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Adaptation of O&M procedures – new operating, maintenance and training requirements

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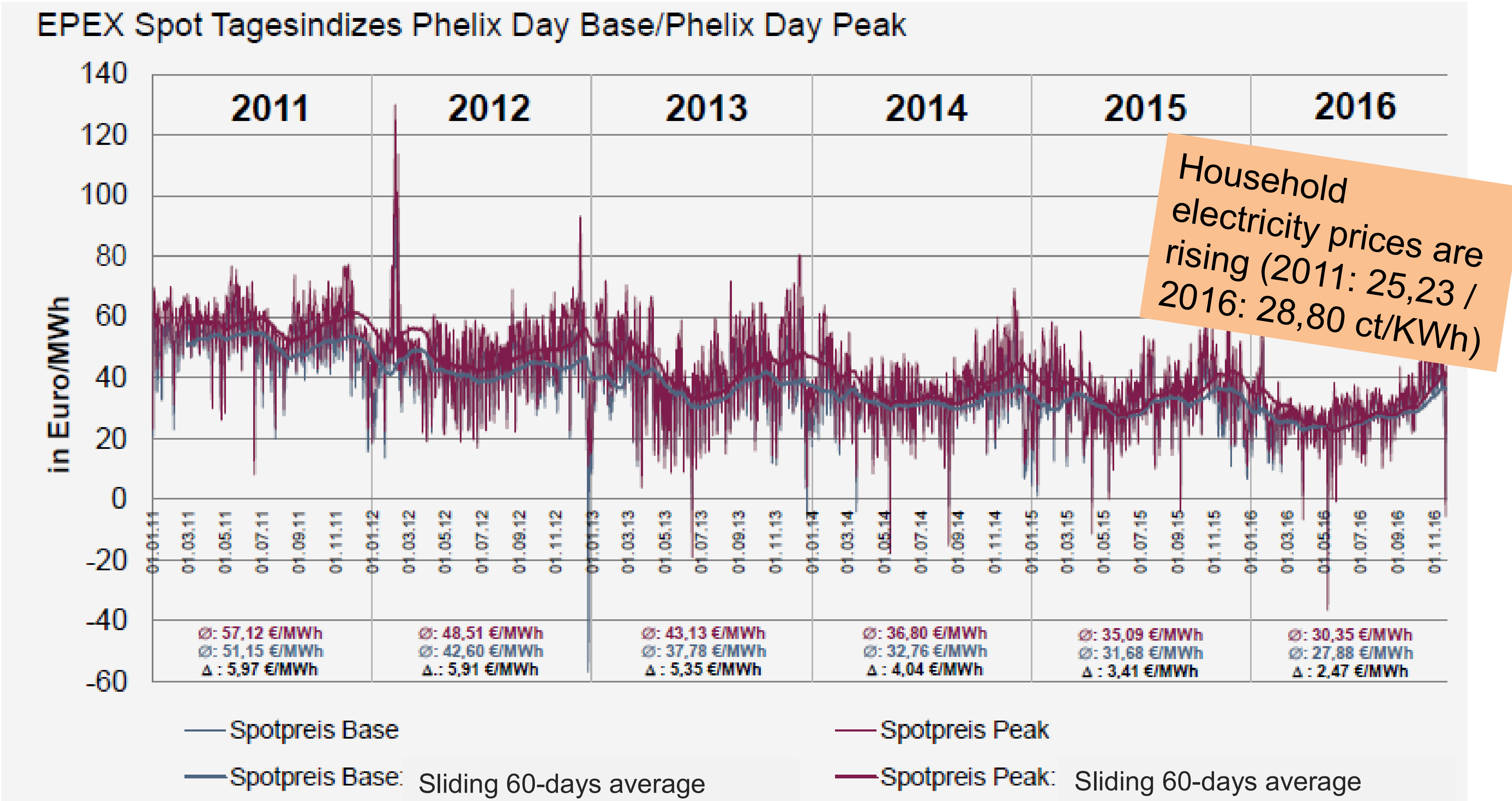
Agenda

1. Challenges
2. Aspects and consequences of flexible operation
3. Modern maintenance strategies
4. New requirements for the power plant personnel
5. Conclusions and outlook

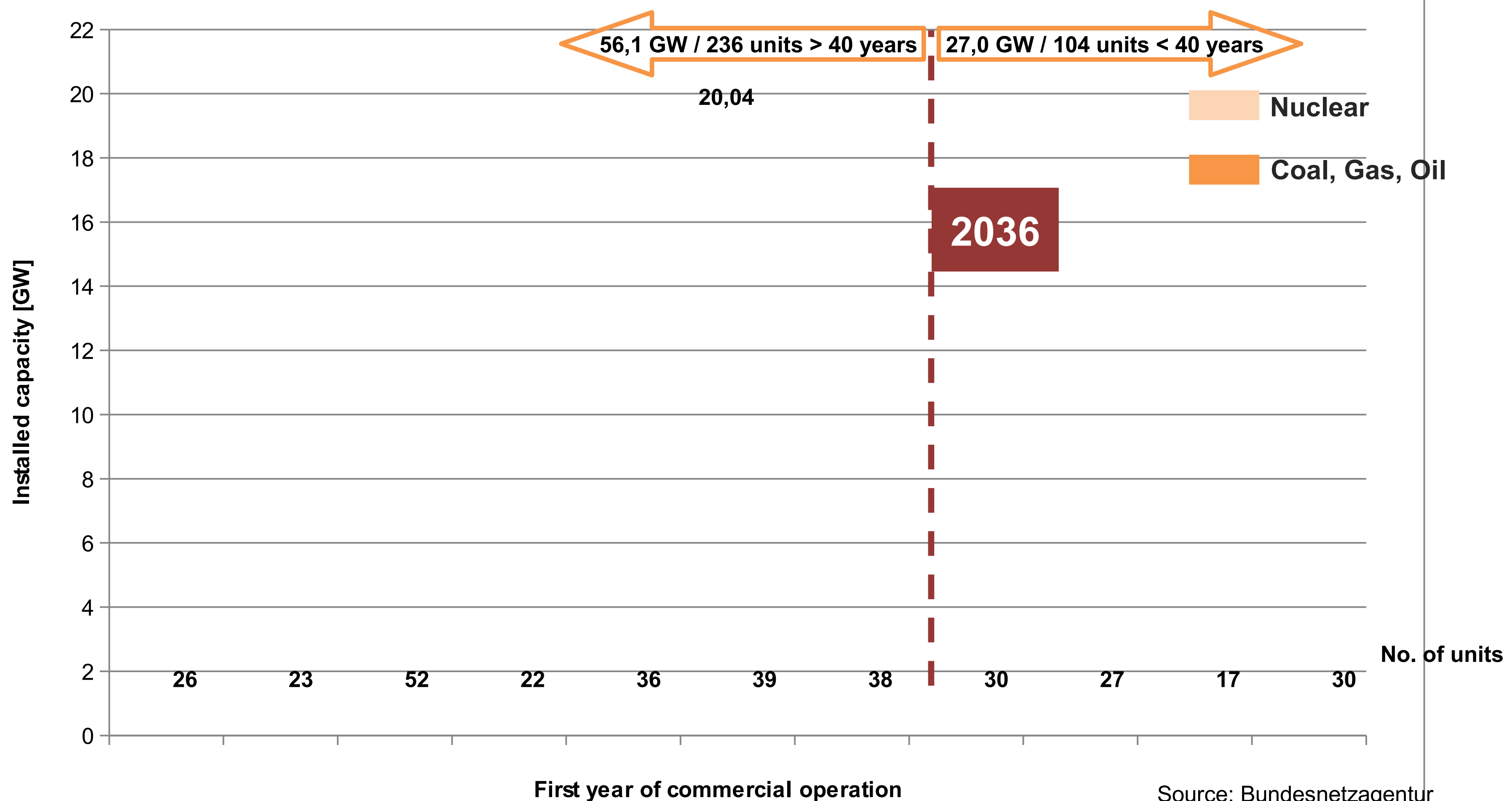
1. Challenges: declining energy prices



Source: EPEX Spot, BDEW

The spot market prices are continuously declining (even negative prices are possible) – the **budget for O&M is very small**.

Thermal plants in Germany > 25 MW in operation (installed capacity 83,1 GW / 340 units)



Source: Bundesnetzagentur

The ageing of the fleet is reducing the secured capacity significantly.

2. Consequences of the new O&M strategies

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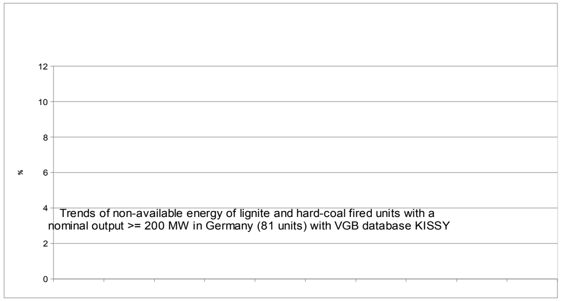
n/a energy - planned

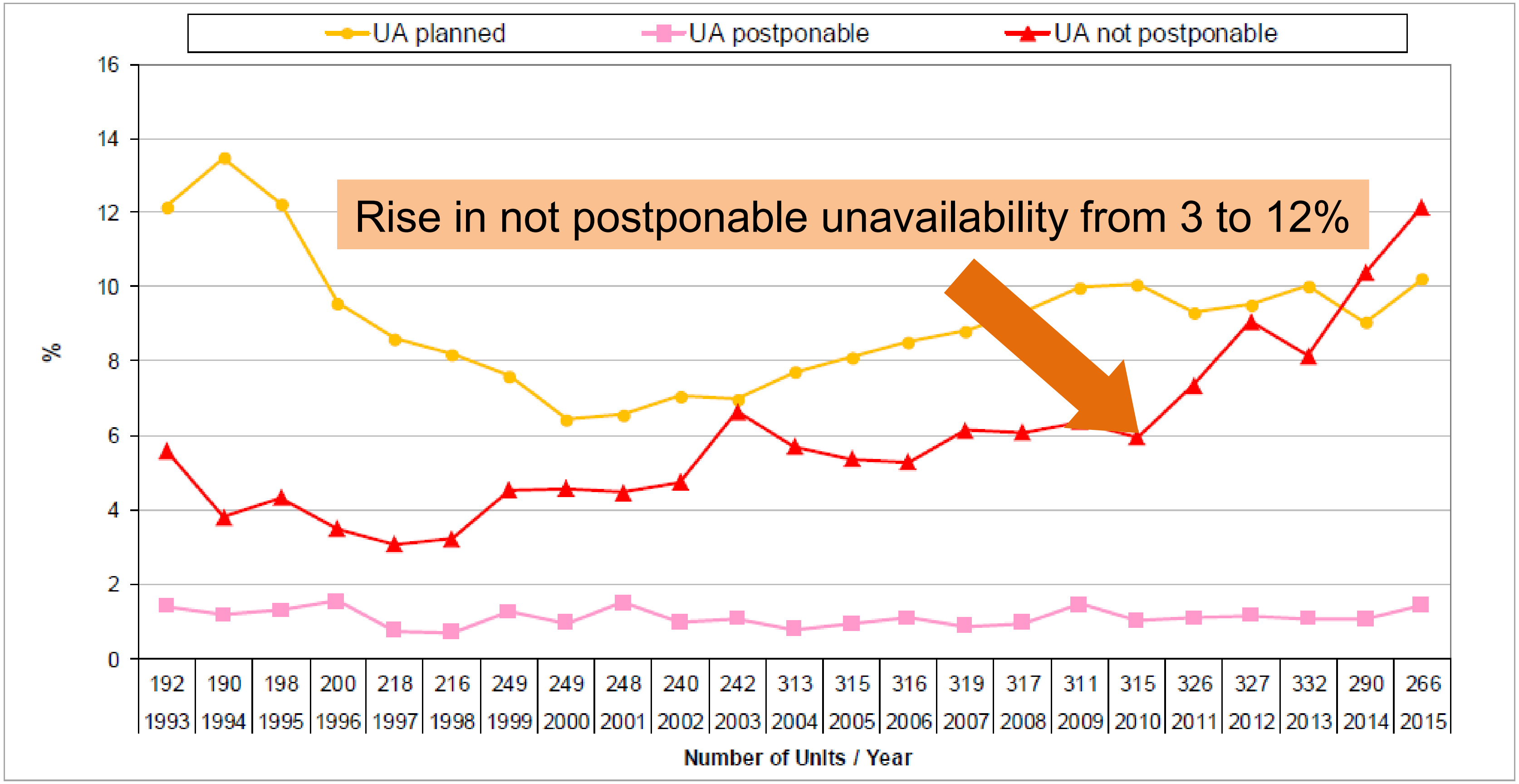
n/a energy – unplanned



During the last ten years planned unavailabilities have decreased whereas un-planned unavailability has increased significantly.

2. Development of the plant unavailibilities

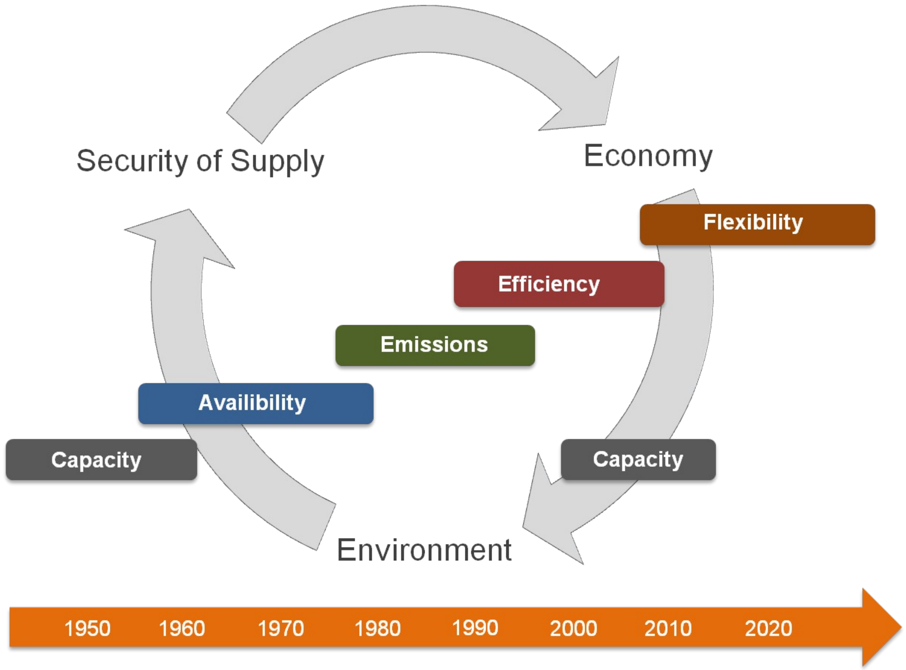
Time range: 1993 - 2015



Annex 5: TSR 'Availability', A.2.1.1 Trend of fossil fired units without CCGT's, total

Availibility has no value if market prices are below the electricity generation costs. This results in a paradigm shift for maintenance strategies.

3. Modern maintenance strategies



Priority in the past:

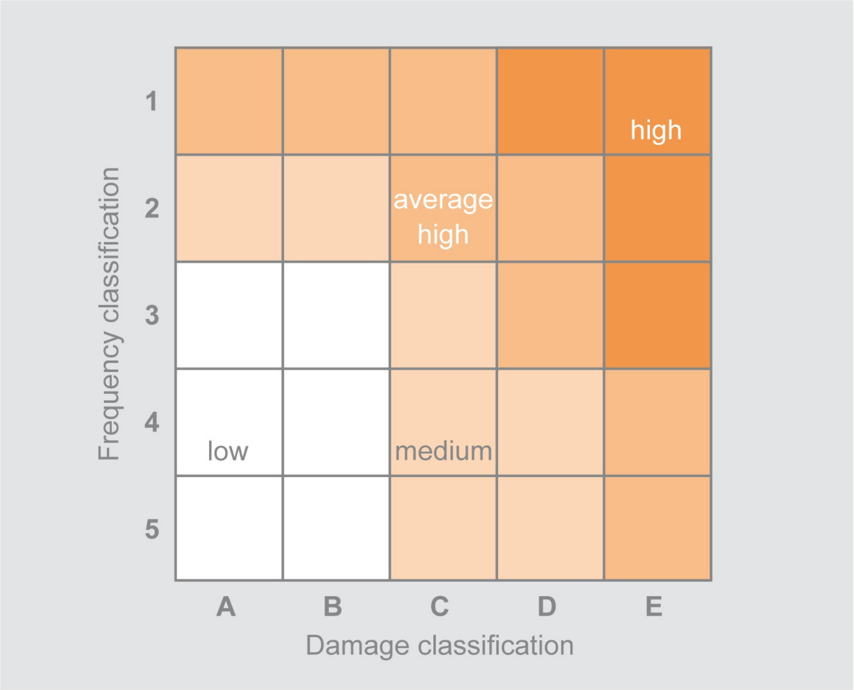
Increase availibility and reliability while keeping the maintenance costs stable

Priority today:

Reduce the maintenance costs while keeping sufficient availibility and reliability

Operators need to preserve the plant availability according to market requirements and increase flexibility of assets with a minimum maintenance budget.

Risk Based Maintenance considers the risk of a potential failure. It is derived from the product of the damage potential and the probability of failure.



Class	Lifetime expectation in years
1	> = 10
2	> = 5
3	> = 1
4	> = 0.5
5	< 0.5

Class	€-costs caused by the damage
A	< = 500
B	< = 5,000
C	< =50,000
D	< = 500,000
E	> 500,000

Risk-based methods have been proven efficient and cost-effective while keeping a high health & safety standard. They require a high transparency about the plant status.

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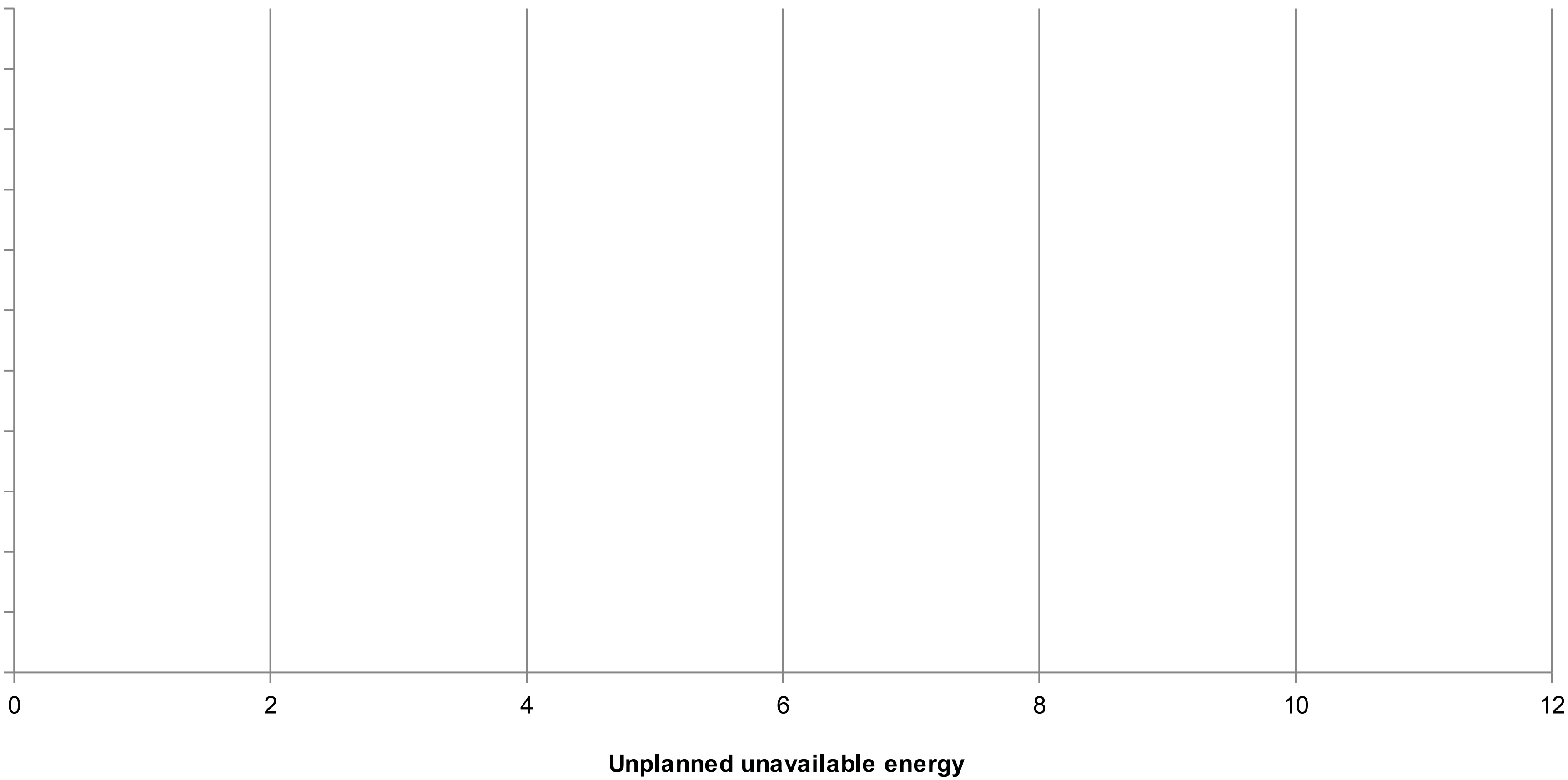
TOP 20 components with highest unplanned unavailability
Evaluation of 3,633 incidents without external influence
Collective: fossil fired units; commis. date ≥ 2000; ≥ 200 MW gross capacity; all countries
Time Period 2000 to 2013



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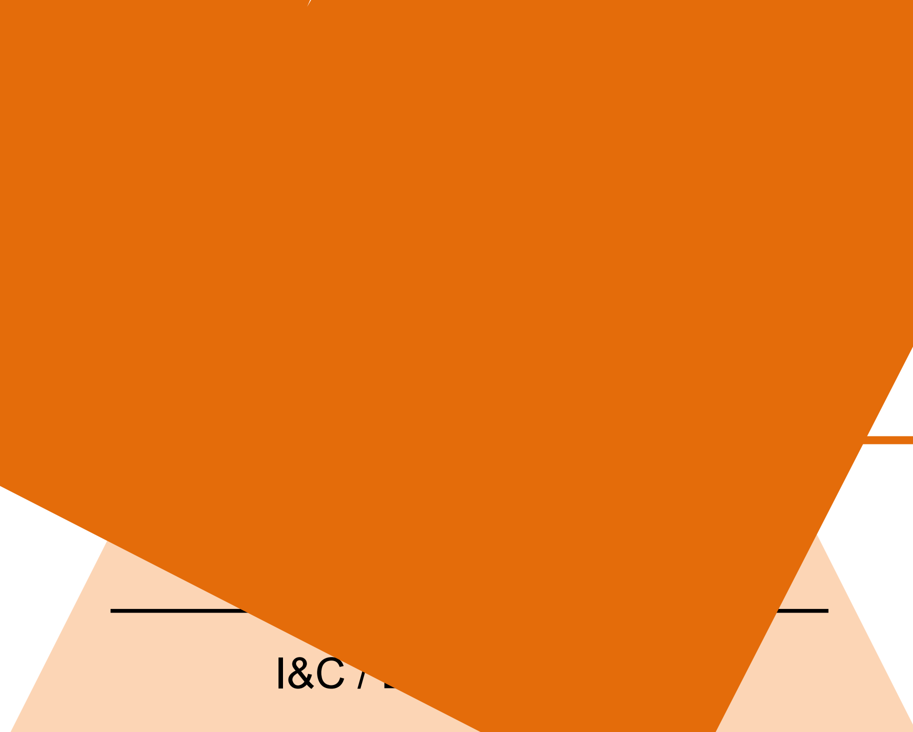
Benefit
Costs
Complexity



O&M system

Linkage between technical and commercial information (company-wide)

pretation of measured values and

d assessment of the actuial process

idation and automatic initiation of measures

ysis

Calculation of paramenters and set values

Comparison between set and actual values

Monitoring

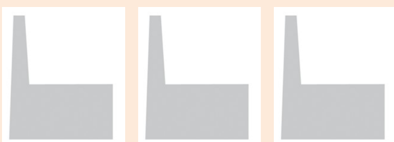
- Collection and Storage of measured data
- Comparison with simple limit values

I&C and DSC

Measuring, operating, monitoring and protection

An optimized mixture of monitoring and diagnostics provides useful information for adapting the plant to flexible operation including modern maintenance strategies.

Fleet approach to realise synergies



Define power plant types

- **market driven** – must-run, reserve, etc.
- **technology driven** – similar equipment (e.g. turbine / boiler)

Assessment and **definition of maintenance strategies** for different power plant types

Overall fleet is equipped with a uniform automation technology ensuring data transparency and advanced data assessment as well as benchmarking

Standardization, harmonized working and reporting procedures and exchange of experiences and lessons learned are benefits of the fleet management approach.

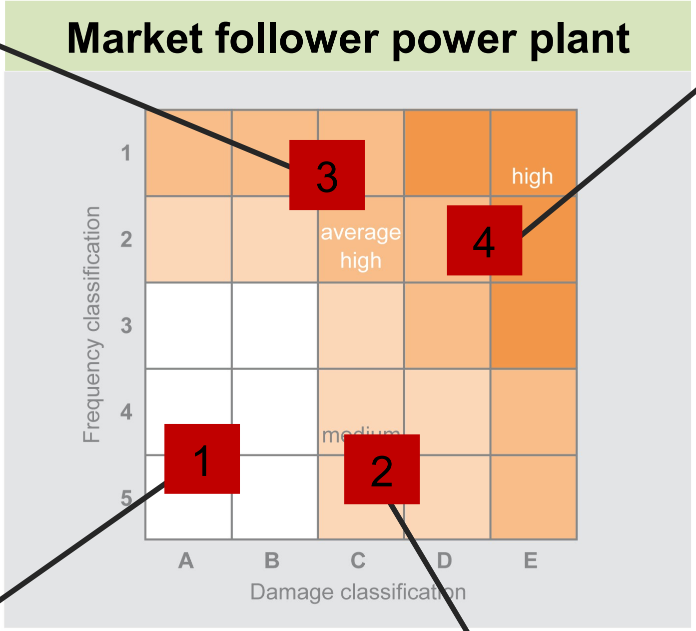
3. Market driven fleet approach

	Must-run (contractual)	Market follower	Reserve
Characteristics	operation according customers' needs for electricity and/or heat	market prices rule the power operation	operation on demand of the TSO
Availibility	> 90 %	< 80 %	not important
Utilisation	70 – 80 %	35 – 50 %	1 – 5 %
Maintenance approach	▪ preventive mainte-nance in wear-intensive areas (mills, boiler, FG-cleaning) ▪ condition based maintenance ▪ overhaul cycles and durations are time-dependent	▪ risk-based maintenance ▪ advanced condition monitoring ▪ overhaul cycles are cost-optimised and based on equivalent operating hours ▪ longer stand-stills	▪ condition based maintenance ▪ frequent plant tests and start-ups to secure reliable operation if requested ▪ long stand-stills ▪ need for a concept to maintain know-how

Source: VGB based on Uniper

The operational regime remains stable over the contractual period for must-run and reserve power plants. Market followers suffer from increased lifetime consumption.

Reduction of failure's consequences by pre-dictive (condition based) maintenance including repair and replacement



Continuous improvement by advanced I&C tools, life time assessment, frequent inspections and solid repair strategy

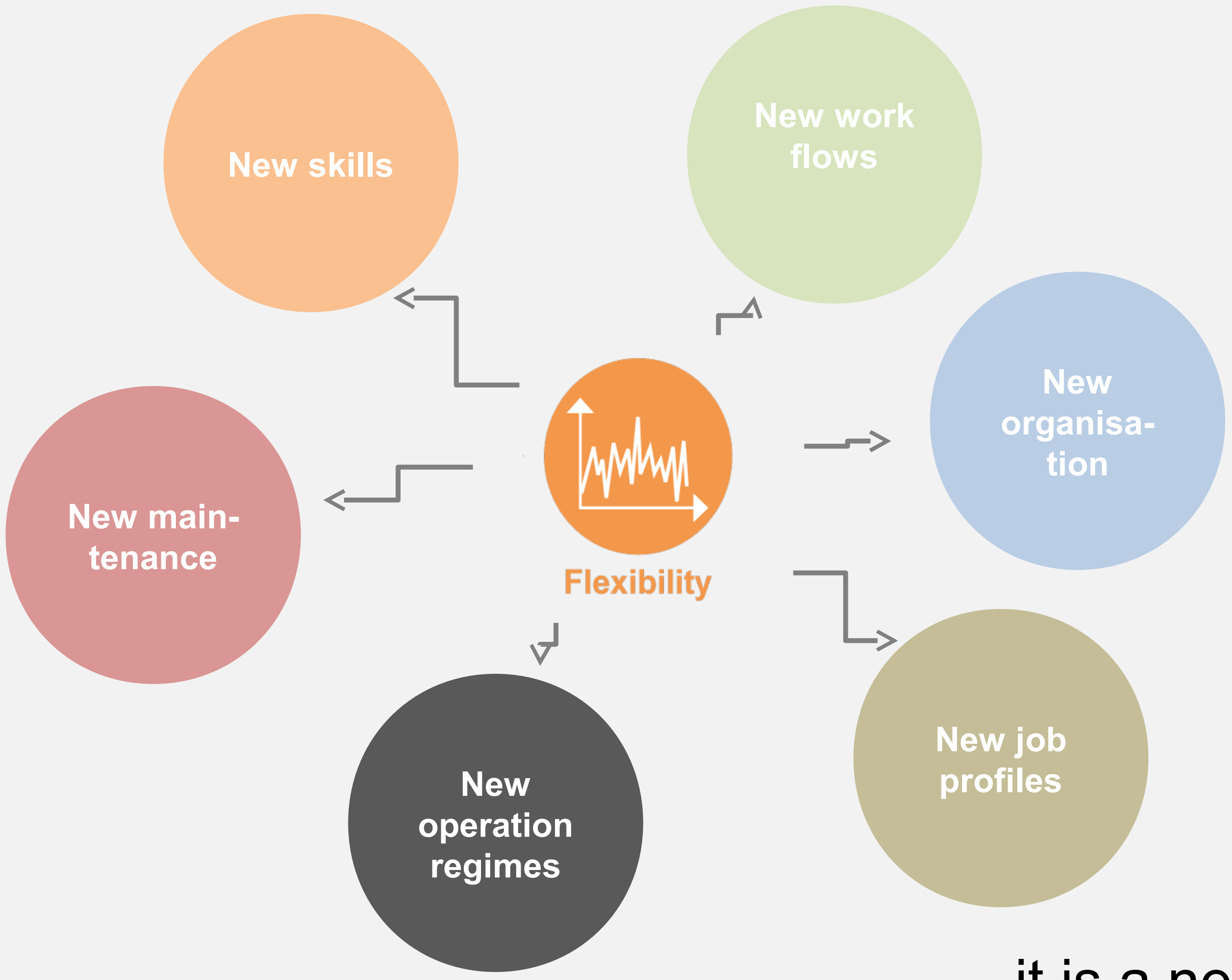
Reduction of failure's consequences by condition based maintenance including repair and replacement

Reduction of failures and degradation by preventive (time-based) mainte-nance measures (e.g. optimised spare part mgt)

Source: EnBW and VGB

The higher the risk the higher the inspection efforts. An optimum needs to be found – based on a reliability-versus-(maintenance)costs-evaluation.

4. New requirements for power plant personnel



…it is a new culture

4. How to deploy the cultural change?

Deriving a fleet approach:

- Installing *Flexibility Cells* to sustain and to transfer know-how and to implement train-the-trainer-concepts

Training for power plant personnel:

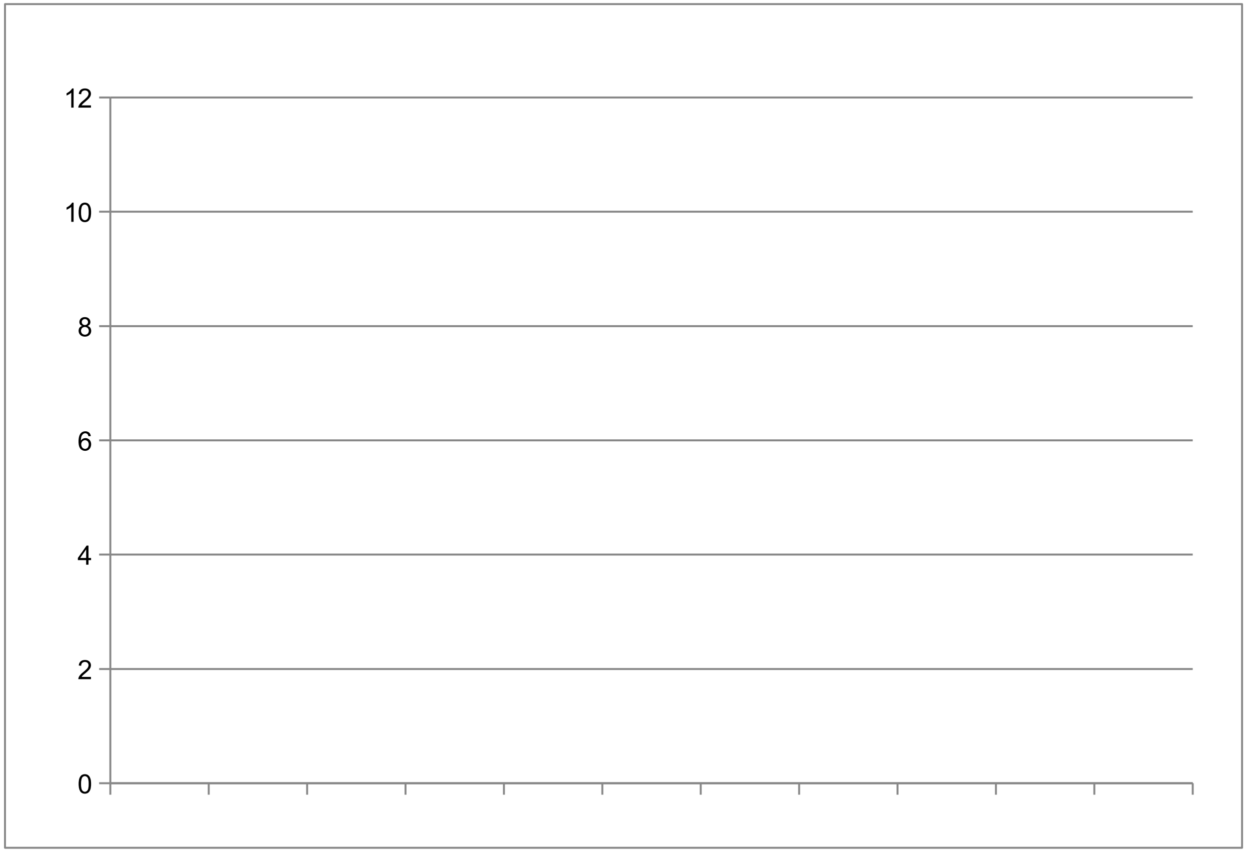
- New operating regimes – simulator training modules to familiarise with new processes and features
- New maintenance routines – specific training to familiarise with new inspection, repair and spare part management
- Specific for different types of personnel but aiming at a intensive co-operation across departments (operation, maintenance and controlling)

Motivation:

- Raise awareness for flexibility and the need for a change

The planning and implementation of flexibility measures in the power plants should go hand in hand with a profound training concept taking the staff aboard for the change.

Development of staff numbers in a reference hard coal power plant with one unit



Due to liberalisation and tight market conditions the average staff count has decreased by 70 percent over the last 18 years – there is limited potential for further reduction.

4. Organisational structure of a German power plant

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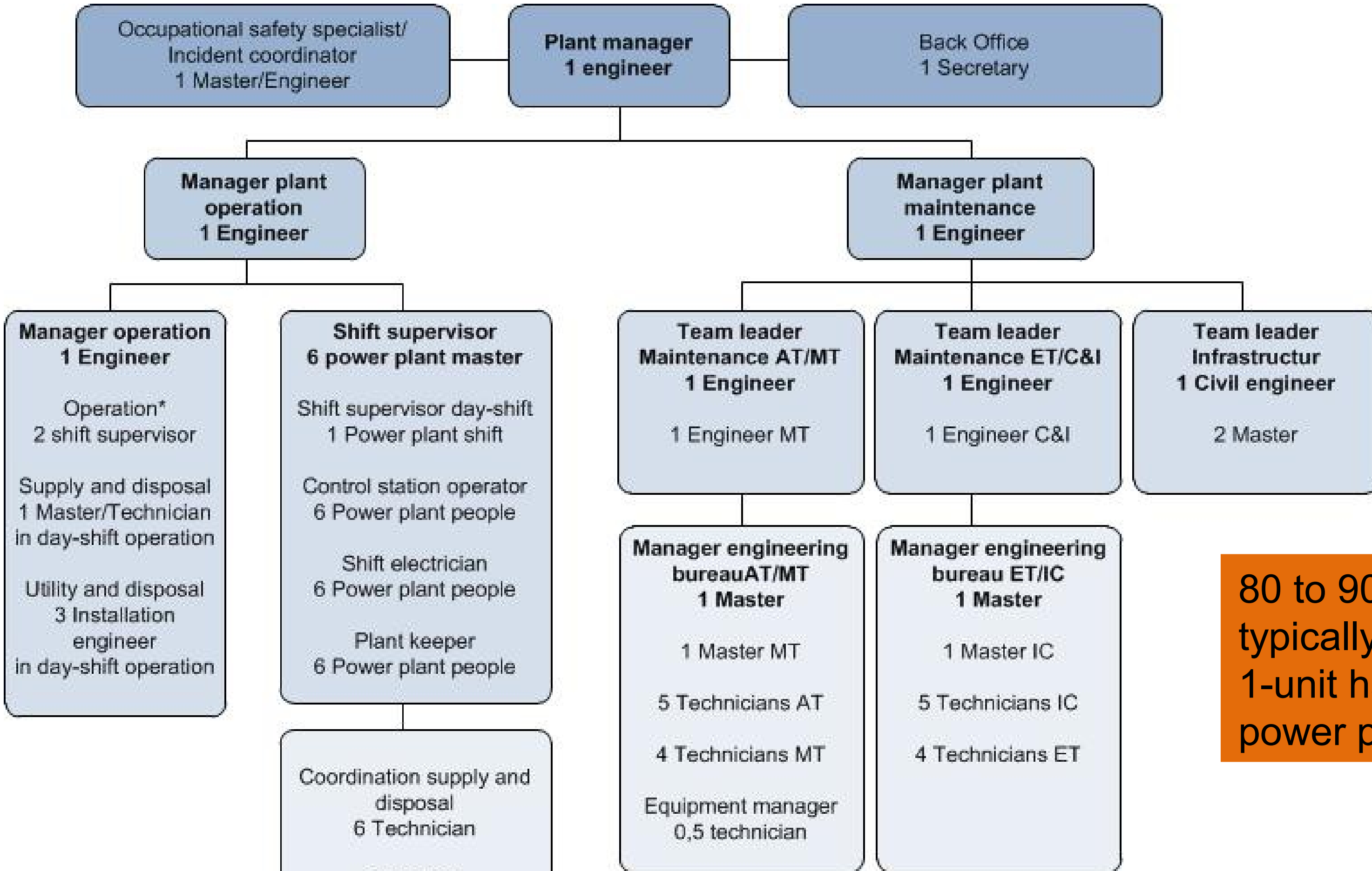

80 to 90 employees typically work in a 1-unit hard-coal power plant

Legend
AT: Apparatus technology
MT: Machine technology
ET: Electrical technology
C&I: Control & Instrumentation technology
*if neccessary

5. Conclusions and outlook

→ **High-level of automation** is required for flexible plant operation and modern maintenance strategies.

→ A **techno-economically assessment** is vital for O&M looking at the trade-off between lost margin due to unavailability and the disposable maintenance budget

→ **Training and skill development** is an inherent part of the change process

→ Intense **co-operation across departments** is necessary

→ Power plants need to become a **permanently learning institution**

Flexible power plant operation implies many challenges: technically and organisa-tionally. A holistic approach is needed to address the complex tasks and requirements.

धन्यवाद

Thank you
for your interest!

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Back-up

2. Aspects of flexible operation

Typical challenges	Problem	Solution	Technical measures
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

2. Fuel flexibility: Enhanced coal range by imported coal

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Typical challenges	Problem	Solution	Technical measure
Higher ash content	· Higher slagging · Higher unburnt hydrocarbons · Higher emissions	· Reduction of burning temperature · Better air/coal mixture · Optimize ESP	· Improve air distribution · Modify burner flow by baffle plates · CFD flow optimization · SO3 dosing
Higher water content	Load restriction	Enhance mill pulverising and drying capacities	· Increase air flow to mill (shift secondary to primary air, flue gas recirculation) · Increase mill air temperature (modify air2air preheater, install steam2air preheater or hot gas burner) · Additives for water bond
Higher volatile content	Avoiding flashbacks at burner	Increase burner outlet velocity and coal/air flow pattern and mixture	· Change from rectangular to round shape of coal header · Install guide and baffle plates
Varying (+/-) sulphur content	· Higher Corrosion (+) · Higher particle emissions (-)	· Ensure oxigen content at burner side walls · Improve FGD	· Install additional burner side wall air nozzles (modify secondary air system) · Optimize pump scheme, additional nozzle layer