Consequences of the German Energy Transition on the operation regime and the availability of coal fired power plants

Delhi, December 1, 2017

Dr. Oliver Then

Agenda

1. Who is VGB?
2. German energy market and consequences on the operation regime
3. Consequences on availability and reliability of coal fired plants
4. Conclusion

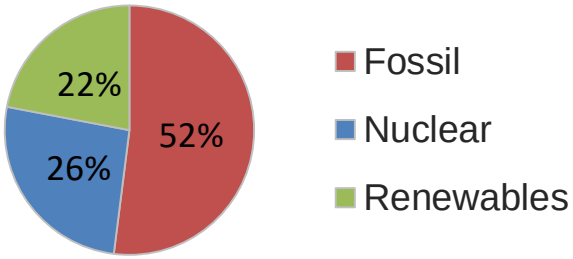
Our mission is…

…to support our members in their operational business.

…to support our members in strategic challenges.

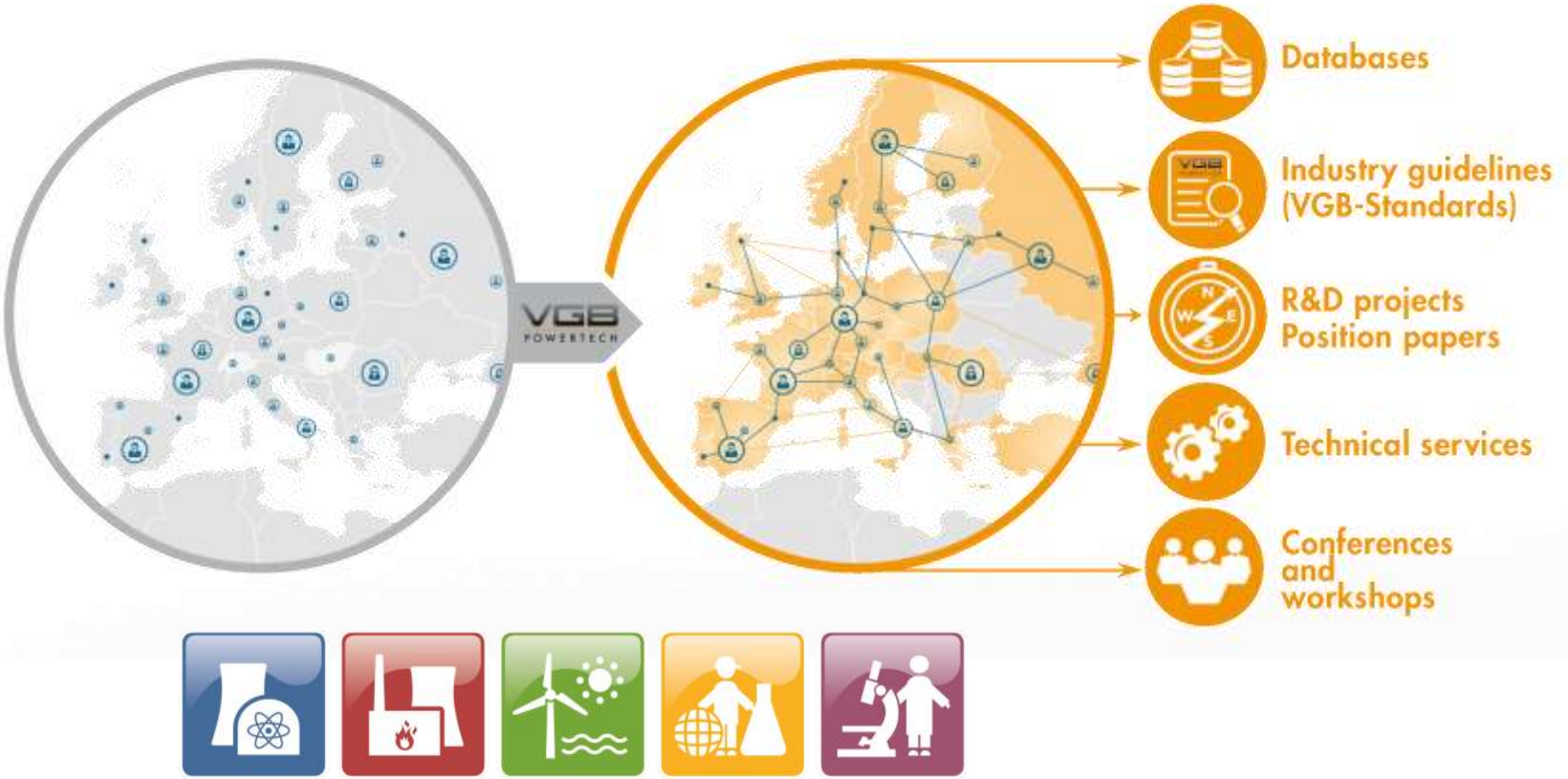
…to be a key contact for international energy stakeholders.

- We have **478 members in 34 countries**, over 90% are European based
- We represent an installed capacity of **466 GW** based on



VGB is the International Technical Association for Heat and Power generation and storage. Founded in 1920 it is based on a voluntary association of companies active in the energy business.

Over 1,700 experts are active in the VGB network.



VGB facilitates the exchange of experiences between the experts and document and disseminate the results for the benefit of all members.

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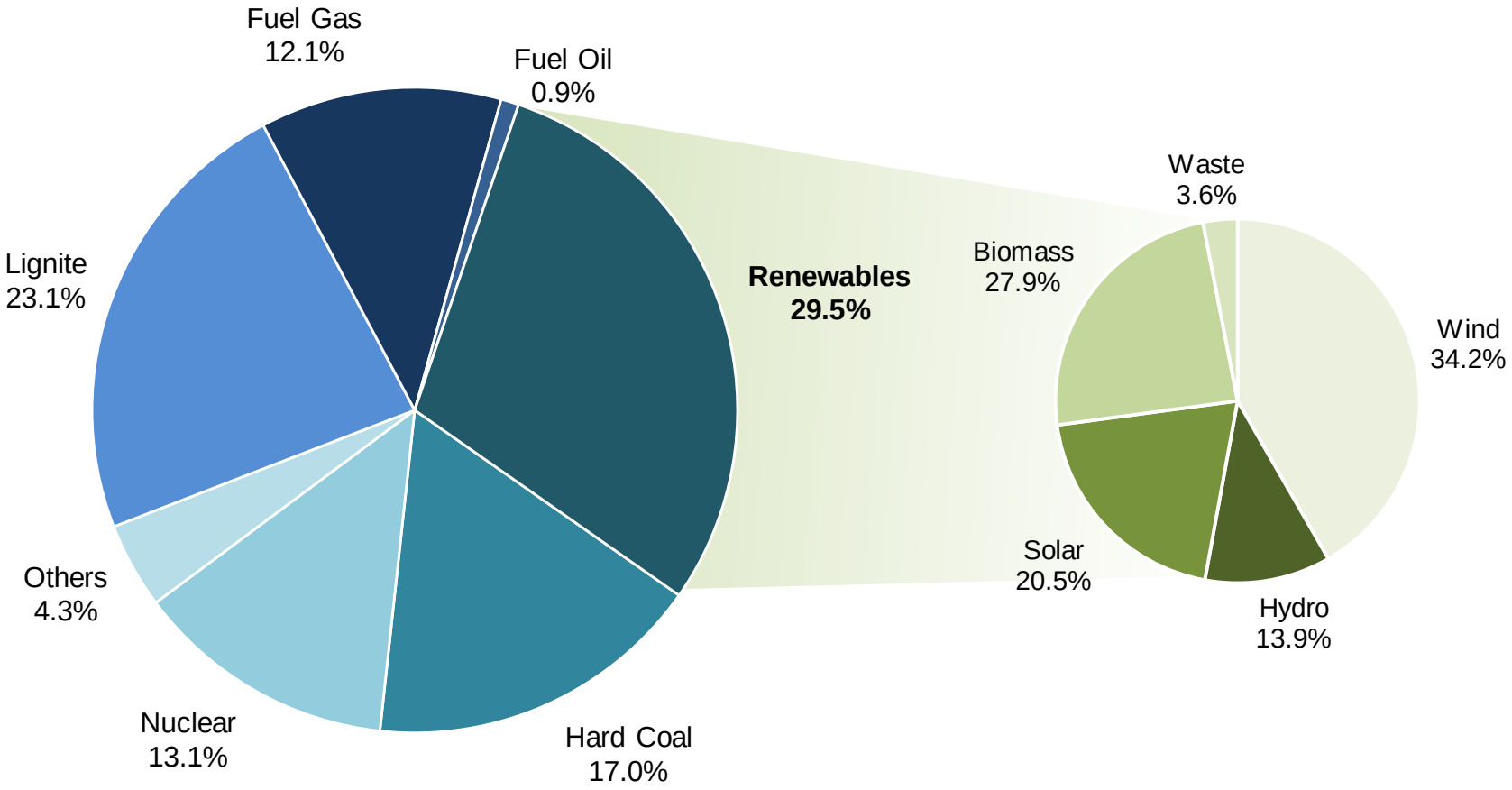
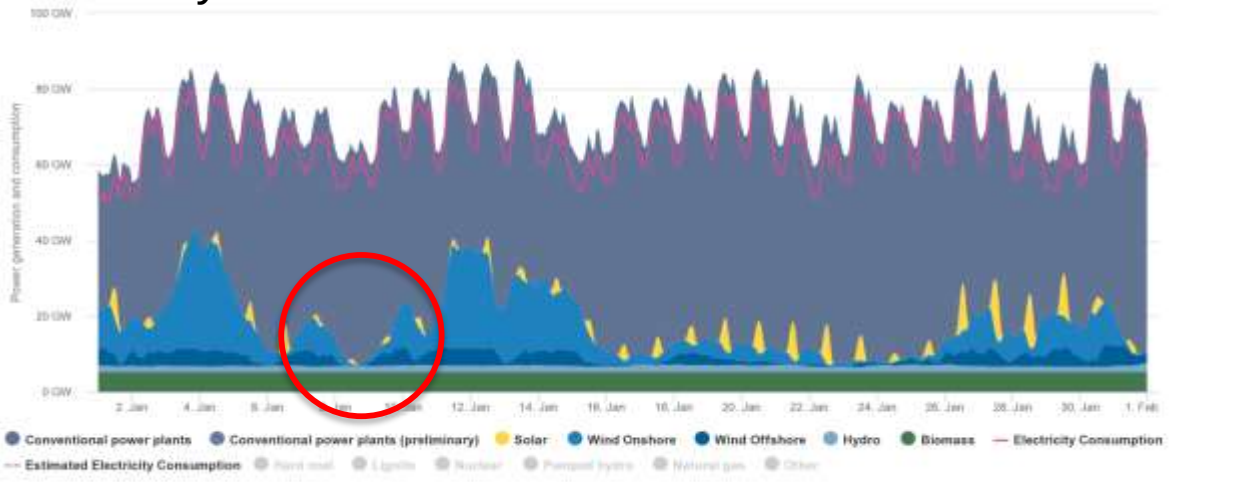
2. German power generation in 2016

- Installed net capacity: 210 GW (thereof 104 GW RES)
- Gross power production: 648 TWh (consumption 593 TWh):

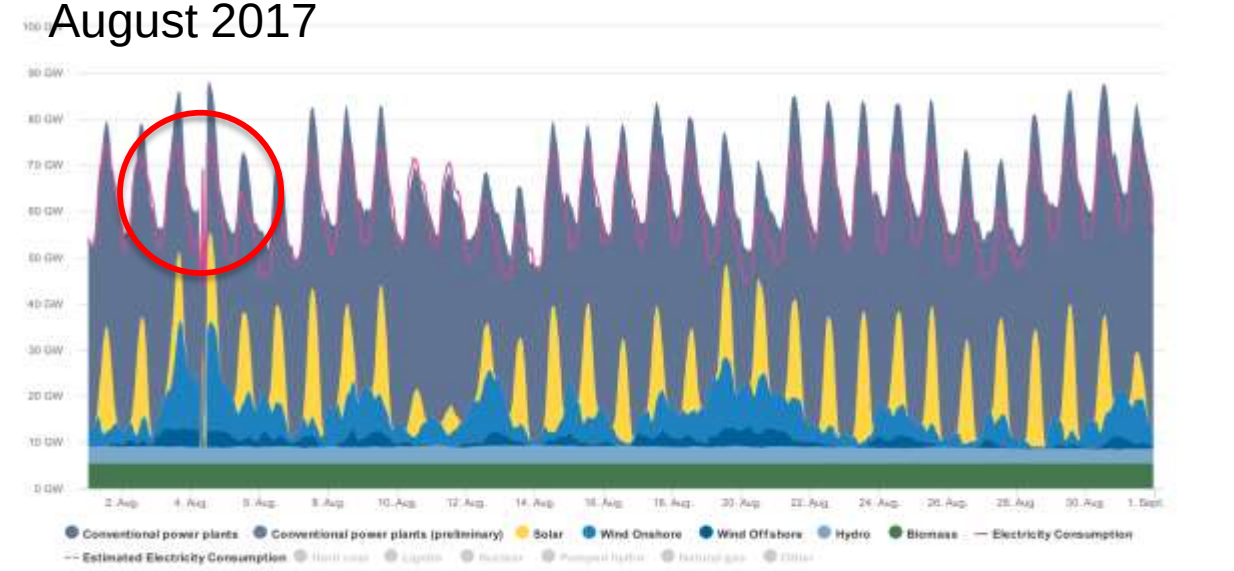


Renewables have outscored lignite as No.1 electricity generation source. More than 50 % of RES is coming from volatile sources. Gas has increased by 25 % from 2015. Installed capacity has grown by 50 % since 2000.

January 2017



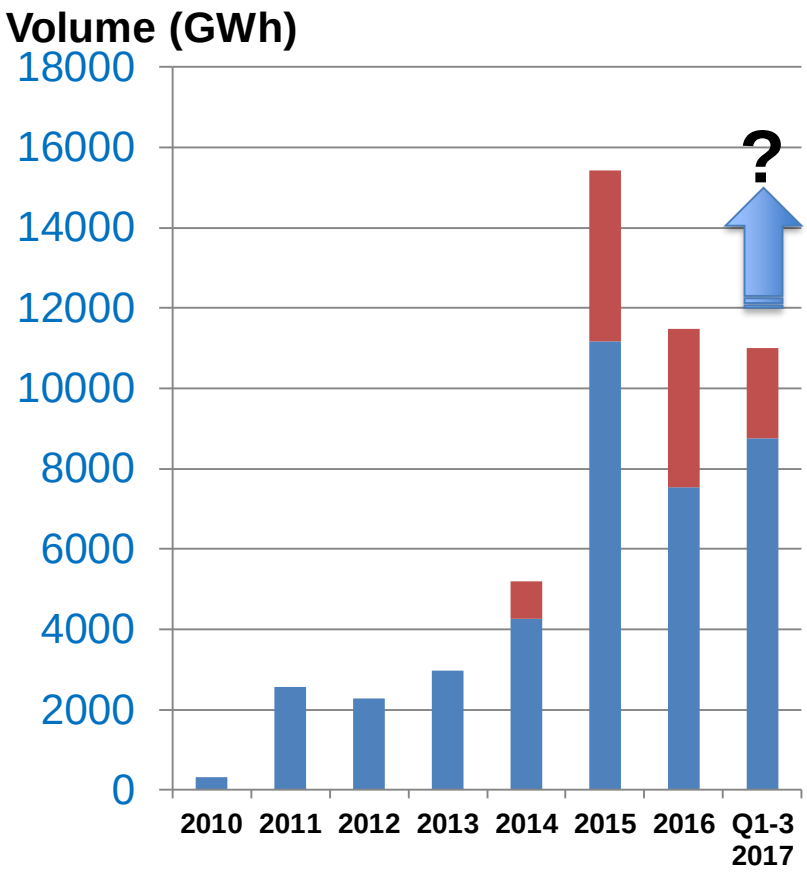
August 2017

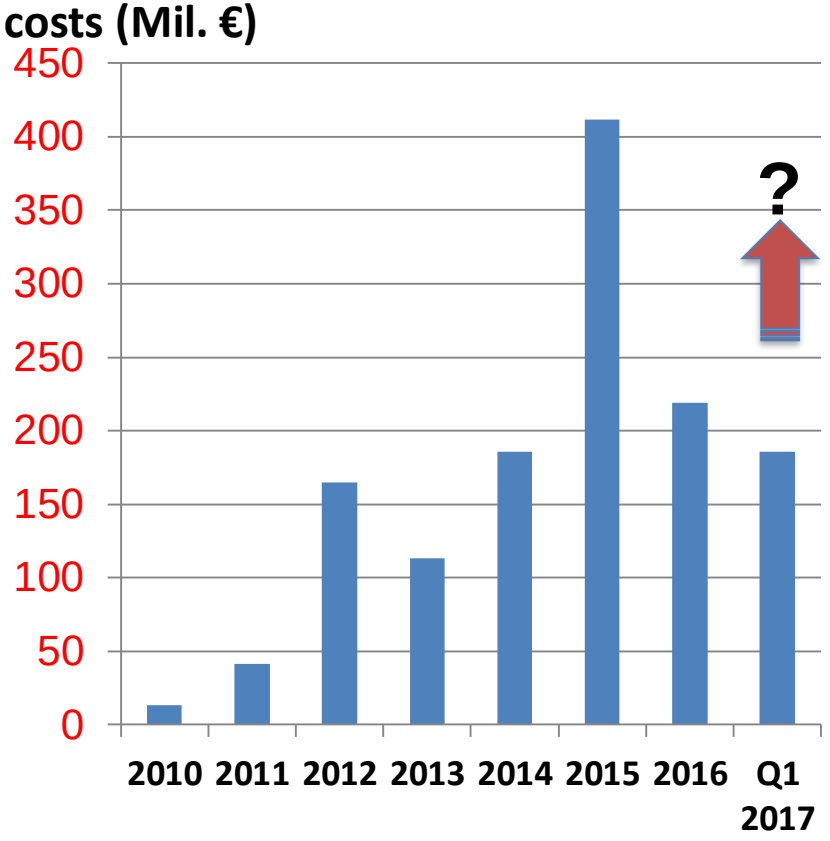


- Wind and solar power are fluctuating on a hourly, daily, weekly and seasonal level thus imposing short- and long-term flexibility requirements on conventional power generation.
- Secured capacity out of wind and PV is neglectable (< 4 % on European scale) thus imposing backup capacity requirements on nearly full peak load level.

Source: Agora Energiewende

Development of TSO redispatch measures in Germany 2017

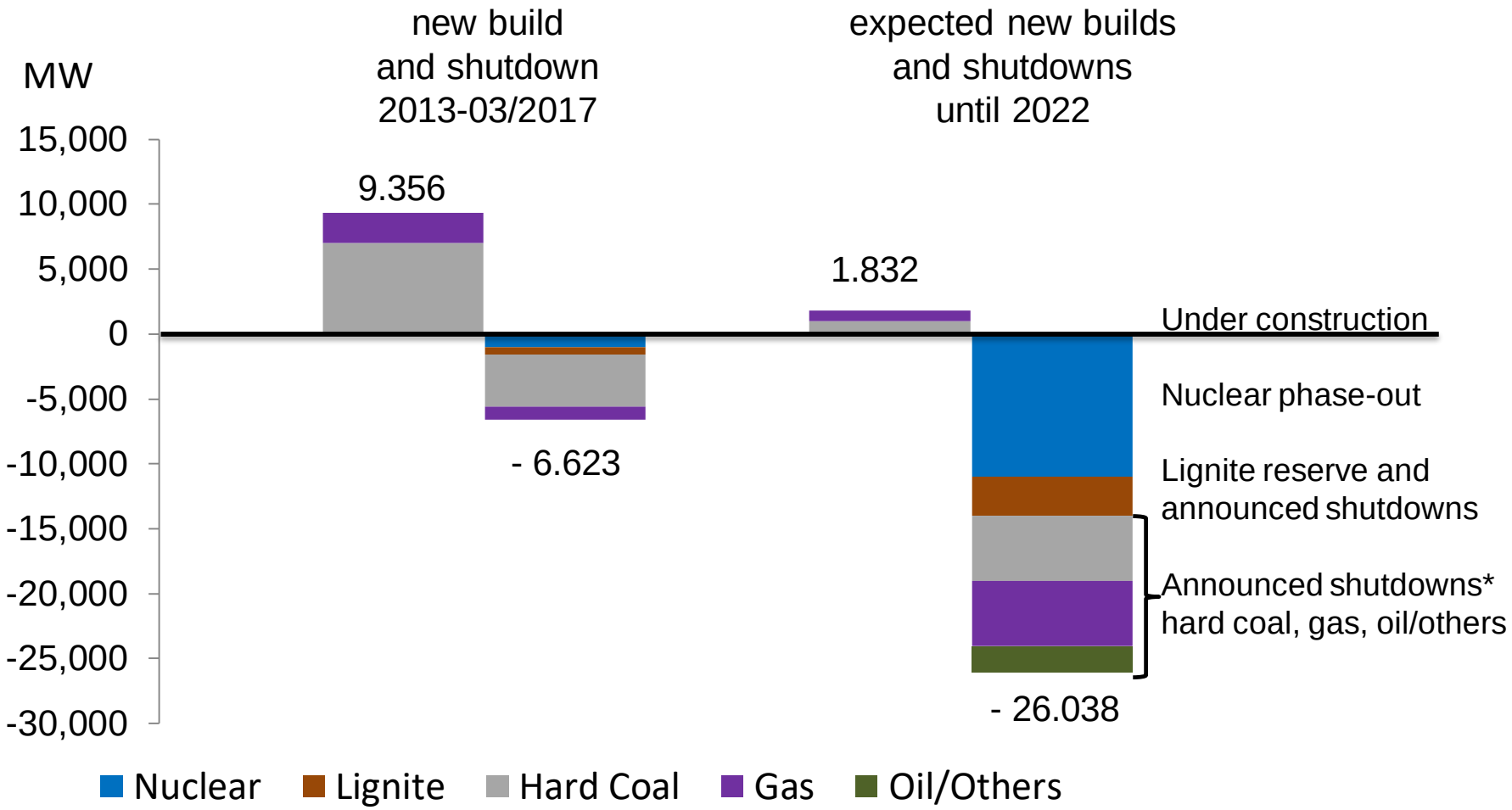




source: German Regulator BNetzA

Total costs of TSO load management increased to appr. 850 Mill. € in 2016 (1,2 billion € in 2015). Optimization ongoing between reserve capacity usage, redispatch and curtailment to limit further increase expected up to 4 to 5 billion €.

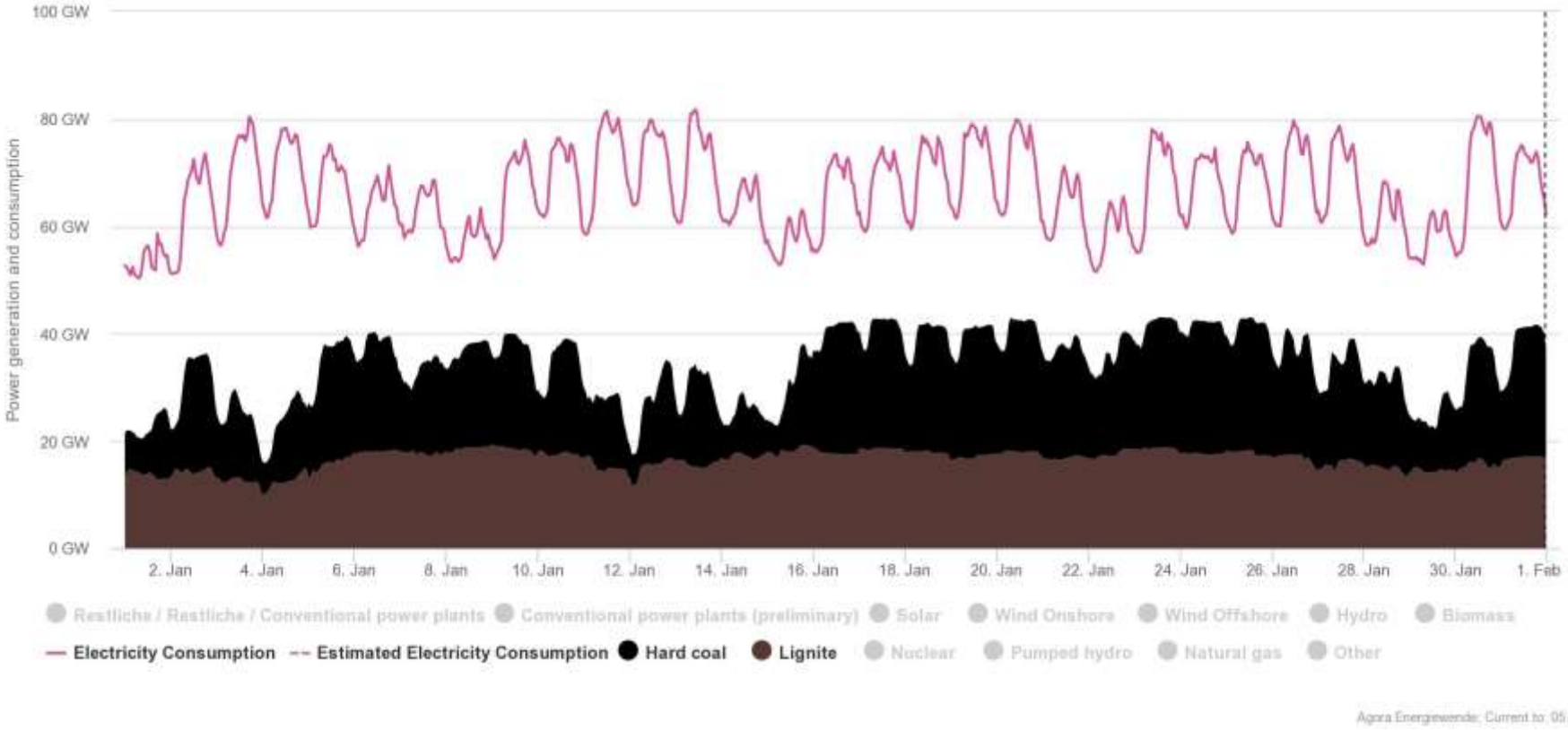
2. Consequences of German “Energiewende”: Capacity development



* Subject to decision of Bundesnetzagentur on system relevance, Source: BNetzA

A significant shutdown of dispatchable conventional generation will not be covered by capacity additions except on basis of volatile RES (mainly wind and PV).

Utilization of hard coal plants in Germany: winter period 2017



Installed net capacity	
Hard coal	ca. 31 GW
Lignite	ca. 20 GW

Maximum load band Jan17:
6 to 25 GW
6 to 18 GW

Lignite plants typically go into part load at low demand or little residual load (even on weekends), whereas hard coal plants shut down (over night, weekend) with some minor exceptions in very low load mode.

2. Flexibility parameters of thermal power plants

POWERTECH

Plant type	Hard-coal	Lignite	CCGT	Gas Turbine
Load gradient [% / min]	2 / 4 / 8	2 / 4 / 8	4 / 8 / 12	8 / 12 / 15
in the load range [%]	40 to 90	50 to 90	40* to 90	40* to 90
Minimum load [%]	40 / 25 / 15	60 / 40 / 20	50 / 40 / 30*	50 / 40 / 20*
Ramp-up time Hot start <8 h [h]	3 / 2 / 1	6 / 4 / 2	1.5 / 1 / 0,5	< 0.1
Ramp-up time Cold start >48 h [h]	7 / 4 / 2	8 / 6 / 3	3 / 2 / 1	< 0.1

Source: VDE and own studies
usual value / state of the art / potential
*as per emission limits for NOx and CO

Thermal power plants are able to significantly contribute to a modern energy system. Technology development is focused on realising the flexibility potentials.

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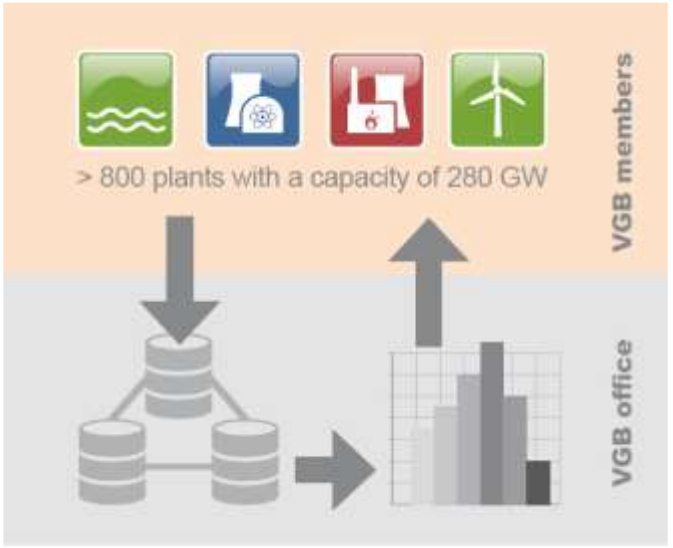
Target: Optimization of power plants in a competitive and harsh market environment



1. Collection of **availability data** and determination of **performance indicators**,
2. Recording of **unavailability incidents** for individual power plant components,
3. Analysis of **reliability indicators** of components,
4. **Benchmarking** of a power plant with a peer group of similar plants,
5. Definition basis: VGB-Standard „Technical and commercial Indicators of Power Plants“ (**VGB-S002-03 2016**)
   free download from www.vgb.org

Products:

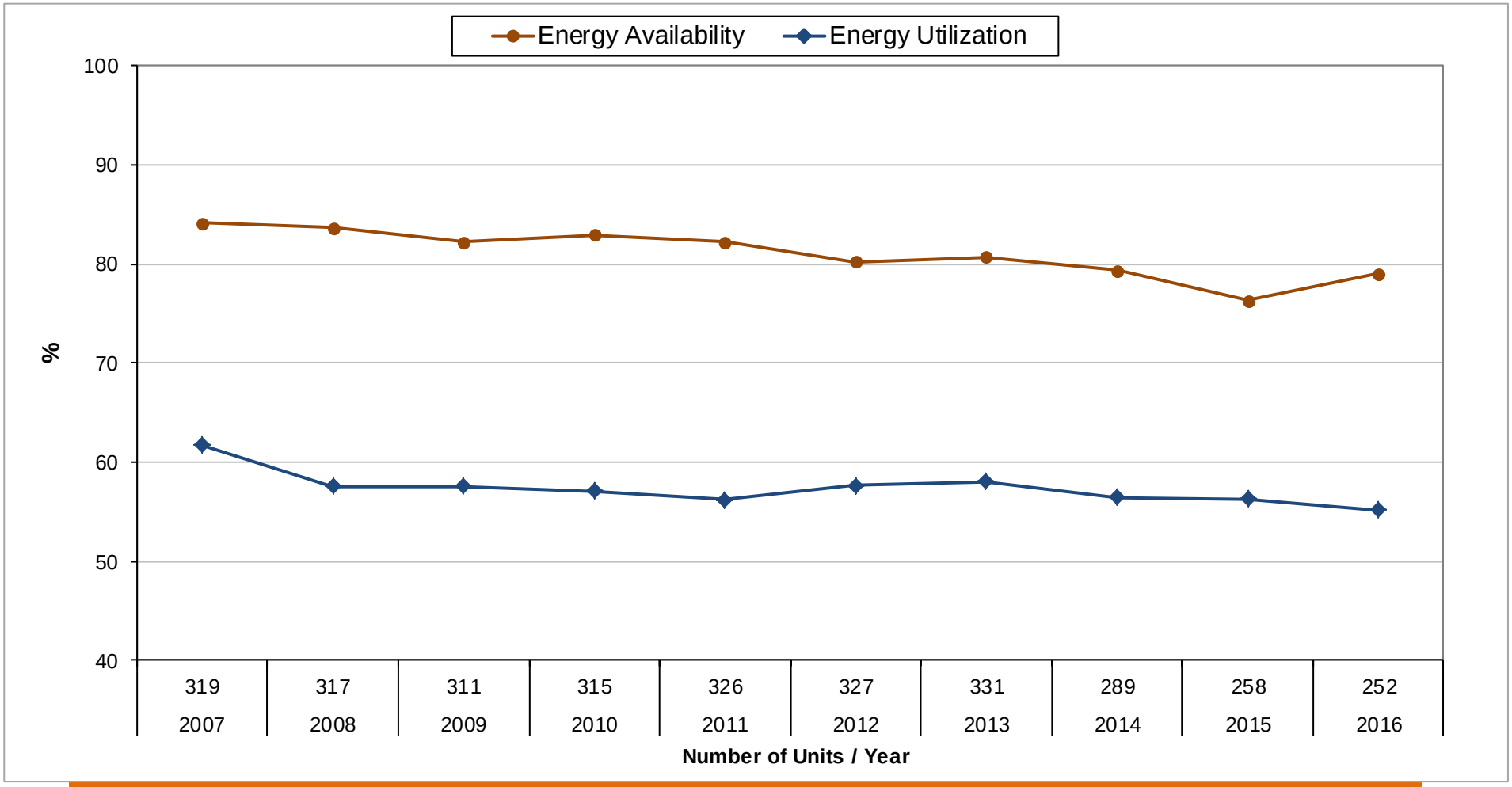
- annual VGB report TW 103 V „Availability of Power Plants“,
- individual analysis,
- Special reports, e.g. VGB/WEC availability report for WEC Istanbul Summit 2016

KISSY is the leading performance database for power plants and renewable-based generating facilities and delivers strategic important KPIs based on internationally recognised definitions and methods for more than 40 years.

3. Trend analysis of unavailability in HC plants > 200 MW global

POWERTECH

Time range: 2007 - 2016



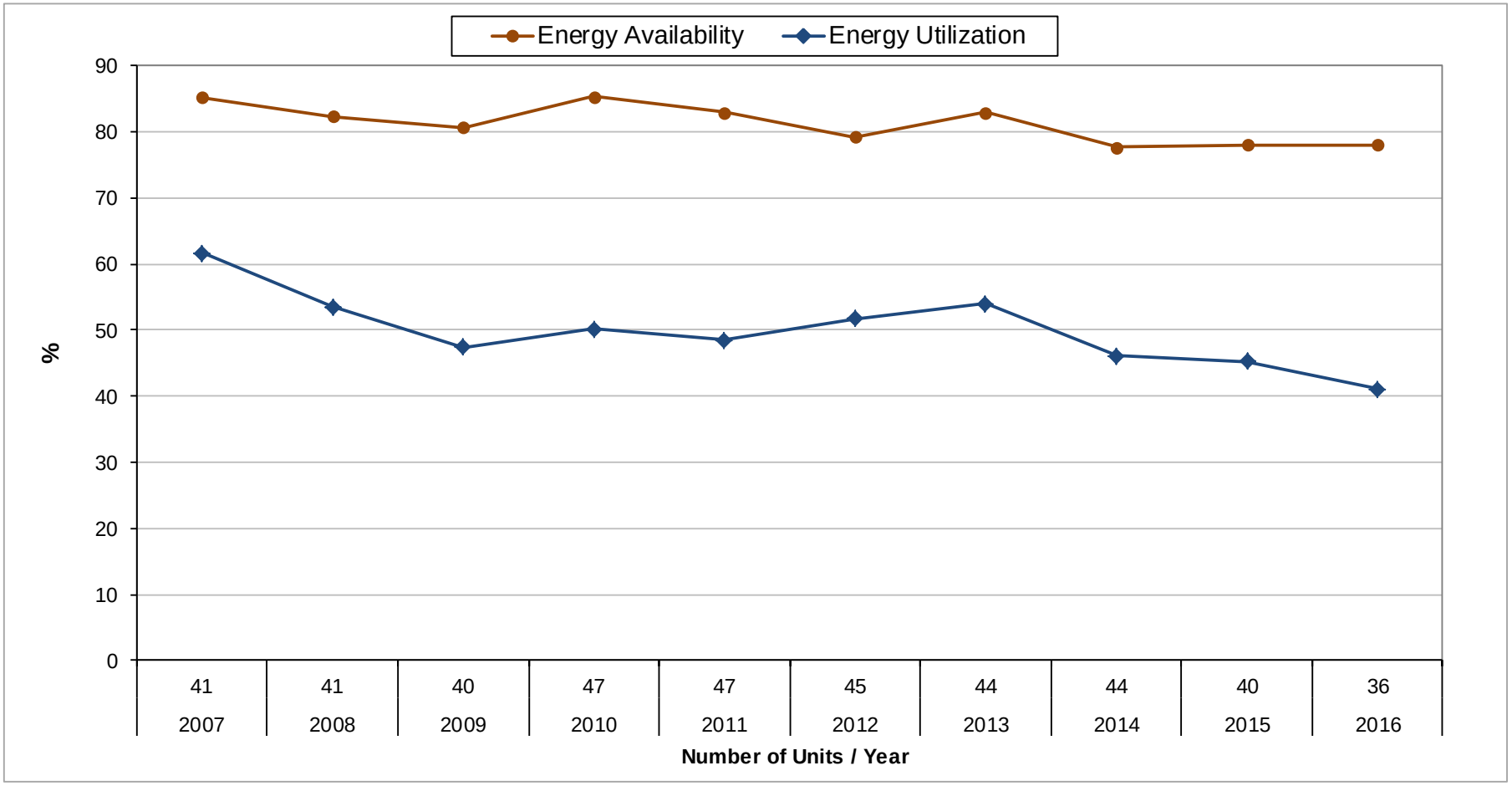
On a global scale the decrease in utilization is moderate from 60 to 55 %, as well as the impact on availability, stabilizing slightly below 80%.

3. Development of Availability and utilization of HC plants in Germany

POWERTECH

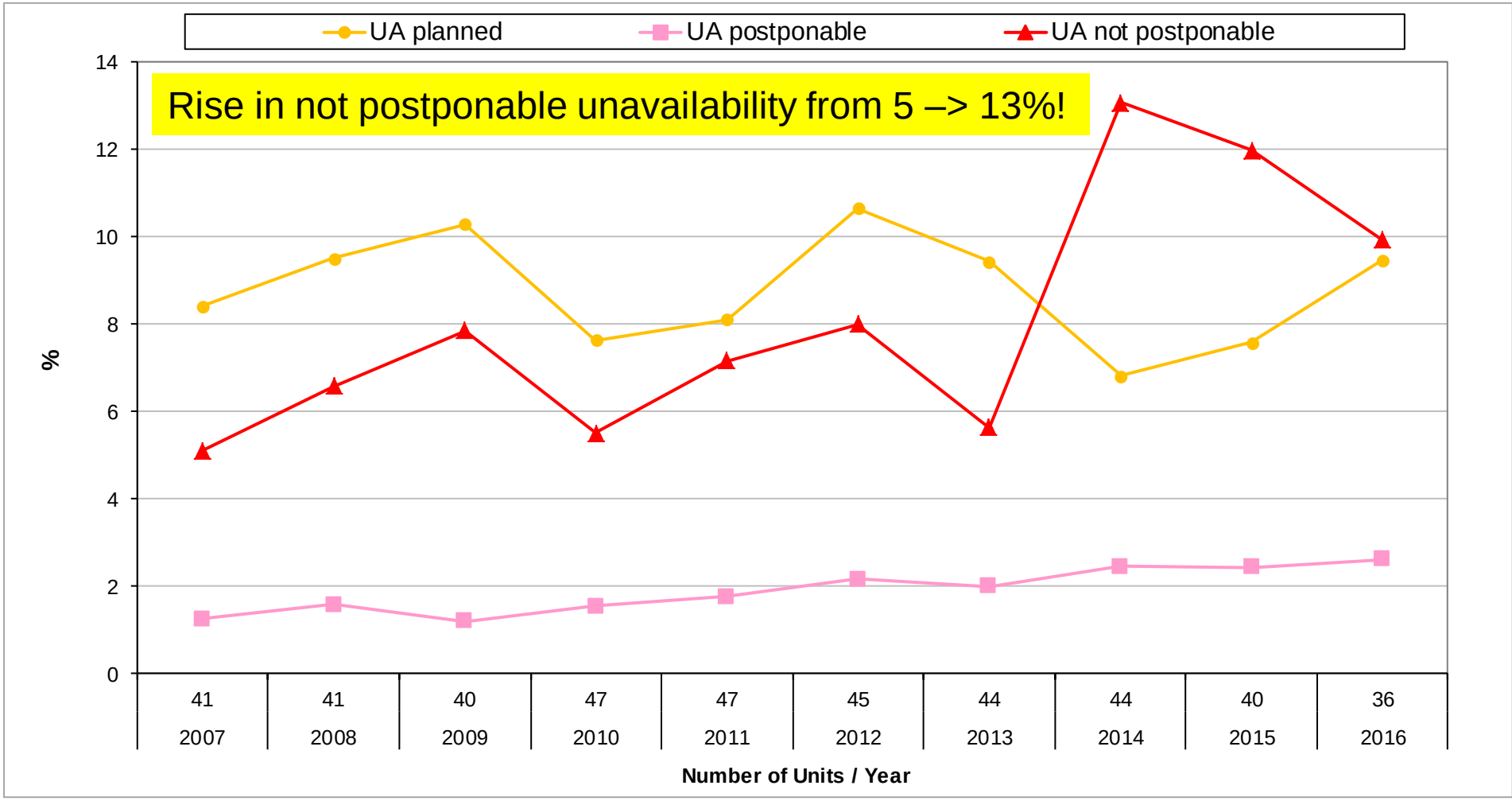
Collective: Hard Coal-fired Units, more than 200 MW

Time range: 2007 - 2016



In Germany utilization has dropped significantly to 40 % but availability has remained nearly constant on a high level around 80 %.

3. Trend analysis of unavailability in HC plants > 200 MW in Germany



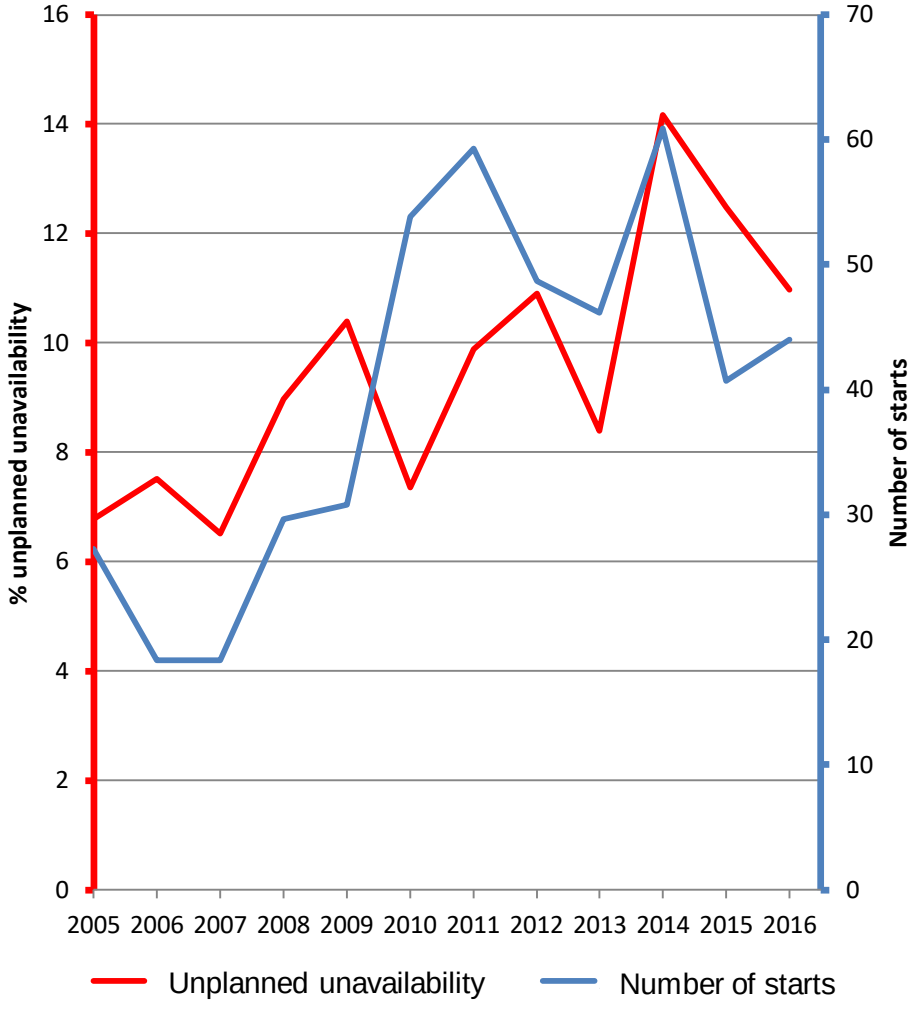
UA: unavailability

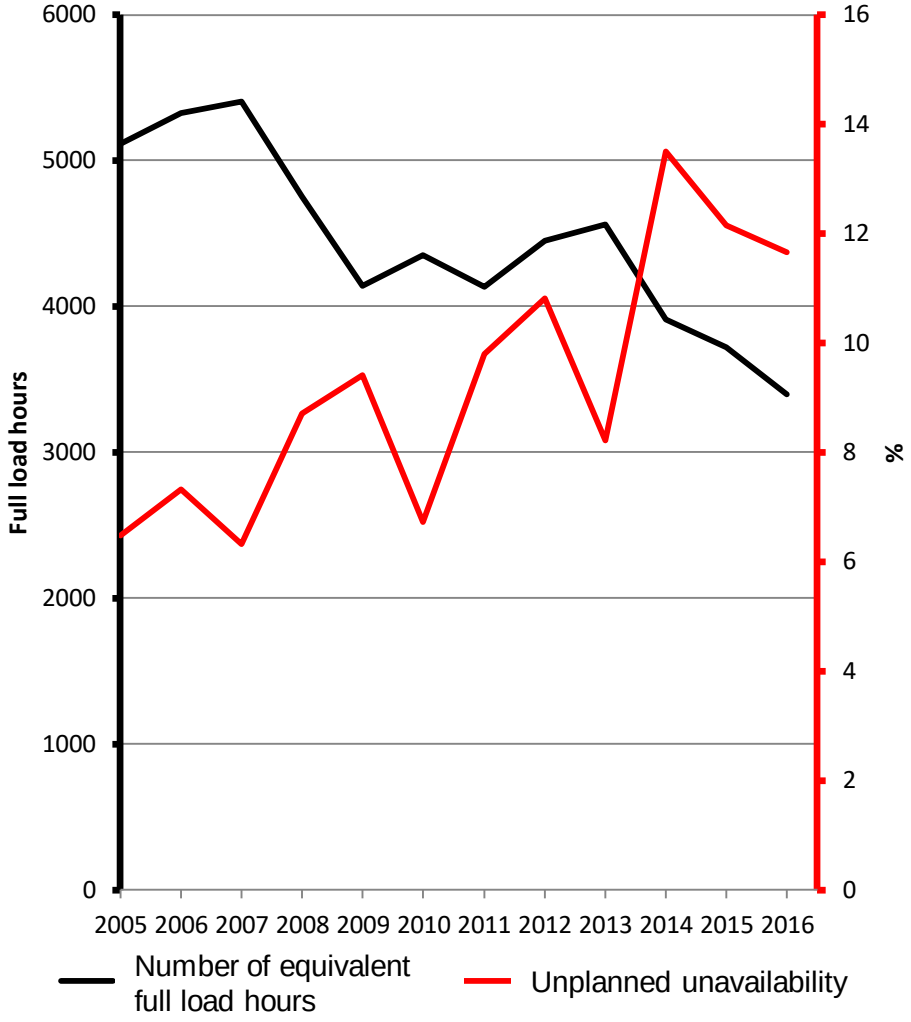
In Germany not postponable unavailability has seen a sharp increase but stabilizes according the latest trend. Planned measures have been reduced but recover.

3. Trend of starts and full load hours vs. unplanned unavailability

POWERTECH

Collective: 49 units, Germany, **hard coal**, > 200 MW, 2006 - 2016



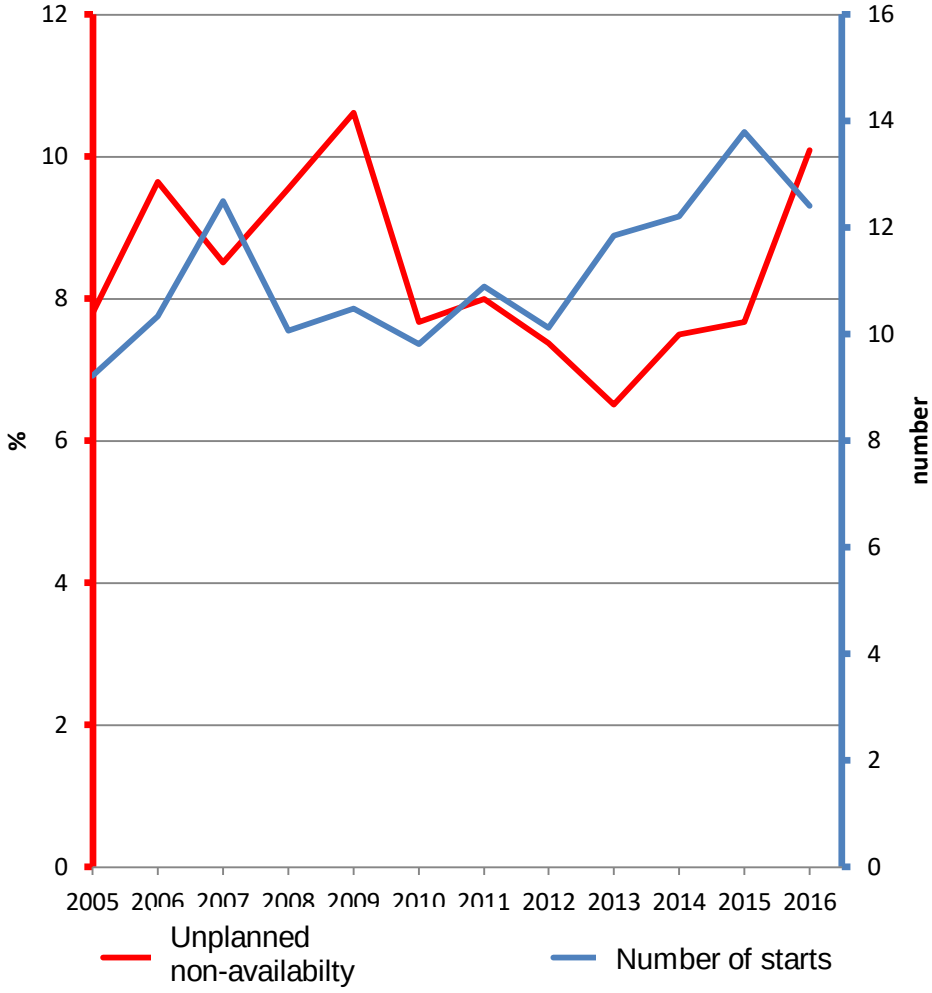


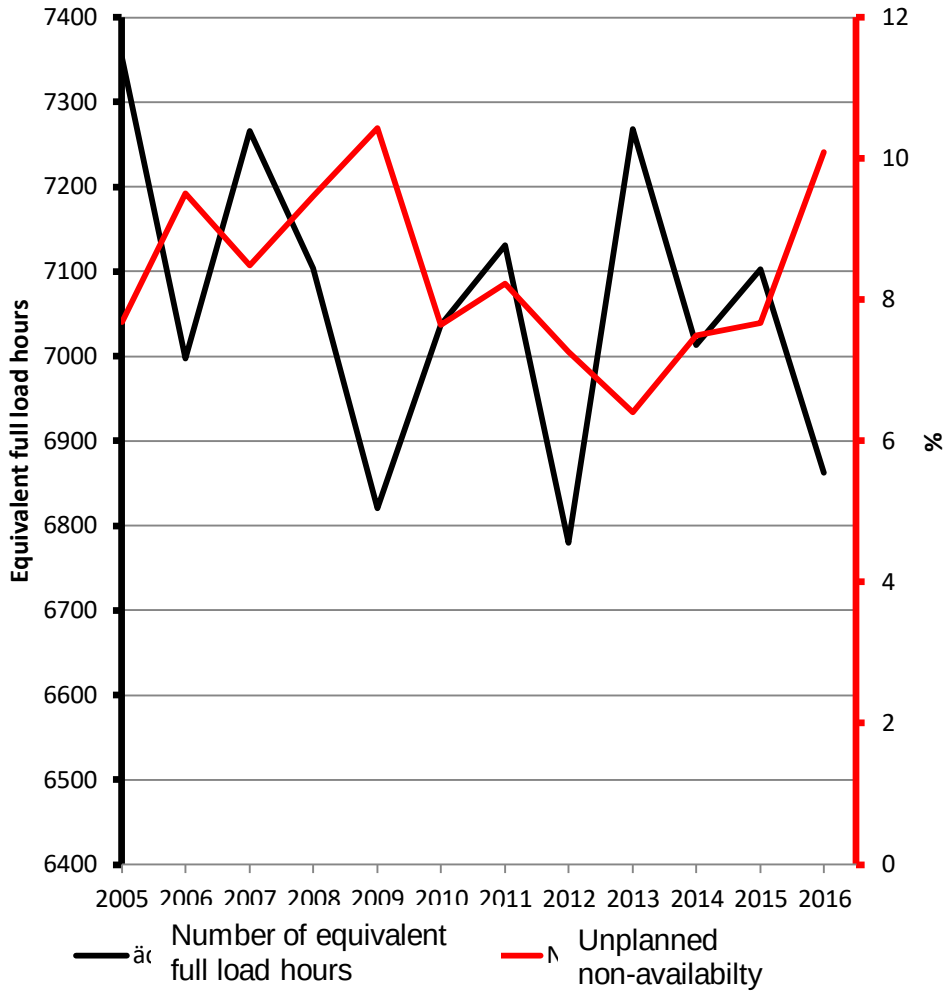
Significant correlation between number of starts, full load hours and unplanned unavailability. Unavailability with dramatic increase over past 10 years but trend reversed.

3. Trend of starts and full load hours vs. unplanned availability

POWERTECH

Collective: 36 units, Germany, **lignite**, > 200 MW, 2005 - 2016



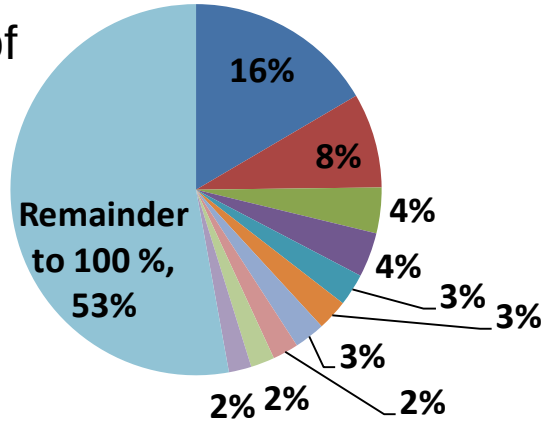


Lignite plants are less affected from flexible operation, start numbers and full load hours remain stable, no trend in unavailability.

POWERTECH

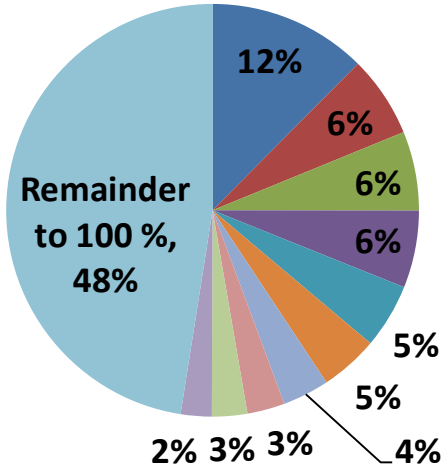
Collective: 30 units, Germany, hard coal, > 200 MW, 2005 - 2015

Number of incidents



- Pulverizing system (incl. classifier)
- Evaporator system
- Feeder system
- Feedwater conveyance
- HP superheater system
- Bunker, feeder and pulverizing system
- Pressure system, feedwater and steam sections
- Support structure, enclosure, steam generator interior
- without Description (e.g. event after revision)
- Reheat system

Lost MWh



- Evaporator system
- Generator, complete, incl. stator, rotor and all integral cooling equipment
- LP turbine
- HP superheater system
- Pressure system, feedwater and steam sections
- Reheat system

The majority of incidents is caused by coal handling devices and the evaporator. Lost generation is mainly caused by systems with extensive repairs (evaporator) and/or long-lead items (tubine, generator).

Example:
explosion of boiler circulation pump 12 May 2014 KW Staudinger Unit 5

Damage at facade boiler house unit 5

Damages at steel structure

Upper part of pump casing ripped off

source: Dr. M. Bader E.ON Anlagenservice MPA-Seminar 2015

1. Increasing number of incidents and damages
2. Especially at components “inconspicious” over decades and not in the focus of monitoring and maintenance
3. Yet no clear reference to more flexible operation. Other contributing factors could be ageing of plants and reduced maintenance efforts.
4. Other VGB-activities: R&D projects e.g. on boiler circulation systems, consultancy, PR

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→ A changing market environment is leading towards a significant more flexible operation regime of conventional power plants.

→ VGB statistics are showing only rudimental consequences on availability of plants and reliability of components.

→ Experiences from operation and maintenance reveal an increasing number of incidents and damages. In most cases an unambiguous assignment to more flexible operation could not be construed. Ageing plants and cut O&M budgets are other potential contributing factors.

→ In various R&D projects the effects of certain aspects of flexible operation could be modelled in great detail yet further work is necessary in that field (e.g. crack propagation, working stress, material properties, monitoring and diagnostic…)

The consequences of a more flexible operation of conventional power plants on the availability and reliability have to be substantiated in the future by continued statistical evaluation (KISSY), focused damage analysis and related R&D efforts.

धन्यवाद

Thank you
for your interest!

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Key changes from 2015 to 2016

1. Gas replaced coal, and hence European power sector emissions fell drastically by 4.5 %.

2. Renewables increased only slightly from 29.2 % to 29.6 % of the electricity mix, mainly due to bad solar and wind conditions.

3. Electricity consumption rises slightly by 0.5 %, with European GDP rising by 1.7 %.

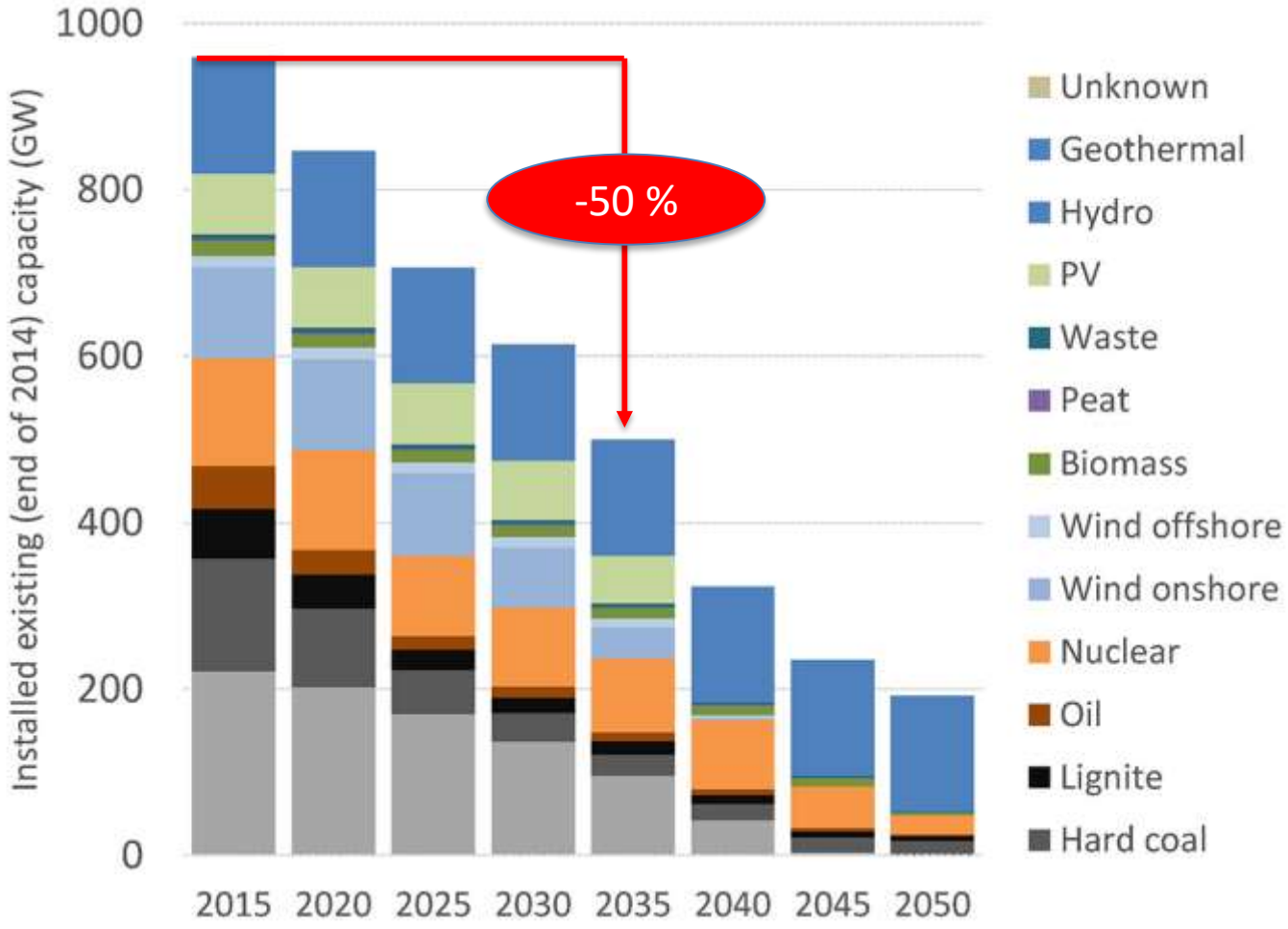
4. The structural oversupply of the EU-ETS has passed the landmark of 3 billion tonnes of CO2 (2016 + 255 mil. tons CO2).

5. The tendency for 2017 is for further significant falls in fossil generation.

COAL PHASE OUT IN EU

Country	Capacity coal-fired power plant 2016	Status
UK	15 GW	Exit announced till 2025
France	~ 3 GW	Exit announced till 2022
Finland	~ 3 GW	Exit announced till 2030
Denmark	< 3 GW	Exit announced till 2025
Portugal	< 2 GW	Exit announced till 2025
Ireland	~ 1 GW	Exit announced till 2025
Austria	< 1 GW	Exit announced till 2025
Sweden	< 0,5 GW	Exit announced till 2025
Germany	~ 48 GW	Exit from coal or shut down under discussion
Spain	~ 10 GW	Exit from coal or shut down under discussion
Italy	~ 8 GW	Exit from coal or shut down under discussion
The Netherlands	< 6 GW	Exit from coal or shut down under discussion

2. European capacity: VGB Project 388 – shutdown curve power plants

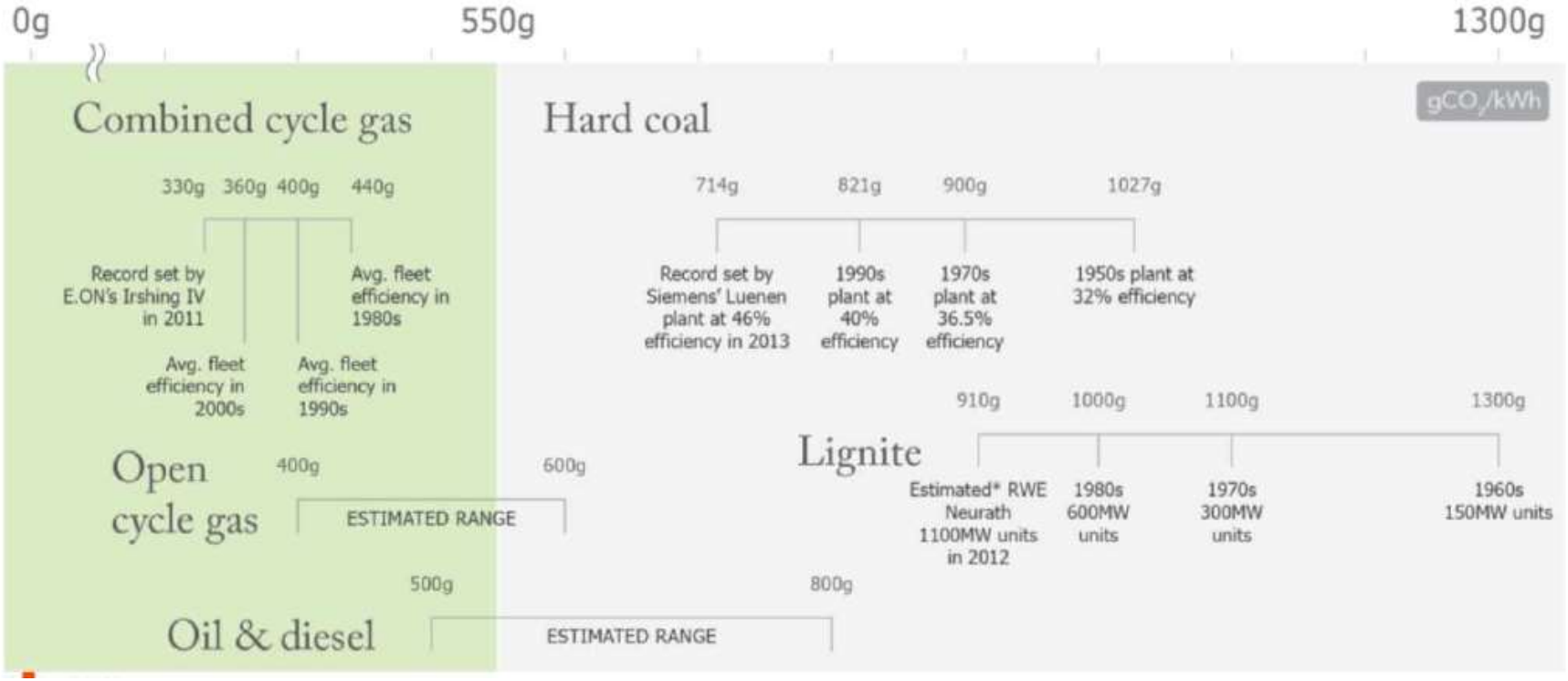


Source VGB: F. Johnson et.al.; Investment requirements in European electricity generation infrastructure towards 2050, 2016

Based on typical life times approx. 50 % of the European power plant fleet will be decommissioned until 2035 (>2%/a). Shutdowns due to missing economics will add on. Current new build projects only cover approx. 60 % of this capacity loss.

EPS IN CAPACITY MARKET (IME ART. 23)

- **"Generation Capacity for which a final investment decision has been made after [OP: entry into force] shall only be eligible to participate in a capacity market if its emissions are below 550 gCO_2/kWh. Generation capacity emitting […] more shall not be committed in capacity market 5 years after the entry into force of this Regulation."**



Source: EDF SA – VGB ETC Environment l October 2017

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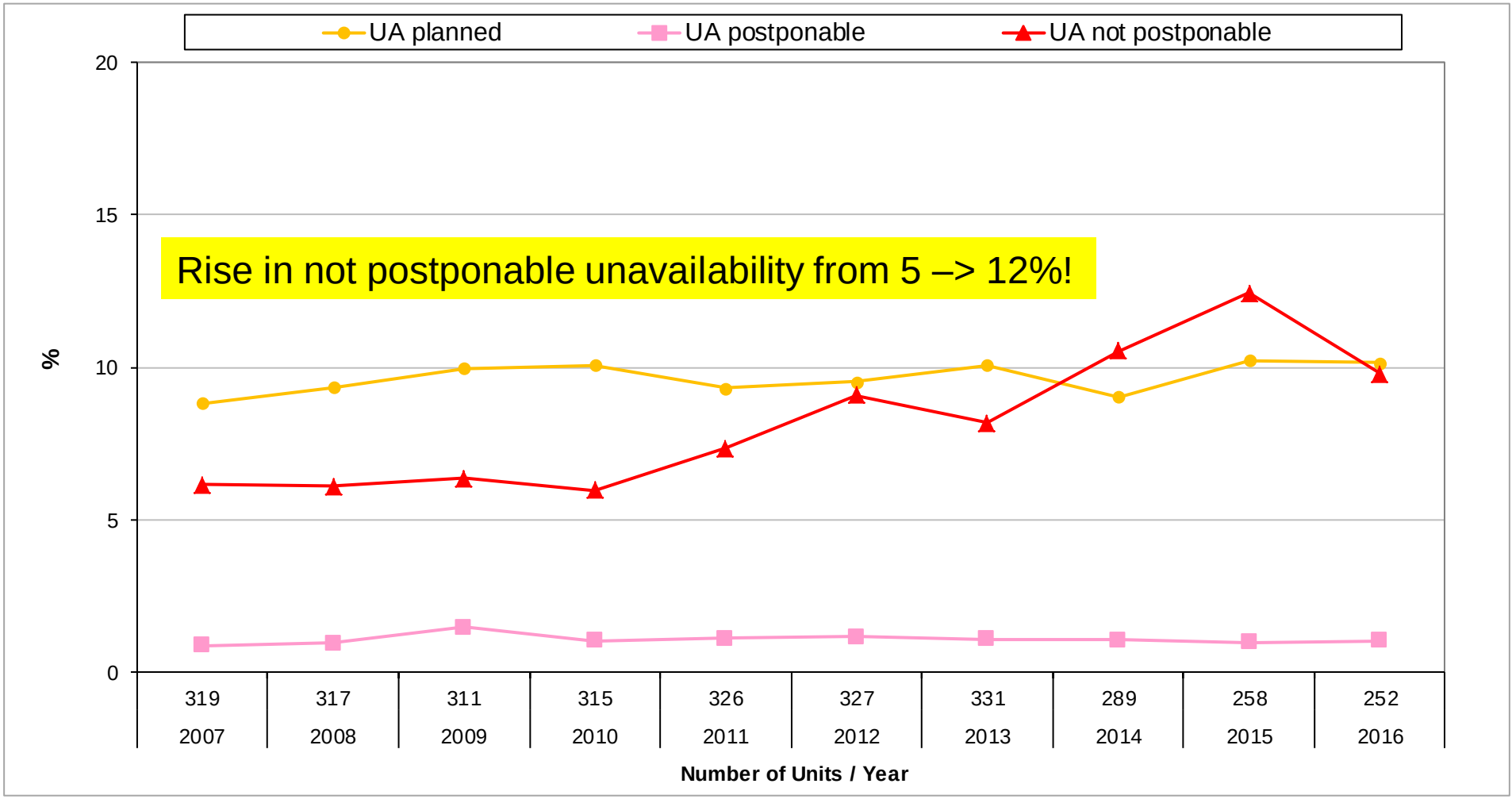
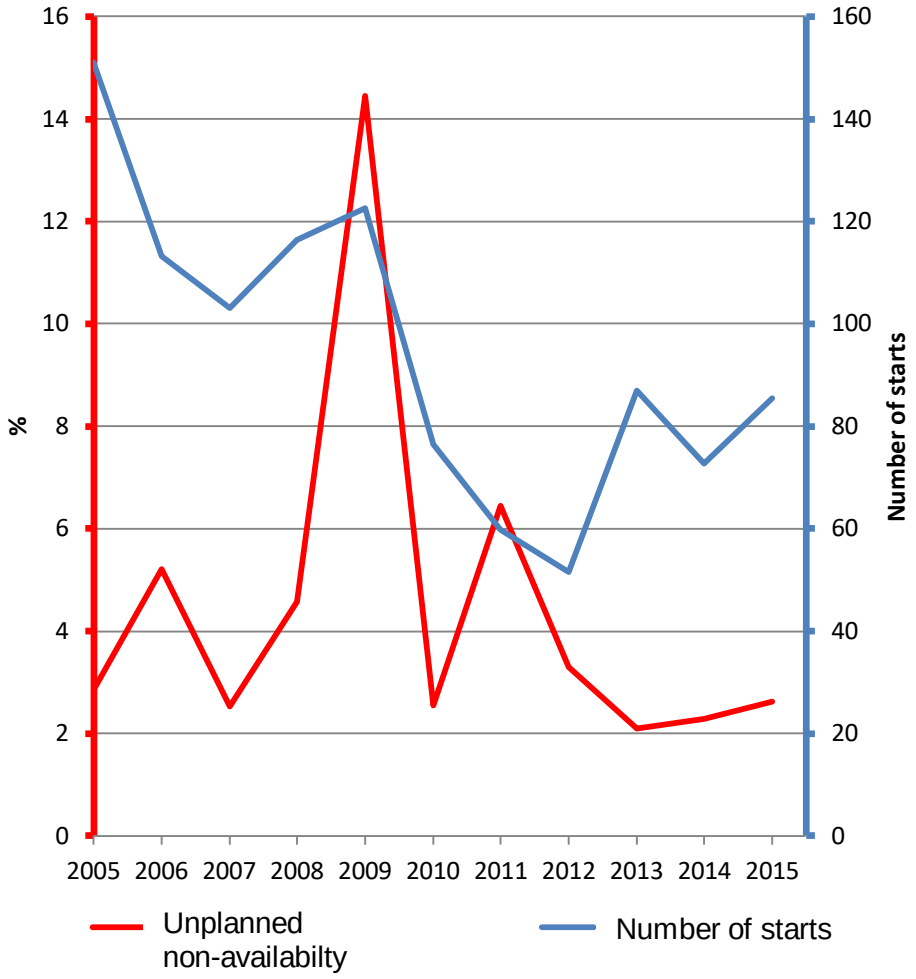


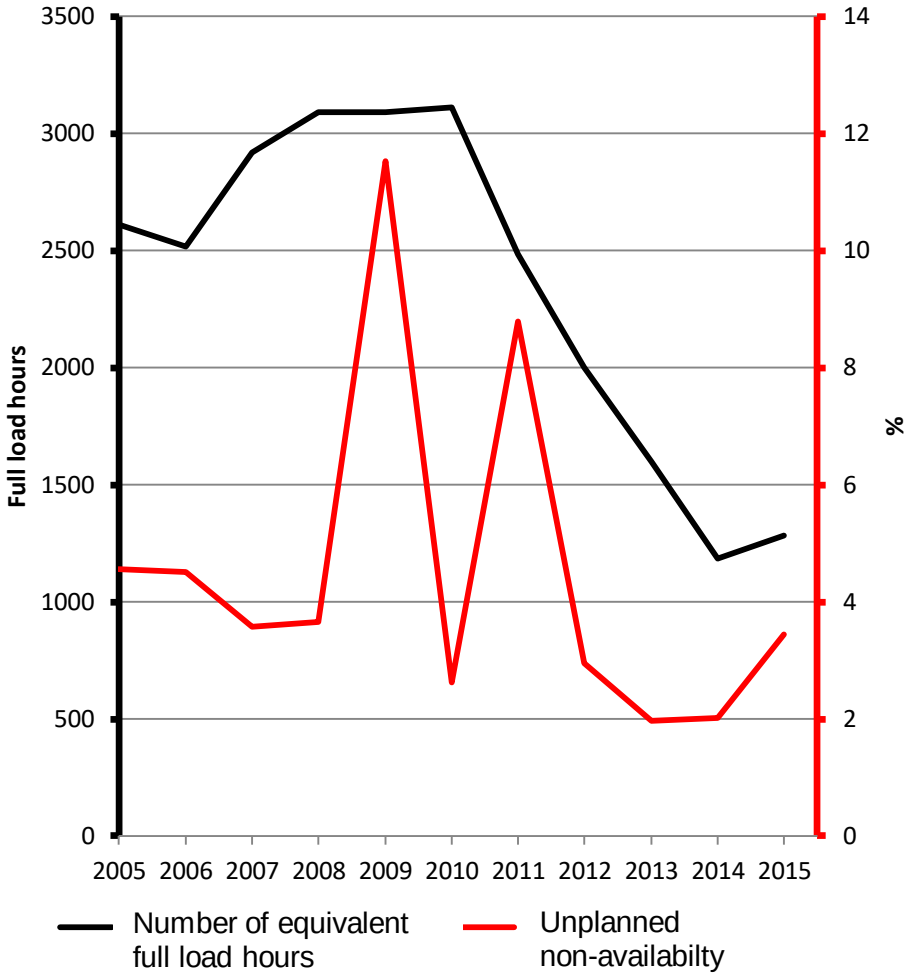
On a global scale especially the not postponable unplanned unavailability mainly caused by major incidents has significantly increased by a factor >2 over the last 10 years.

3. Trend of starts and full load hours vs. unplanned availability

POWERTECH

Collective: 21/32 units, Germany, **CCGT**, > 200 MW, 2005 - 2015





CCGT operation has dramatically declined in Germany over the last 10 years. Power-only plants without CHP with marginal hours or complete standstill.