„Wege zu einer sicheren und stabilen voll-regenerativen Elektrischen Energieversorgung“

Prof. Dr. Harald Weber

Institute for Electrical Power Engineering
University Rostock

Mittwoch, 13. März 2019,

Electric Power and the distribution of wealth

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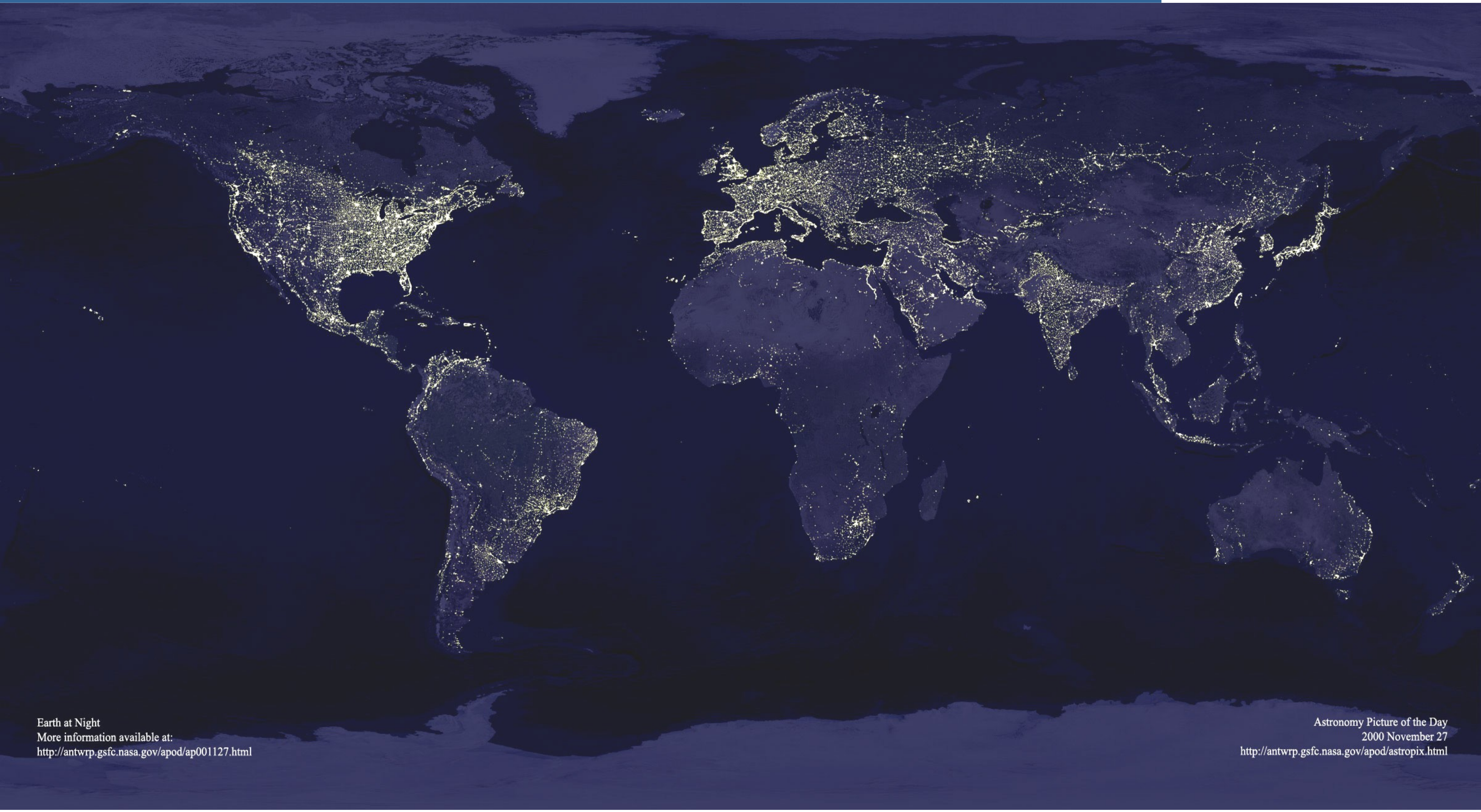
Prof. Dr. H. Weber



AN ALTERNATIVE VIEW OF THE WORLD

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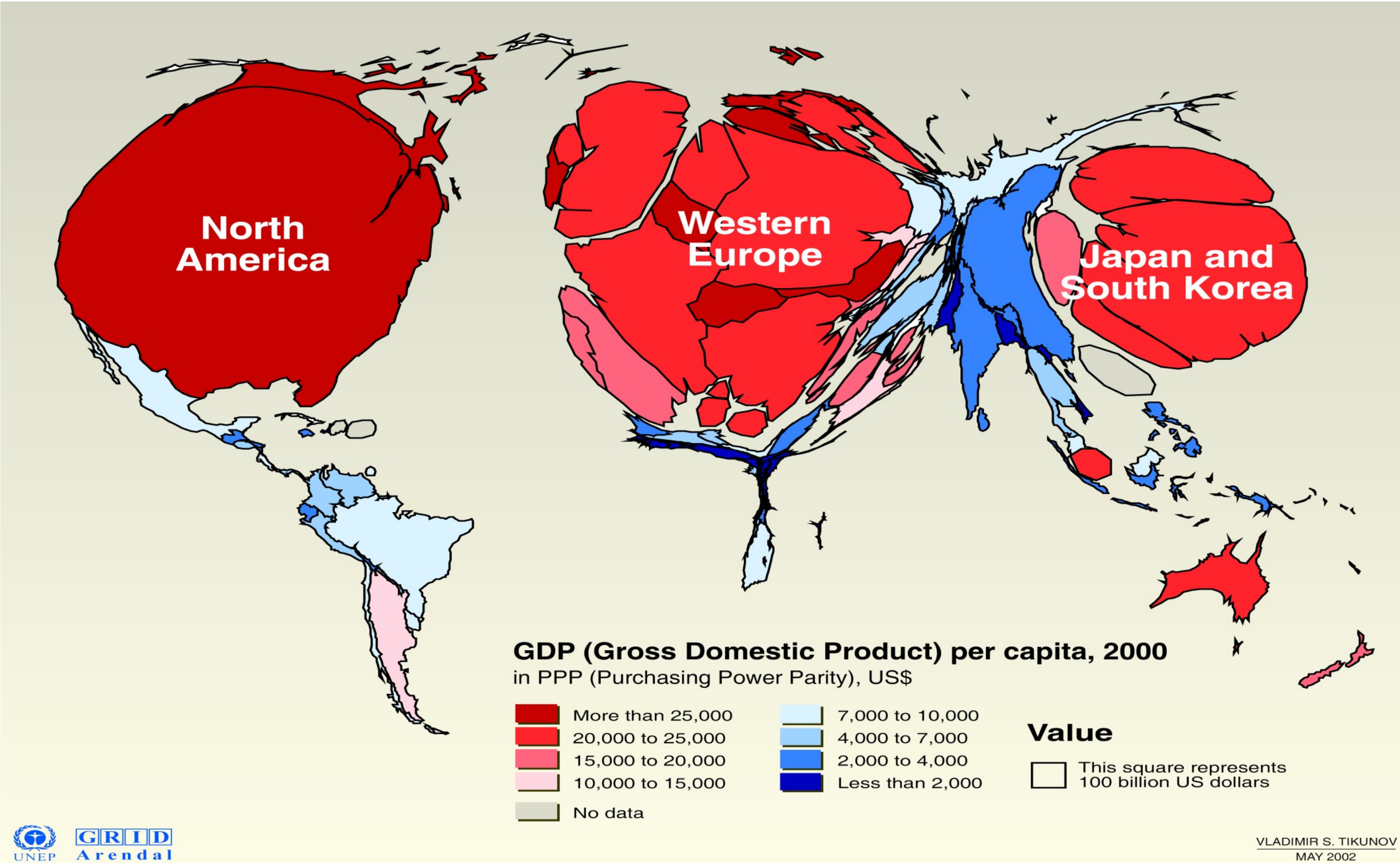

1769: James Watt and the total alteration of the world

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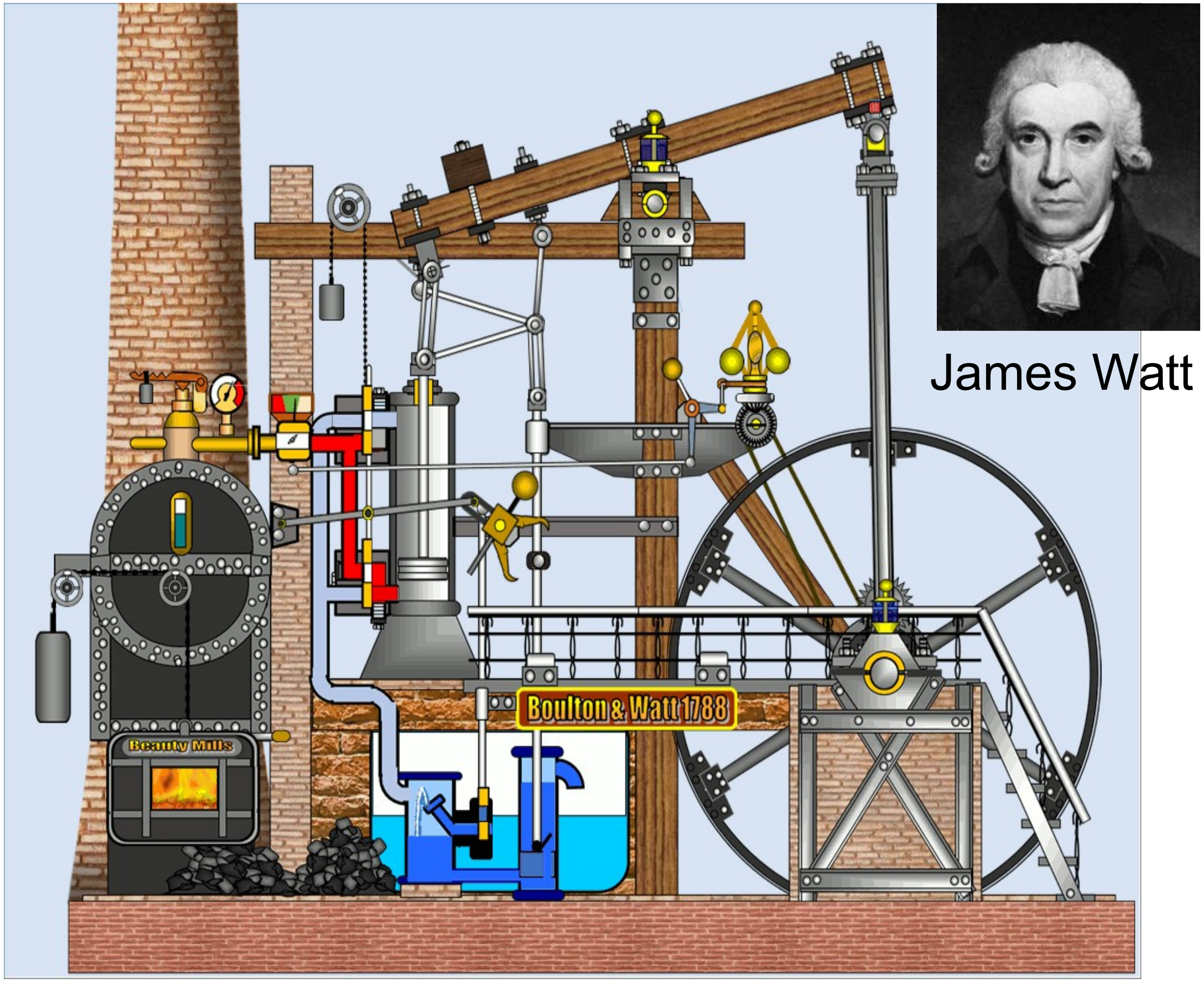


Steam engine by James Watt

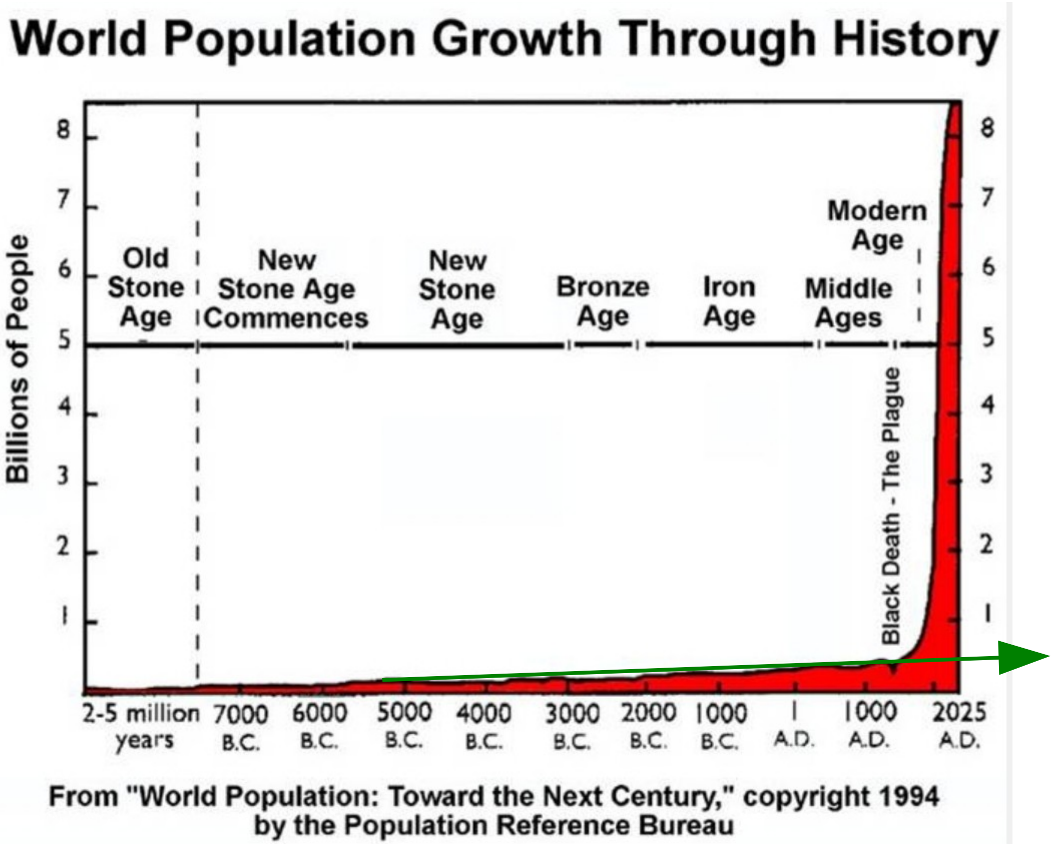
James Watt

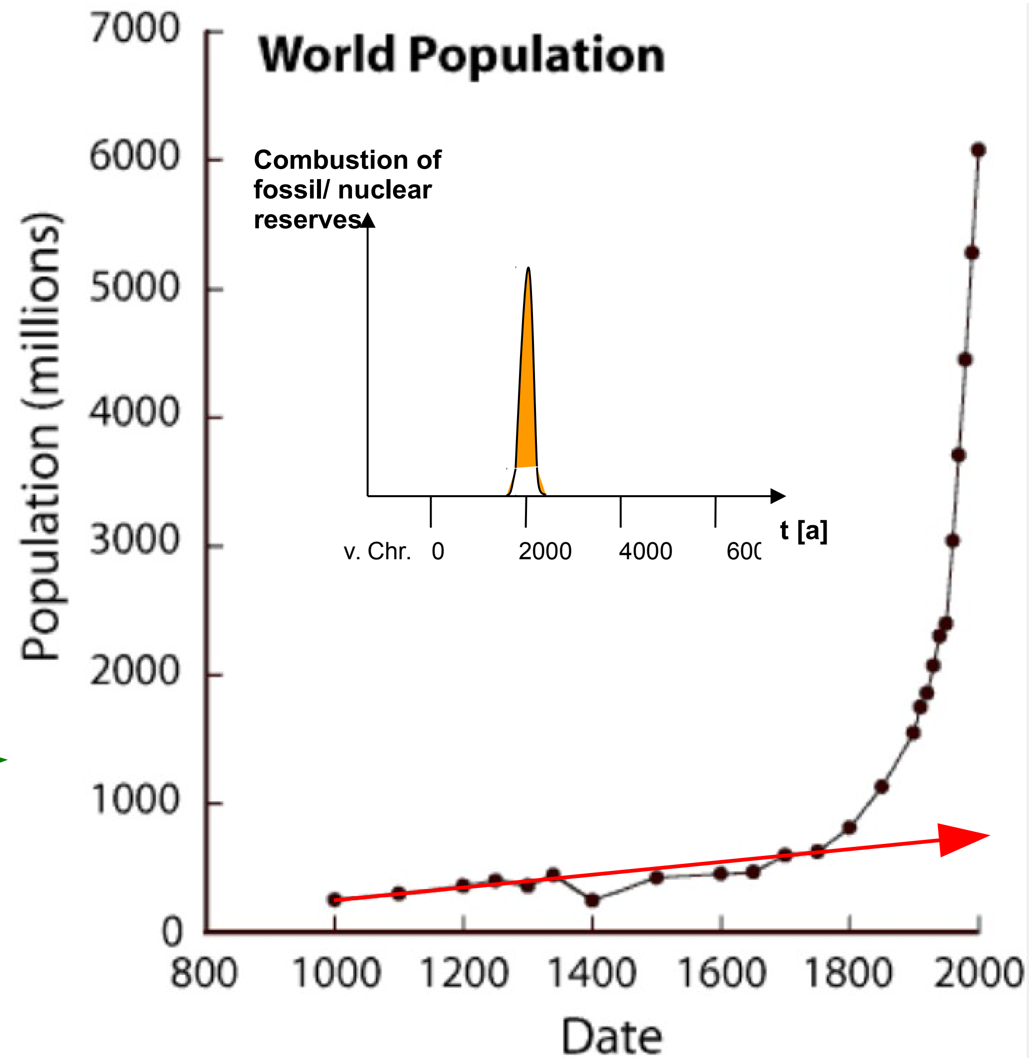
Work by Hand: Threshing

LIS - Landkreis Rhön-Grabfeld - Heimatpflege

Work by fire: Threshing machine

Population growth





VGB: Energy demand EU and World

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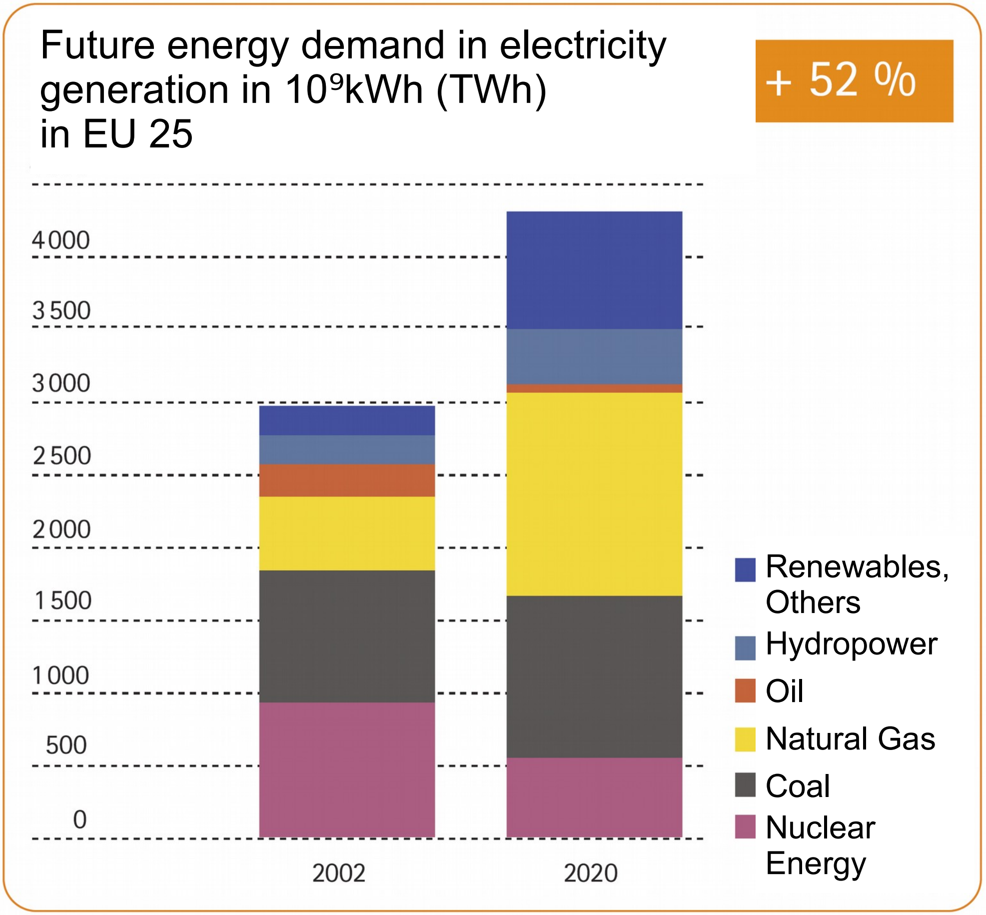
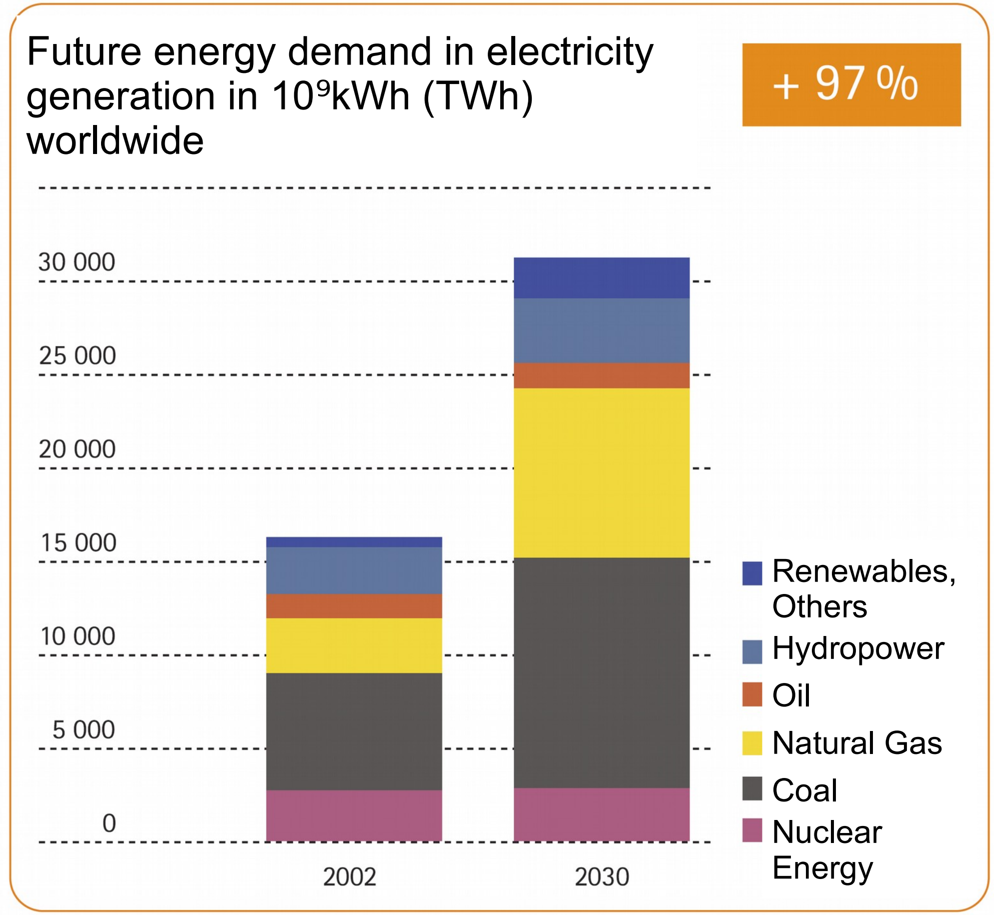


Quelle: E.ON Ruhrgas/IEA



Quelle: E.ON Ruhrgas/IEA

Fossil reserves are finite: coal, oil and natural gas

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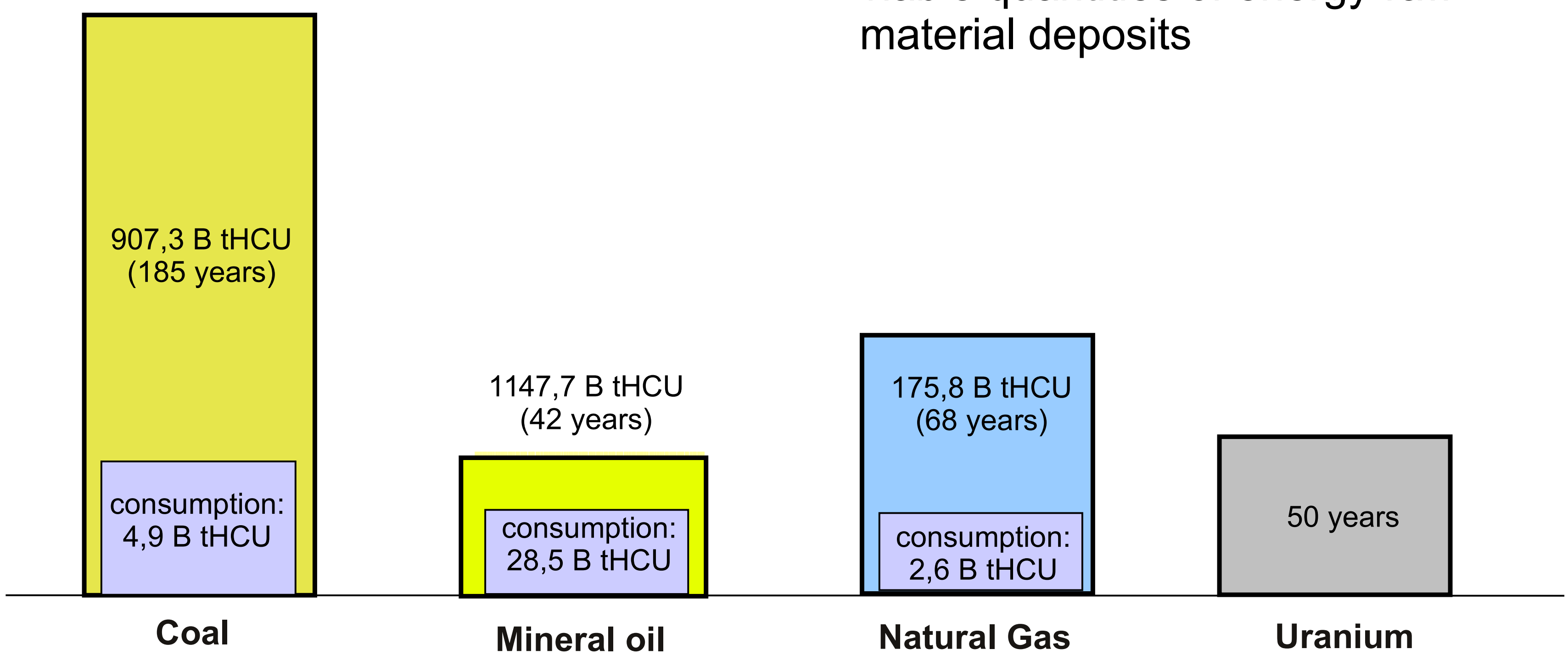
<u>Reserves</u>: At today's prices and with today's technology, economically viable quantities of energy-raw material deposits



Fossil reserves are finite: coal, oil and natural gas

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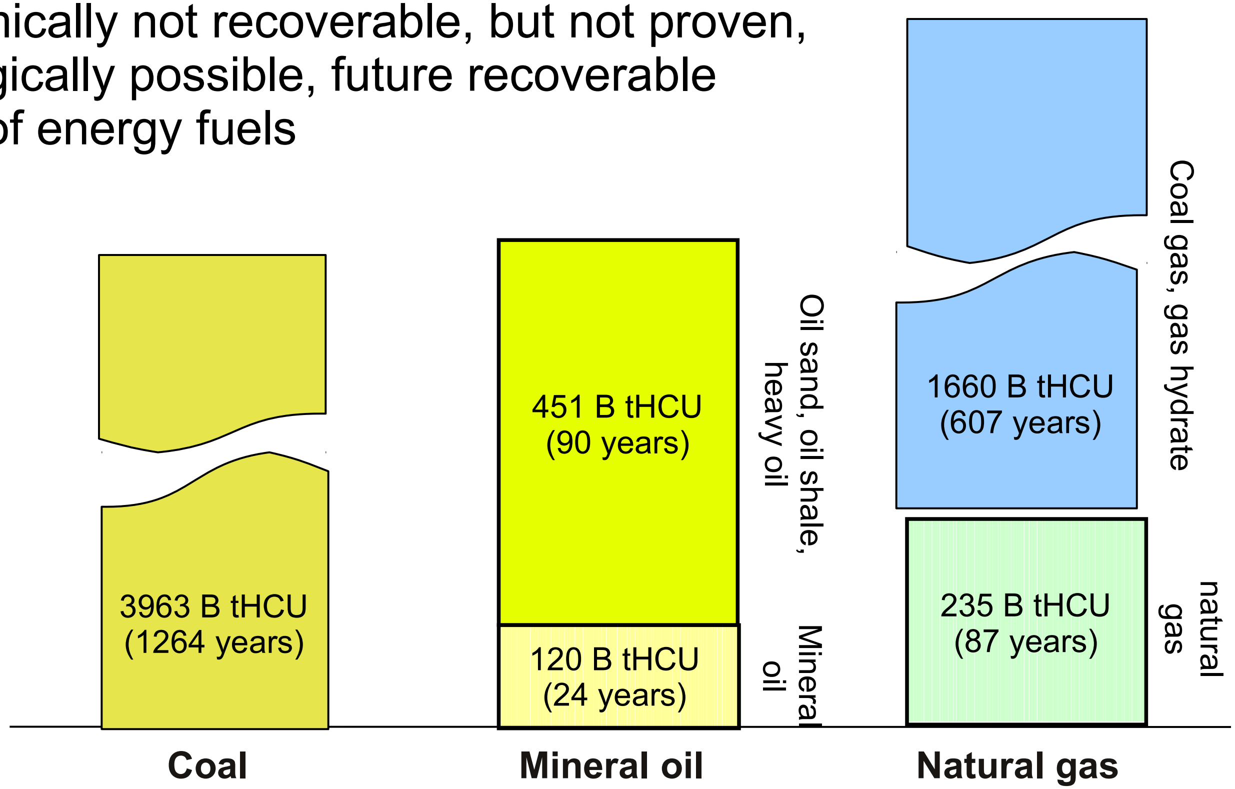
Resources: Proven, but currently technically and/ or economically not recoverable, but not proven, but geologically possible, future recoverable amounts of energy fuels



VGB: Climate stability of the EU-25 and worldwide

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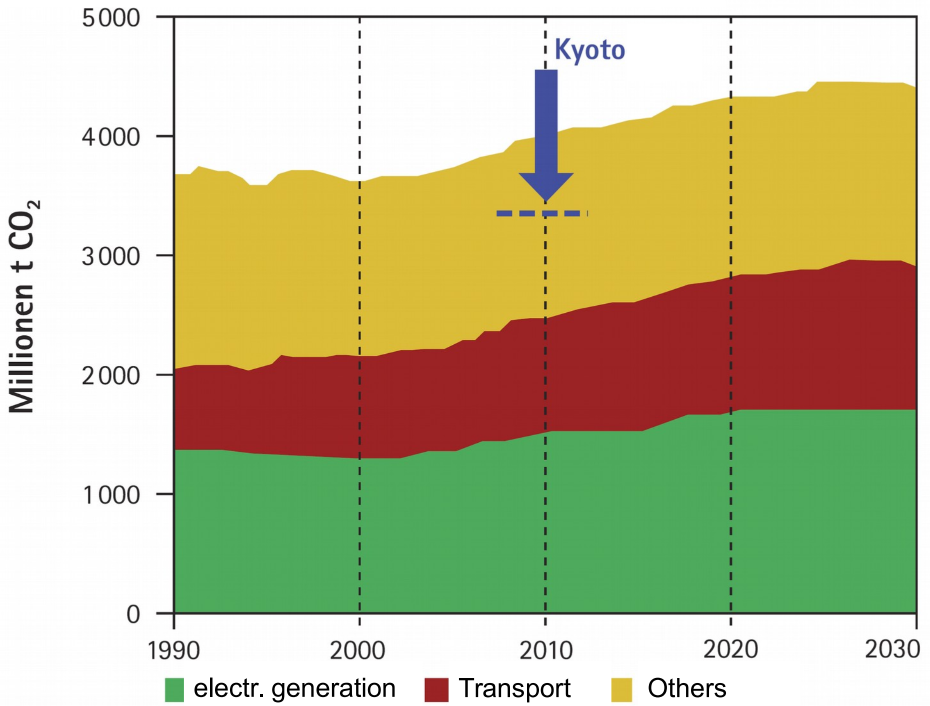
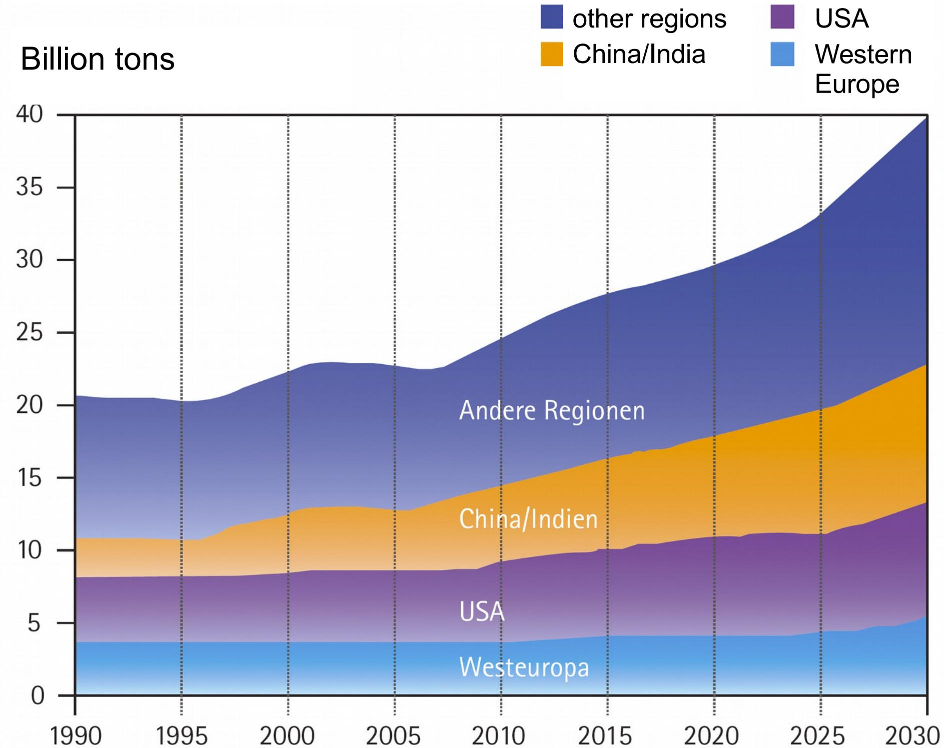
CO_2 – emissions in EU 25
1990 until 2030



Quelle: Energy Information Administration/International Energy Outlook 2004

CO_2 – emissions worldwide
1990 until 2030



Quelle: Energy Information Administration/International Energy Outlook 2004

Transformation of the Electrical Energy System: Motivation, Goals and Challenges

University Rostock
Prof. Dr. H. Weber

Motivation:

- → Replacing fossil fuels with renewable energy sources
  - Massive reduction of CO2 emissions
- → No further production of radioactive waste
  - Exclusion of risk of nuclear accidents such as Fukushima 2011

Goals:

- Reduce CO2 emissions in Germany by 80% by 2050
- Nuclear energy exit until 2022
- Increase the share of renewable energies from today 18% to 40% in 2020 and to 80% to 2050

Challenges:

- Maximum possible direct use of regenerative energy
- Maximum utilization of existing potentials
- Because of losses only save as much as necessary
- Problems caused by the transmission of power over long distances
- Balancing the intermittent feed-in with thermal power plants
- Ensuring security of supply and system stability

Entwicklungstrend von Windkraft-nutzung und Photovoltaik in Deutschland

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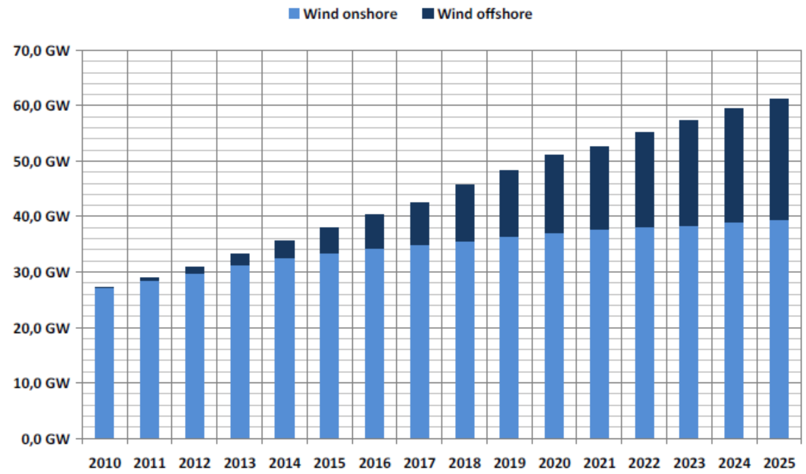
Spitzenlast Deutschland: ca. 80 GW (konstant bleibend erwartet)

Erwartete installierte Leistung bis 2025

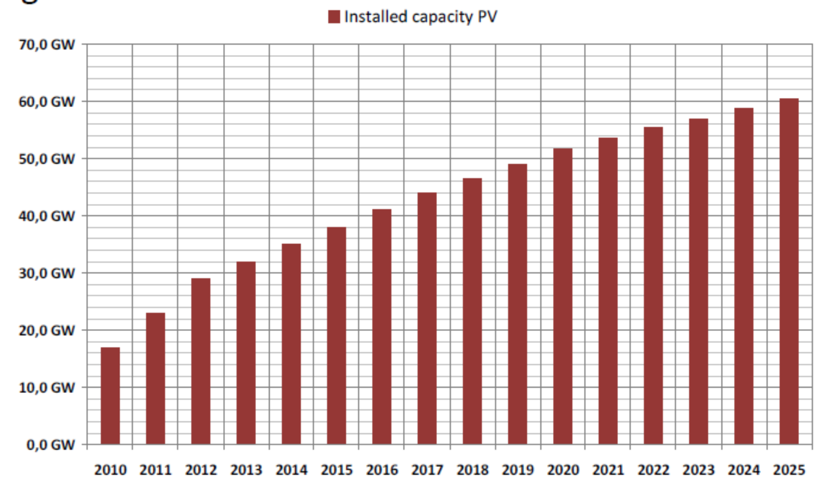


Installiert 2020:

Wind **PV**

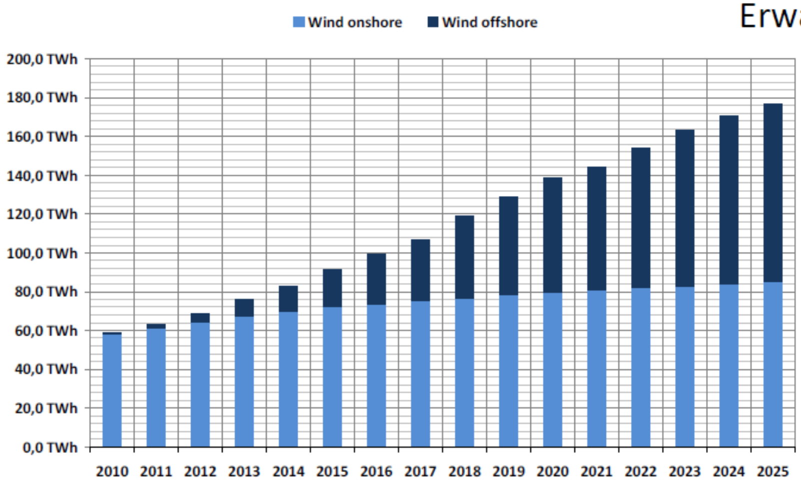
51,0 GW + 51,7 GW

Σ 102,7 GW



Stromverbrauch Deutschland 2011: app. 600 TWh (konstant bleibend erwartet)

Erwartete "erntbare" Arbeit bis 2025

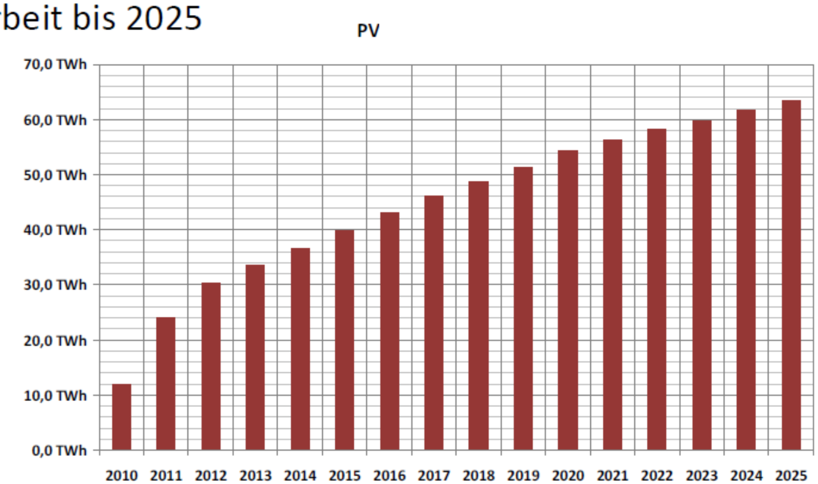


Ertrag 2020:

Wind **PV**

138,8 TWh + 54,2 TWh

Σ 193 TWh



Charakteristik der intermittierenden und anderer nicht-dispatchbarer Erzeugung

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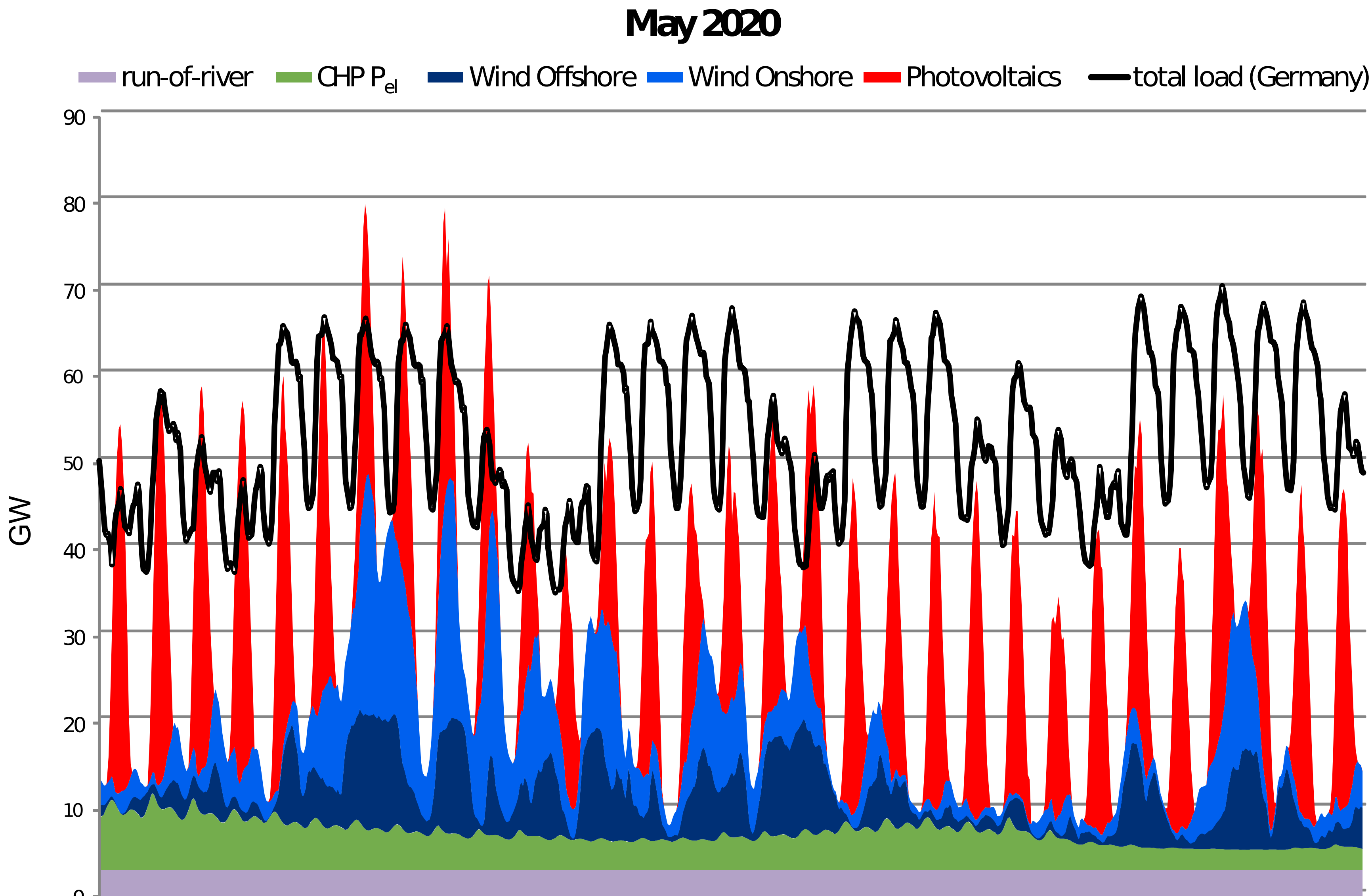

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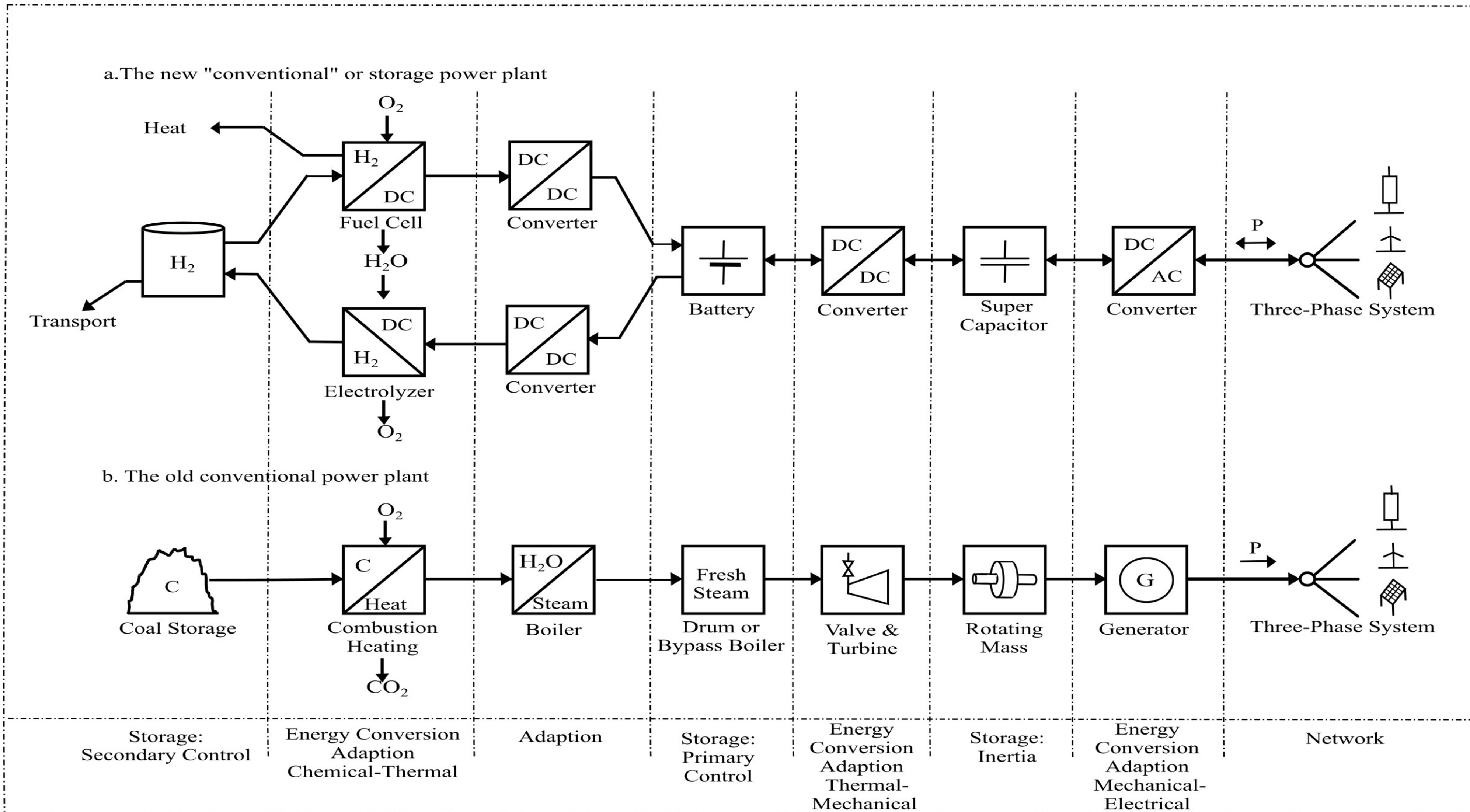

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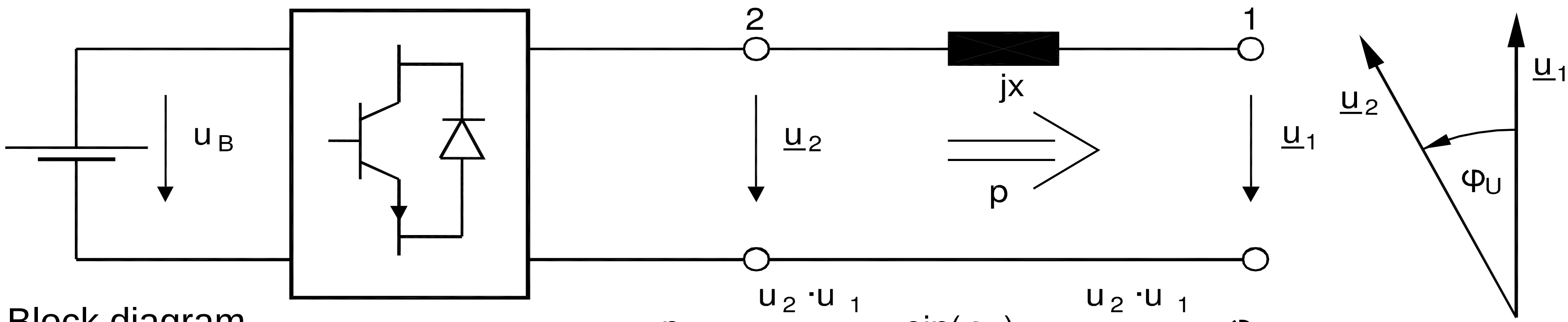
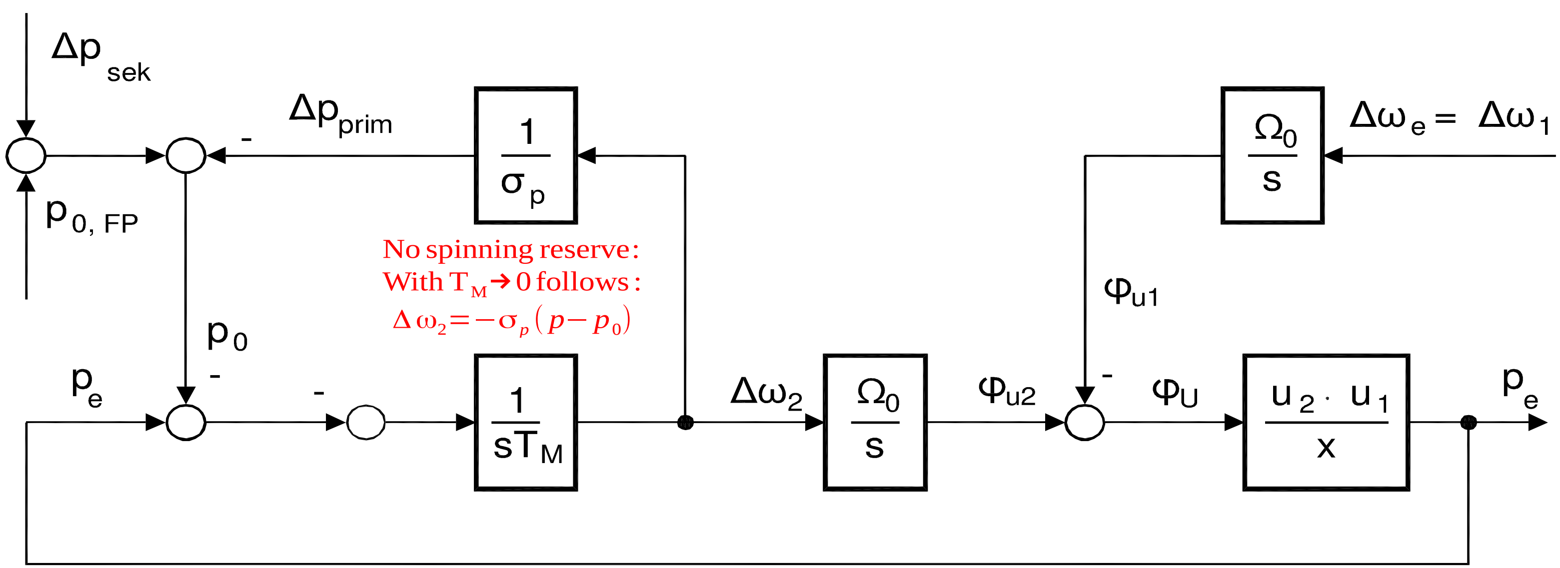
a. Circuit diagram



$$p = \frac{u_2 \cdot u_1}{x} \cdot \sin(\varphi_U) \approx \frac{u_2 \cdot u_1}{x} \cdot \varphi_U$$

b. Block diagram



Synthetic generation of Instantaneous reserve, Primary and Secondary control Power at the storage power station

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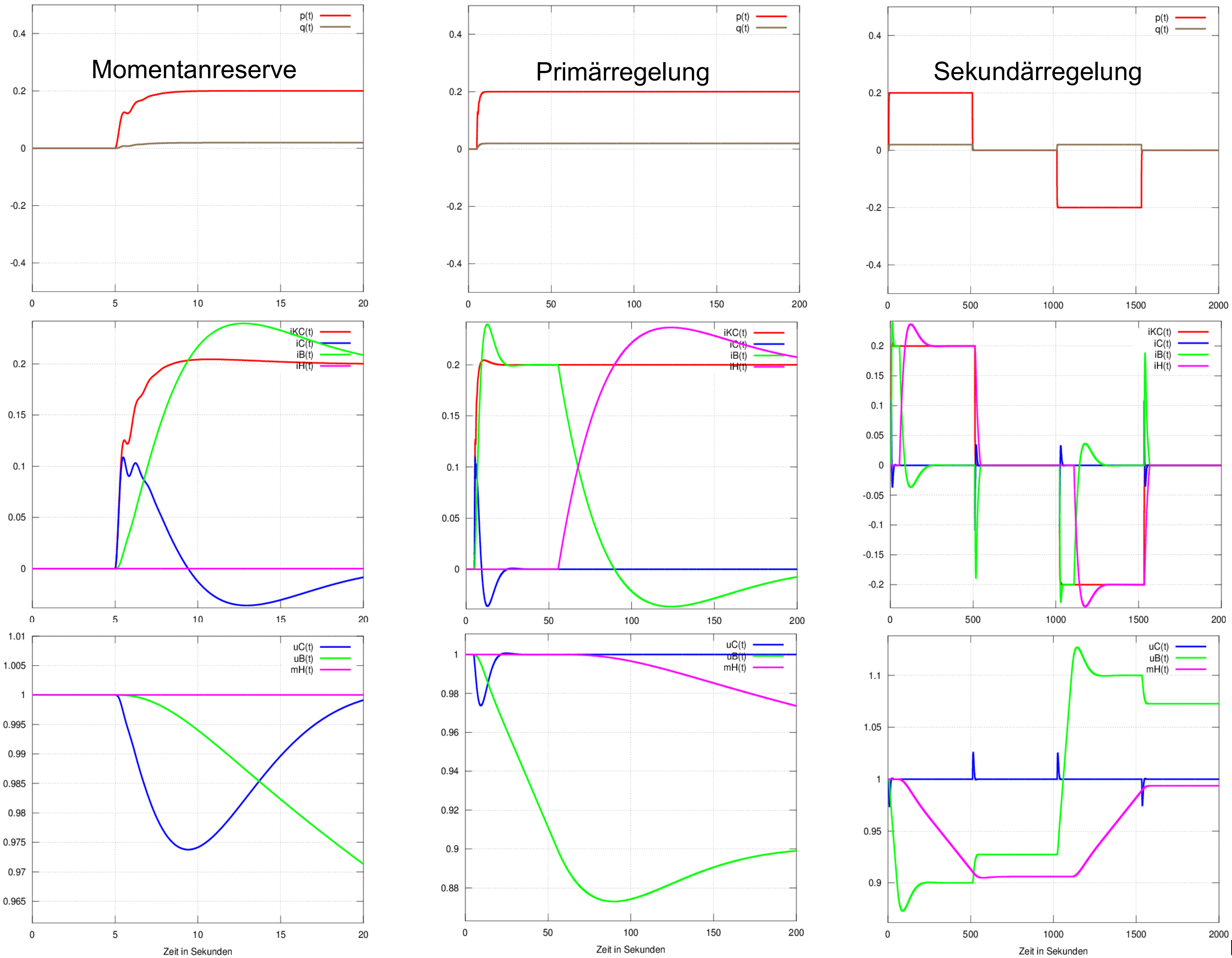
Leistungsan-forderung Netz:

Leistungsbereit-stellung Speicher:

Energieinhalte Speicher:



25-node example network (5 Slack, 6 PV and 14 PQ nodes each with 10 MW consumption)

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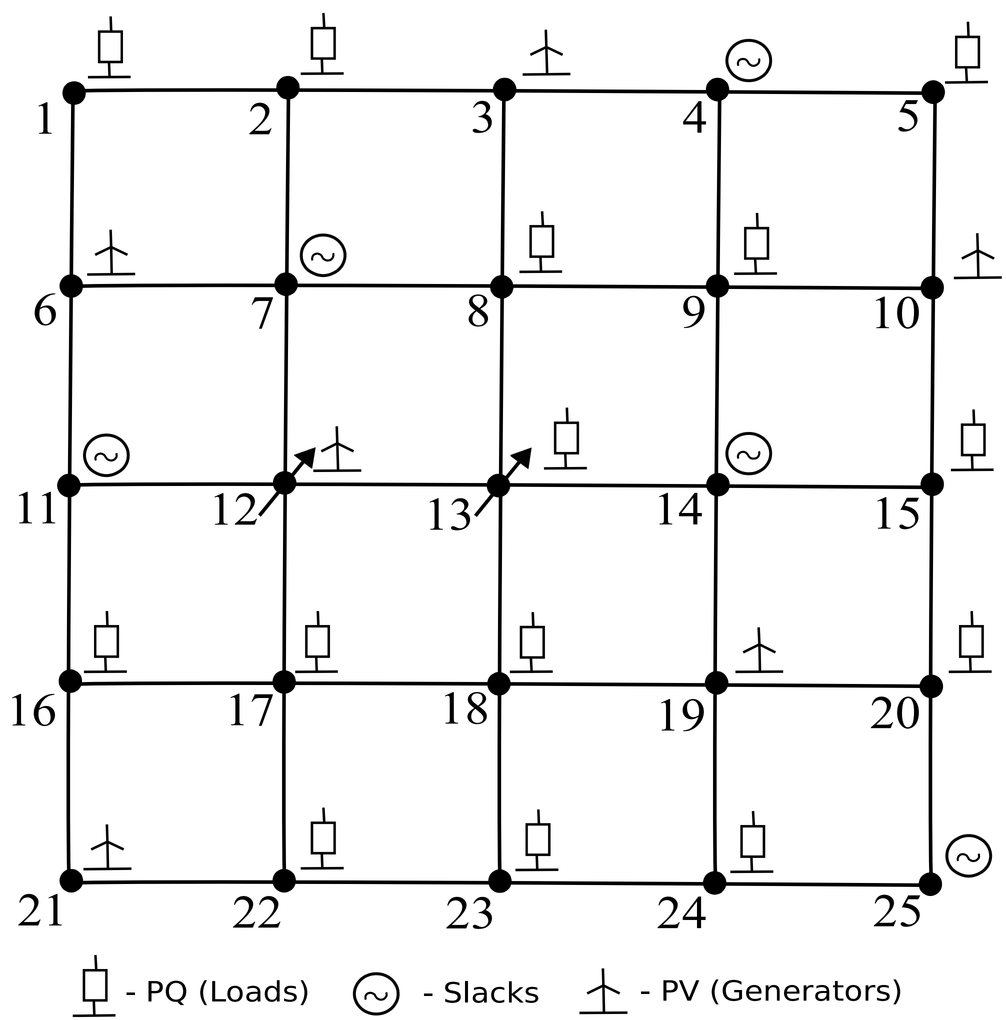
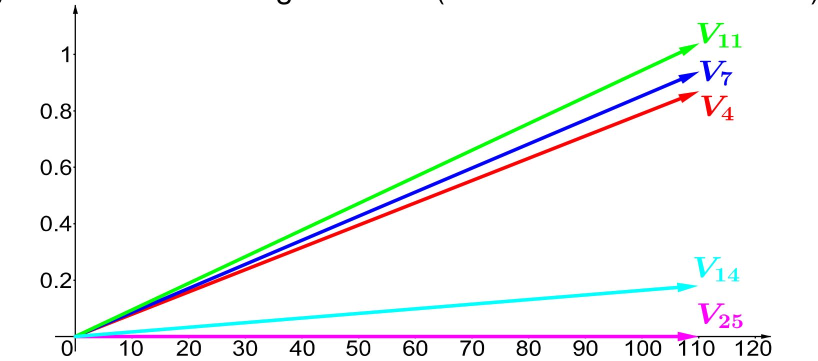
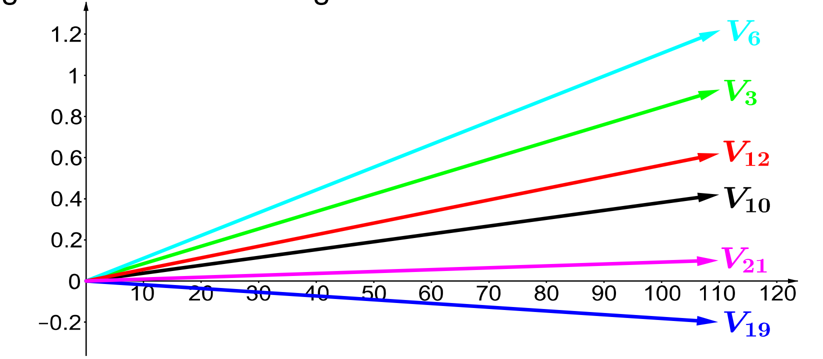
a. Network



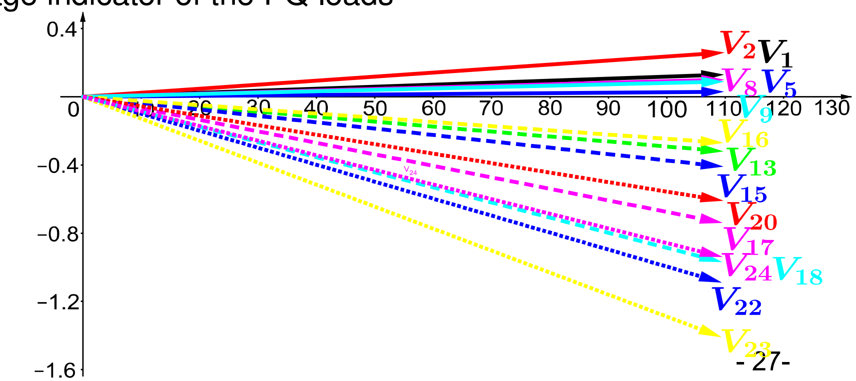
b. Voltage indicator of slack generators (initial load flow calculation)



c. Voltage indicator of the PV generators



d. Voltage indicator of the PQ loads



25-node example network: Consumption increase at node 13 from 10 MW to 110 MW in 10 steps

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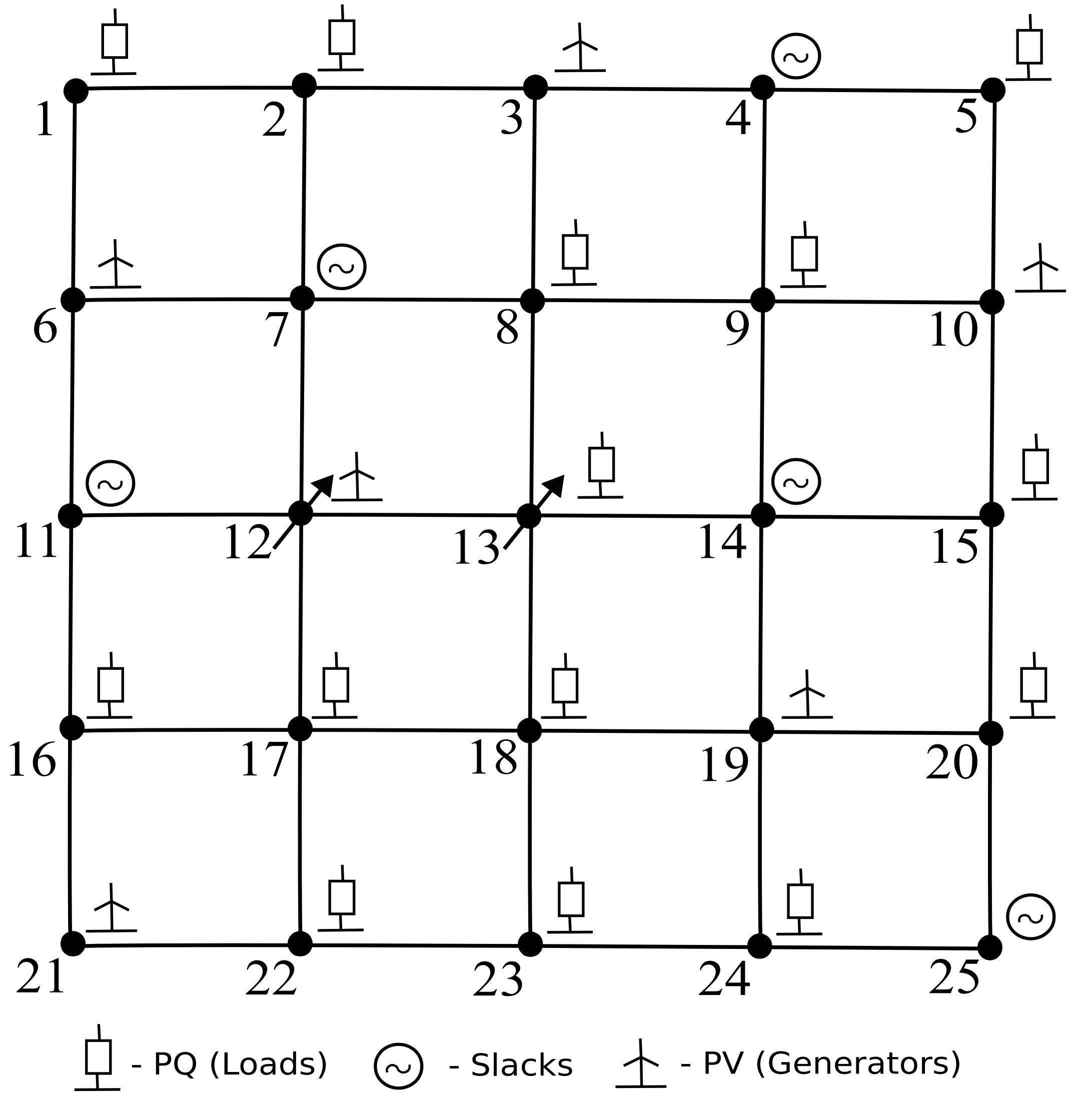
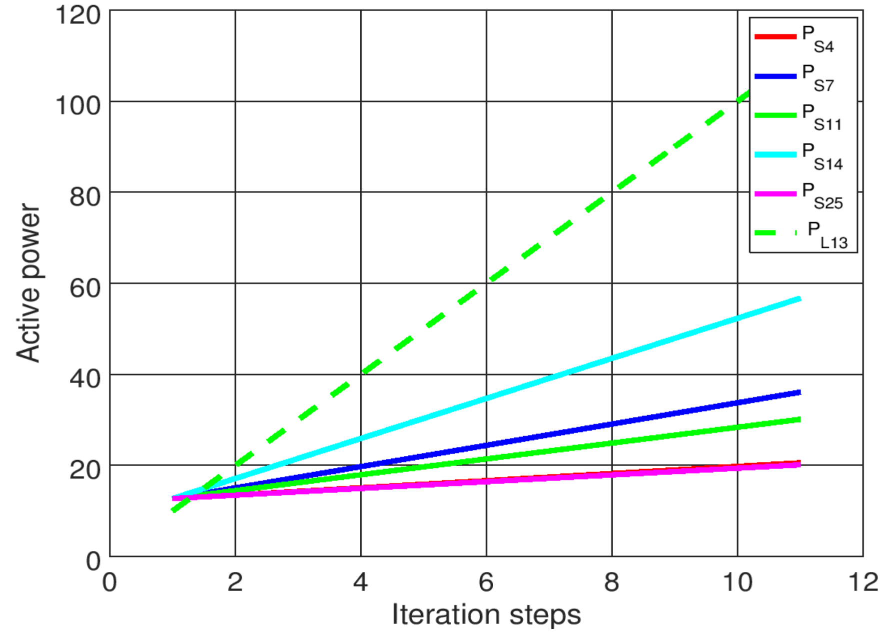
a. Network



b. Power Consumption in Consumer nodes 13 and Slack-storage power plants



25-node example network: Consumption increase at node 13 from 10 MW to 110 MW in 10 steps

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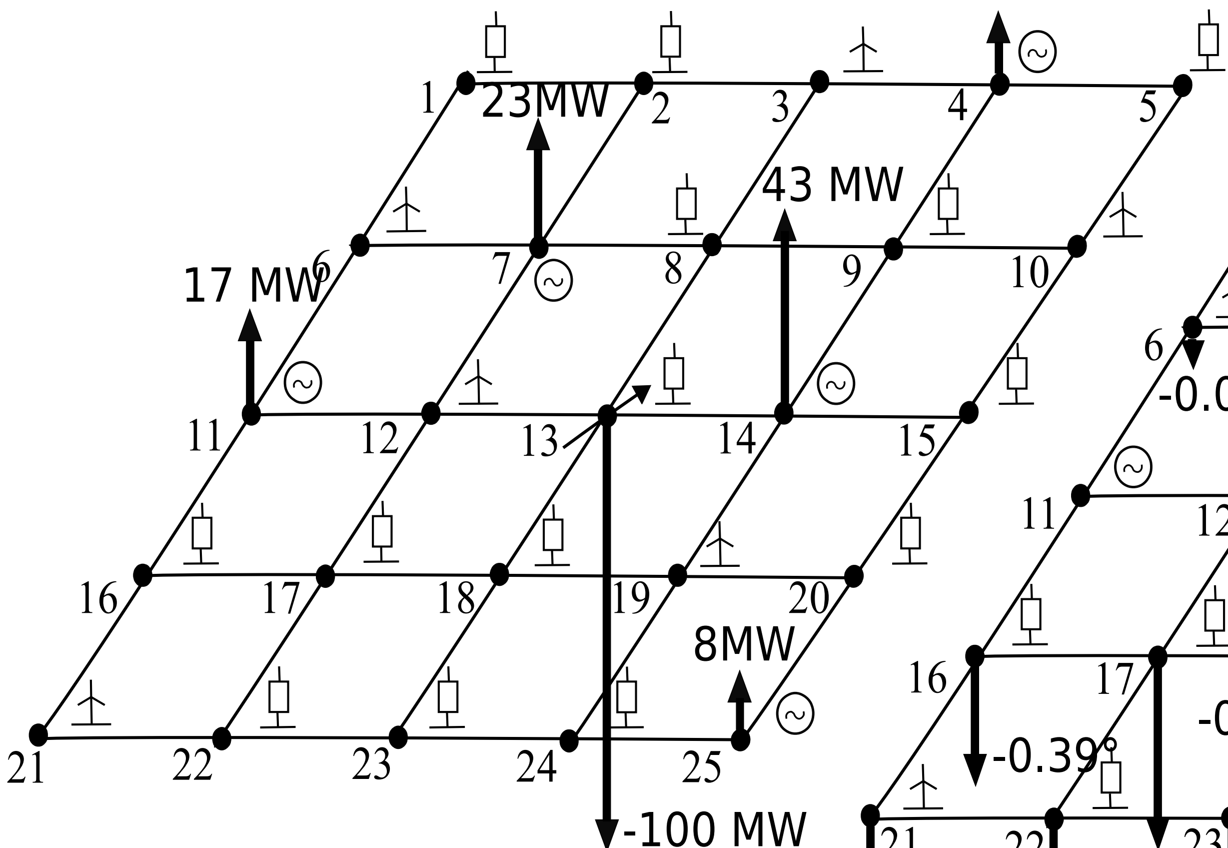
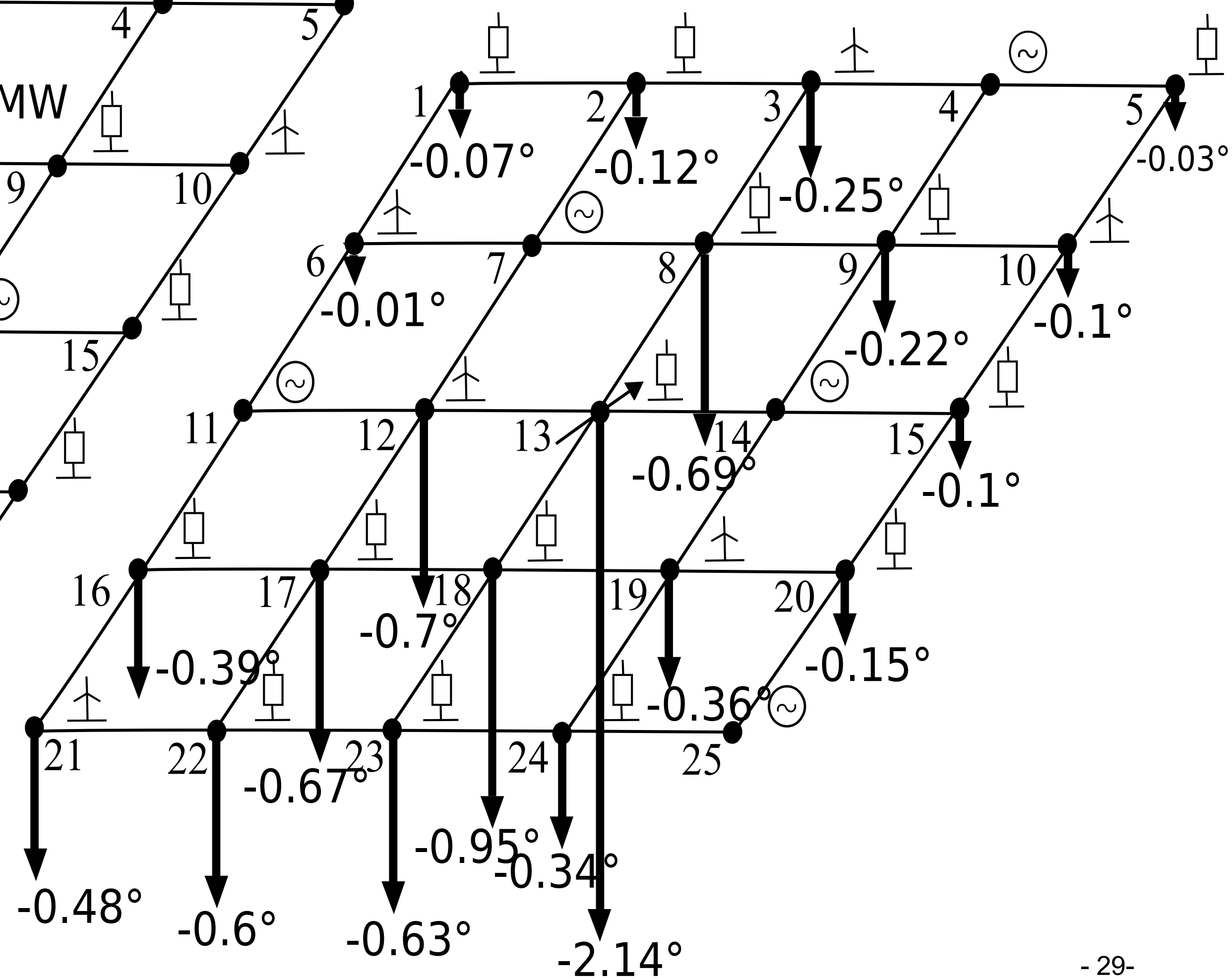
a. Increase in consumption in Node 13: Share of slack power plants at the power supply stage



b. Consumption increase in Node 13: Voltage angle change of the PV power stations and PQ loads



25-node example network: Feed-in increase at node 12 from 15.6 MW to 115.6 MW in 10 steps

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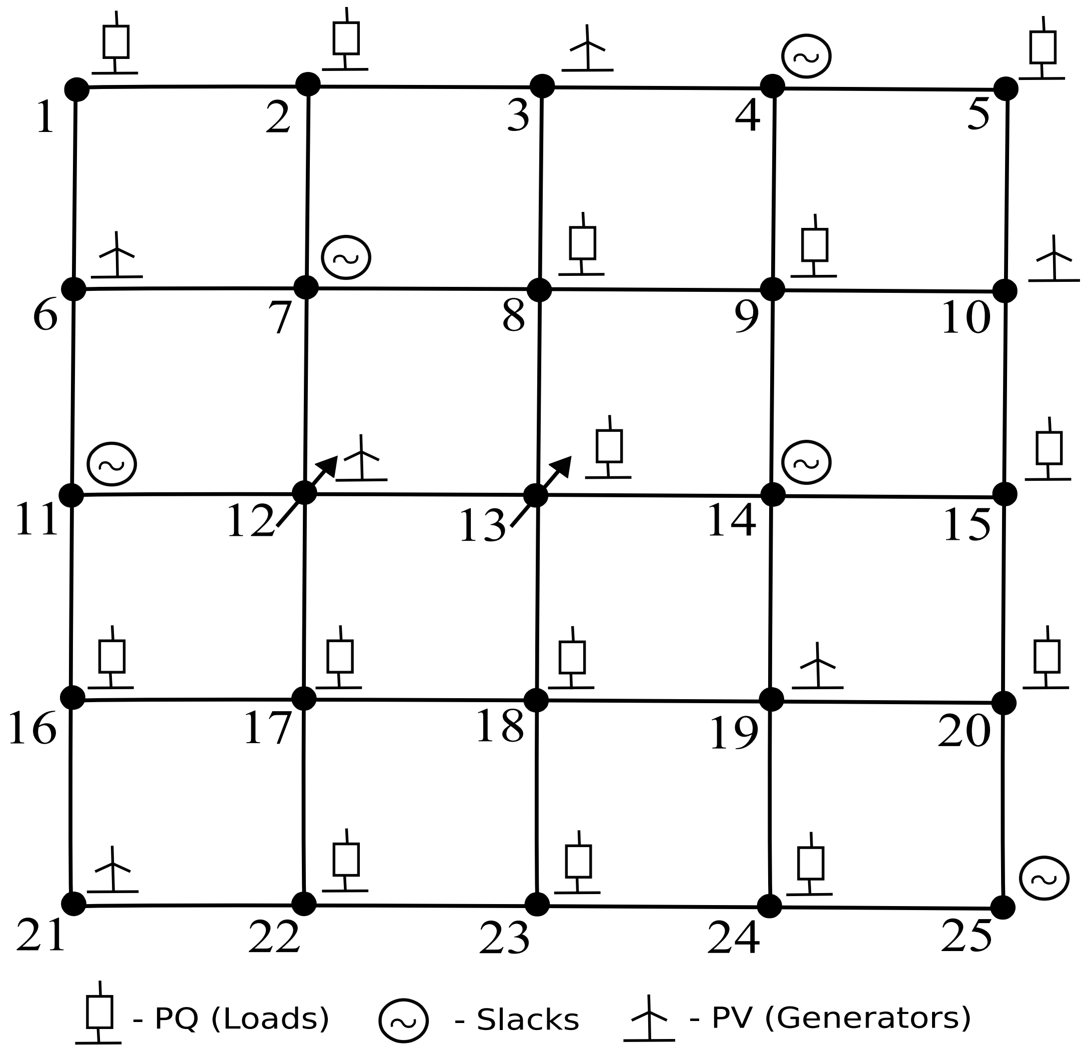
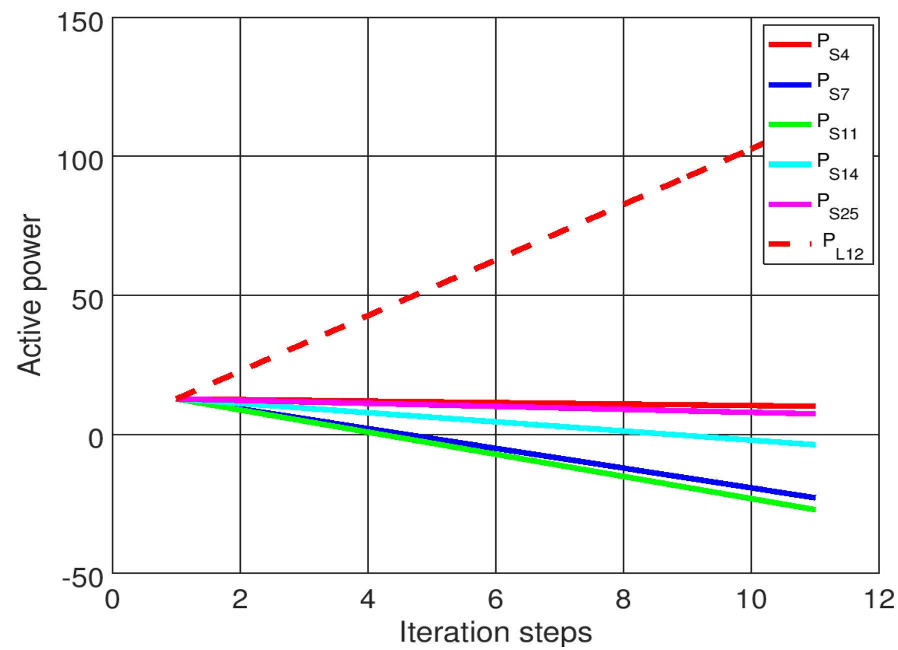
a. Network



b. Performance of PV power station (wind power) Node 12 and Slack storage power plants



25-node example network: Feed-in increase at node 12 from 15.6 MW to 115.6 MW in 10 steps

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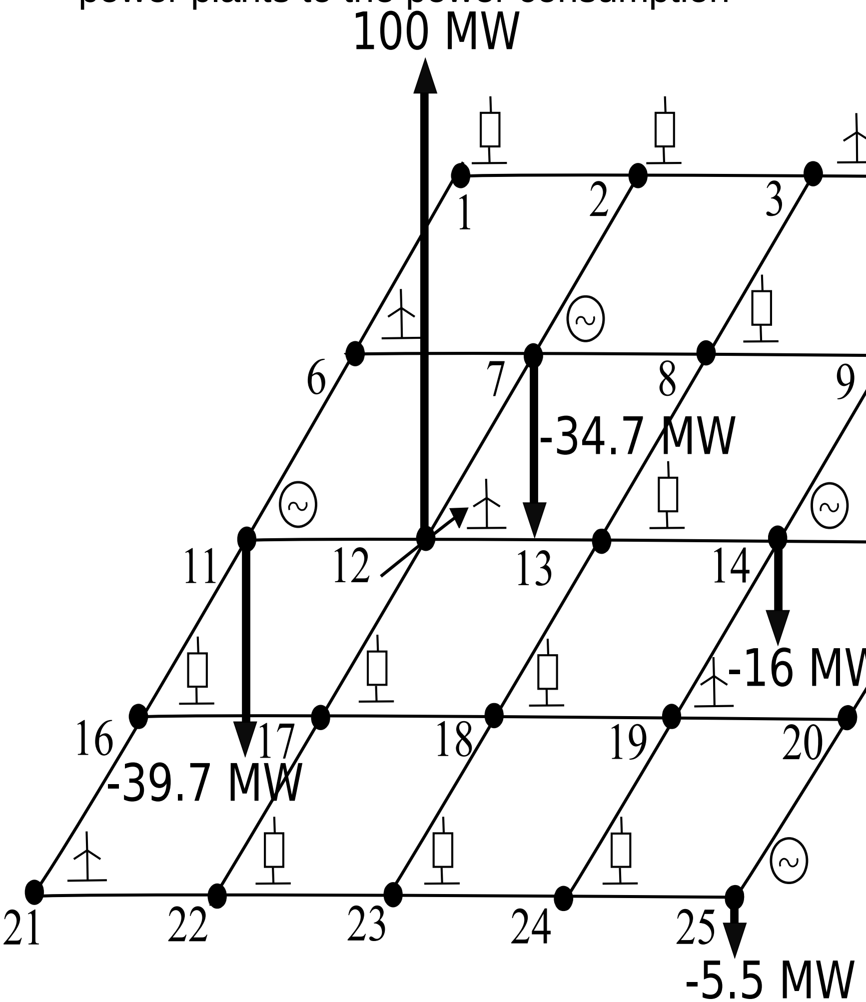
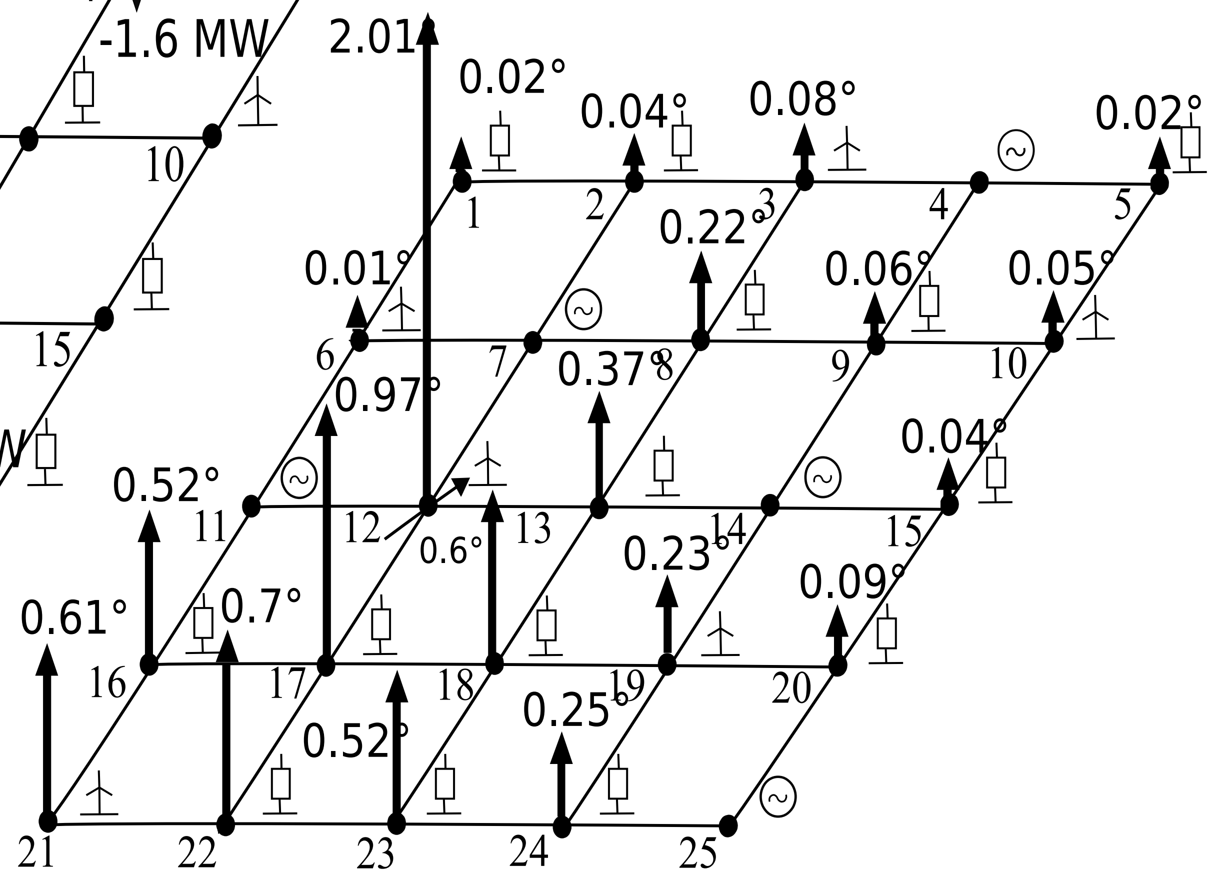
a. Generation increase in Node 12: Proportion of slack power plants to the power consumption



b. Generation Increase in Node 12: Voltage Pointer Angle Change of PV Power Plants and PQ Loads



Der Untergang der Vasa oder
die Folgen nicht umgesetzter Einsichten

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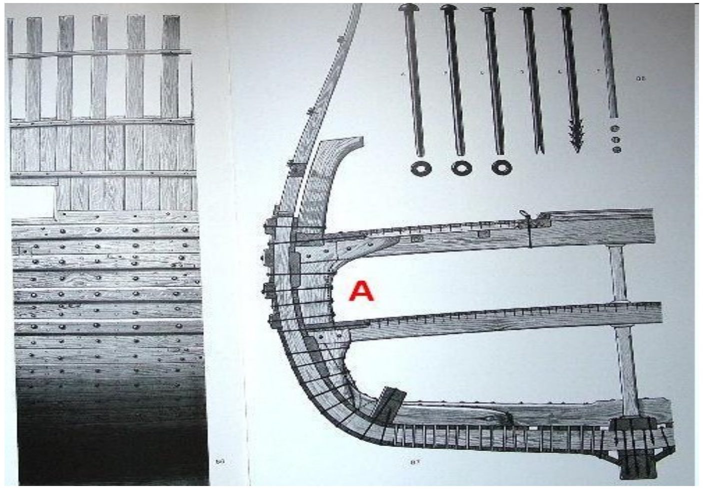
Das Schiff:

Der Fehler:



Der Weg:

Das Ende:

Thank you for your attention!