CREATING A DIGITAL TWIN OF A POWER PLANT WITH CLARA

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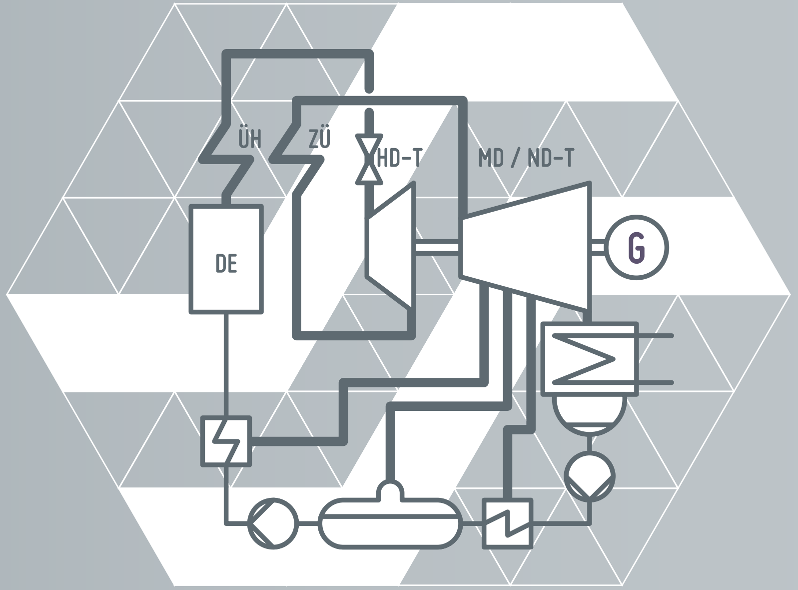
Lausitz Energie Kraftwerke Ag

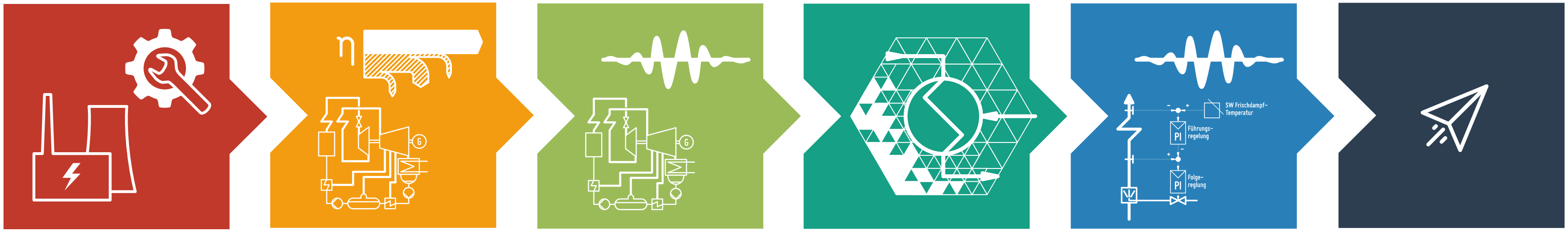


ROSTOCK
Universität Rostock
Traditio et Innovatio
Forschungszentrum Verbrennungsmotoren Thermodynamik Rostock
LEAG

01 Vorgehen Optimierung
- Ausgangslage
- Themenfelder
- Herausforderungen

03 Dynamische Bewertung
- Messdatenverläufe
- Statistische Auswertung
- Wirtschaftliche Bewertung

05 Anwendung des Modells
- Szenariensimulation
- Verfahrens- und leittechnische Optimierungen
- Bewertung Lebensdauerverbrauch



02 Stationäre Bewertung
- Verteilung Prozessgrößen
- Einfluss auf Brennstoffverbrauch
- Zusammenfassung und Bewertung

04 Dynamische Modellierung
- Überblick
- Struktur Gesamtmodell
- Validierung

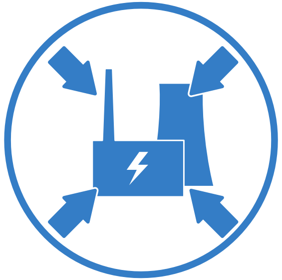
06 Fazit
- Zusammenfassung
- Ausblick

01 Procedure Plant optimization

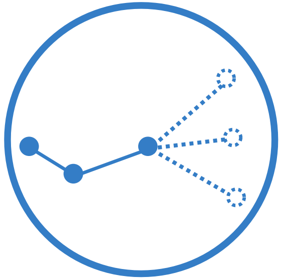
starting position

Energiewende

Fallende Strompreise



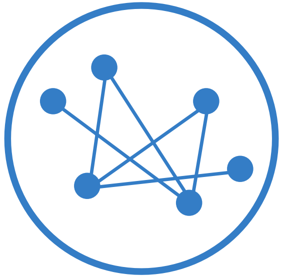
Neue Anforderungen



Verändernde Rahmenbedingungen & Unsicherheiten

01 Procedure Plant optimization

challenges

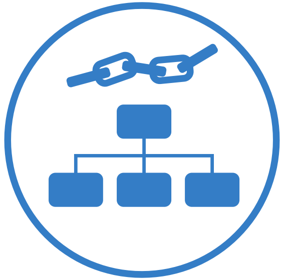


Hohe Komplexität
der technisch-ökonomischen
Zusammenhänge

Große Datenmengen

Unvollständige
Informationen

Unterschiedliche Standpunkte &
qualitative Diskussionen



Einschränkungen aufgrund
der Organisationstruktur

Betrieb: Fokus auf
Volllaststunden

Führung: Fokus auf
Kostensenkung

Technik: Fokus auf
Anlagenoptimierung

01 Procedure Plant optimization
Target

I. Evaluation flexibility:

- Definition of evaluation criteria
- Description Actual status
- Comparison of systems
- Comparison with the state of the art
- Identification of flexibility potentials

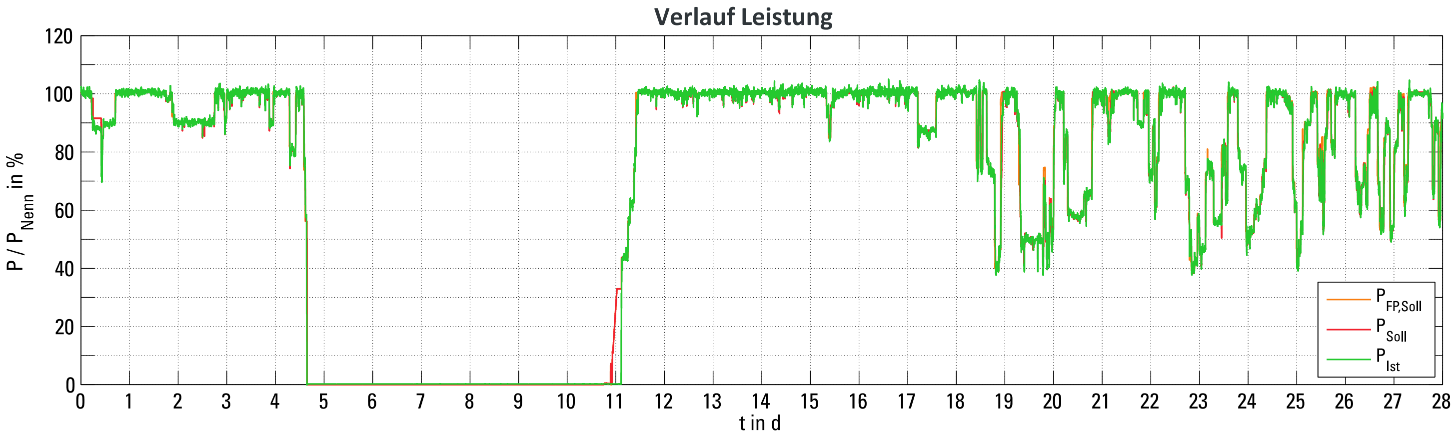
II. Evaluation of economic benefits:

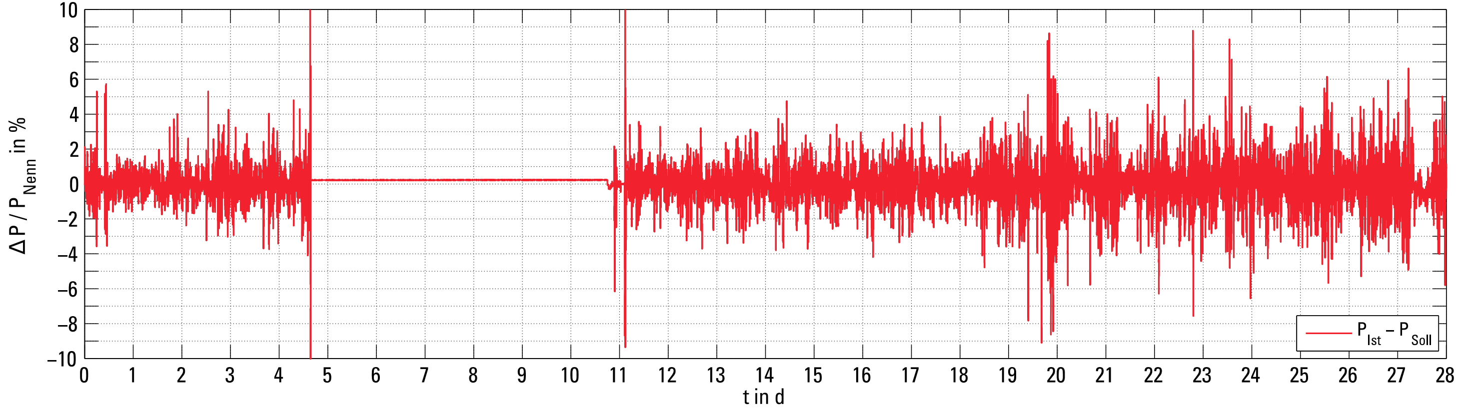
- Scenario simulations with variation of plant flexibility
- Evaluation of the driving style
- Identification of additional revenues or cost savings
- Discussion with Controlling and Power Plant Economics

III. Technical Actions:

- Development of the necessary process and I&C optimizations
- Evaluation of the adapted driving style (testing or modelling):
  - ➢ Feasibility
  - ➢ efficiency
  - ➢ control accuracy
  - ➢ Component stress (creep rupture strength and alternating fatigue))

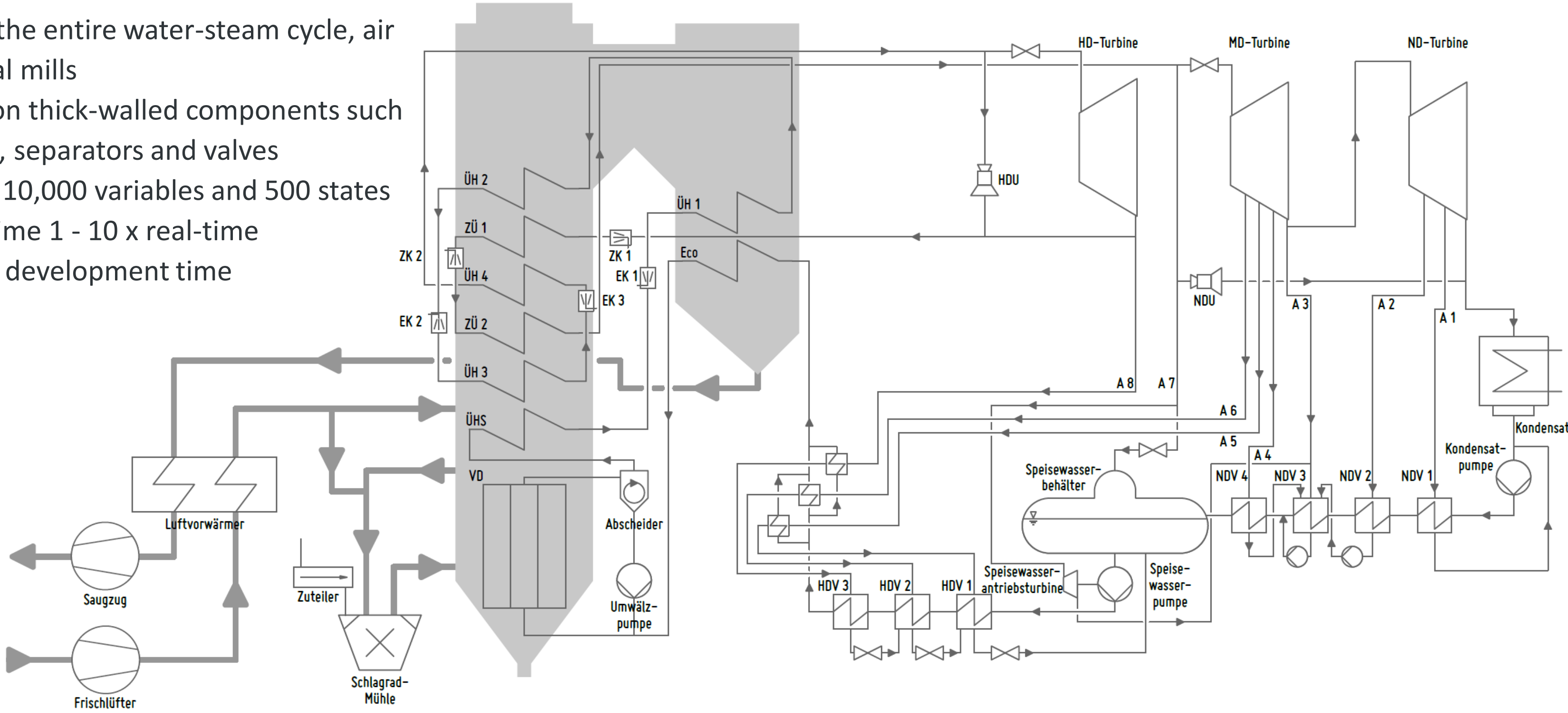
03 Dynamic Evaluation





Scope dynamic model:

- Mapping of the entire water-steam cycle, air path and coal mills
- Main focus on thick-walled components such as collectors, separators and valves
- Model size - 10,000 variables and 500 states
- Simulation time 1 - 10 x real-time
- 2 man-years development time



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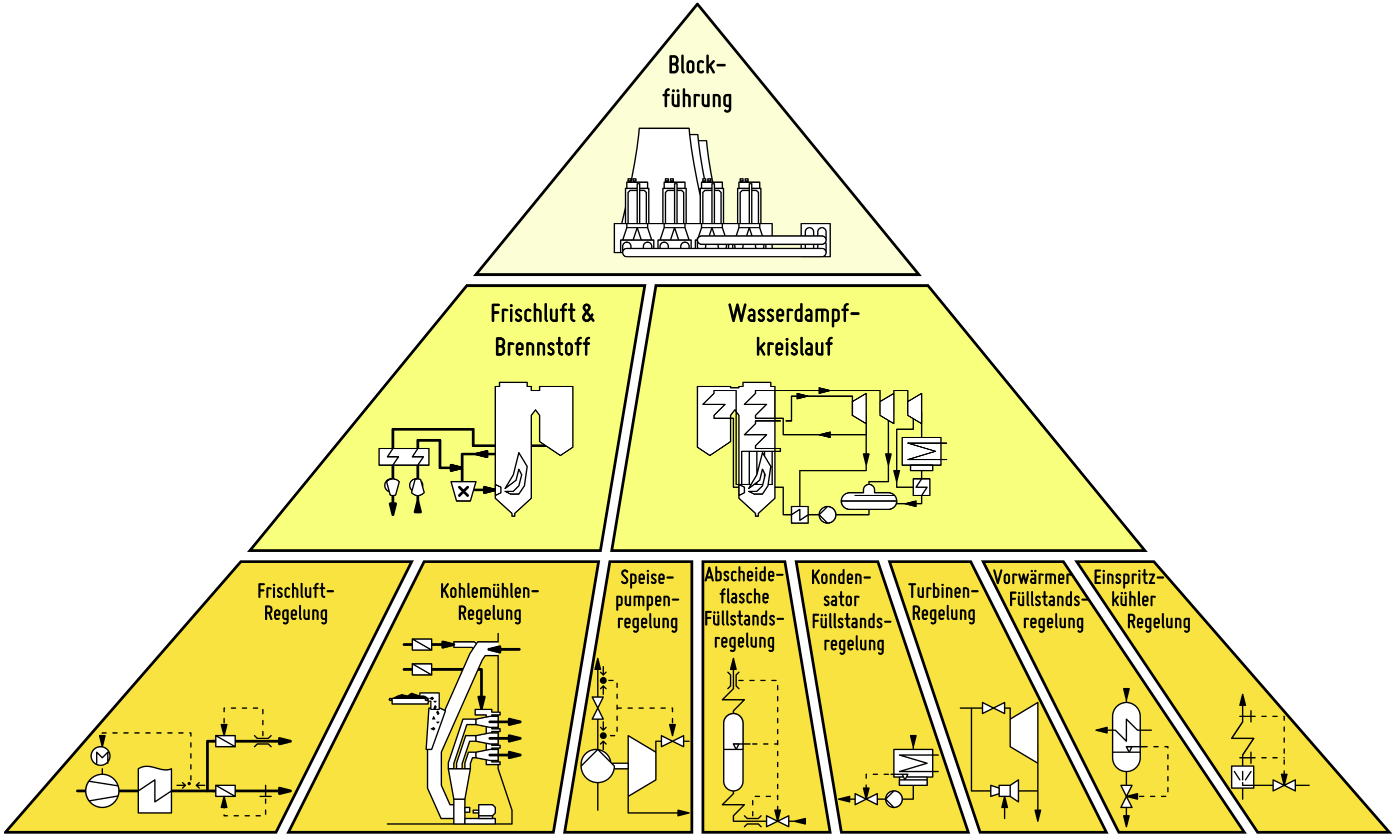
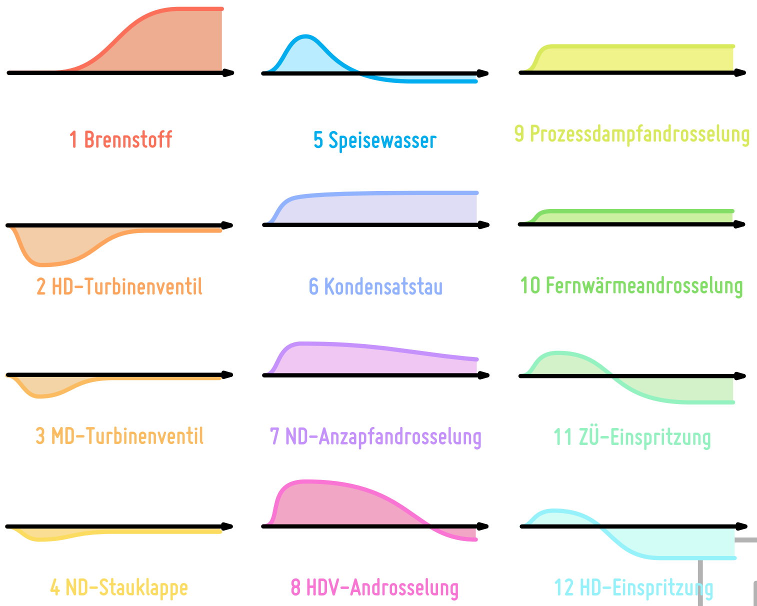
04 Dynamic power plant modelling

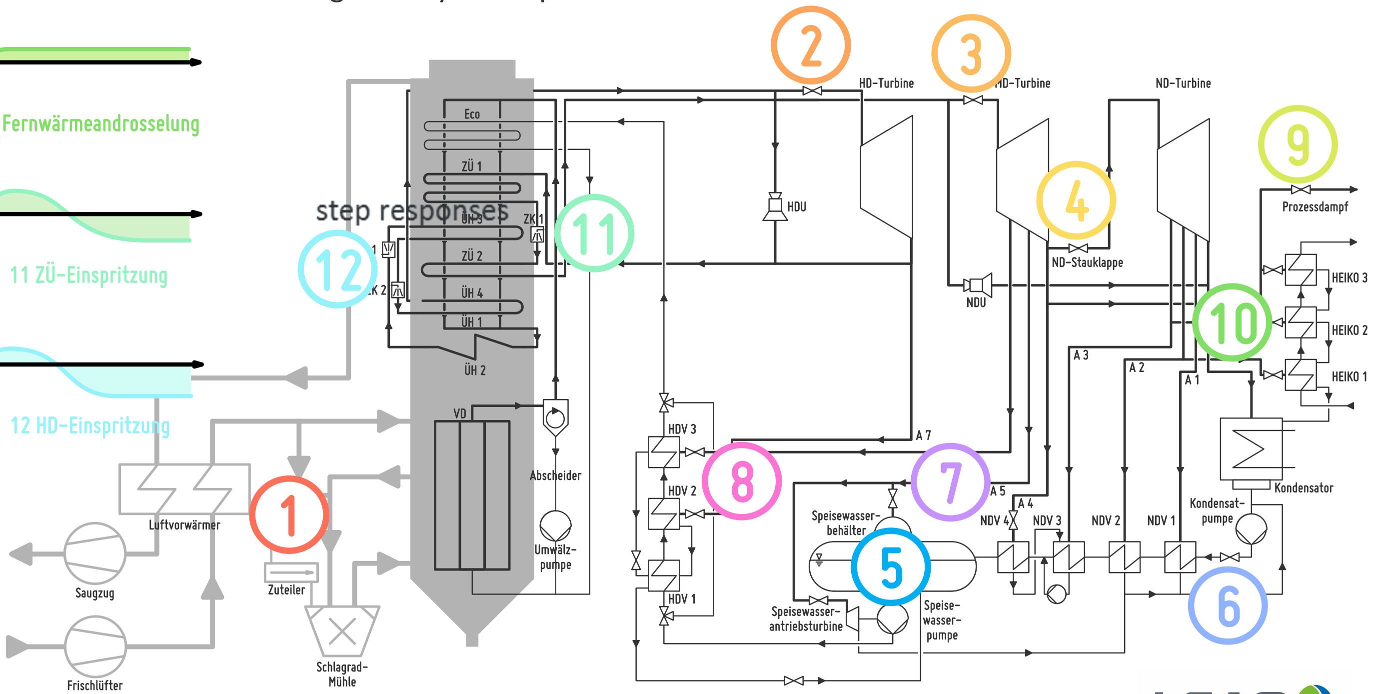
Overview of implemented I&C systems





Step responses :

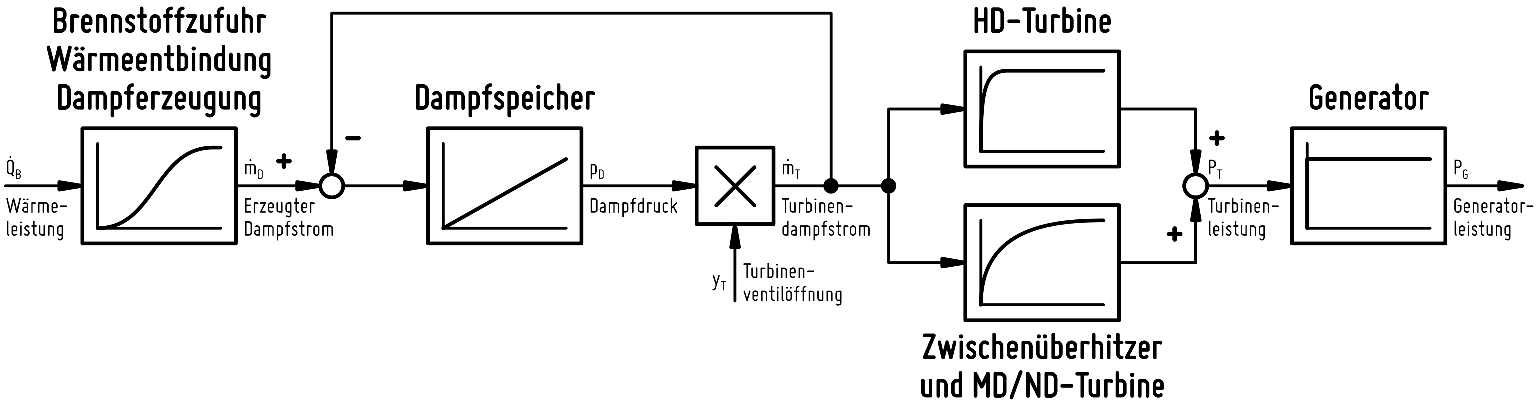
- Determination of the step responses of the different control interventions
- The load-dependent system dynamics form the basis for further controller design and system optimization.



05 Using the model

analyse the I&C System

Scheme of the dynamic processes in a steam power plant

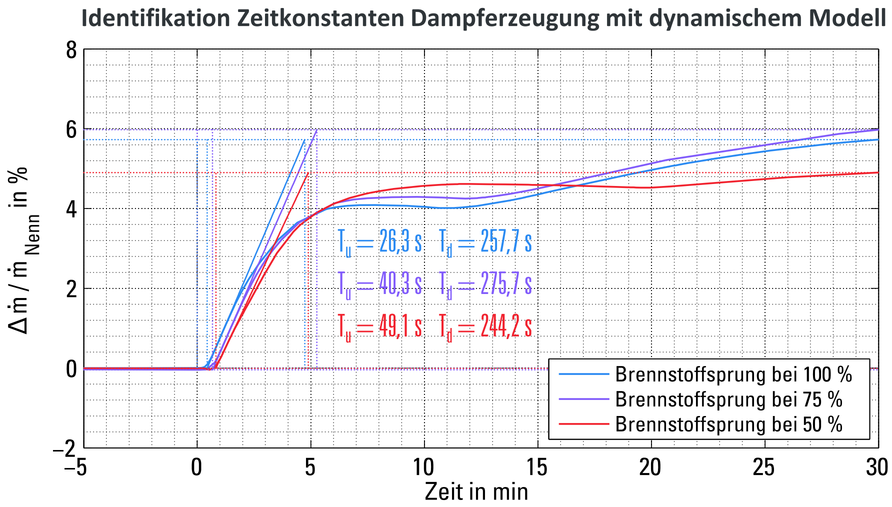


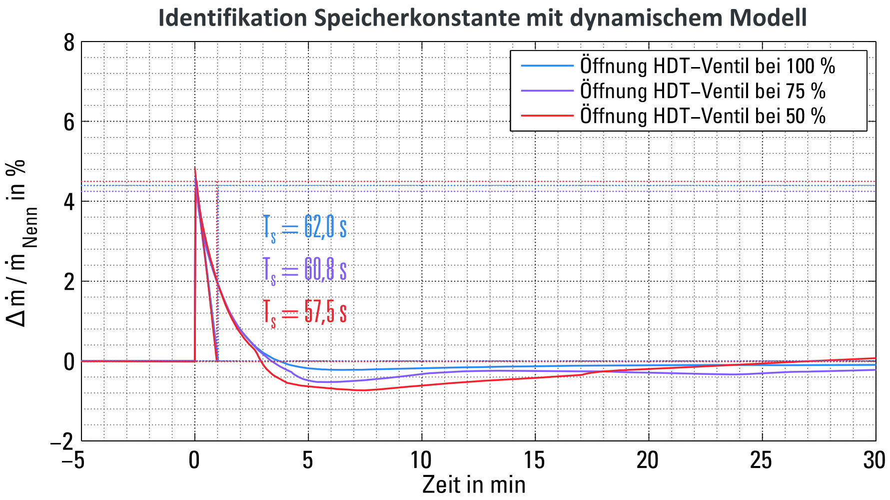
Description Dynamic steam power plant according to VDI/VDE 3508::

- Sub-process of fuel supply, heat transfer and steam generation, characterized by higher order time behaviour with delay time T_u and compensation time T_g
- Characterization of the steam generator storage capacity by an integrator with a time constant
- the reheater has a storage capacity with a first-order time response

05 Using the model

Identifying the time constants

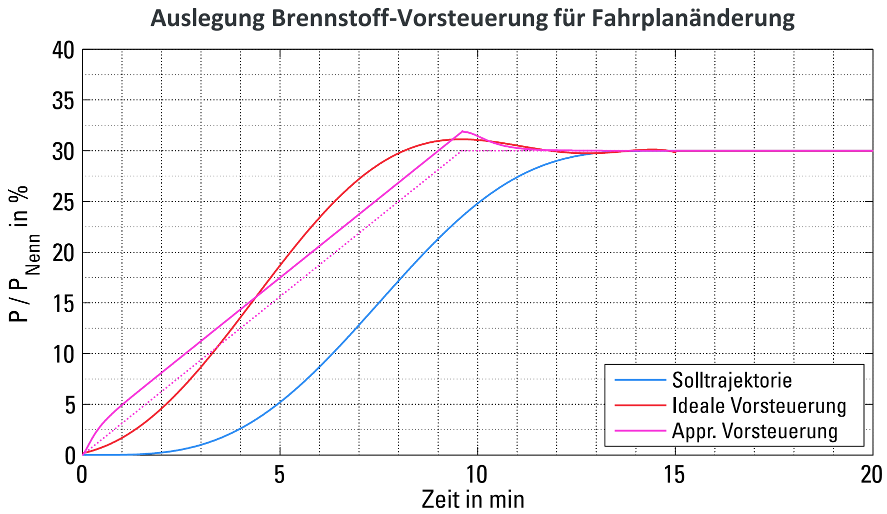


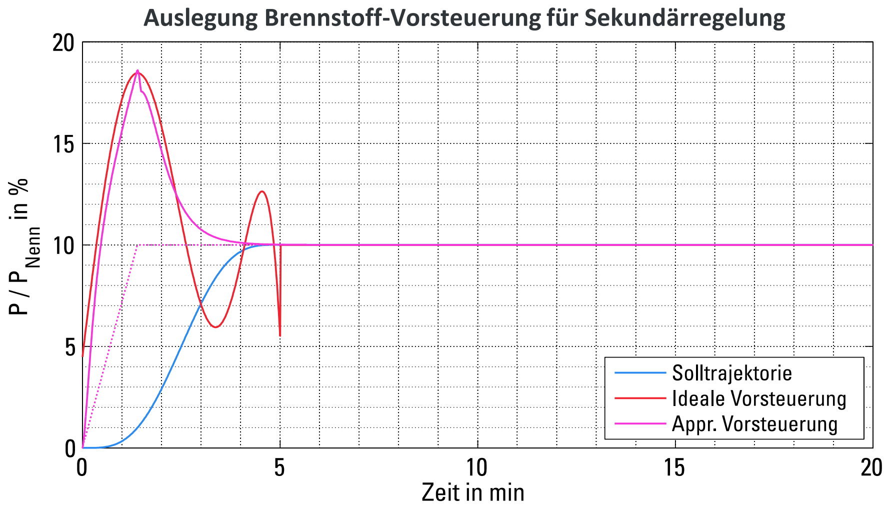


- Step response of the steam quantity to a fuel jump and HP turbine valve opening
- comparable dynamic in full and partial load recognizable
- typical values for the dynamics of steam generation and storage in lignite-fired continuous-flow boilers 30 to 60 s for delay time T_u and 250 s for compensation time T_g
- According to the guideline, 60 to 140 s are typical time constants for the steam storage of the boiler.

05 Using the model

Design Precontrol Timetable change / minute reserve

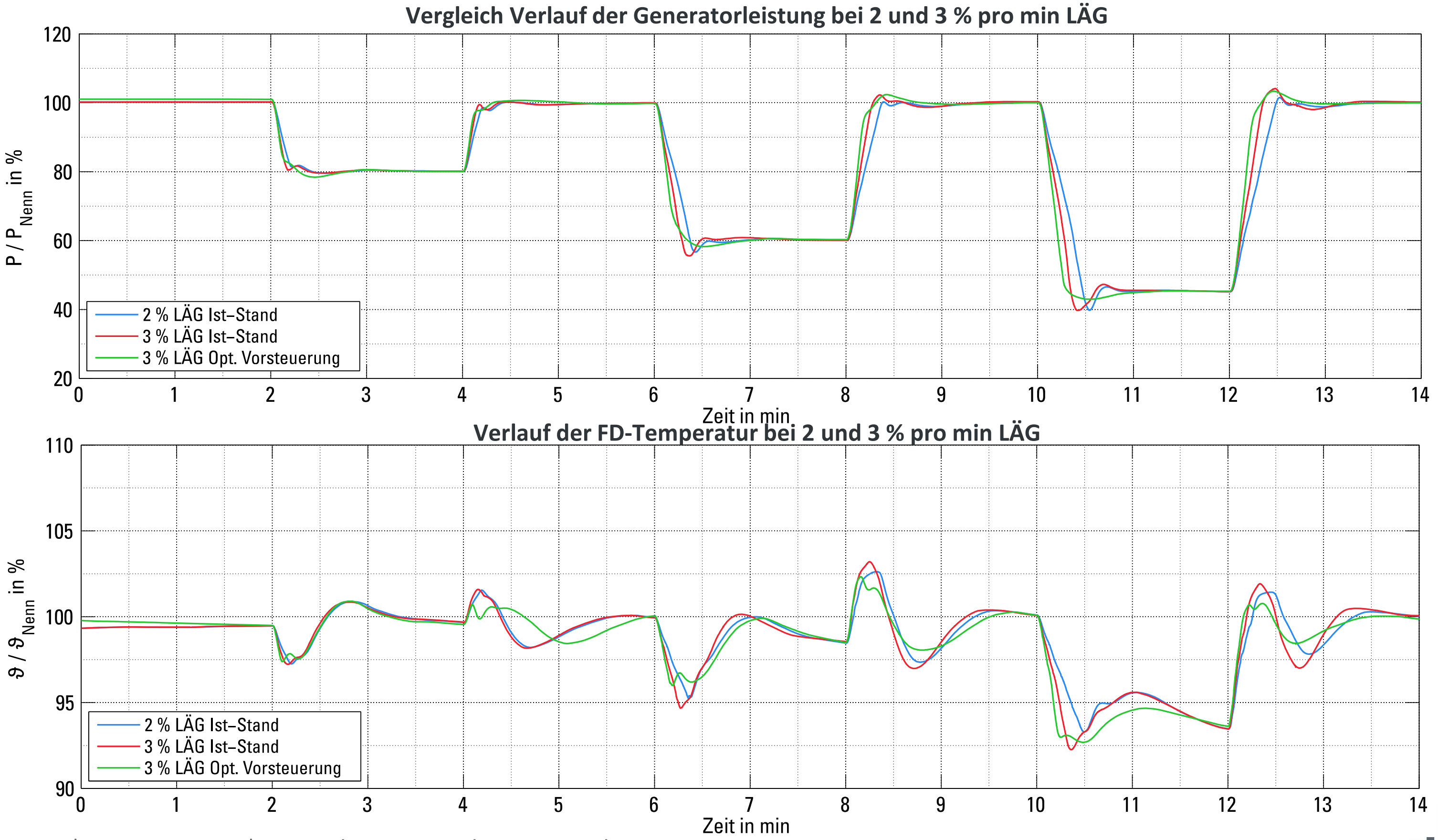




- In the event of a change in the timetable, an increase in performance of 30 % in 15 minutes or 2 % per minute is achieved
- For secondary control Power increase of 10 % in 5 min
- The shorter time of the target trajectory in relation to the time contants of the steam generator requires noticeably more aggressive oversteering than in the case of a timetable change.
- Calculation of an ideal pre-control of the heat output depending on the inertia of the DE and the target trajectory
- Approximation of the ideal feedforward by means of load ramp and overload

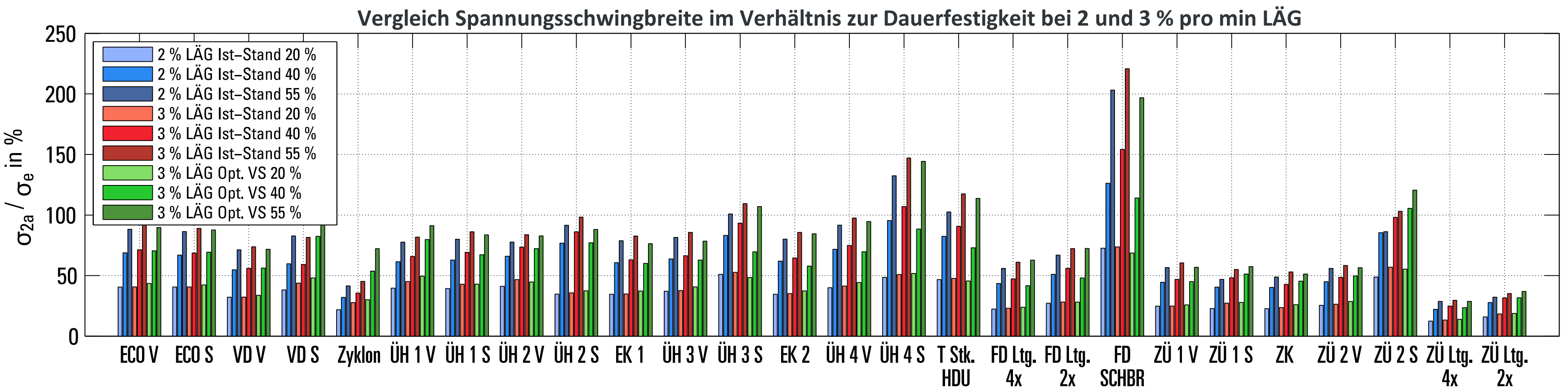
05 Using the model

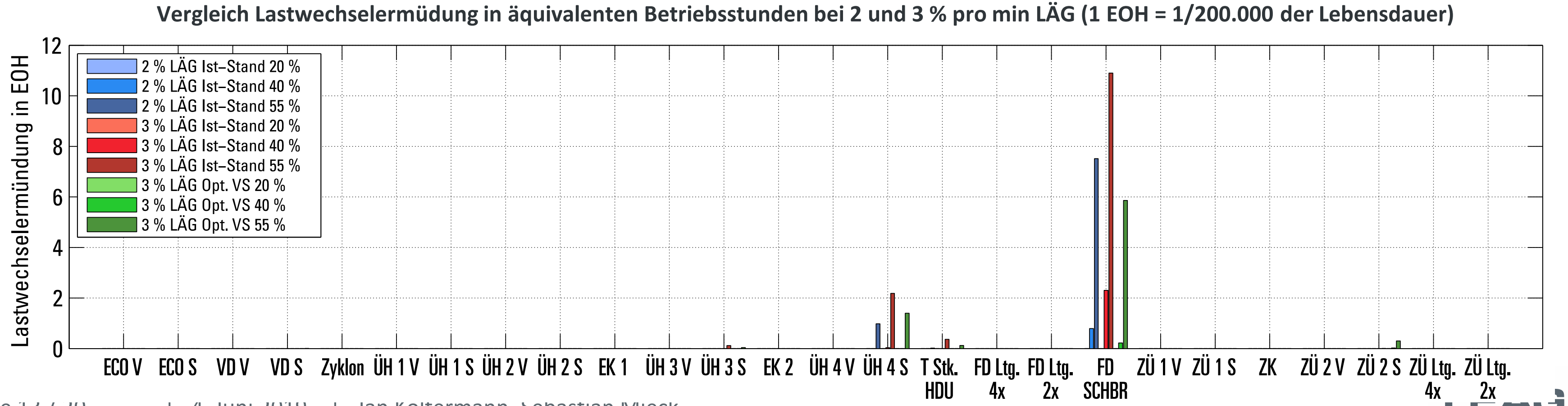
Simulation of the I&C change



05 Using the model

Simulation der leittechnischen Änderung





Model Jänschwalde :

- Model development in cooperation with the University of Rostock 2012-14
- investigation of:
  - ➢ Mod. Sliding and fixed pressure operation
  - ➢ Increased load change rates with consideration of change exhaustion
  - ➢ Provision of system services and potentials of second reserve measures
  - ➢ Evaluation of I&C optimizations - block control and steam temperature control
- The results are included in the project "Increase of secondary control power KW JÄW".

KW Jänschwalde

Model Schwarze Pumpe:

- Creation of a dynamic model 2015-17 and parallel performance of stationary and dynamic operating data analyses to identify optimization potentials with the FVTR
- investigation of :
  - ➢ Increased load change rates with consideration of change exhaustion
  - ➢ Jump tests and evaluation of load-dependent system dynamics
  - ➢ Evaluation of I&C optimizations - Correction of enthalpy setpoint for load increases and partial loads
  - ➢ Evaluation of process engineering adaptations - HD step valve
  - ➢ Simulation of load shedding with provision of process steamVorstellung der Ergebnisse am Standort Ende Juni

KW Schwarze Pumpe

06 Fazit

Ausblick

Model Boxberg Q:

- Start of work in Q2 2018 with FVTR
- Parallel creation of a dynamic operating data analysis
- Project kick-off and presentation of the analysis results at the site at the end of June
- Cooperation with ABB in the mapping of control technology within the WiR project
- Planned completion of model creation in Q 3 2019
- Subsequently, simulation of adapted operating modes and evaluation of process and I&C optimizations

KW Boxberg Q

Langfristige Zielstellung:

- Interlocking of existing tools for comprehensive evaluation of possible measures for plant optimization :
  - ➢ Power plant deployment planning model to determine the future operation mode and boundary conditions
  - ➢ Stationary operating data analysis with the aid of PGÜ
  - ➢ Dynamic operational data analysis using operational measurements and PDN
  - ➢ Joint development of a requirement specification for plant optimization in cooperation with the controlling department
  - ➢ Analysis of the accounting data of the maintenance with regard to the effects of the adapted driving style

VIELEN DANK FÜR IHRE AUFMERKSAMKEIT!

Jan Koltermann
Abt. Modernisierung & Effektivitätssteigerung