 2014: > 3400 MW from Germany to Austria

Threat for TS stability, installation of “phase shifters”, 1st installation in 2015-2016 (Hradec)

Thank you for your attention !

Děkuji za pozornost!