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# Introduction to Electricity Industry III

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- Merit Order Effect
- Regulation of Electricity
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# Electricity Markets

- **Energy-only Market + Balancing Market**
  - only compensates power that has actually been produced

vs.

- **Capacity Market**
  - compensates the mere readiness, or capacity, for power production

# Price of Electricity (Producers‘s side)

| Factors influencing the price of electricity production | |
|---|---|
| **Supply Side** | **Demand Side** |
| • Production capacity<br>• Capital expenditures (CAPEX) through depreciation<br>• Operational expenditures (OPEX)<br>  • Fuel<br>  • Emission Allowances<br>• Weather<br>  • Hydrology<br>  • Wind<br>  • Temperature<br>• Global price of energy (oil) | • Macroeconomic factors<br>• Weather |
| Source: Next Finance (2007): *Trh s elektrickou energií v Evropě* (http://www.pxe.cz/pxe_downloads/Info/pxe_analyza.pdf),p.5 | |

# Merit Order Effect (MOE)

- way of ranking of available sources of electricity based on their marginal costs
- marginal costs of production reflect the order
- ***marginal costs*** is the change in the total cost that arises when the quantity produced is incremented by one unit, that is, it is the cost of producing one more unit of a good. In general terms, marginal cost at each level of production includes any additional costs required to produce the next unit. For example, if producing additional vehicles requires building a new factory, the marginal cost of the extra vehicles includes the cost of the new factory.

# Merit Order Effect (MOE)

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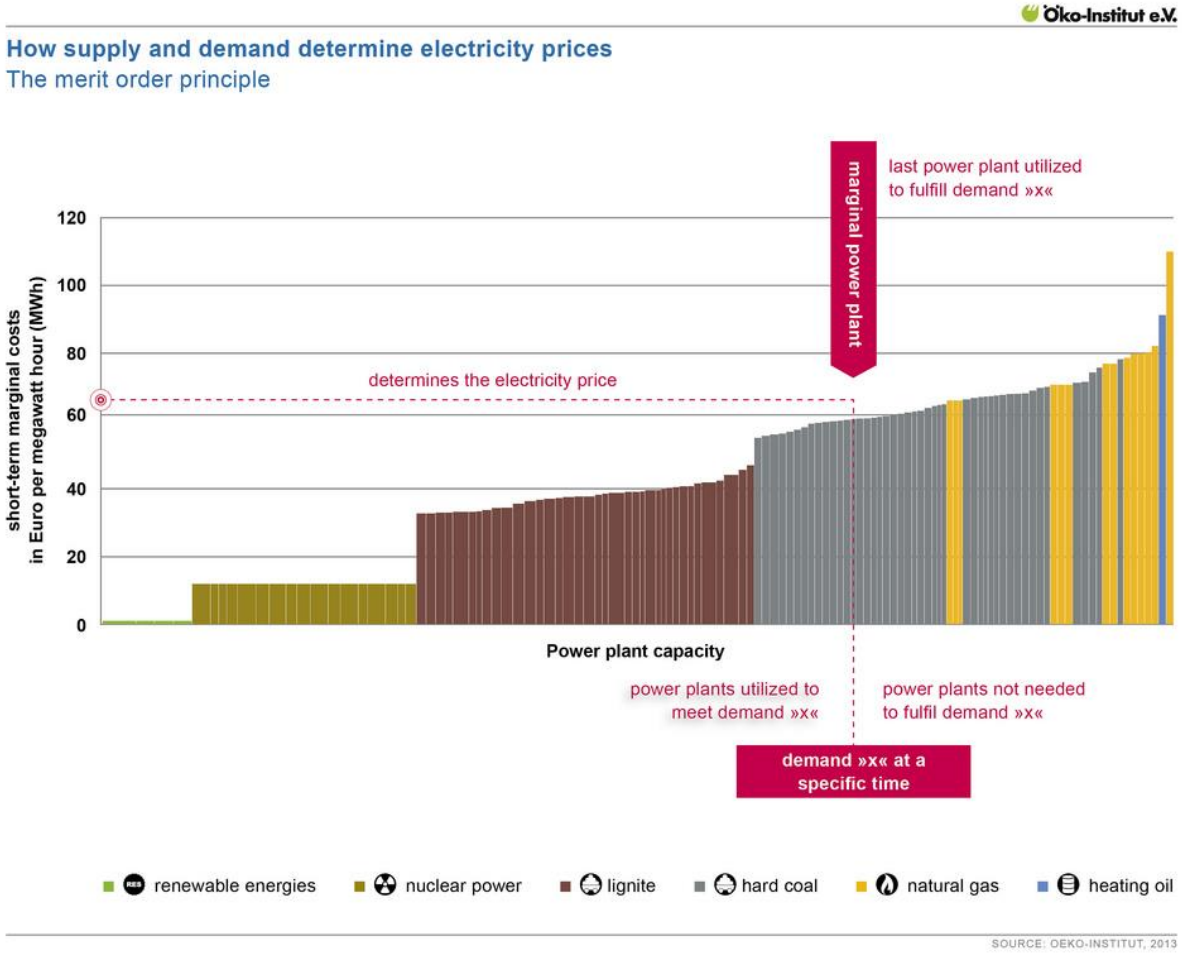


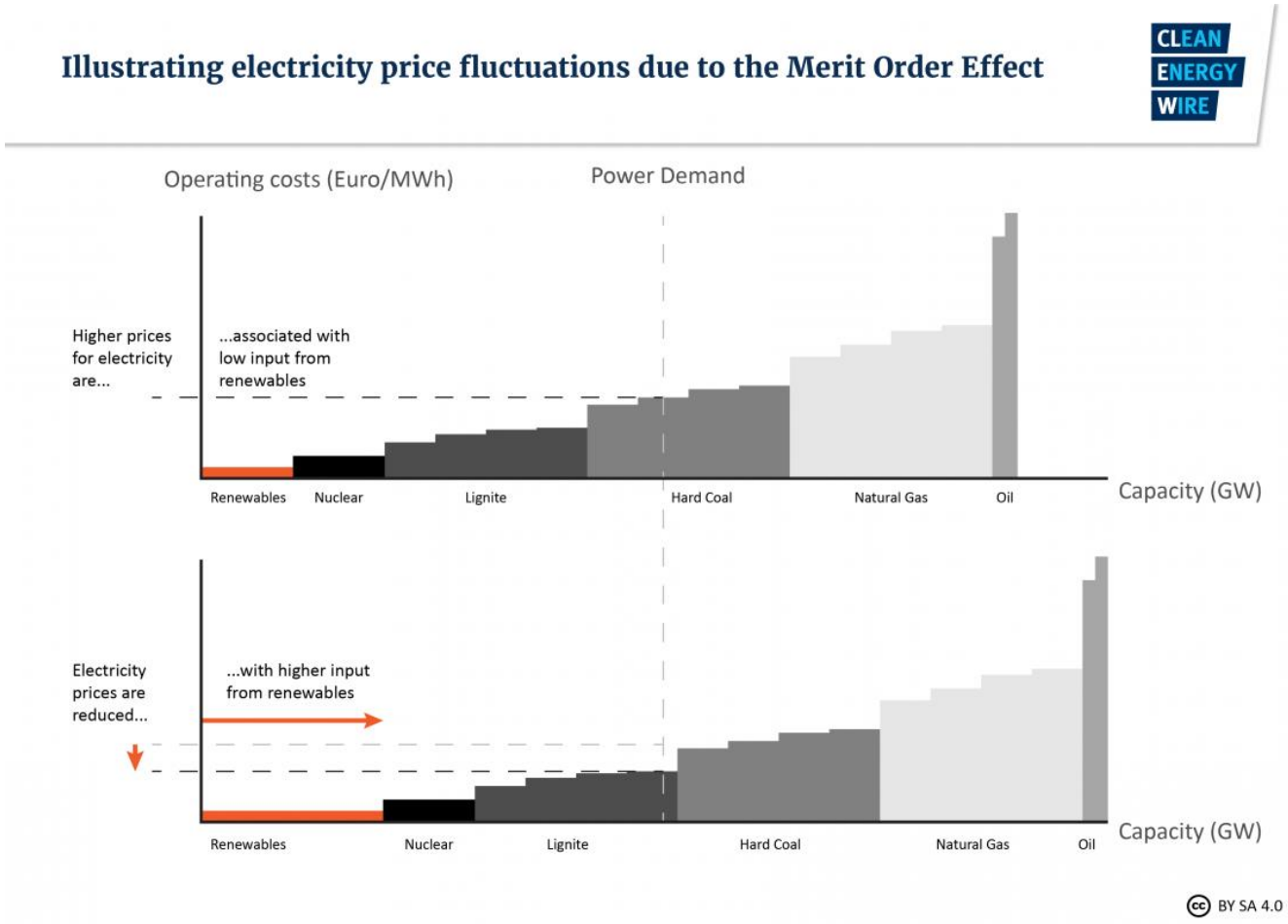




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# Merit Order Effect (MOE)

**Are RES good or bad?**

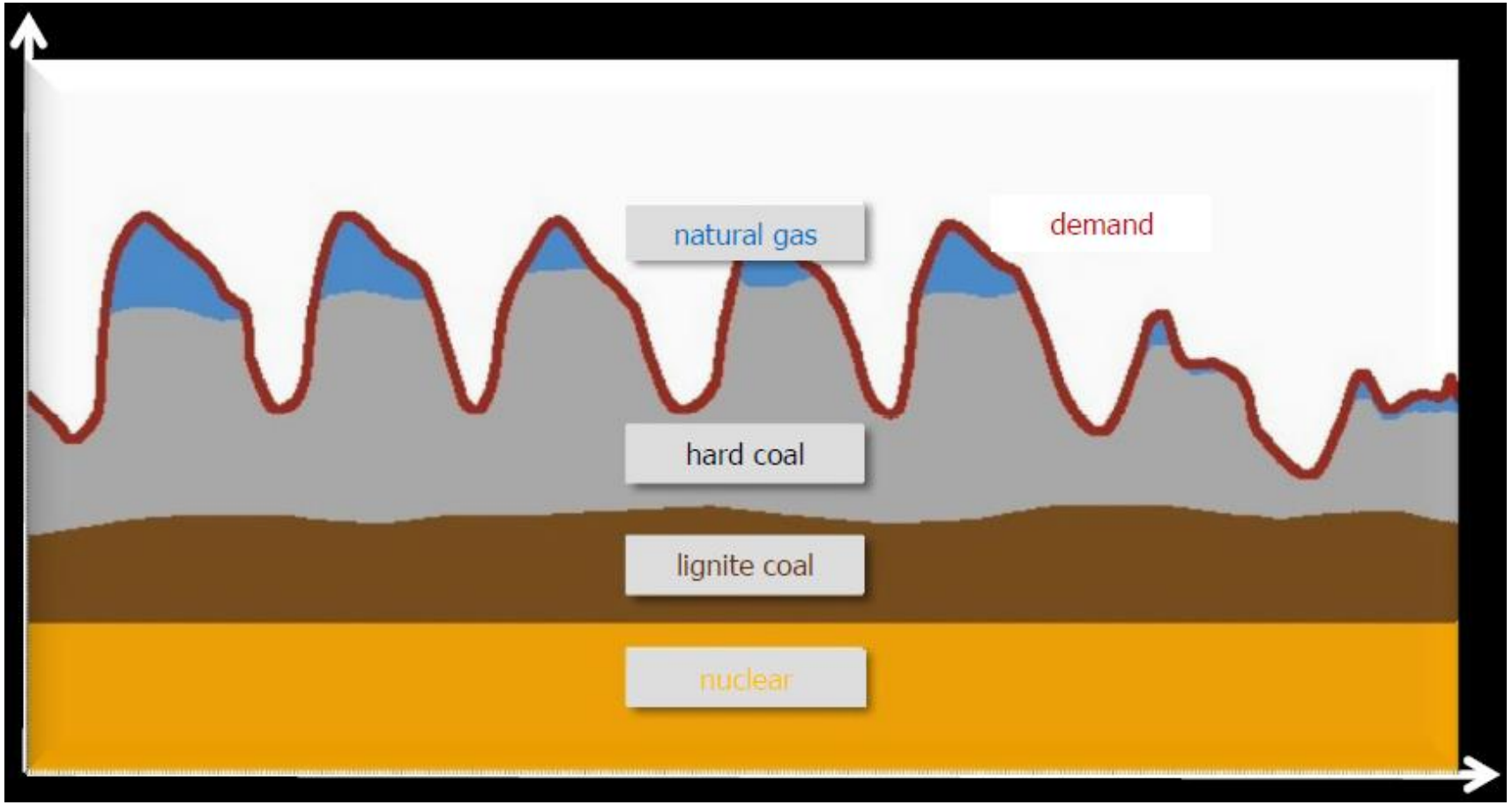
**Customer‘s point of view**

- Electricity price dropped considerably
- Higher competitiveness for industry vs. support of RES paid by both

**Producer‘s point of view**

- Lower revenues
- Deformed investment environment
- New market opportunities vs. loss of market

# Merit Order Effect (MOE)




Electricity price is determined by the most expensive plant. 1,000 MWe in coal or nuclear makes no difference for the market. **Nuclear does not equal cheap electricity for the consumer, only sufficient generating capacity equals cheap electricity!**



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# Price of Electricity (Consumer‘s side)

- In a liberalized market the final price of electricity consists of the price of electricity (commodity) and a number of regulated components that reflect the naturally monopolistic character, such as transmission and distribution.
- The support for RES development is among the price components.
- The regulated components are set by Energy Regulatory Office.

# Price of Electricity (Consumer‘s side)

| Price components for electricity supply to households in the CR in 2010, 2014, and 2019 | | | |
|---|---|---|---|
| **Electricity incl. margin** | 51.17 % | 36.4 % | 45.58 % |
| **Market operator** | 0.15 % | 0.24 % | 0.8 % |
| **System services of ČEPS** | 4.77 % | 2.43 % | 2.15 % |
| **Renewables, cogeneration and decentralized sources** | 5.34 % | 12.14 % | 13.35 % |
| **Electricity distribution and transport** | 38.57 % | 48.79 % | 38.12 % |
| Source: Energetický regulační úřad | | | |

+ Ecological tax and VAT (21%)

# Price of Electricity (Consumer‘s side)

| **The development of end consumers' contribution to Renewables, cogeneration and decentralized sources in the CR** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Year** | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
| **Contribution in CZK per 1 MWh** | 39.45 | 28.26 | 34.13 | 40.75 | 52.18 | 166.34 | 370 |
| **Year** | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| **Contribution in CZK per 1 MWh** | 419.22 | 583 | 495 | 495 | 495 | 495 | 495 |
| Source: Energy Reuglatory Office of the Czech Republic | | | | | | | |



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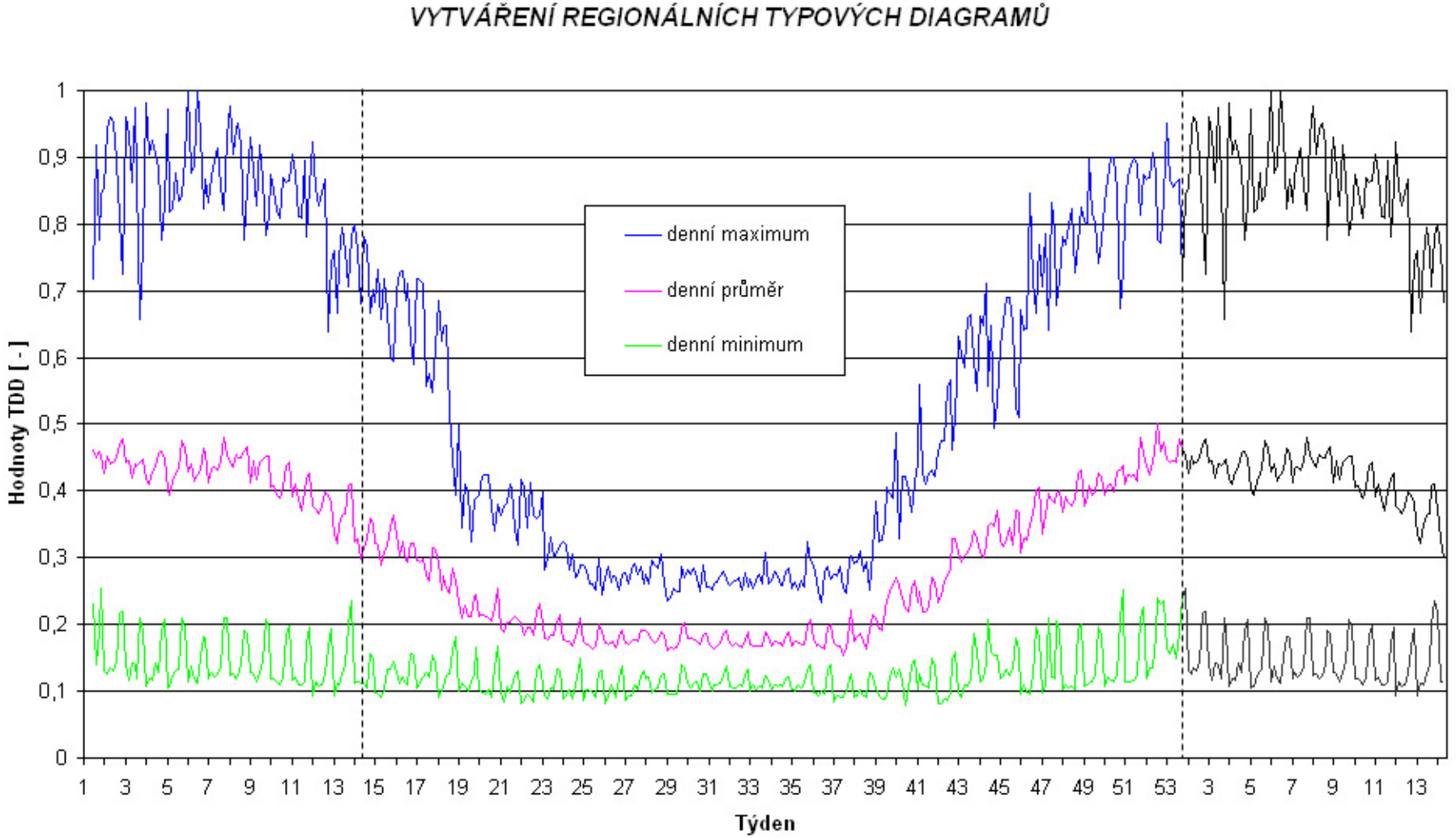
# Regulation of Electricity

- The power system is dynamic, permanently active, and within seconds changing system.
- In Europe it is optimized for 50 Hz frequency.
- In this network frequency, the generated active power (which is equal to the sum of active power producing generators throughout the system) is exactly equal to consumption (sum of inputs of all appliances and network losses).
- The balanced supply of electricity and its consumption is the optimum state of the network.

- Negative symptoms: worsening power quality (frequency reduction), overvoltage, undervoltage, brownout, blackout, island operation
- The reasons for the emergence of those conditions are different from planned and unplanned shutdowns of generating units, through unexpected damage to transformers, substations and networks, the consequences of the current weather conditions (eg. heavy snowfall, the sharp drop in the outdoor temperature, etc..), or changes in electricity production from renewable resources (ie., wind and solar power).
- These conditions are prevented by regulatory backups

# Baseload and Peakload



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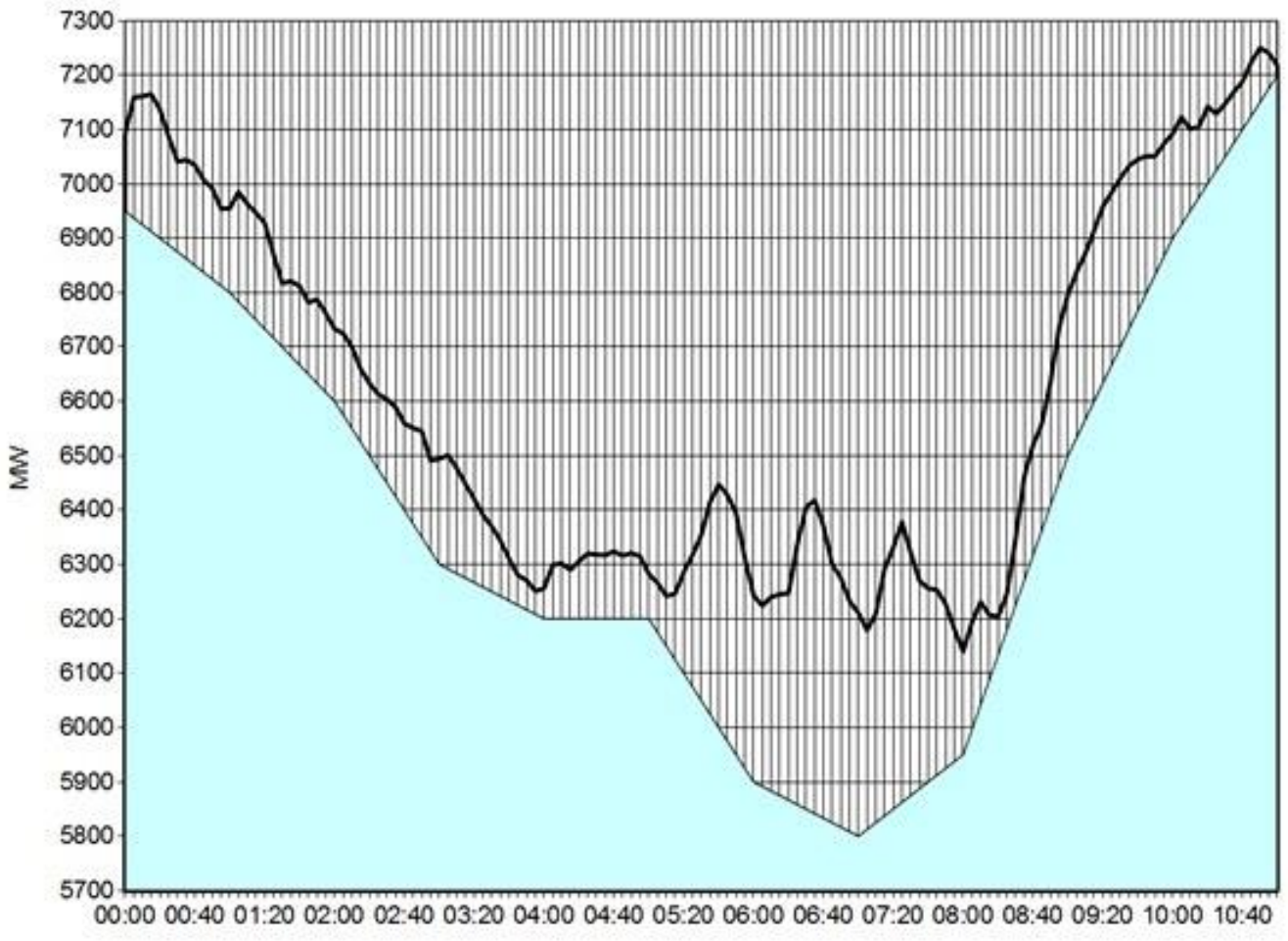
# Baseload and Peakload

More than 90% of risk situations are planned and prepared for using regional diagrams from previous years.

In the last 30 years there was only one situation, where the divergence from the regional diagrams was critical:

Sunday, February 22, 1998

Czech Republic played ice hockey finale match against Russia (and won) during Nagano 1998 Winter Olympics




Source: www.idnes.cz



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# Baseload and Peakload

BBC TV Series "Britain from Above”  https://www.youtube.com/watch?v=slDAvewWfrA




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# Regulation of Electricity

| A Simplified Division of Regulation Reserves as part of ČEPS System Services in the Czech Republic | | | |
|---|---|---|---|
| **System Service** | **Mark** | **Timeframe** | **Description** |
| Frequency Containment Process (Regulation Reserve Seconds) | RZV | 30 seconds | Serves for the automated primary frequency control (PR) |
| Minute Reserve available within 5 minutes (positive) | mFRR5 | 5 minutes | Minute reserve available within 5 minutes (manual Frequency Restoration Reserve, mFRR5) |
| Regulation Reserve available within 10 minutes (positive) | aFRR+ | 10 minutes | Serves for secondary regulation, it consists of sources available within 10 minutes (automatic Frequency Restoration Reserve positive, aFRR+) |
| Regulation Reserve available within 10 minutes (negative) | aFRR- | 10 minutes | Serves for secondary regulation, it consists of sources available within 10 minutes (automatic Frequency Restoration Reserve aFRR-) |
| Minute Reserve available within 15 minutes (positive) | mFRR15+ | 15 minutes | Minute reserve available within 15 minutes (manual Frequency Restoration Reserve, mFRR5) |
| Minute Reserve available within 15 minutes (negative) | mFRR15- | 15 minutes | Minute reserve available within 15 minutes (manual Frequency Restoration Reserve, mFRR5) |
| Regulation Reserve available within 30 minutes (negative) | RZ30 | 30 minutes | It serves for tertiary regulation, it consists of regulation reserve for power reduction within 30 minutes |
| Regulation Reserve available in over 30 minutes | RZN>30 | 30+ minutes | It consists of dispatch reserve, regulation energy and regulation energy from abroad, all available in over 30 minutes EregZ>30+, EregZ>30-) |
| Note: a positive reserve means an increase in capacity, while a negative reserve means an increase in consumption.<br>Source: ČEPS, a. s., 2018, p. 117. | | | |

# Regulation of Electricity

https://youtu.be/9Fi-eu4lQMo?t=5m5s




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# Regulation of Electricity

| Maximum Regulation Reserves in the Czech Republic in 2019 (Mwe) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | aFRR | | | | mFRR | | | | | |
| | aFRR+ | | aFRR- | | mFRR5 | | mFRR15+ | | mFRR15- | |
| | Night | Day | Night | Day | Night | Day | Night | Day | Night | Day |
| Working days | 335 | 365 | 335 | 365 | 505 | 505 | 280 | 330 | 220 | 270 |
| Non-working days | 330 | 345 | 330 | 345 | 505 | 505 | 275 | 315 | 215 | 255 |
| Source: ČEPS, a. s., 2018, p. 118. | | | | | | | | | | |



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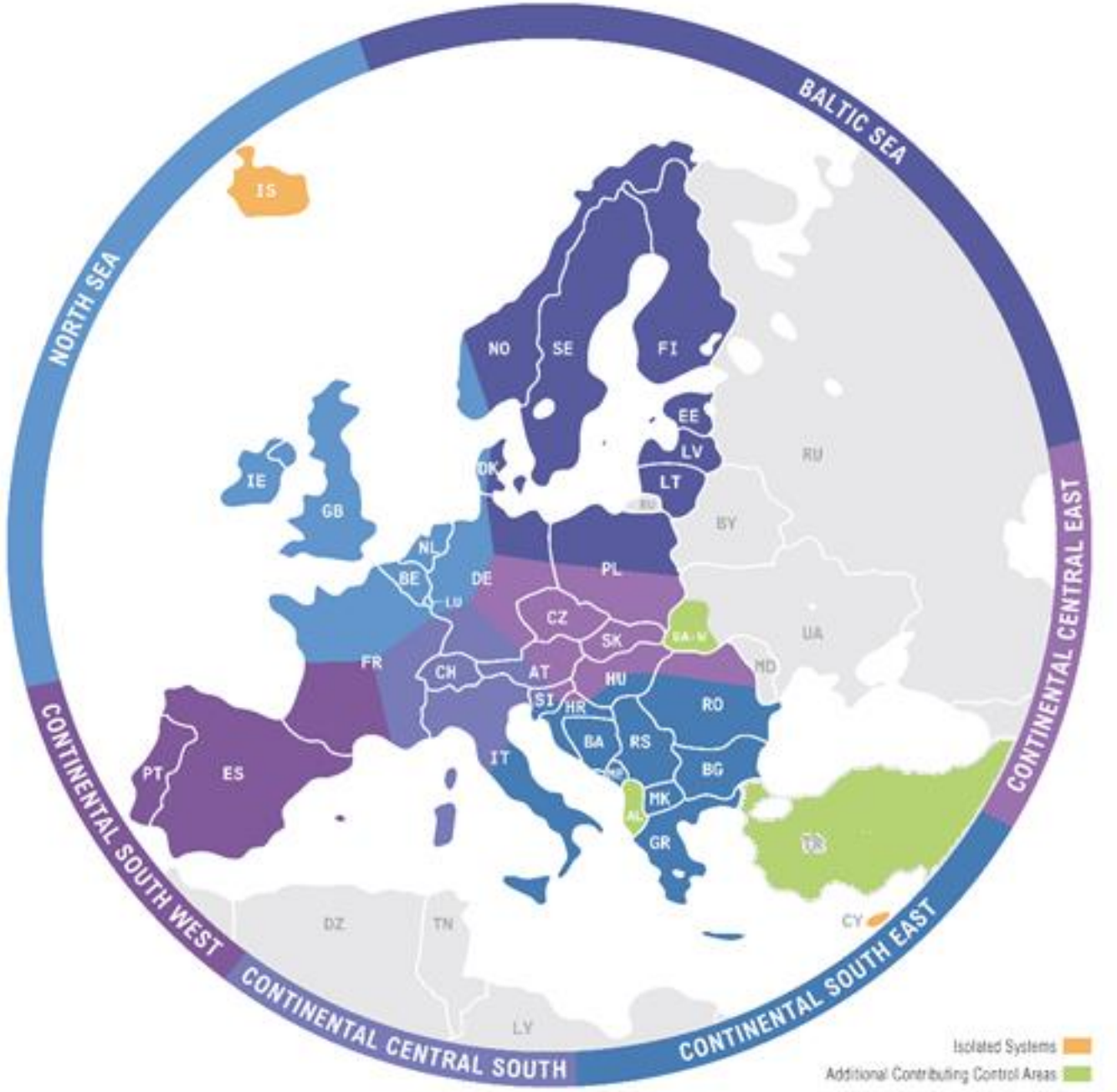
# ENTSO-E

- If a power unit fails, another will take over its operation depending on its distance from the power outage. This substitution works on the principle of solidarity across the network.



# Regulation of Electricity - Example

3,100/4300 MW NPP

6,600/11000 MW StPP

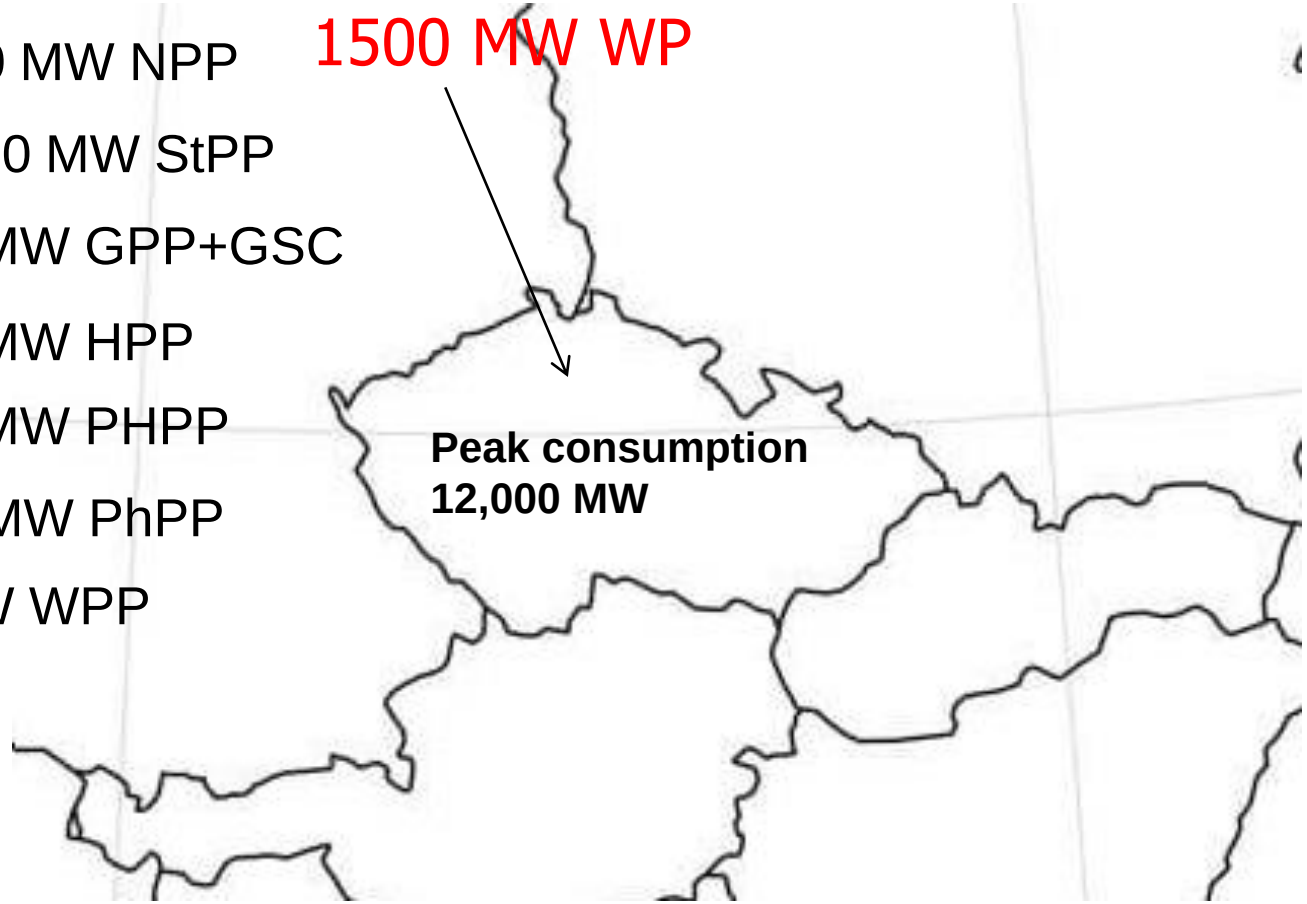
750/2300 MW GPP+GSC

600/1000 MW HPP

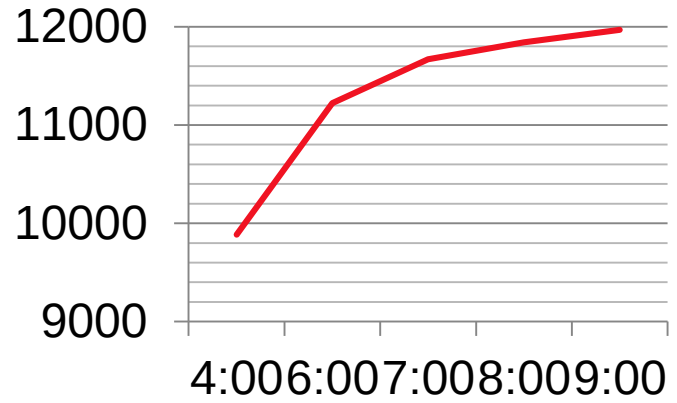
200/1200 MW PHPP

700/2000 MW PhPP

70/300 MW WPP




**Consumption 28.2.2018**




<u>Known consumption</u>
Base 9400 MW
Peak 11000 MW

9:00 Consumption 12000 MW
9:30 +1500 MW WPP from neighbour, rising frequency, overvoltage imminent



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# Regulation of Electricity - Example

3,100/4300 MW NPP

6,600/11000 MW StPP

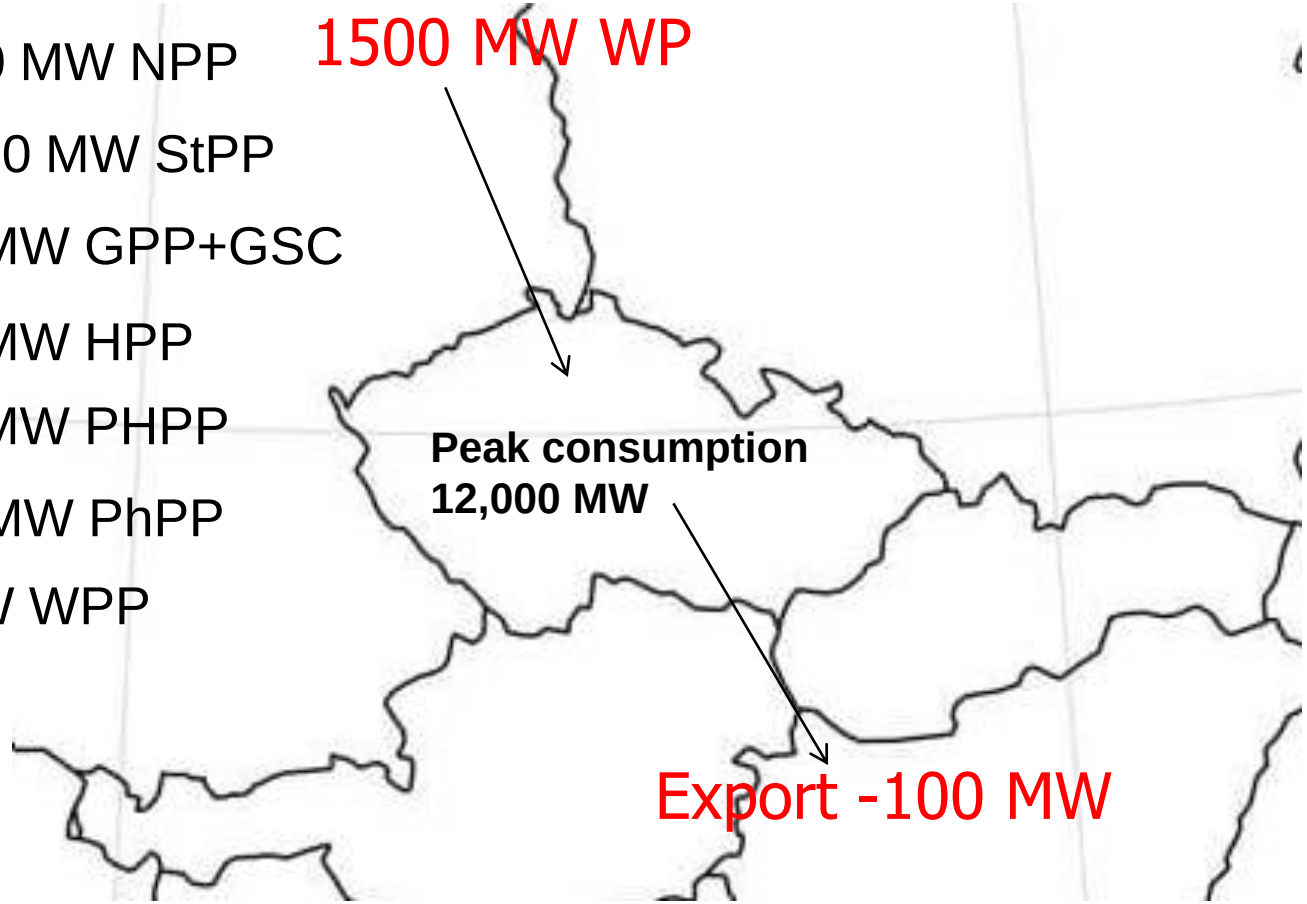
100/2300 MW GPP+GSC

250/1000 MW HPP

000/1200 MW PHPP

500/2000 MW PhPP

70/300 MW WPP




**Solution**:
PhPP drop by 200 MW

*Primary regulation*
-650 GSC+GPP
-350 HPP
-200 PHPP
Export -100 MW

*Secondary regulation* will take over in 30 minutes.

With the peak spot electricity price of 40 euro the regulation costs EUR 48,000 per hour.
(100 MW export, 200 MW PHP used, 1200 MW regulated)



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# Regulation of Electricity - Example

3,100/4300 MW NPP

6,600/11000 MW StPP

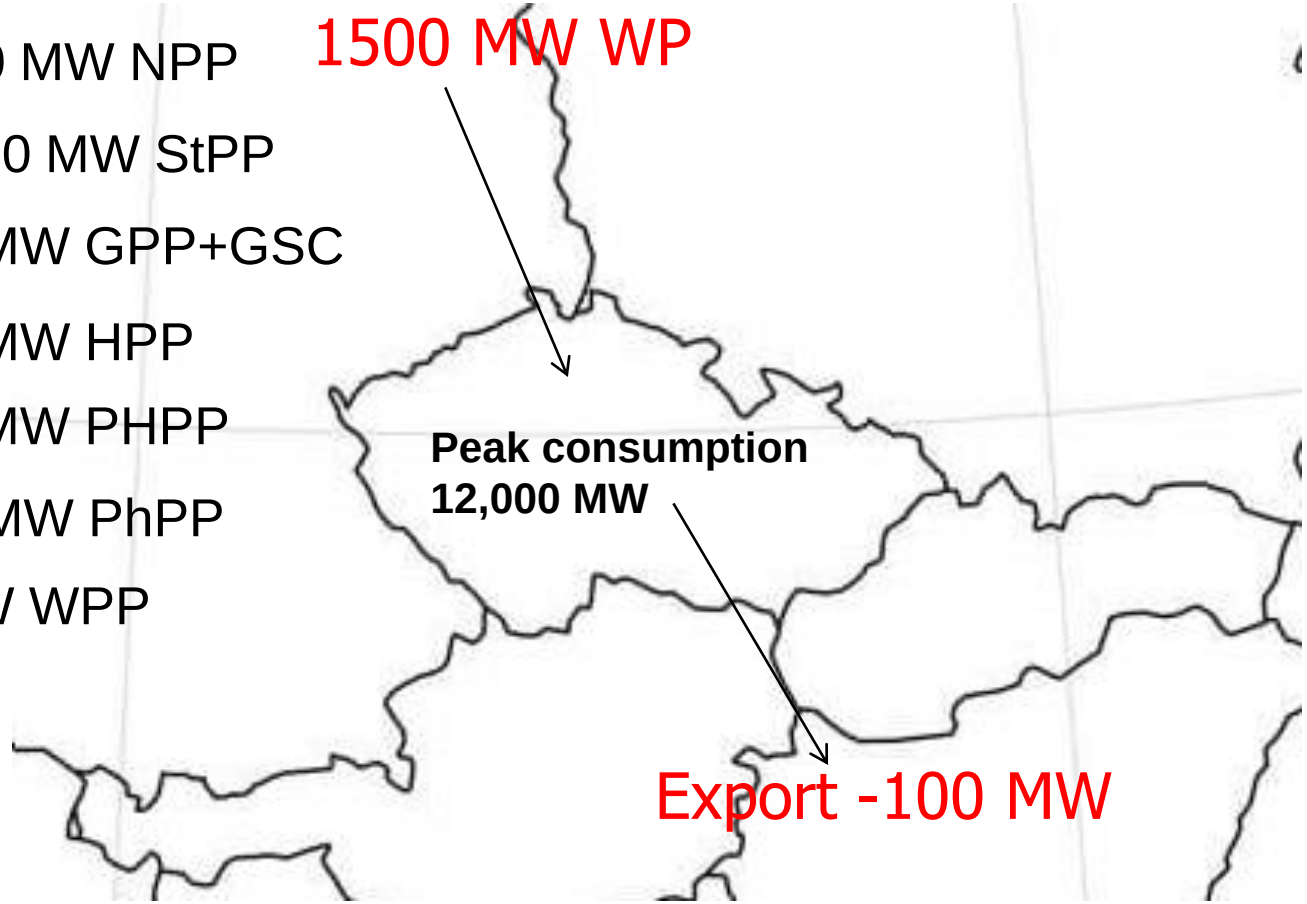
100/2300 MW GPP+GSC

250/1000 MW HPP

000/1200 MW PHPP

500/2000 MW PhPP

70/300 MW WPP

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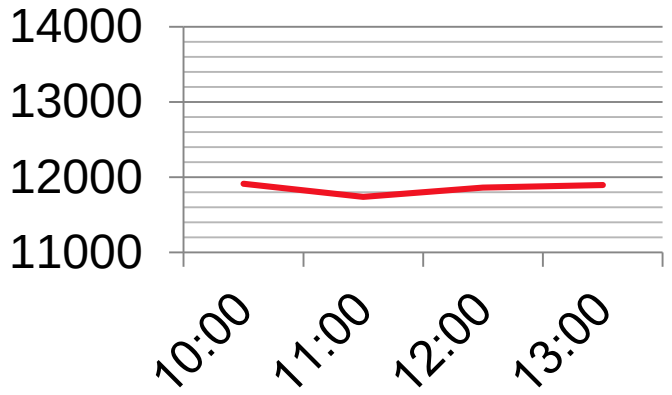


<u>Known consumption</u>
Base 9400 MW
Peak 11800 MW

13:00 Consumption 12000 MW
14:00 Expected cons. 11000 MW
13:30 drop in WPP from neighbour, to 0 MW in 30 minutes, drop in frequency, undervoltage imminent



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# Regulation of Electricity - Example

3,100/4300 MW NPP

6,600/11000 MW StPP

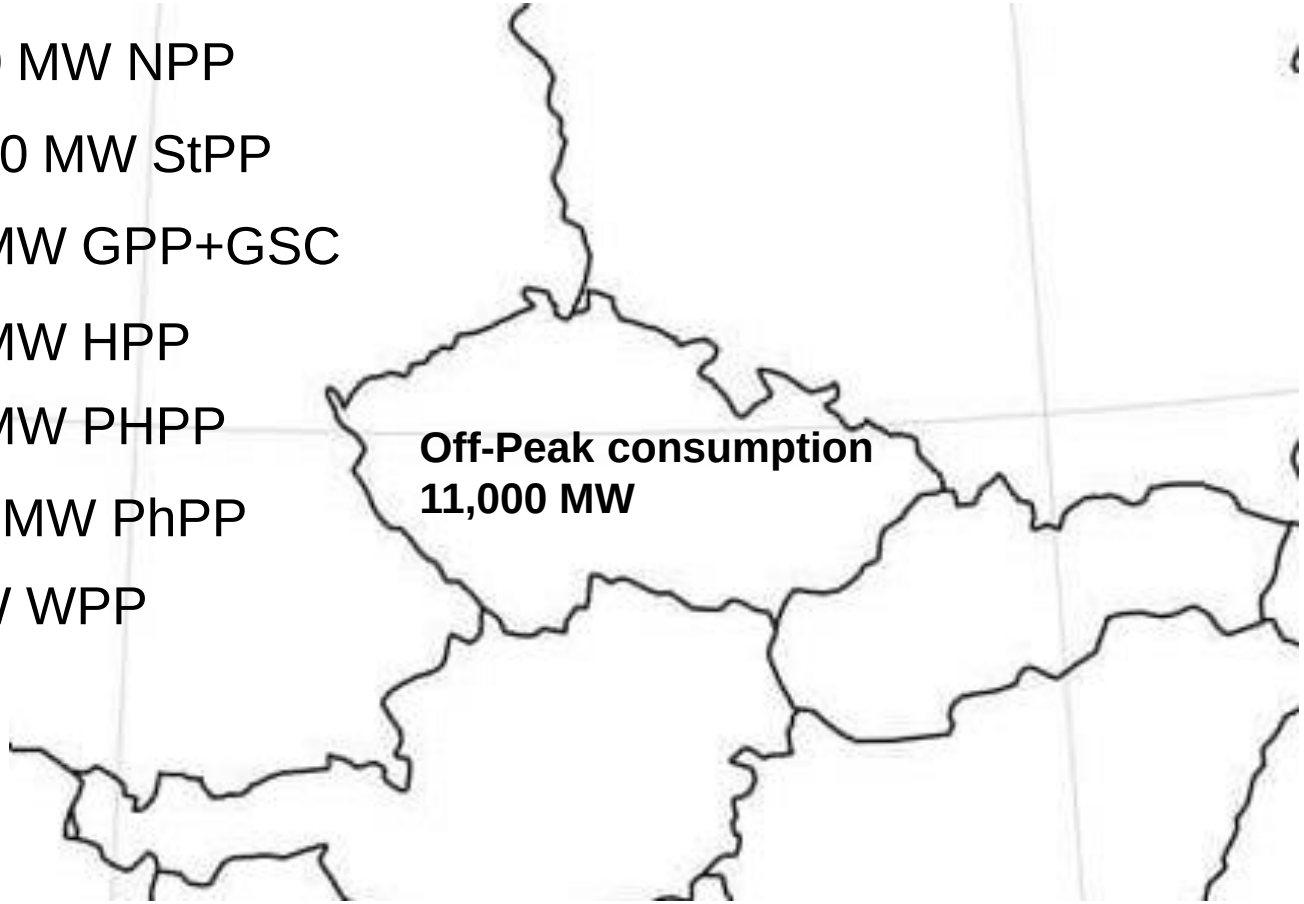
850/2300 MW GPP+GSC

680/1000 MW HPP

000/1200 MW PHPP

1100/2000 MW PhPP

70/300 MW WPP




**Solution**:

Required regulation 2500 MW by 14:00
PhPP rise by 600 MW

*Primary regulation*
+750 GSC+GPP
+430 HPP
End of export +100 MW
End of import -1500 MW

With the peak spot electricity price of 40 euro the regulation costs EUR 84,000.
(600 MW PHP used, 2100 MW regulated)

The regulation between 9:30 and 14:00 costs EUR 252,000.



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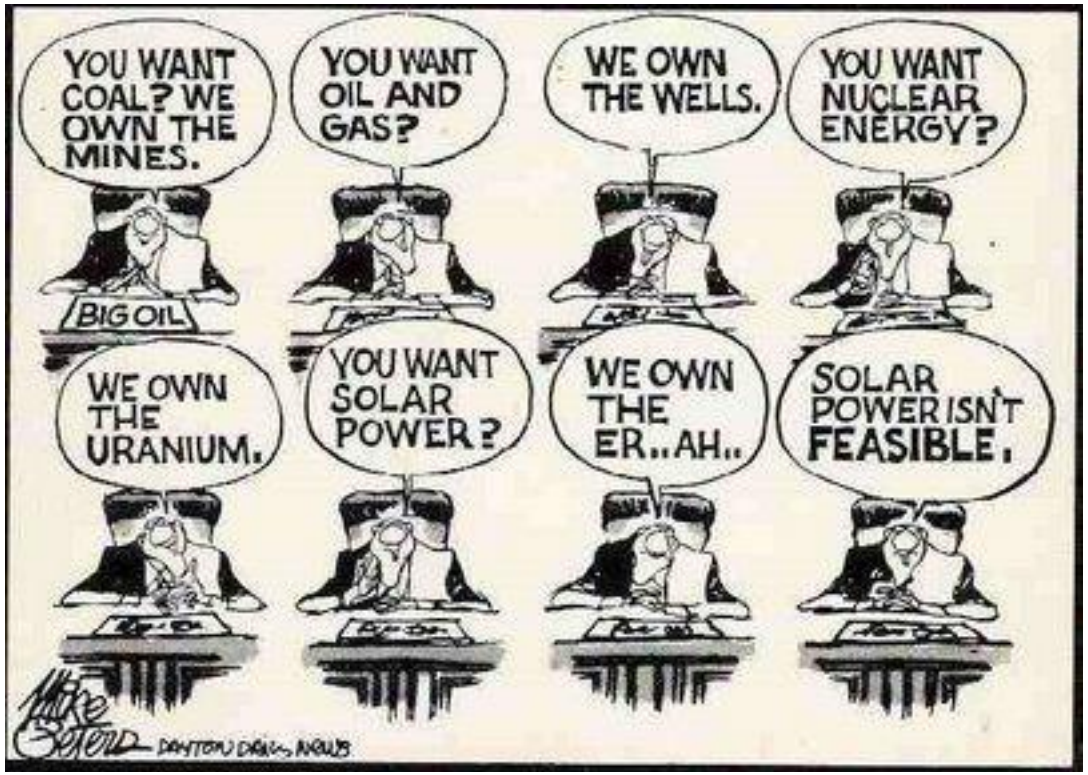
Thank you for your attention.



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