Flexibility is Key in Germany’s Energy System

Dr. Claudia Weise

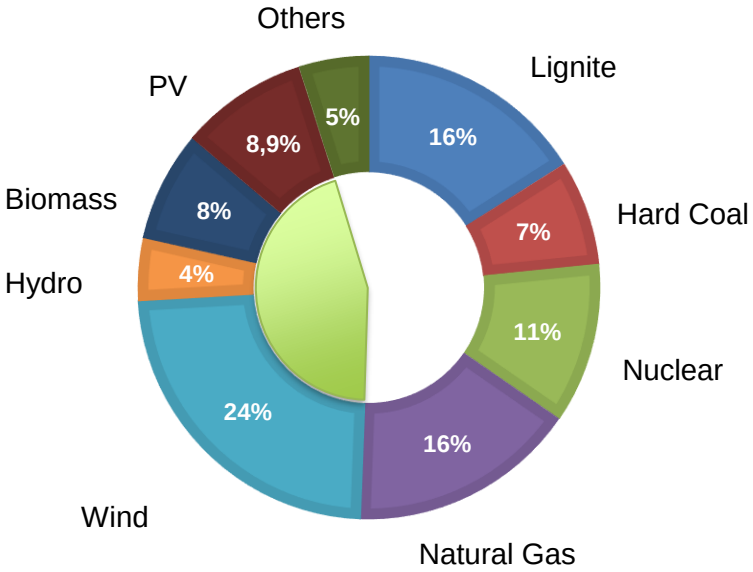
September 2021

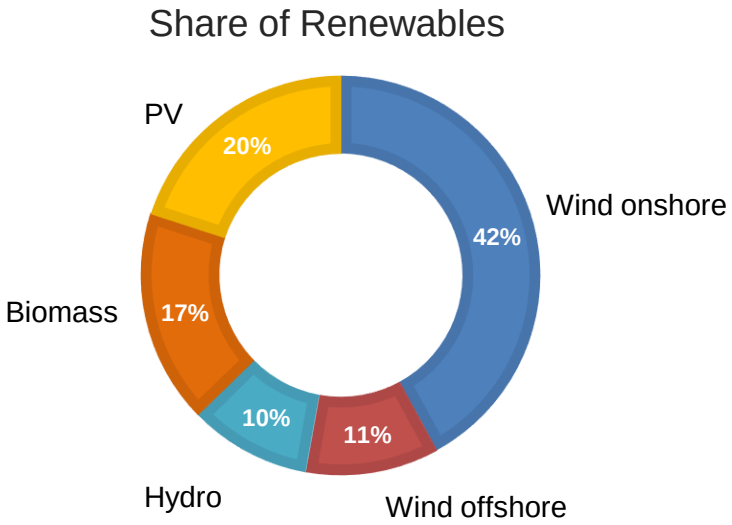
Agenda

1. **Electricity Mix**
2. Energy Market Design
3. Flexible Thermal Power Plants
4. Outlook and Perspectives
5. Key Take Aways

German Power Generation in 2020

Gross generation: 574 TWh
Installed capacity: 229 GW, 128 GW Renewables
Import/Export: 23.6 TWh/48.8 TWh (2019)

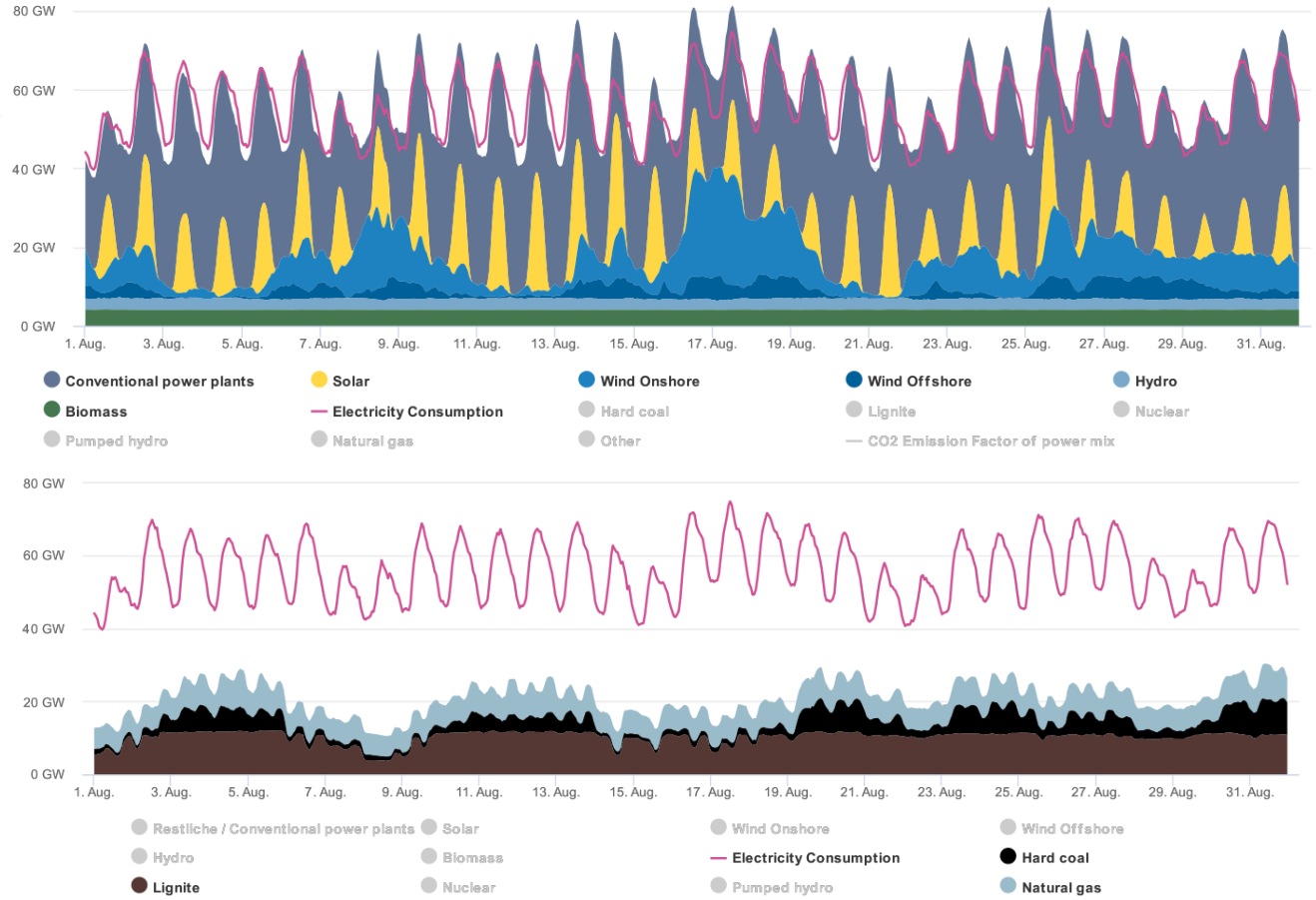




Source: AG Energiebilanzen

The share of renewables accounted for almost 45 per cent in gross electricity generation – wind is the main energy source.

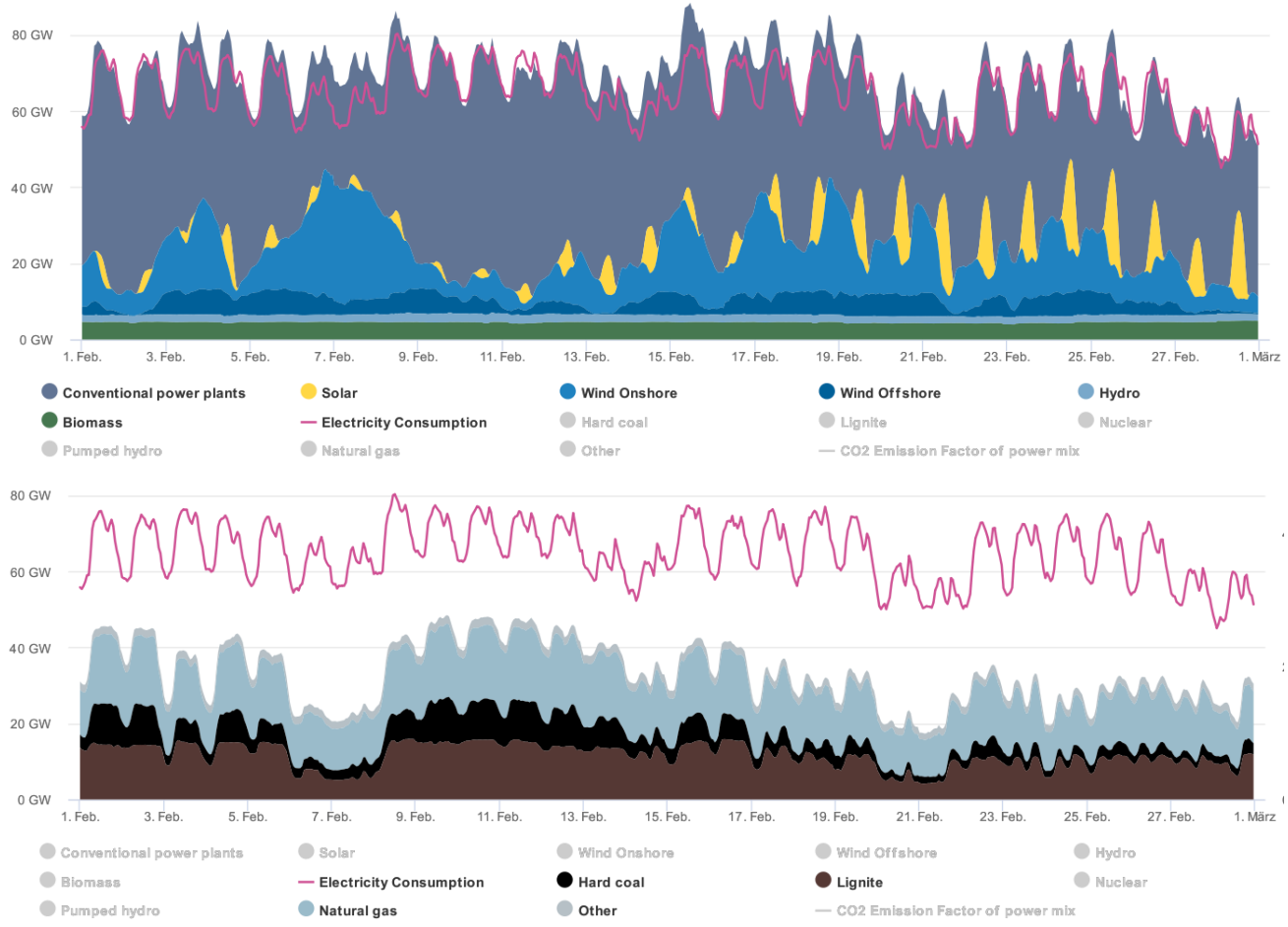
Generation Mix in Summer



August 2021

Source: Agorameter

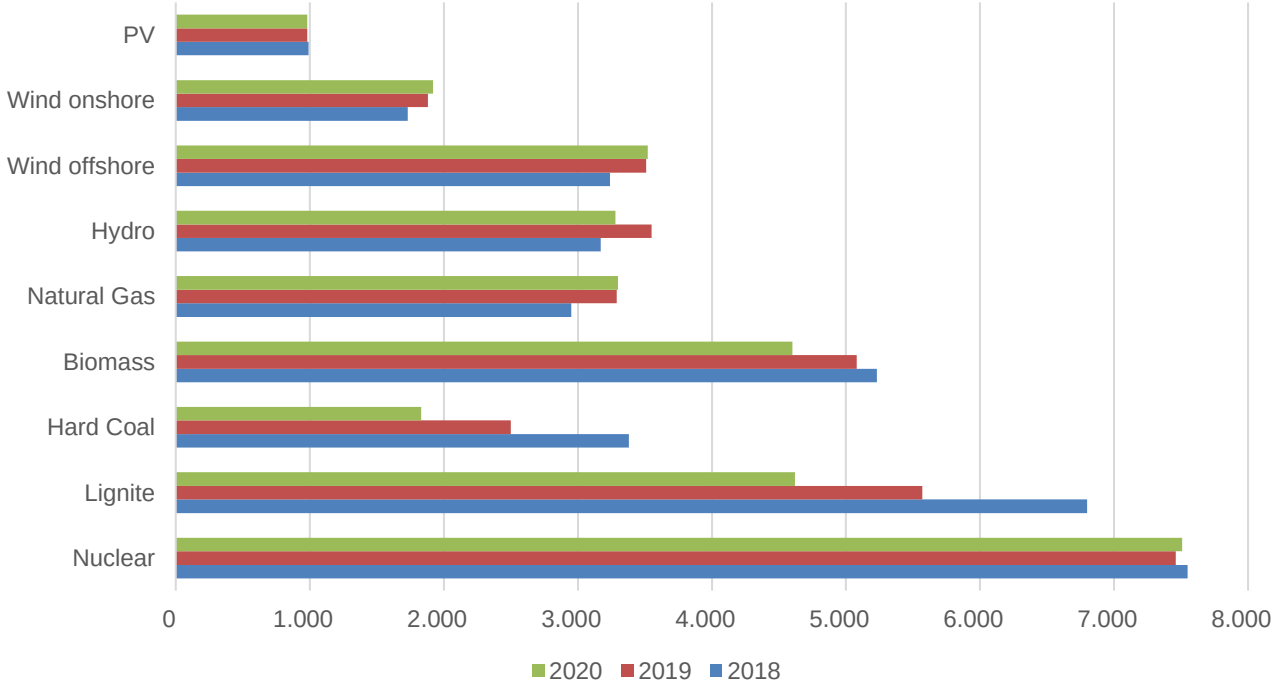
Generation Mix in Winter



February 2021

Source: Agorameter

Full Load Hours of German Plants



Data source: BDEW

Agenda

1. Electricity Mix
2. **Energy Market Design**
3. Flexible Thermal Power Plants
4. Outlook and Perspectives
5. Key Take Aways

Market Design in Germany

Market based

- Energy-only-market
- Balancing power market

Non-market – security of supply

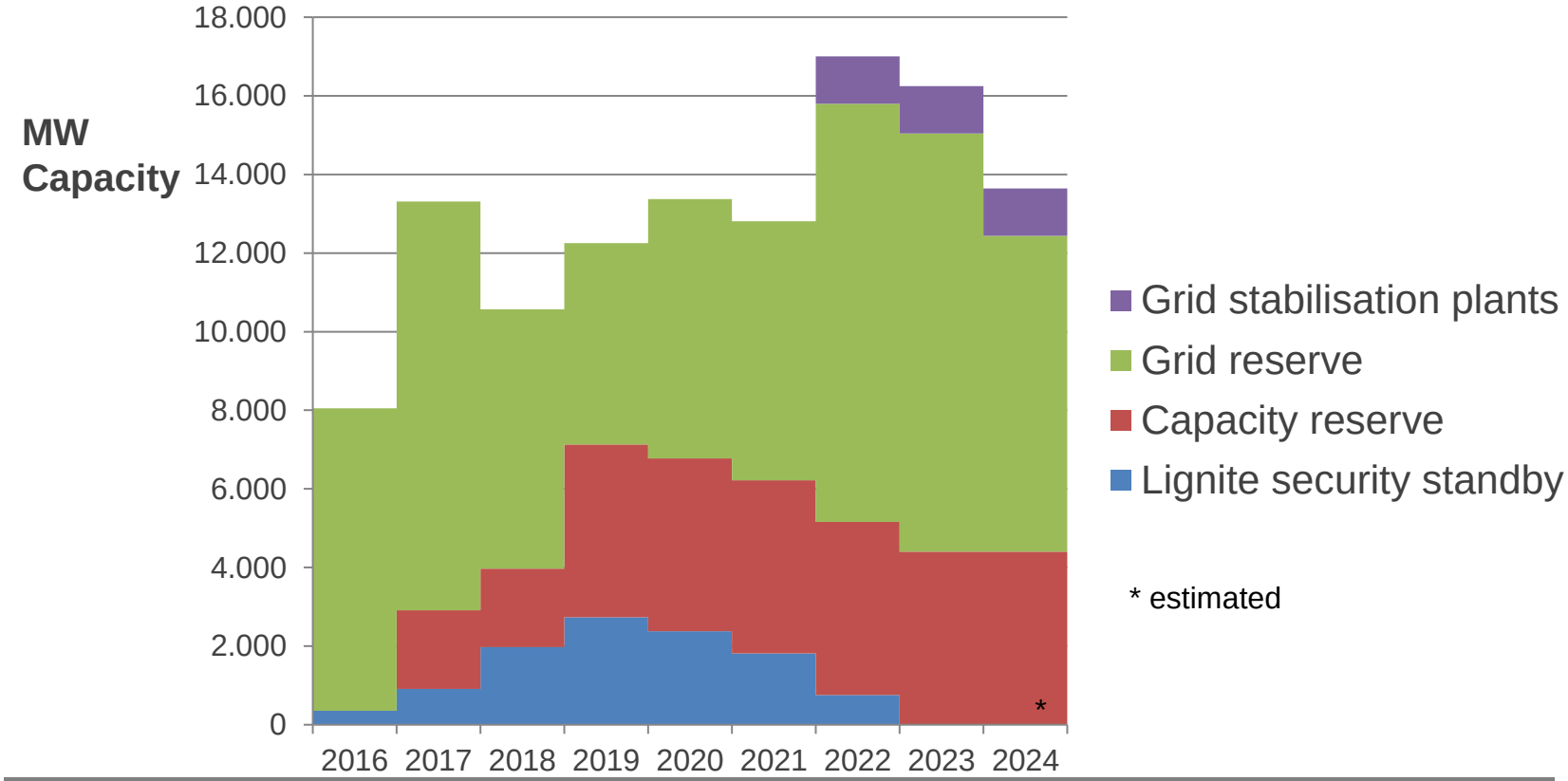
- Grid reserve
- Capacity reserve
- Grid stabilisation plants
- Safety disposition (security standby lignite)

Market Design in Germany

Area	Energy	Congestion management	Balancing power	Other ancil-lary services	Capacity
Market products	▪ exchange spot market with day ahead products and intraday tra-ding in 15-min. blocks ▪ OTC (over the counter)		▪ primary control ▪ secondary control ▪ Minute reserve ▪ sheddable loads		
Non-market measures		▪ redispatch of conv. plants ▪ reserve plants ▪ curtailment of VRE		▪ reactive power ▪ black start capability/ power system restoration	▪ additional capacity/ +safety disposition
Involved disp. gen. capacity	**~ 86.4 GW** (conventional)	**~ 5.9 GW**	**7,400 MW**	**~ 30,000 MW** (demand for reactive power)	**~ 5,000 MW**

Source: Bundesnetzagentur, Monitoring-Bericht 2020

Market Design in Germany

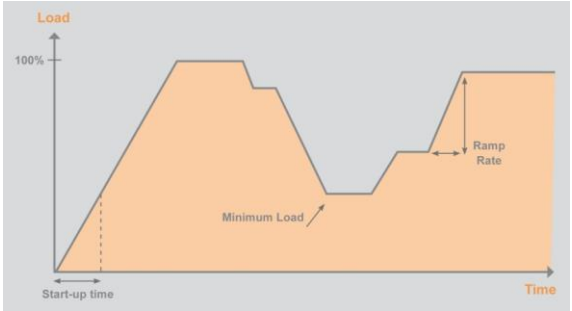


German politics favors Energy Only Market. In order to ensure system stability and capacity adequacy different reserve mechanisms are in place.

Agenda

1. Electricity Mix
2. Energy Market Design
3. **Flexible Thermal Power Plants**
4. Outlook and Perspectives
5. Key Take Aways

Flexibility of Dispatchable Generation



Low Minimum load

- important for the provision of residual load and for fast start up in case of high demand (e.g. two-shifting)
- more economic than shut-down of the whole plant

High ramp rates

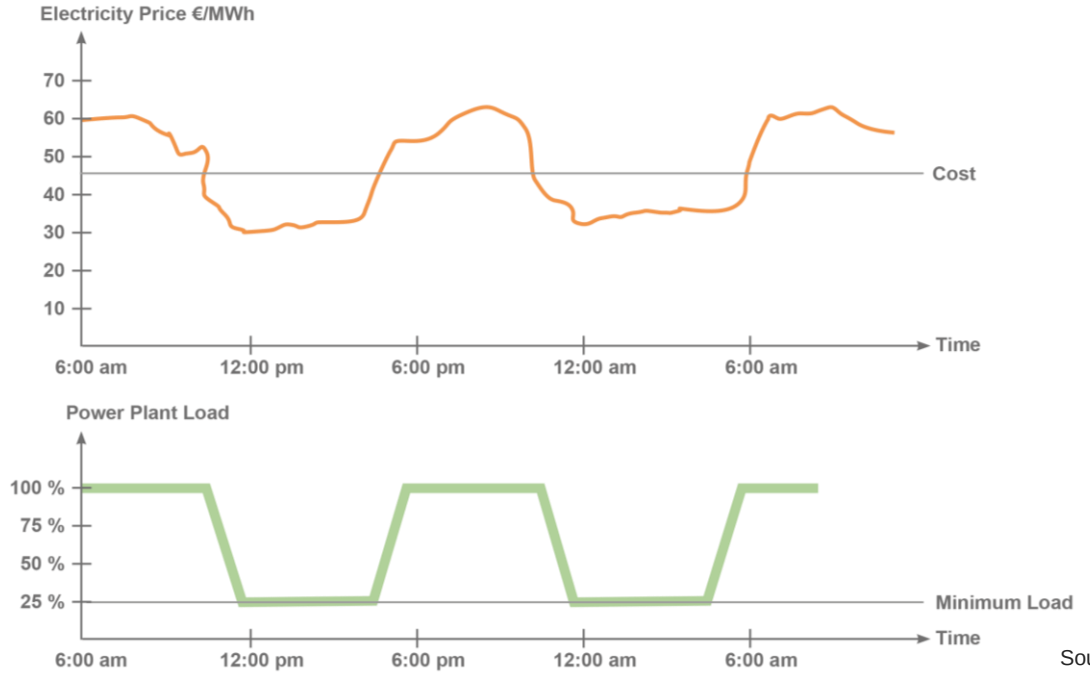
- high ramp rates ensure a fast reaction to changed market condition
- power plants with dynamic behaviour can participate in different markets

Short start-up and shut-down time

- short start-up and show-down times are beneficial to reduce cost
- thermal stress during start/stop is most severe w.r.t. life-time consumption

Flexible operation aims at achieving low minimum load, high ramp rates and fast start and stop time. Measures might contribute to one or more targets.

Minimum Load Operation in an Energy-Only-Market



Source: VGB on the basis of Hofbauer, T. (EnBW)

In an energy-only-market with high shares of variable renewables flexible operation is essential for the economic viability of the plant.

Flexibility Parameters of Thermal Power Plants

Plant type	Hard Coal	Lignite	CCGT
Ramp rate [% / min]	2 / 4 / 9	2 / 4 / 8	4 / 8 / 12
in the load range [%]	40 to 90	50 to 90	40* to 90
Minimum load [%]	40 / 25 / 10	60 / 40 / 20	50 / 40 / 30*
Start-up time hot start <8 h [h]	3 / 2 / 1	6 / 4 / 2	1.5 / 1 / 0.5
Start-up time cold start >48 h [h]	7 / 4 / 2	8 / 6 / 3	3 / 2 / 1

Source: VDE and own studies
Conservative / state of the art / very advanced; *as per emission limits for NO_x and CO
CCGT = Combined Cycle Gas Turbine Plant

Flexibilization as a Holistic Approach

Technology

- Ensure proper instru-mentation and condition monitoring
- Implementation of advanced control
- Adjustment of the key components or systems
- Replacement of components or systems

Processes

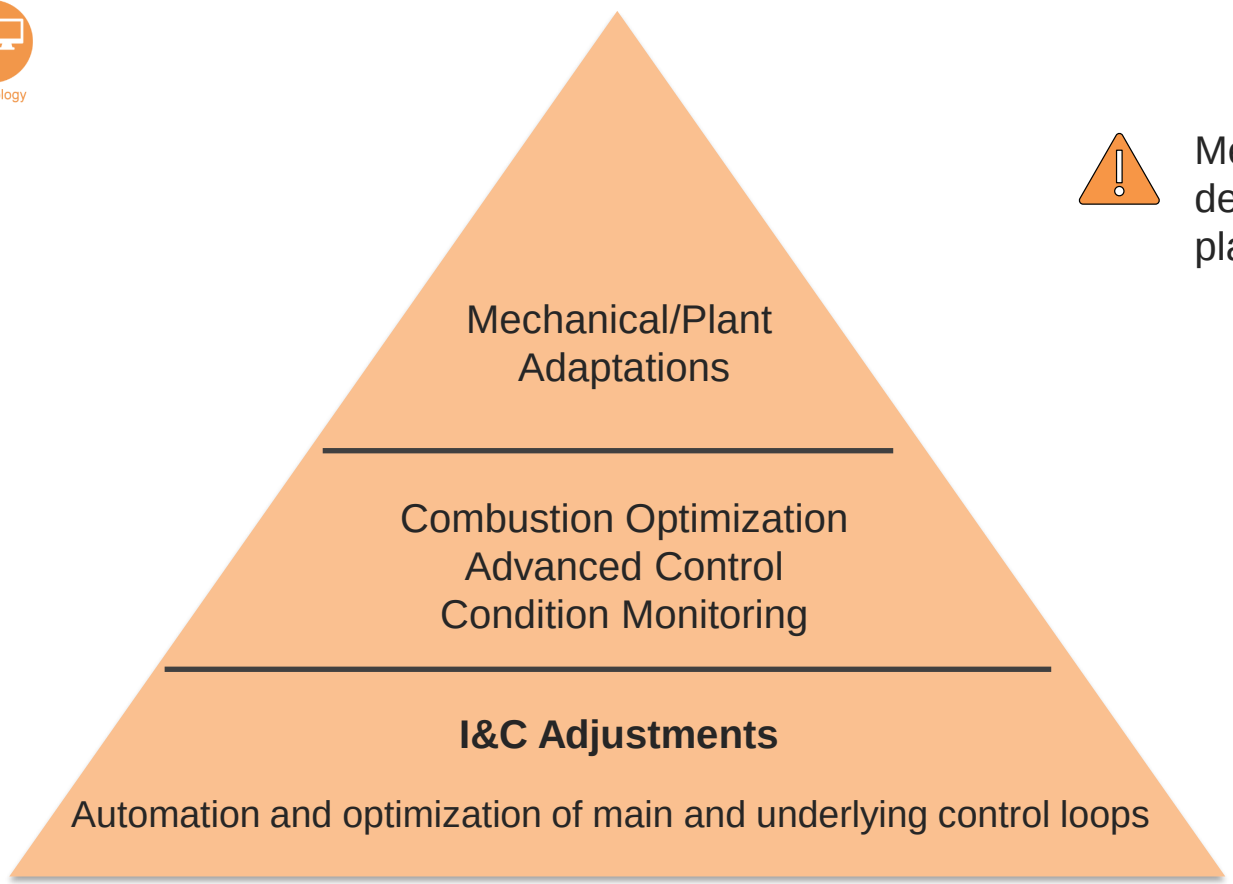
- Implement preservation concepts
- Adjustment of maintenance strategies
- Adjustment of shift-planning and staffing
- Re-assessment of coal-supply and by product strategies

Personnel

- Raise awareness for the need of flexibility
- Familiarize staff with new requirements arising from flexible operation
- Long-term training strategies for all types of personnel

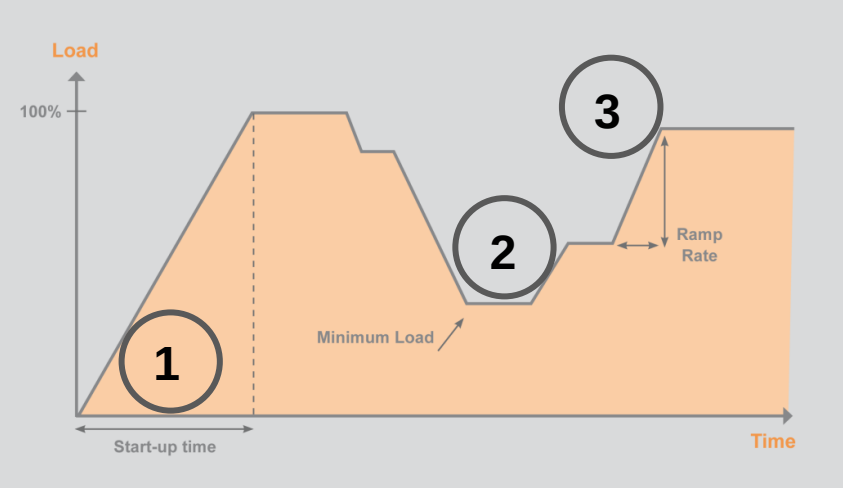
Measures for Flexible Operation

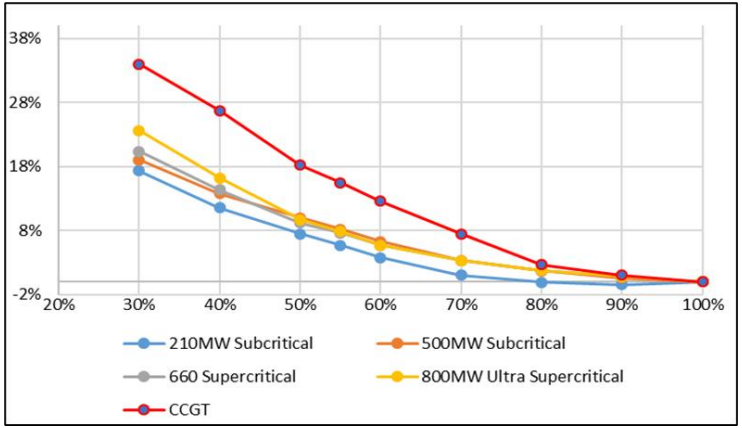
Technology



Measures need to be defined for each plant specifically.

Main O&M cost levers: fuel, personal and spare parts





Heat Rate Increase during Part/Minimum Load Operation
Sinha, Anjan: Recipe Book for the Flexibilization of Coal Fired Power Plants

(1) Start-up costs: The costs of start-up fuel and auxiliary power form a significant part of the total costs of cycling.

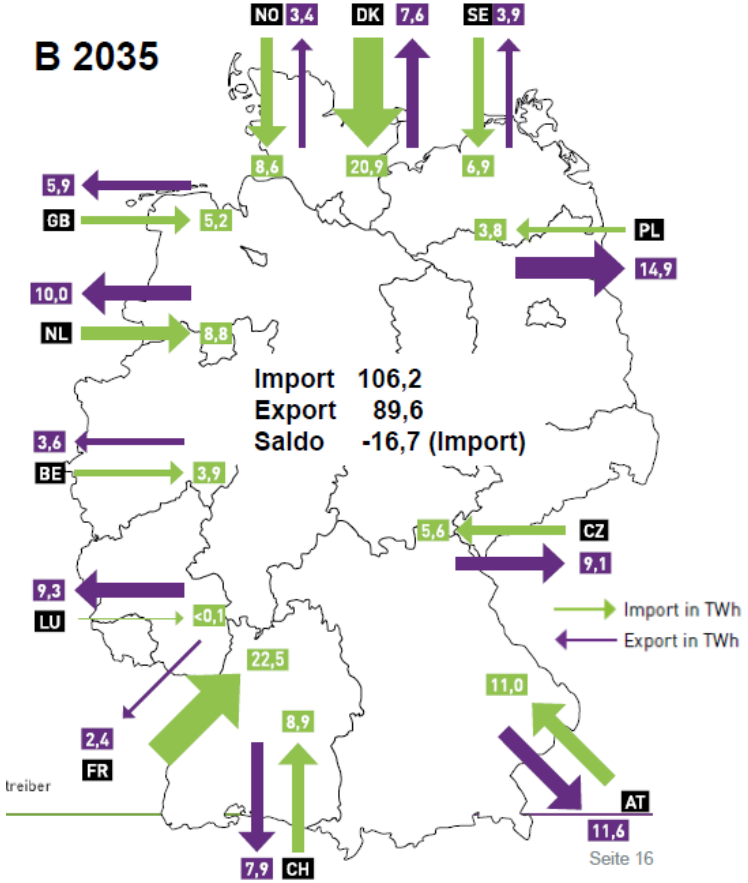
(2) Minimum load operation implies reduced efficiency resp. higher heat rates in part load operation which cause an increase in specific fuel consumption.

(3) Ramping and cycling increase thermal-mechanical stress on the equipment and thus require intensive inspection and monitoring.

Agenda

1. Electricity Mix
2. Energy Market Design
3. Flexible Thermal Power Plants
4. **Outlook and Perspectives**
5. Key Take Aways

Grid Expansion Plan until 2035



Assumptions:

Increase of Gross Electricity Demand: 650–700 TWh (+100–150 TWh)

Share of Renewables: 73 to 77 % mainly PV, off- and onshore wind

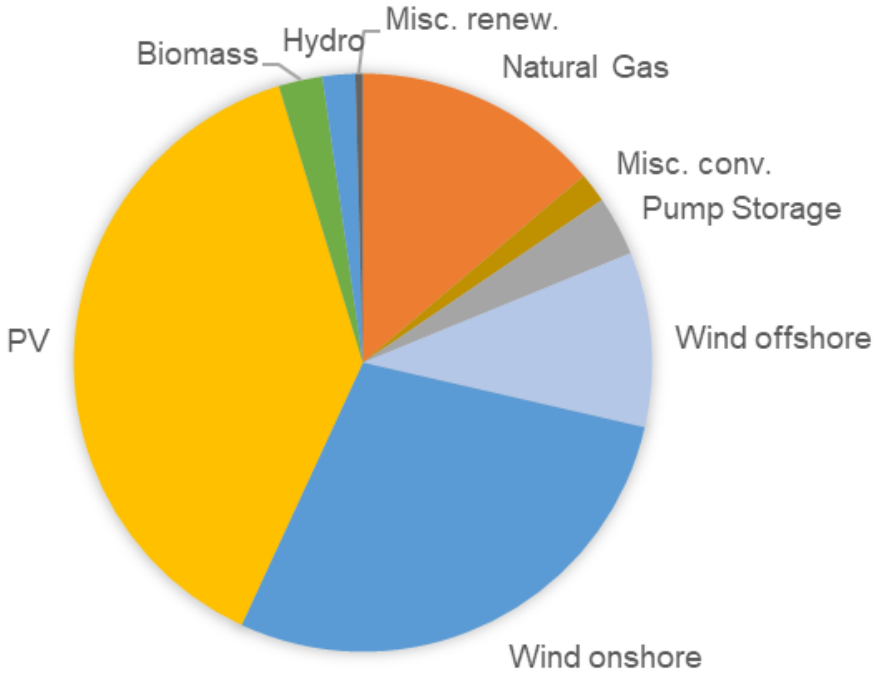
Conventional Power Plants: 3 GW coal in one scenario, 40 GW+ gas; highly flexible

CO_2-Emissions: max. 120 Mio. t CO_2 in 2035 und max. 60 Mio. t CO_2 in 2040

Source: www.netzentwicklungsplan.de

Energy Mix in 2035

Projections outlined in the grid expansion plan
Scenario B 2035

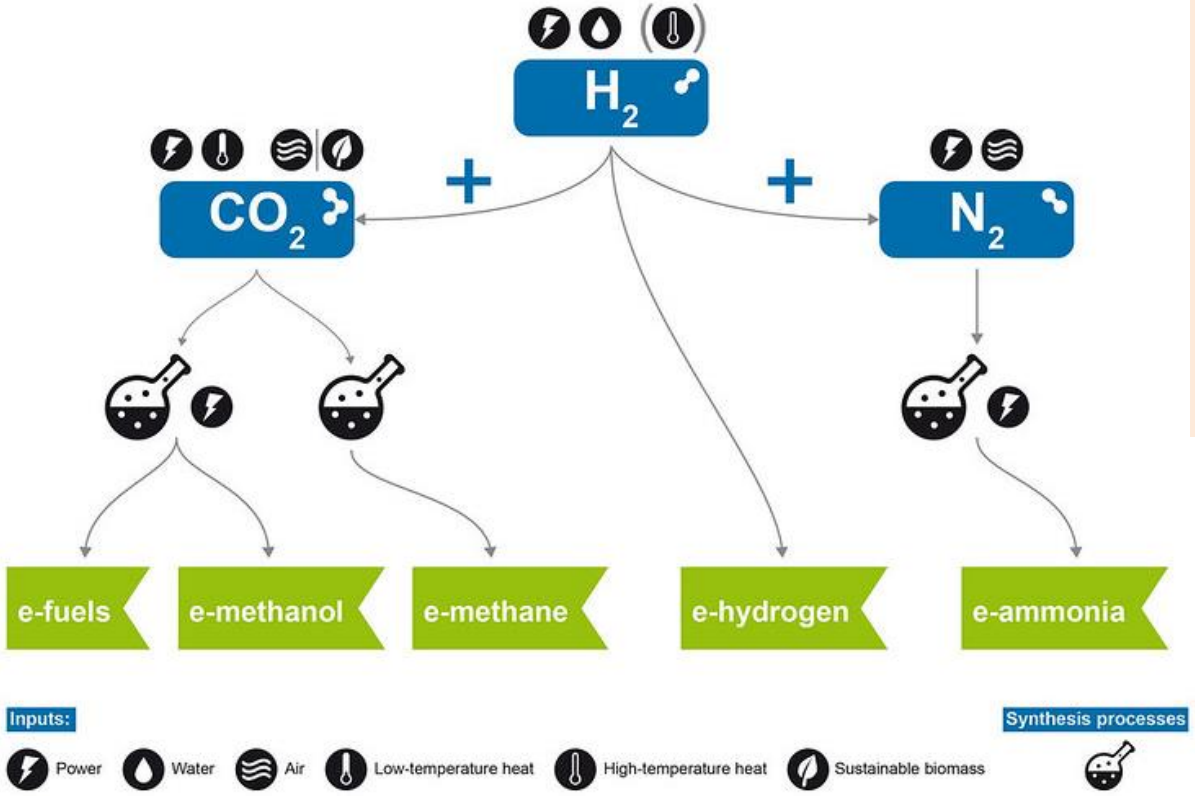


Installed capacity in GW

Natural Gas	42.4
Misc. conv.	5.1
Pump Storage	10.2
Wind offshore	30.0
Wind onshore	86.8
PV	117.8
Biomass	7.5
Hydro	5.6
Misc. renew.	1.3
Sum	**306.7**

Source: www.netzentwicklungsplan.de

Power-to-X



- As of today appr. 100 MW H_2 production capacity
- National Hydrogen Strategy issued in 2020: H_2 production capacity target of up to 5 GW

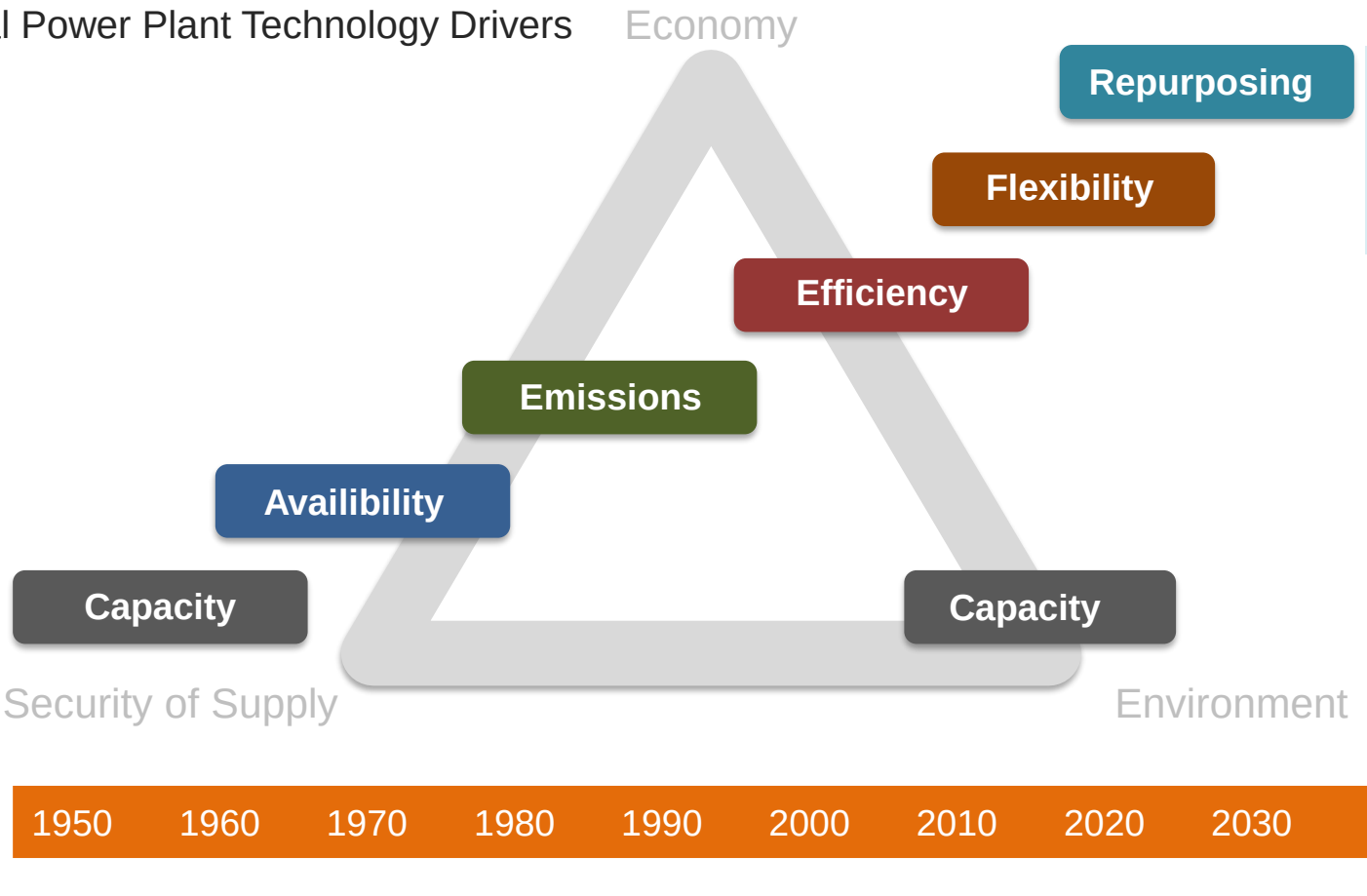
Source: Öko-Institut
https://www.oeko.de/en/research-consultancy/issues/mobility-and-transport/electricity-based-fuels-the-future-of-ptx

Agenda

1. Electricity Mix
2. Energy Market Design
3. Flexible Thermal Power Plants
4. Outlook and Perspectives
5. **Key Take Aways**

Key Take Aways

Coal Power Plant Technology Drivers



→ Fuel switch e.g. to biomass
→ H_2 production / sector coupling
→ www.recpp.eu

Key Take Aways

- ✓ Germany is continuously increasing the share of wind and PV – nuclear and coal based generation will be phased out.
- ✓ Flexibility in the energy system is a must-have.
- ✓ Germany relies on an energy-only market.
- ✓ Natural gas is supposed to function as a bridging energy carrier.
- ✓ Energy storage and hydrogen-based sector coupling will play a key role in the future energy system.

Thank you very much for your interest!

Contact:
Dr. Claudia Weise
Project Director of International Affairs
Deilbachtal 173
45257 Essen (Germany)
Phone: +49 201 8128 335
Mobile: +49 151 2524 8343
claudia.weise@vgb.org
www.vgb.org