R&D-project: Steam Power Plants as Partners for Renewable Energy Systems

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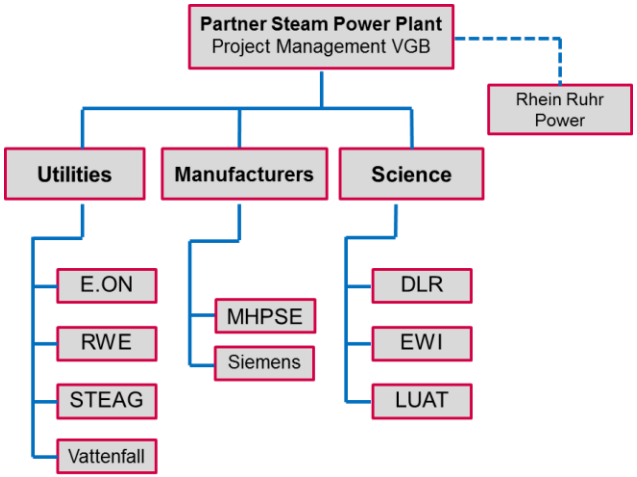
Overview of the partial projects



- Requirements for the future power plant mix (EWI)
- Definition of reference plants (STEAG)
- Simulation of thermodynamic performance (LUAT)
- Reduction of boiler load (MHPSE)
- Reduction of steam turbine start-up time and shut-down time (SIEMENS)
- Integration of storage systems in thermal power plants (DLR)
- Summary

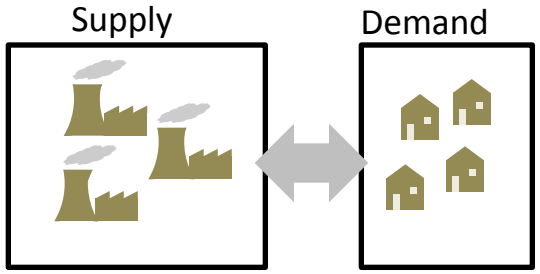
The R&D-project has been initiated by the RheinRuhrPower network and is funded by the Federal Ministry of Economics and Energy.

Requirements for the future power plant mix (EWI)

POWERTECH

Modeling of European power plant operation with more:

- Individual power plant blocks modelled in hourly resolution
- Detailed technical profiles for individual power plants
- Different flexibility options within the electricity market considered



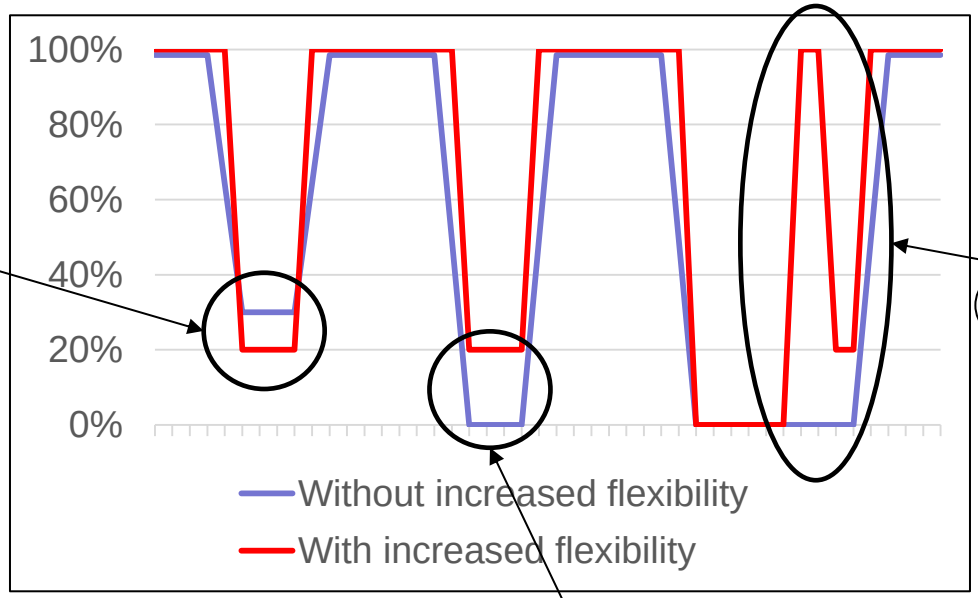
Target: Calculation of added value of flexibility within the overall European power plant system

Methodology: Comparison of different model setups

Approach: Variation of flexibility parameters for reference power plants
- Reduction of minimum load by ~30-40%
- Shorter startup time (by -50%) and lower costs (by -20%)

Effects of increased power plant flexibility

1 Lower minimum load …
… saves fuel (costs) and CO_2 emissions



3 Short start-ups with low ramp-up time will cover residual demand best

2 Lower minimum load (instead of no load) …
… saves start-up costs and contributes to grid stability

Increased flexibility can improve the technical, economical, and environmental performance of power plants

Definition of Reference Plants (STEAG)

- **Criteria**

Existing plants in Germany with sufficient remaining life time

Sufficient data available

Hard coal and lignite

- **Power plant Schwarze Pumpe**

Lignite

Two units of 800 MW each

Start of operation: 1997

Operator: Vattenfall

Net efficiency: 41,2%

- **Power plant Voerde**

Hard coal

Two units of 761 MW each

Start of operation: 1982 / 1985

Operator: STEAG

Net efficiency: 39,8%

Power plant Schwarze Pumpe. Source: Vattenfall

Power plant Voerde. Source: STEAG

Partner Steam Power Plant must meet requirements with respect to flexibility:

- Lowest minimum power output possible
- Lowest start-up costs possible
- Sufficient fast power output changes

Flexibility requirements

- arise from the market
- hence, are different for hard coal and lignite plants

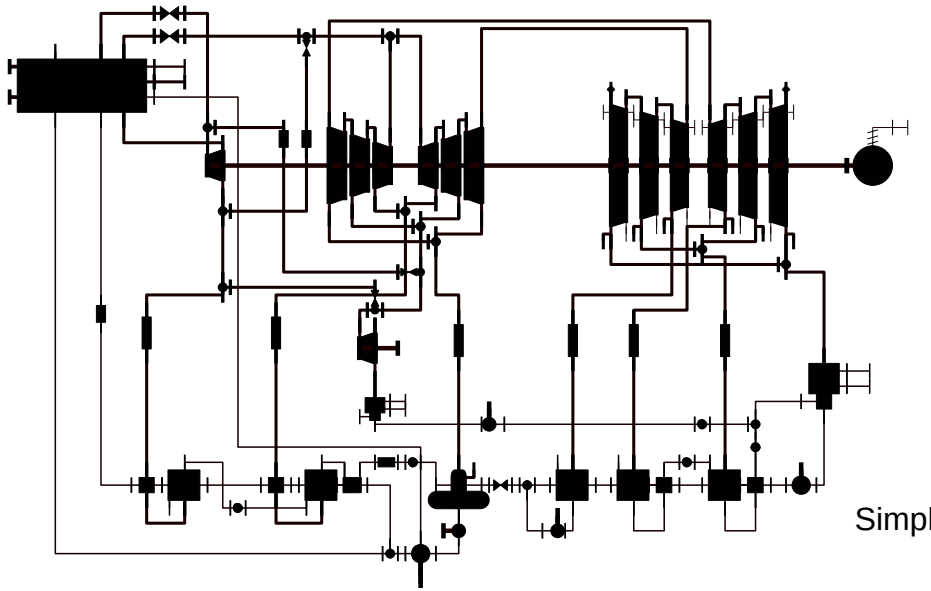
Different components limit flexibility

Many limitations can be removed by using appropriate measures

The result is a highly flexible power plant as a partner for renewable energies.

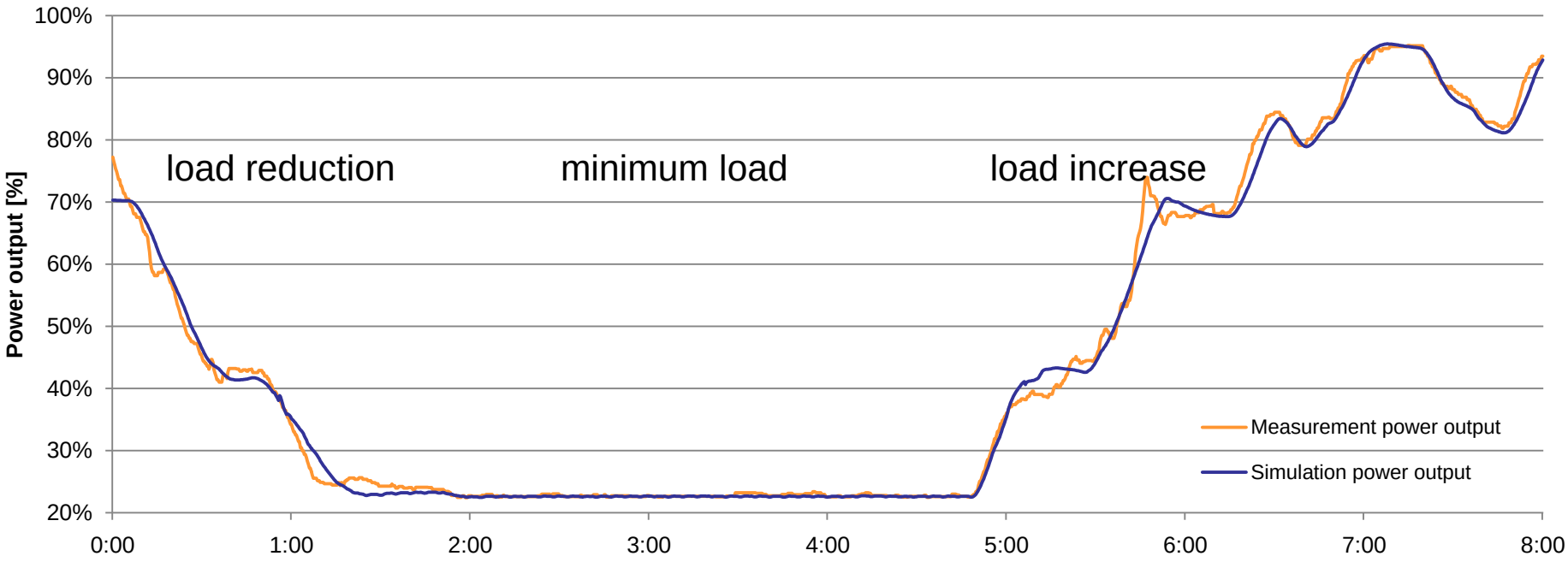
Targets

- Building of the stationary and dynamic overall system models
- Integration of thermal storages into the power plant process
- Simulations of several strategies/measures to increase the power plant flexibility (minimum load reduction, increasing load change rates, etc.)
- Applicability of the results to existing and new power plants



Simplified power plant scheme

Comparison of measurements and simulation results



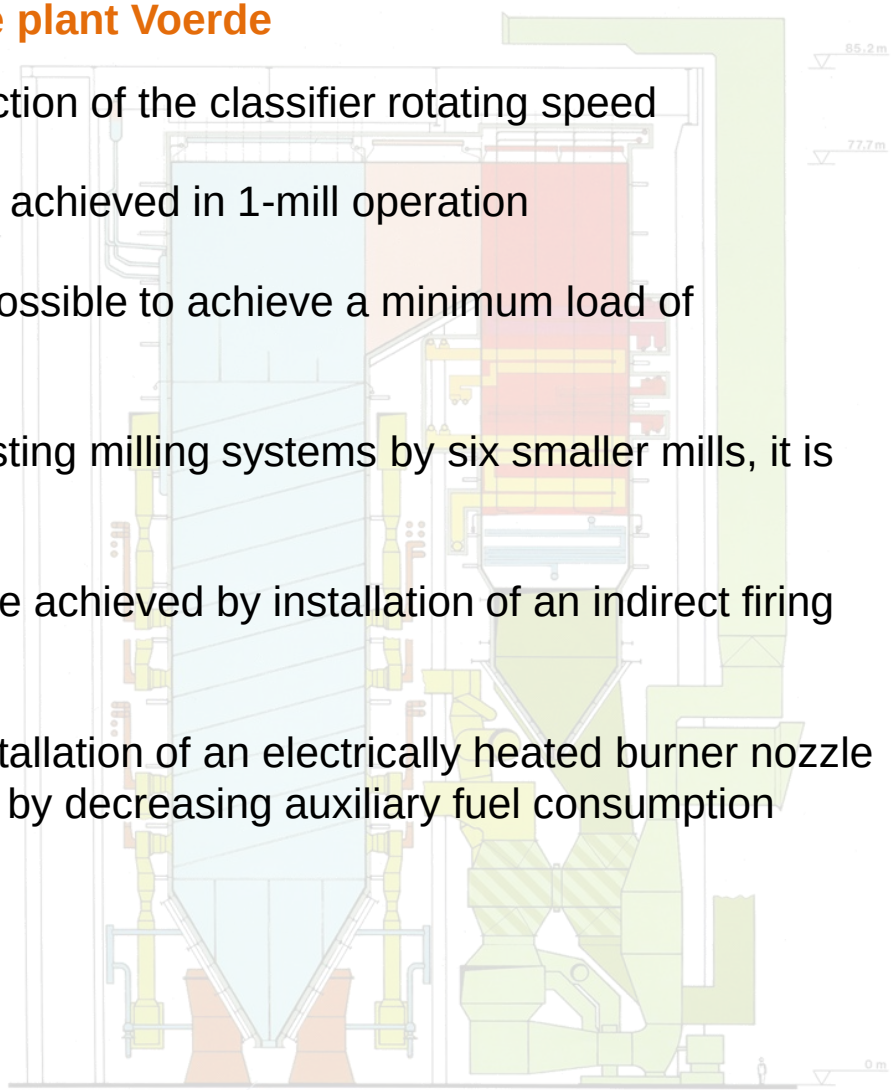
- Good accordance between measurements and simulation results
- Basis for additional simulation studies

Targets

- Development of technical solutions to reduce minimum boiler load
- Minimizing efficiency losses of the boiler system
- Realizing a quicker boiler response on the fluctuating load demand
- Optimization of boiler sub-systems and critical single components such as:
  - Firing system
  - Milling systems
  - Water-steam part
  - Thick-walled components
  - Material selection
- Concept studies on boiler operation characteristics

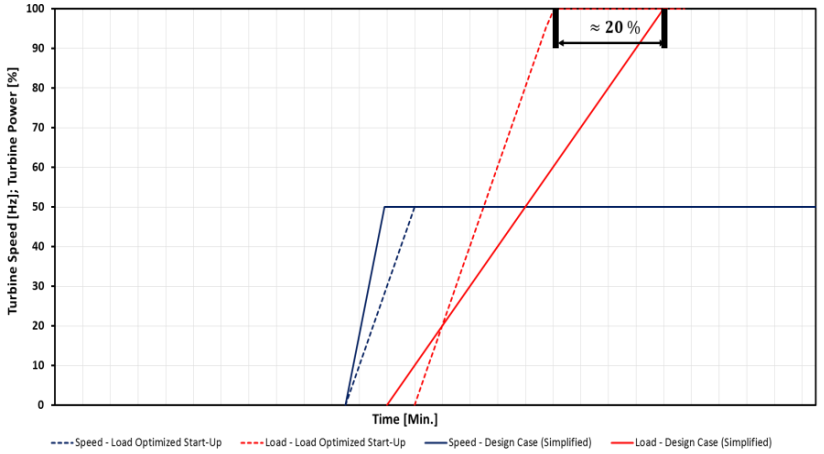
Some results from examined reference plant Voerde

- Increase of boiler load leads to a reduction of the classifier rotating speed
- Boiler load of 15% might be preferably achieved in 1-mill operation
- By installing two additional mills, it is possible to achieve a minimum load of 20% to 15%
- Through a replacement of the four existing milling systems by six smaller mills, it is possible to cover the total load regime
- Higher load ramp up/down rates can be achieved by installation of an indirect firing system
- Start up of the lower burner row by installation of an electrically heated burner nozzle may lead to considerable cost savings by decreasing auxiliary fuel consumption



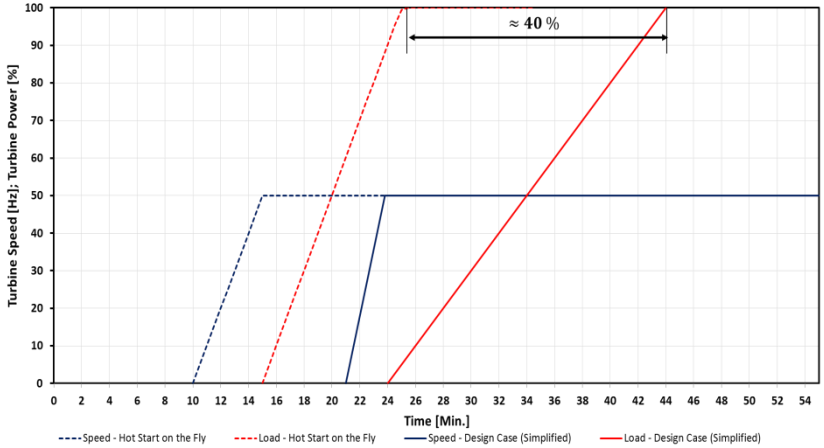
Improved turbine start-up time

- Start-up times can be reduced by about 20% for hot start conditions
- Main & re-heat steam temperatures are reduced for start-up
- This prevents excessive thermal stresses during start-up processes



Improved plant start-up time

- Overall plant start-up times can be reduced by about 40%
- In collaboration with project partners, steam turbine roll-off has been improved
- Focus was set on hot start-conditions



Alternative Inspection Concept – HP turbine is replaced by an identical HP spare turbine

Benefits:

- Shorter inspection times (up to 50 %)
- Optimization of time and expenses projection for inspections
- Less risk of unexpected findings during inspections
- Increased lifetime of turbine components
- More flexible use of equivalent operating hours (EOH)
- Revolving change of components in similar power plants
- State of the art upgrades, so that
  - Optimization for changing operation principles is possible
  - The replaced turbine will have a better efficiency

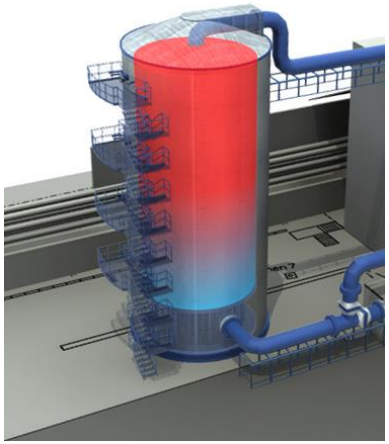
Storage technologies for power plant application

Liquid salts (commercial)

Steam storage (commercial)

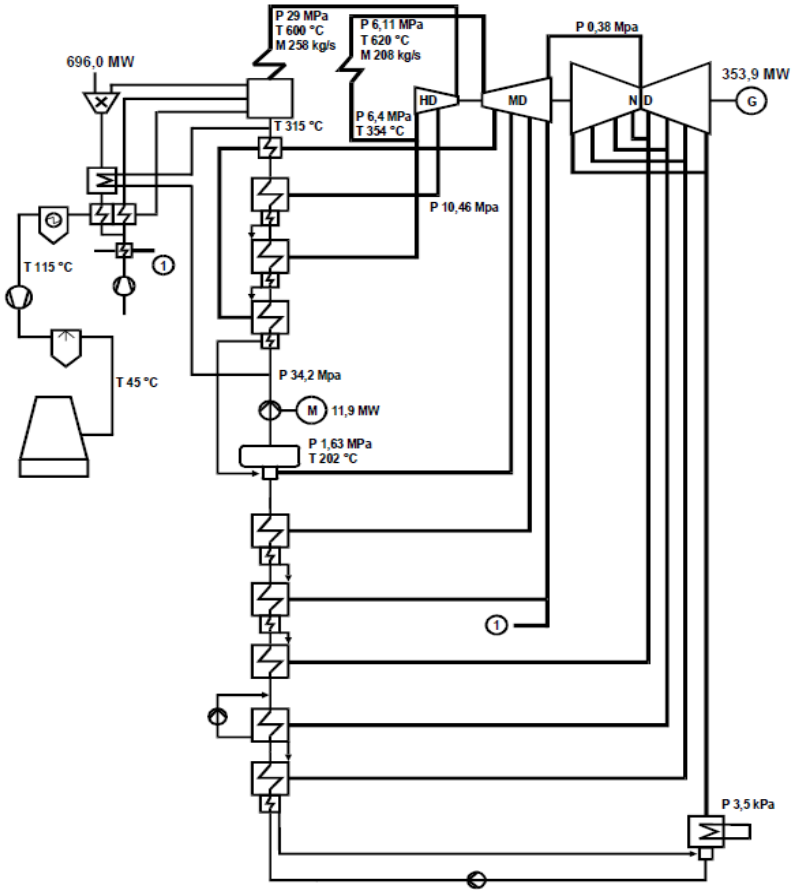
Phase change materials
(pre-commercial)

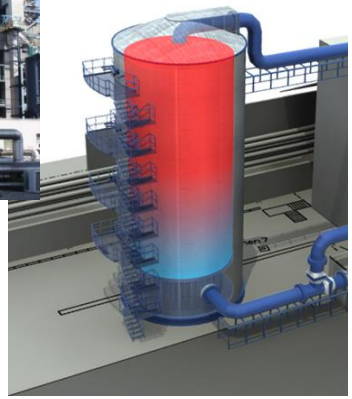
Solid materials
(demonstration stage)



- Wide range of storage technologies for power plant applications available
- Adaptation for specific application necessary

Multiple purpose of storages in power plant operation





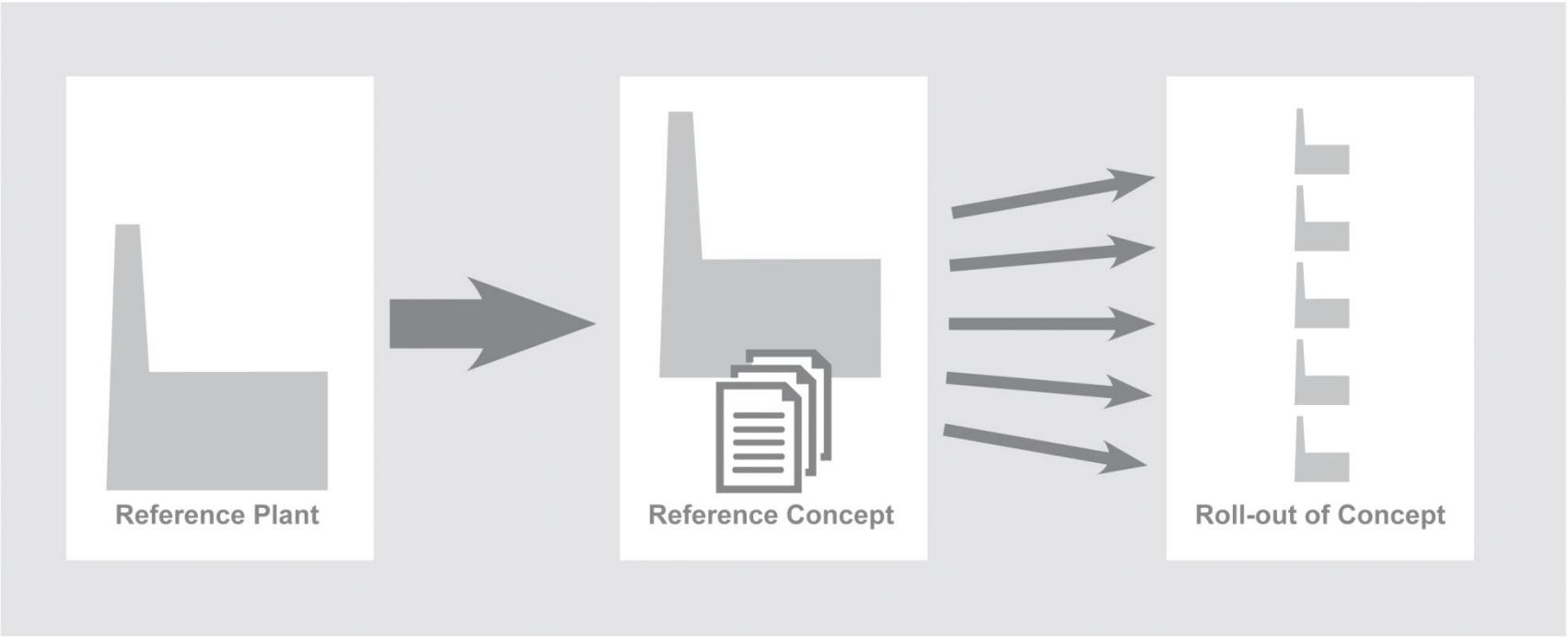
- Reduction of the minimum load ✓
- Improvement of load gradients ✓
- Accelerated start-up ✓
- Decoupling of firing and power generation ✓

Conclusion

- Due to the remaining residual load security of supply on the basis of renewable energy sources (RES) is technically not feasible in the next decades
- Use of the existing fleet of thermal power plant capacity is an efficient solution to support an increased share of RES
- The mentioned flexibility measures need a market design with at least capacity provision remunerations
- Capacity markets work in an integrated European market; UK and FR are pioneers and good examples that capacity markets are highly cost efficient
- Flexible power plants lead to increased economical and ecological efficiency and reduced CO_2 emissions

Transition to flexible operation already proceeded well, for satisfying the future demand additional options for flexibility have to be elaborated.

Outlook: Flexibility project for the Indian power sector



The project aims at providing a guidance paper for existing power plants how to increase its flexibility. To develop such guidance paper the following approach needs to be applied.

1. Select a representative reference plant (to have multiplier effects)
2. Analysis of the status quo of this plant
3. Assessment of the flexibility potential of this plant
4. Identification of improvement measures based on a cost-benefit-evaluation
5. Implementation of the recommended measures
6. Deriving a guidance paper based on the showcase-results

german cooperation
DEUTSCHE ZUSAMMENARBEIT

धन्यवाद

Thank you

for your interest!

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