Flexibility replaced efficiency as a technology driver

Delhi, Mumbai, Hyderabad,
August/September 2015

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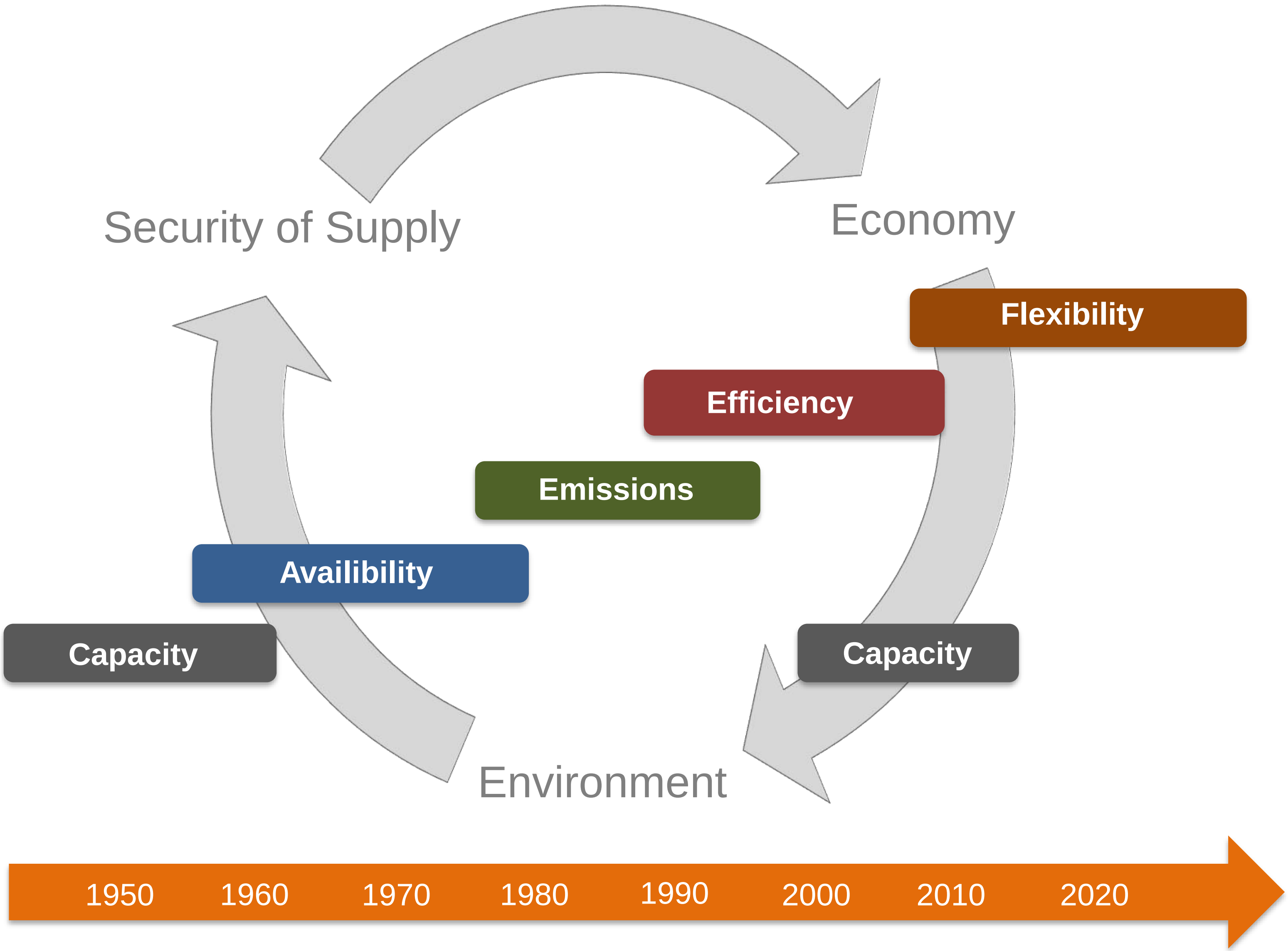
Agenda

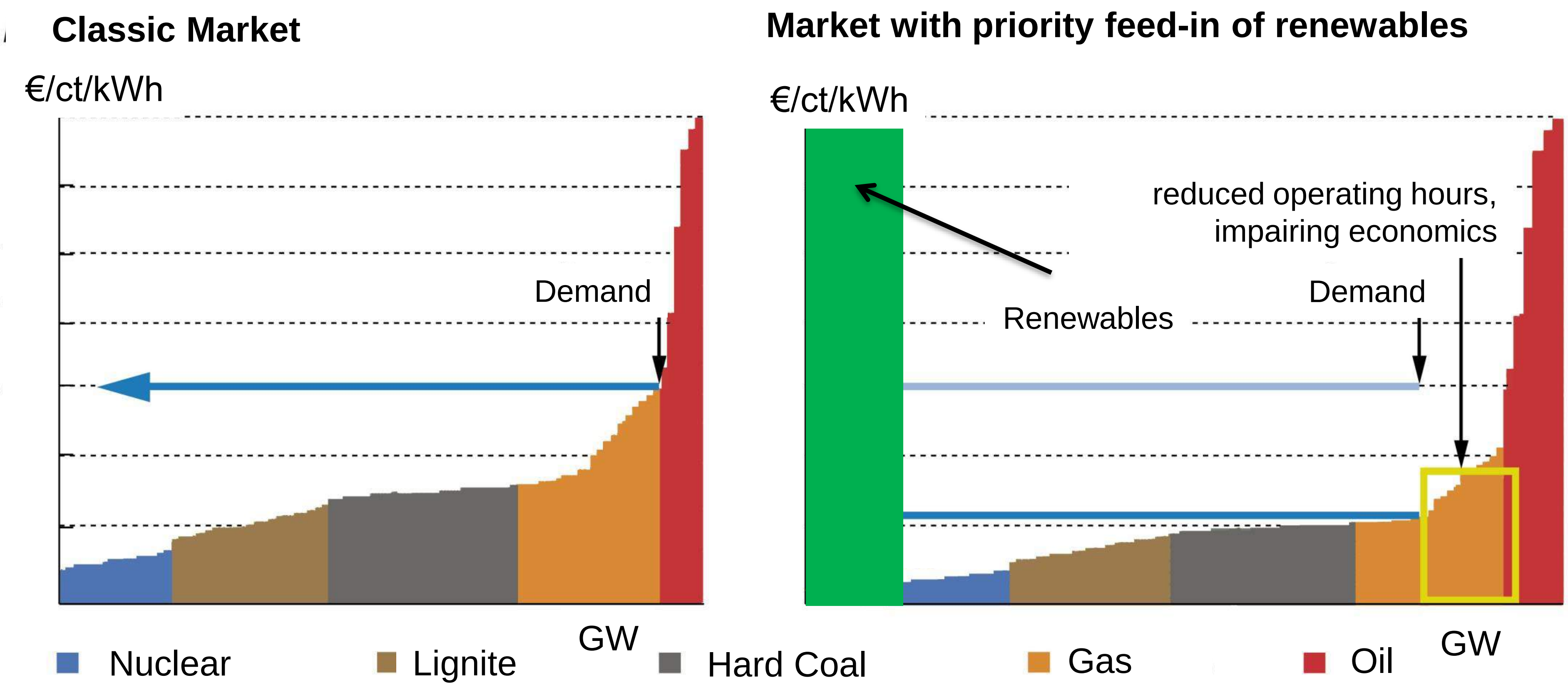
- Introduction: drivers in the energy sector
- Importance of flexibility
- Dynamics and operational flexibility
- Fuel flexibility
- Thermal Storage
- Efficiency developments
- Summary

Drivers of the power sector – an European perspective



Merit order: missing-money-problem

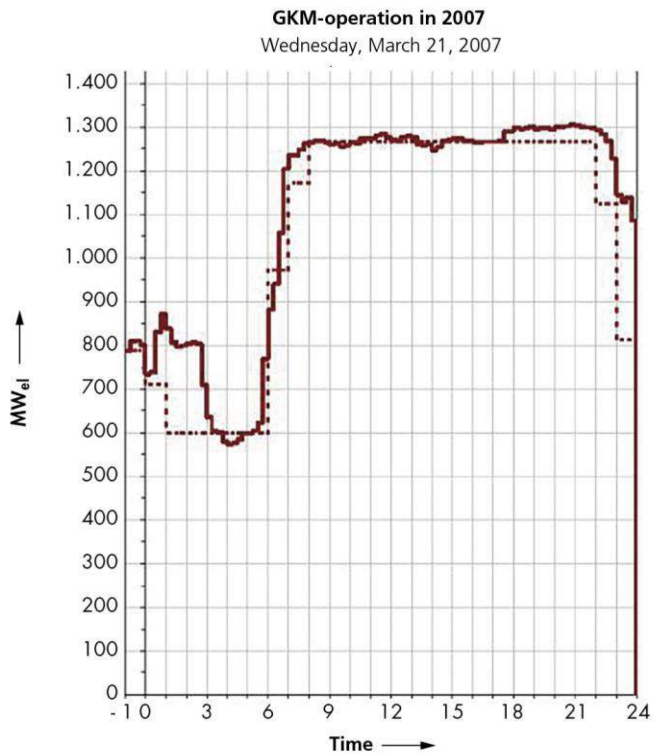
Example for the market development

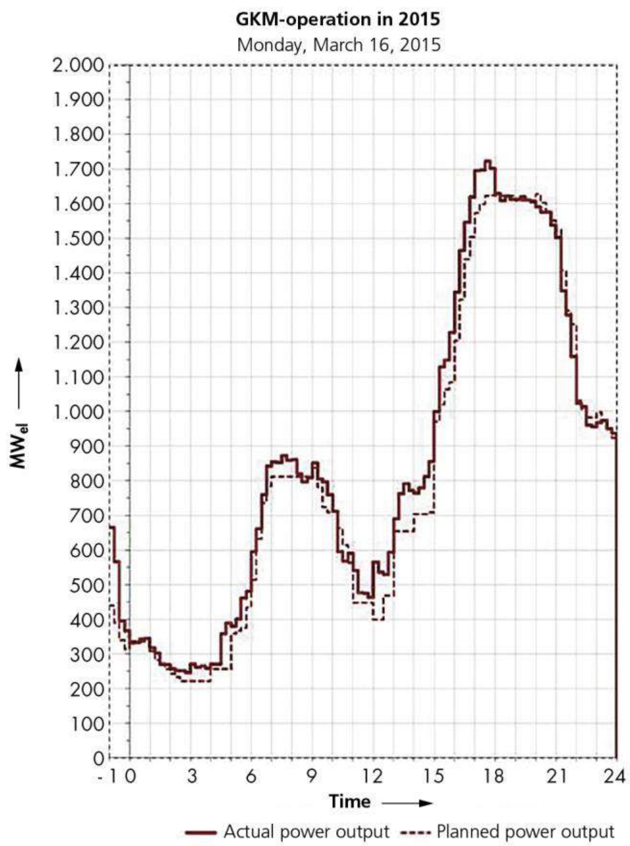


Consequences of the merit order distortion are lower wholesale prices and less operating hours.

The missing-money-problem

Example Coal-fired Power Plant GKM (all units)

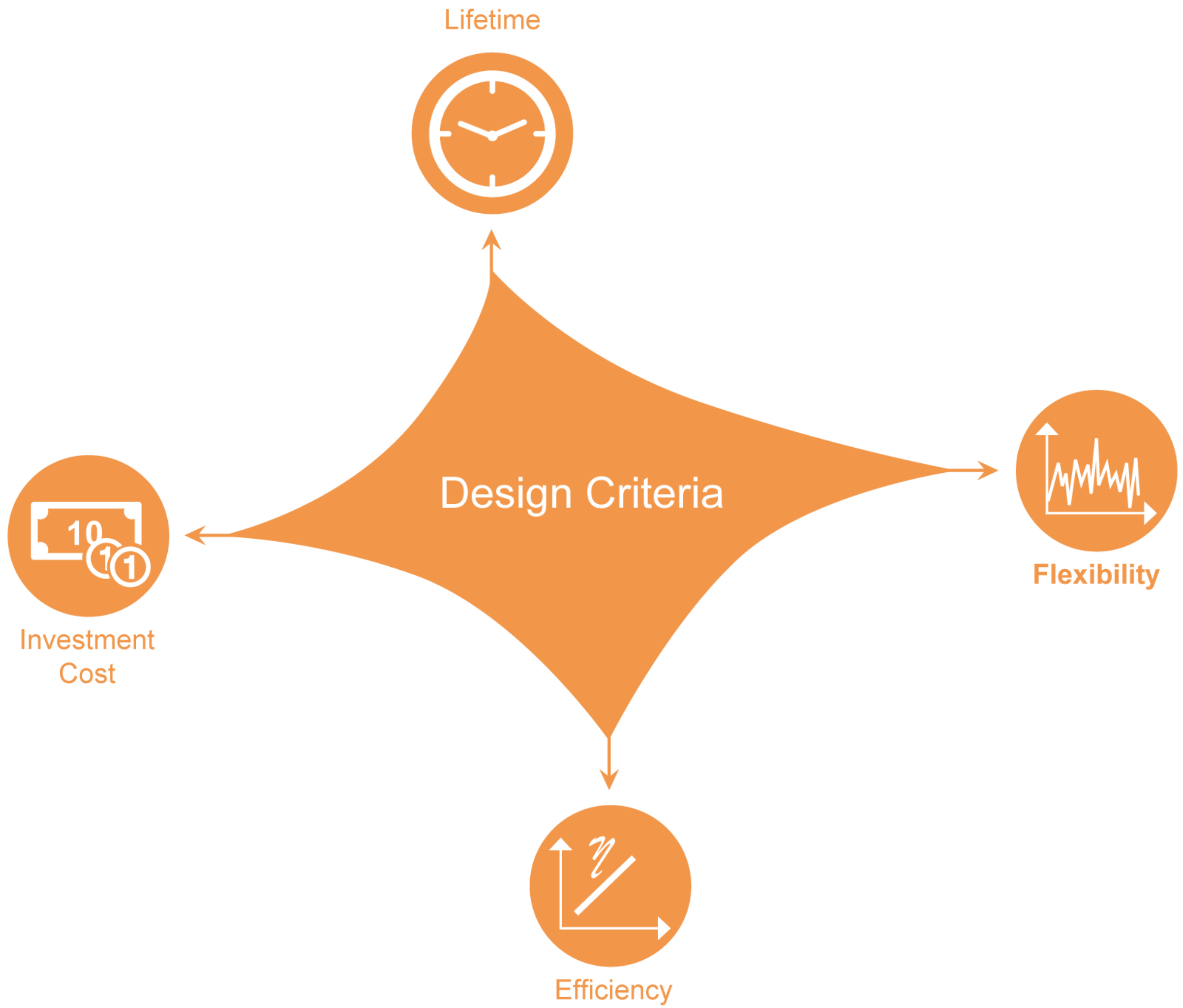




Is the Energy-only market the right market design to stimulate and ensure investments and operation of conventional power plants in the long-term?

Design criteria for future plants

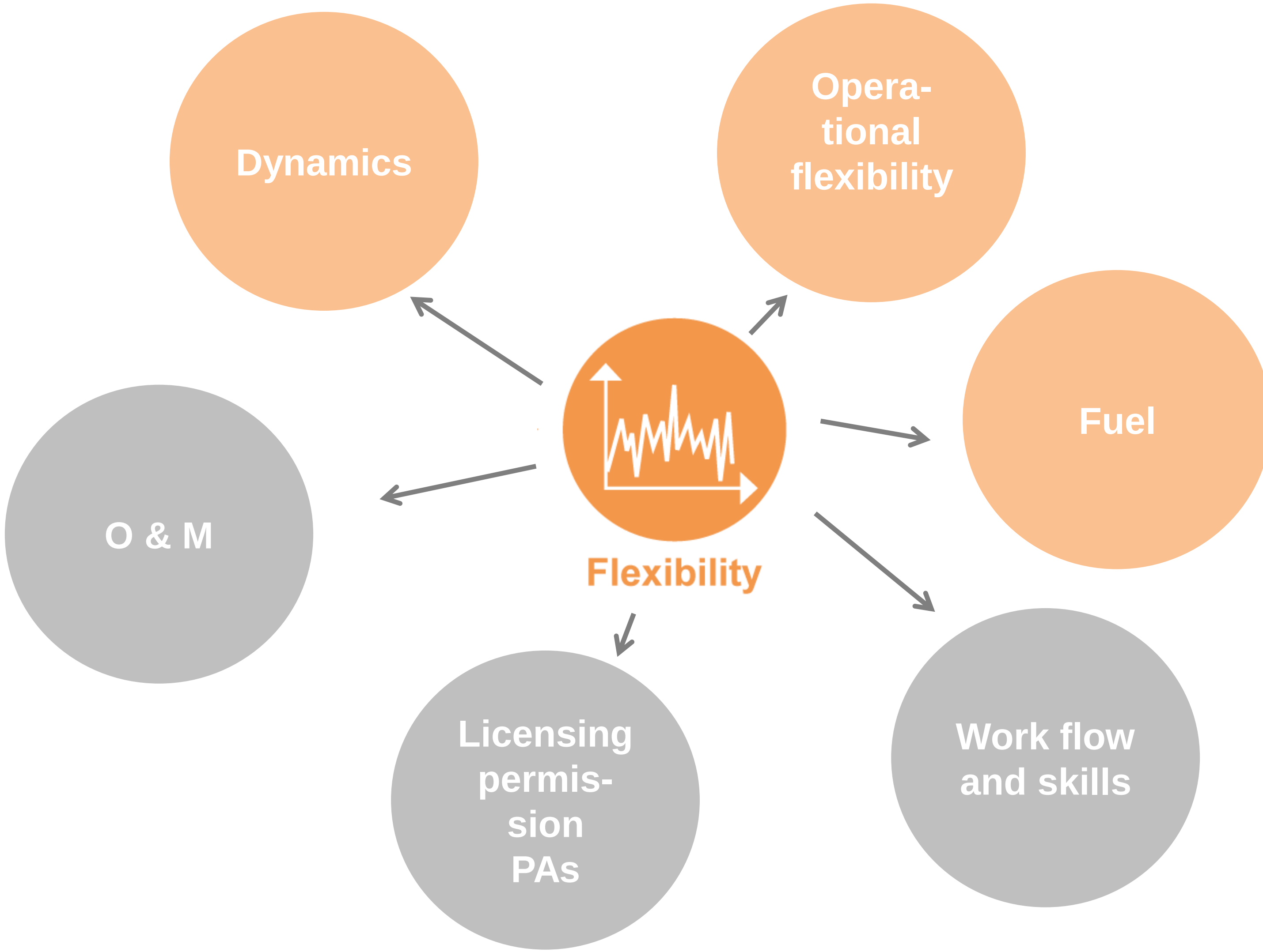
POWERTECH



The future design concepts are determined by costs, lifetime requirements, efficiency and flexibility. The prioritization of these criteria depends on the value of flexibility.

What does flexibility mean?

POWERTECH



Flexibility is more than technology. It comprise aspects from system stability, design, operational concepts to shift organization and personal skills.

Technical flexibility comprises several aspects

Dynamics

- high operational gradients (load change rate)
- short ramp-up time for minimal and nominal load
- short minimal stand-still time

Operational flexibility

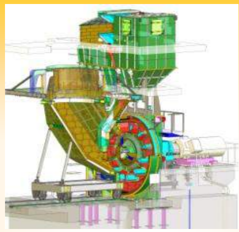
- high number of start-ups and load cycle at reduced life-time consumption
- low minimal load with high efficiency
- uniform high-level efficiency-profile at a wide load range

Fuel flexibility

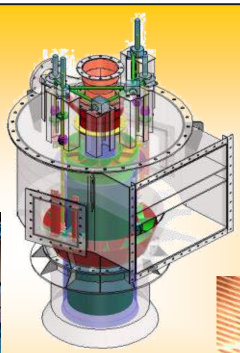
- high plant availability in spite of coal blending and imported coal
- coal treatment technologies and plant modifications (e.g. combustion processes)
- biomass co-firing with a secure supply chain

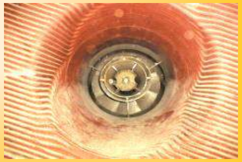
The flexibility potentials are limited by emission and dew-point values, efficiency and lifetime requirements as well as the minimum steam flow.

Principal measures for flexibilisation of coal fired plants

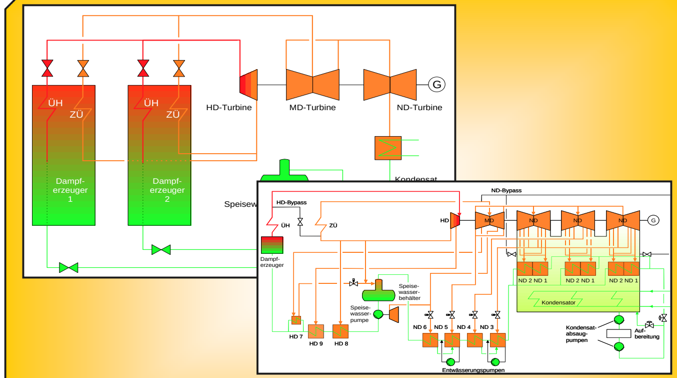



Optimization conventional combustion

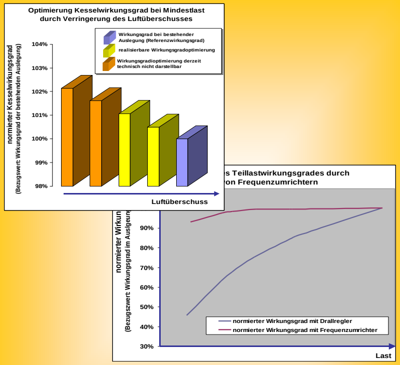





Introduction of the bin (-and feeder) system



Process optimization water/ steam system



Part load optimization of components



Optimization material concept pressure containing component

Source: Vattenfall

Dynamics and operational flexibility

POWERTECH

Main flexibility contributors are: high load gradients, low minimum load, short ramp-up times

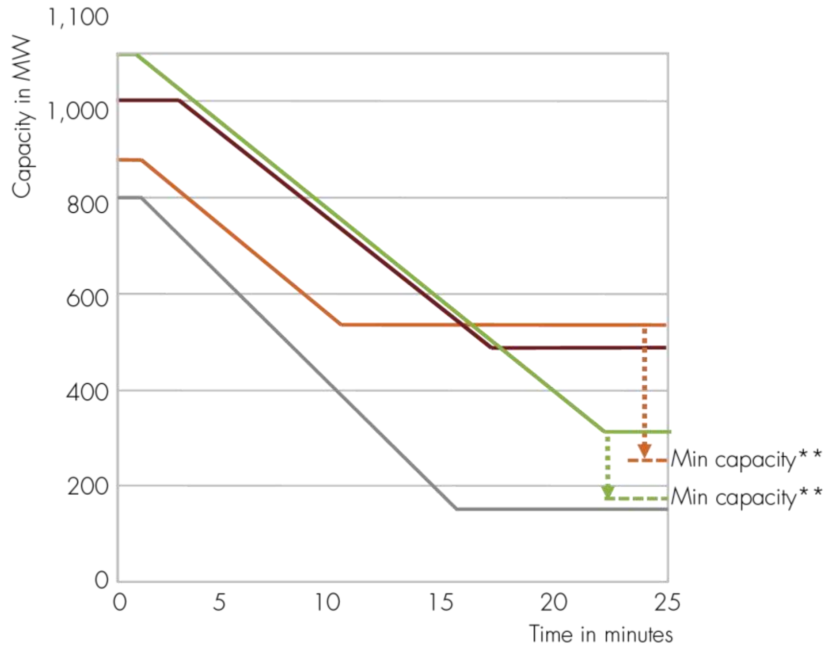
Plant type	Hard-coal	Lignite	CCGT	Gas Turbine
Load gradient [% / min]	1.5 / 4 / 6	1 / 2.5 / 4	2 / 4 / 8	8 / 12 / 15
in the load range [%]	40 to 90	50- 90	40* to 90	40* to 90
Minimum load [%]	40 / 25 / 20	60 / 50 / 40	50 / 40 / 30*	50 / 40 / 20*
Ramp-up time Hot start <8 h [h]	3 / 2.5 / 2	6 / 4 / 2	1.5 / 1 / 0,5	< 0.1
Ramp-up time Cold start >48 h [h]	10 / 5 / 4	10 / 8 / 6	4 / 3 / 2	< 0.1

Source: VDE
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 realizing the potentials for flexibility.

Dynamics and operational flexibility

Comparison of flexibility and ramp capacities of state-of-the-art CCGT and lignite-fired power plants



BoA*** 1 to 3	
Max capacity	~ 1,000 MW
Min capacity	~ 500 MW
Max ramp rate	+/- 30 MW/min

CCGT	
Max capacity	~ 2 x 440 MW
Min capacity	~ 520*/260** MW
Max ramp rate	+/- 32 MW/min

BoAplus	
Max capacity	~ 2 x 550 MW
Min capacity	~ 350*/175** MW
Max ramp rate	+/- 30 MW/min

Hard coal	
Max capacity	~ 800 MW
Min capacity	~ 176 MW
Max ramp rate	+/- 40 MW/min

High and fast ramp capabilities are flexible and complement intermittent renewables.

* Operation with two boilers ** Operation with one boiler *** BoA - optimised operation of a lignite-fired power plant.

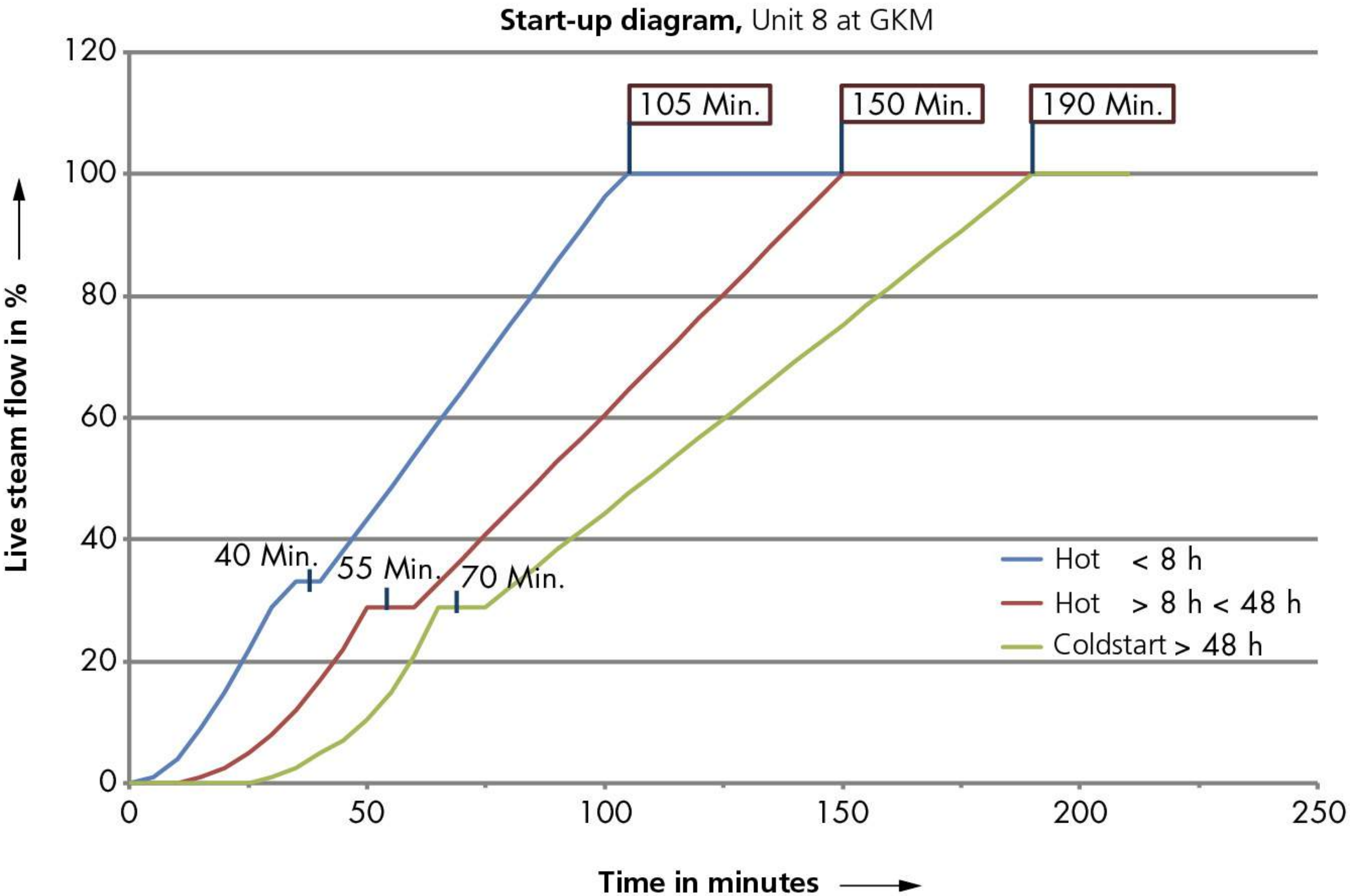
Technical measures to increase of operational load gradient:

→ separation of grinding and combustion, decreasing wall-thickness and aligned component design

Technical measures to reduce the minimal load:

→ increase of numbers of mills, optimization of grinding process and optimized combustion process (e.g. flame detection)

Example Coal-fired Power Plant GKM (Unit 8)



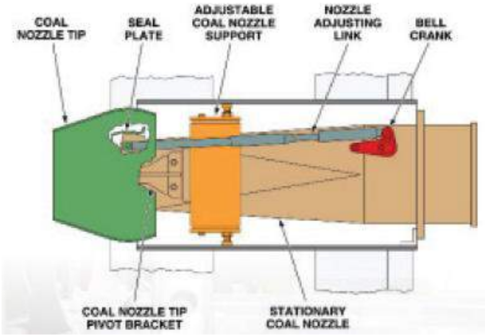
Reduction of minimum load

Typical technical measures :

→ **Boiler**

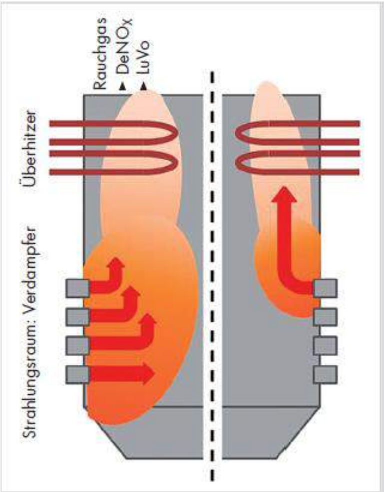
low minimum load thus low thermal firing capacity

- Increase of numbers of mills
- Optimization of grinding and combustion process
- Installation of tilting burners
- Switch to 1-mill operation

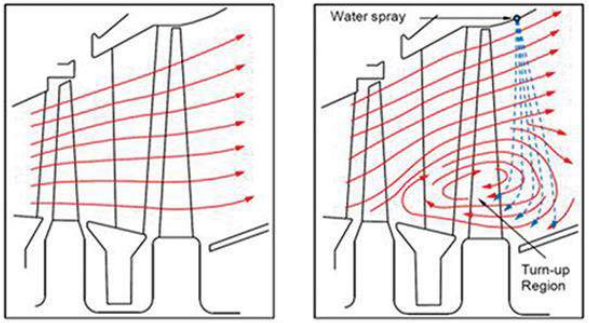


→ **Water Steam Cycle**

- Minimum feedwater flow
- Boiler temperature profile



→ **Turbine**



Normal Rating Operation

Low Load Operation

→ **Flue Gas Cleaning**

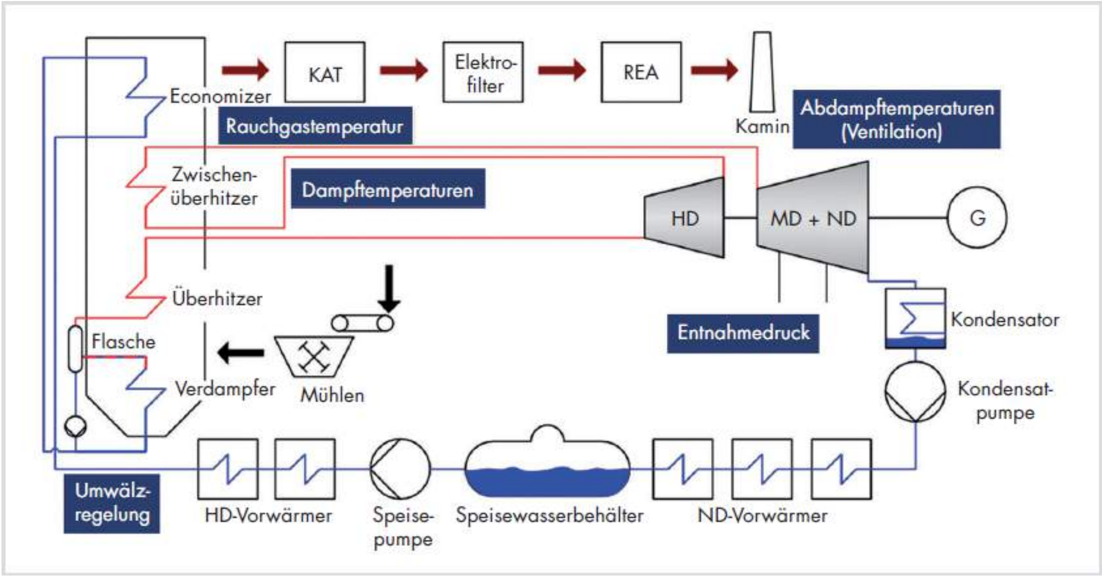
→ **Auxiliaries**

- Minimum load of pumps, fans and other aux.equipm.
- Protection systems (I&C)

low-load operation: Basic considerations

Typical challenges	Problem	Solution	Technical measure
Flame stability and flame detection	Flame pulsation and blow-off	▪ Modify burner operation ▪ Modify burner ▪ Support burners (oil/gas) ▪ Additional flame detectors	▪ Imrpove fuel to air ratio ▪ Increase mixture and swirl ▪ Reduce cooling air flows ▪ Change pulverization ▪ install flame holder rings
Thermal firing capacity per burner level	Mill minimum load	▪ Ensure minimum coal content in burner fuel/air flow ▪ Ensure equal coal dust distribution to burners ▪ Reduce cooling air flows ▪ Improve positioning accuracy of air control flaps	▪ Reduce cooling air flows ▪ Avoid leaking air flaps ▪ Modification of characteristic curves of flap drives and more accurate flow and position measurements
Stable and equal distribution of feed water in evaporator	Over-heating and excessive tension in boiler tubes	• Check for design buffer in minimum feedwater flow • Use circulation mode	
Boiler temperature profile changes	High temperature gradients in thick-wall components and turbine	▪ Minimize temperature changes ▪ Check turbine ventilation protection	▪ Improve/extend measurements in water/steam cycle ▪ Optimize mode change procedure between once-through and circulation operation
Higher dosing of NH_3 in SCR due to low flue gas temperature (~ < 280 °C)	NH_3 slip Fouling/corrosion	▪ Additional flue gas re-heating ▪ Improve dosing control	▪ Eco-Bypass water- or flue gas side ▪ Use higher burner level ▪ Use higher air ratio
FGD separation ratio	Residual time of droplets decreases	▪ Increase L/G ratio	▪ Improve pump operation scheme

1-Mill-operation: where to look at



Online mill monitoring:

- ❑ **Reduce minimum load**

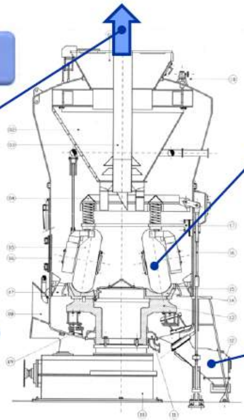
  Advanced diagnostic and management system to reduce mill load

  Target: 15 - 20%

COAL FINENESS AND UNBALANCE MONITORING

COAL FINENESS MONITORING
Validation completed with good results

COAL FLOW UNBALANCE MONITORING
Validation completed with acceptable results



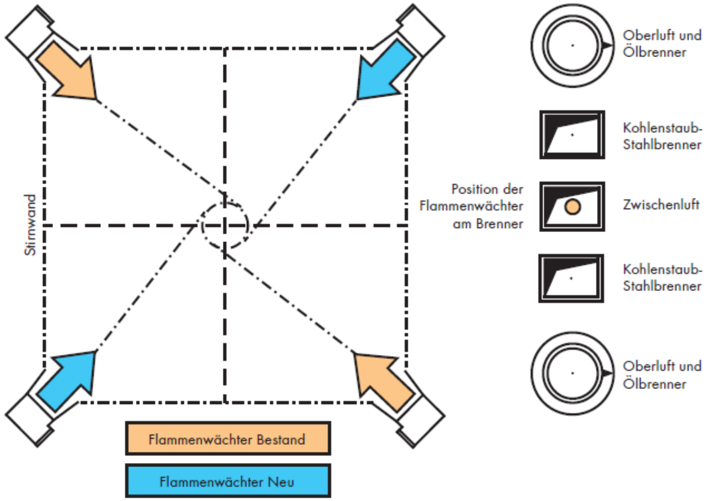
VIBRATION MONITORING

Stress-tests, aimed at simulating mill malfunctioning events **successfully performed**

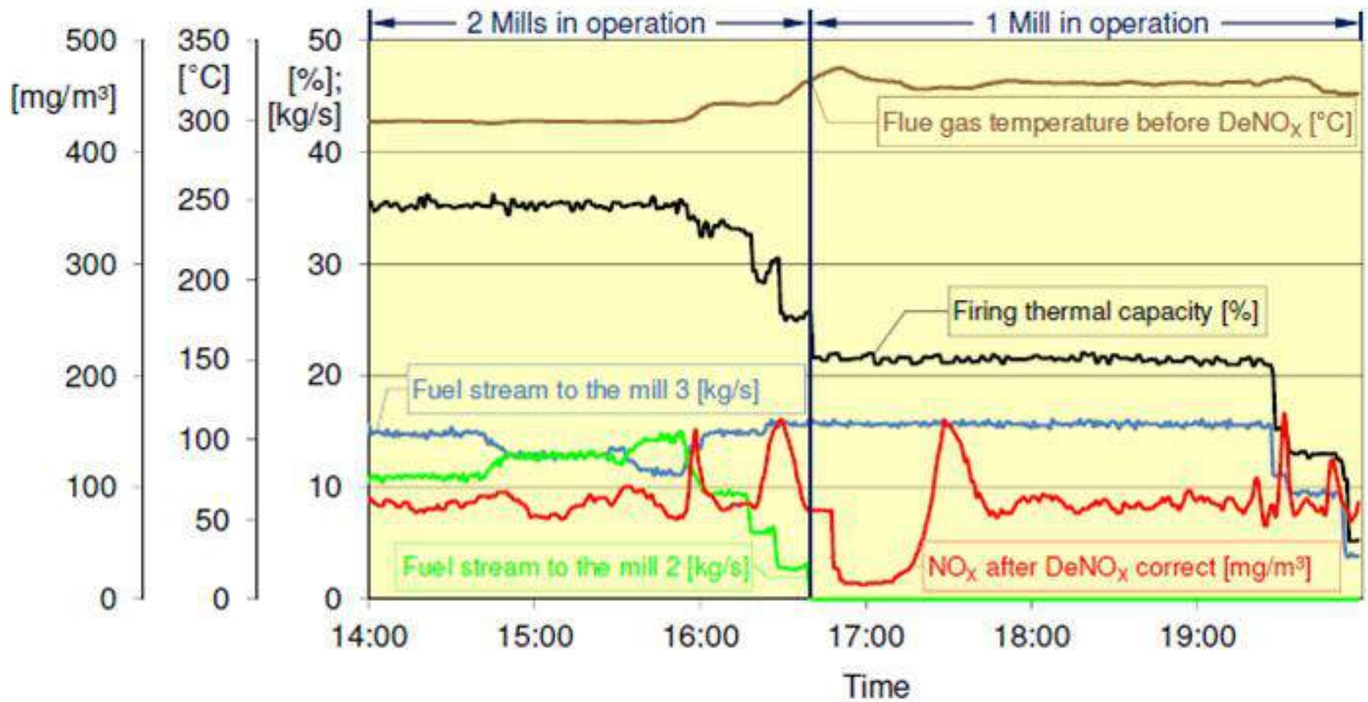
PRIMARY AIR FLOW MONITORING

Advanced measurement system **installed** and **successfully validated**

Additional flame detectors:



Operation at minimum technical load by change from two to one mill in service



V15 – Design concept and operation experience of recent hard coal fired power boilers – 22/04/2015 – P 15

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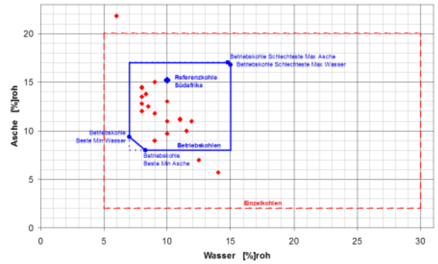
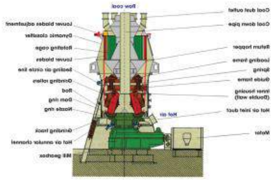
Source: RWE/Alstom

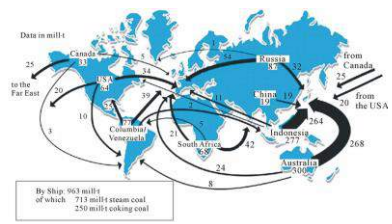
Fuel flexibility

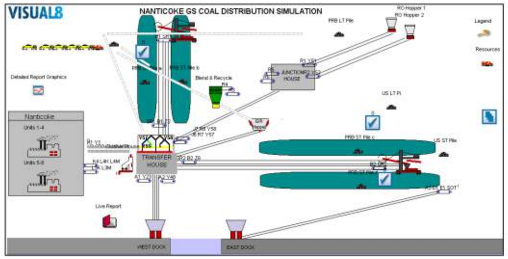
Imported coal



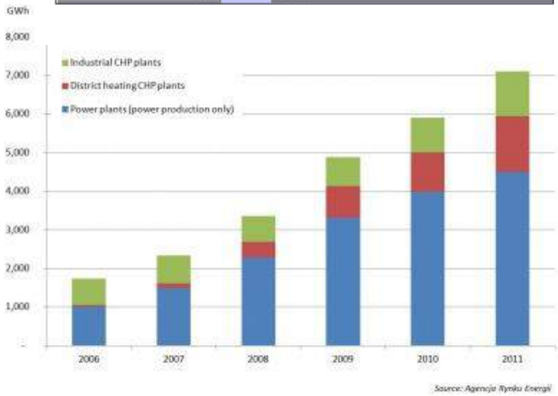


Coal blending





Biomass co-firing



Challenges:

⟶ high plant availibility in spite of changing fuels

⟶ necessity of plant upgrades and technological modifications (e.g. combustion, FGC)

⟶ secure supply chain (e.g. for biomass)