Methodology to collect and to analyse data for damages and failures in power plants

Effect of the Higher Flexibility Demand
Overview and description of one example

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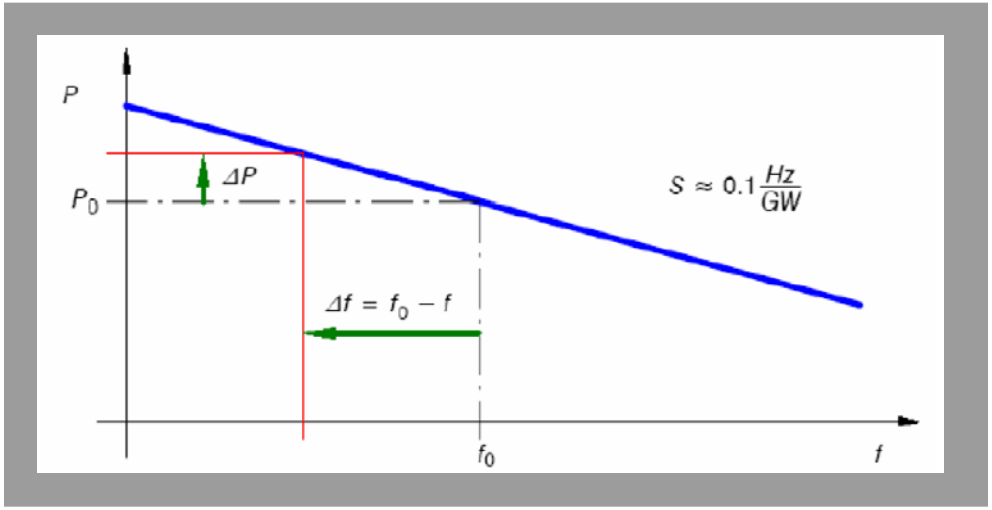
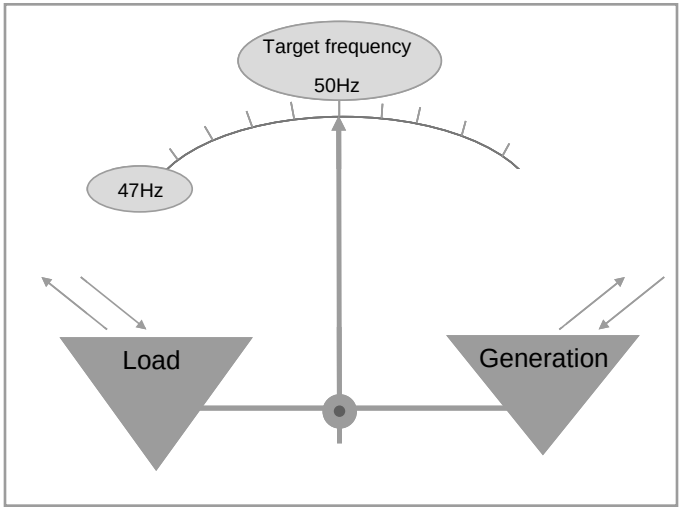
1 Motivation → main frequency stability

Imbalance between energy supply and demand leads to displacement in frequency

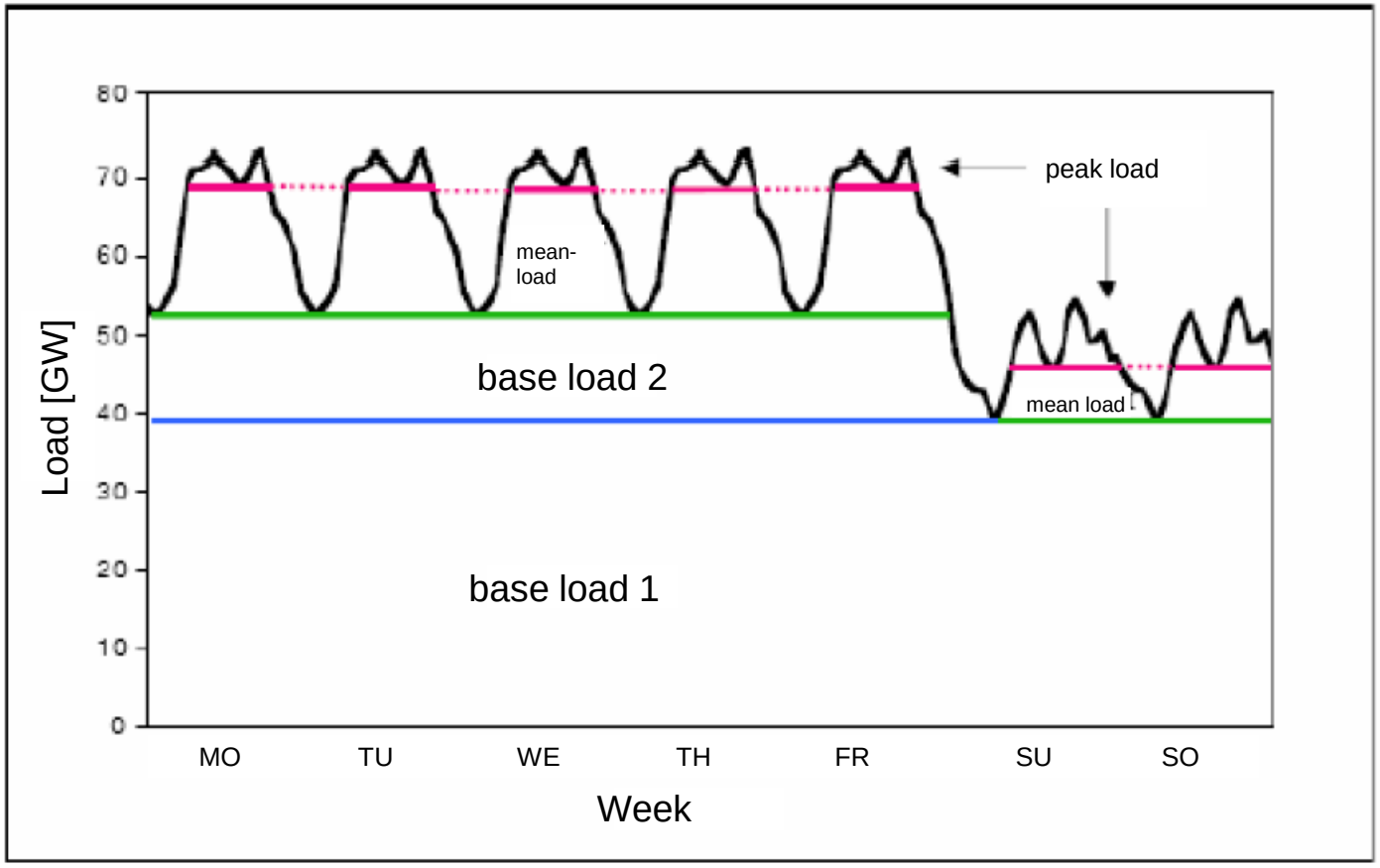
Cause: Loads are predominantly inductive





Frequency [Hz]	Measurement
50,25	Automatic cut-out of power plant by rotary speed control (over drive)
49,8	Automatic warning of the grid operator, use of all available resources
49,4	Cut-off of selected consumer (low frequency relays …)
48,4	Turn on the emergency supply of the auxiliary power (cooling etc.)
47,6	Disconnect the grid to island nets

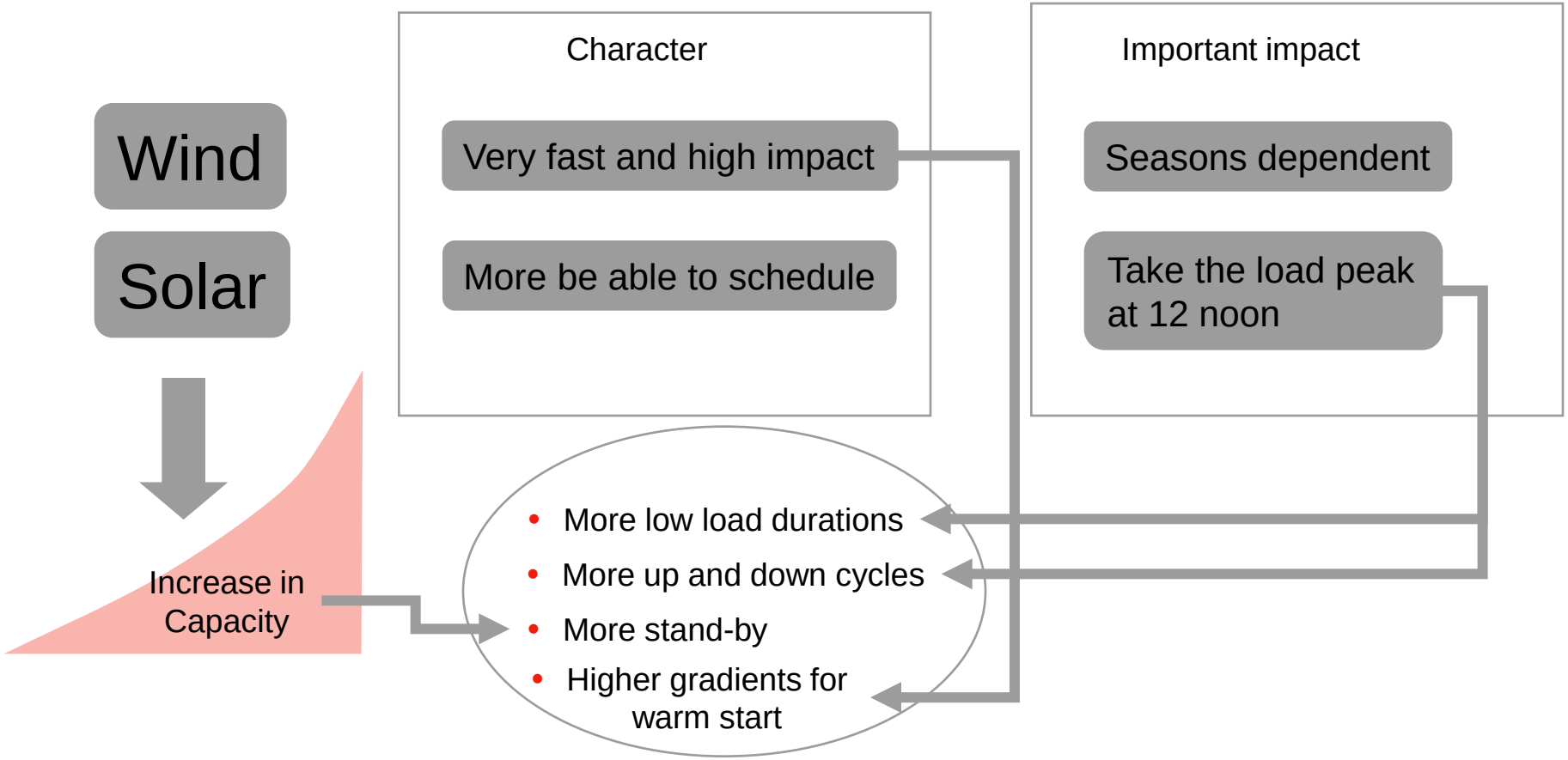
1 Motivation → main frequency stability – load



[acc. Klemm 2008]

Typical load curve

1 Motivation → important changes on the supply side



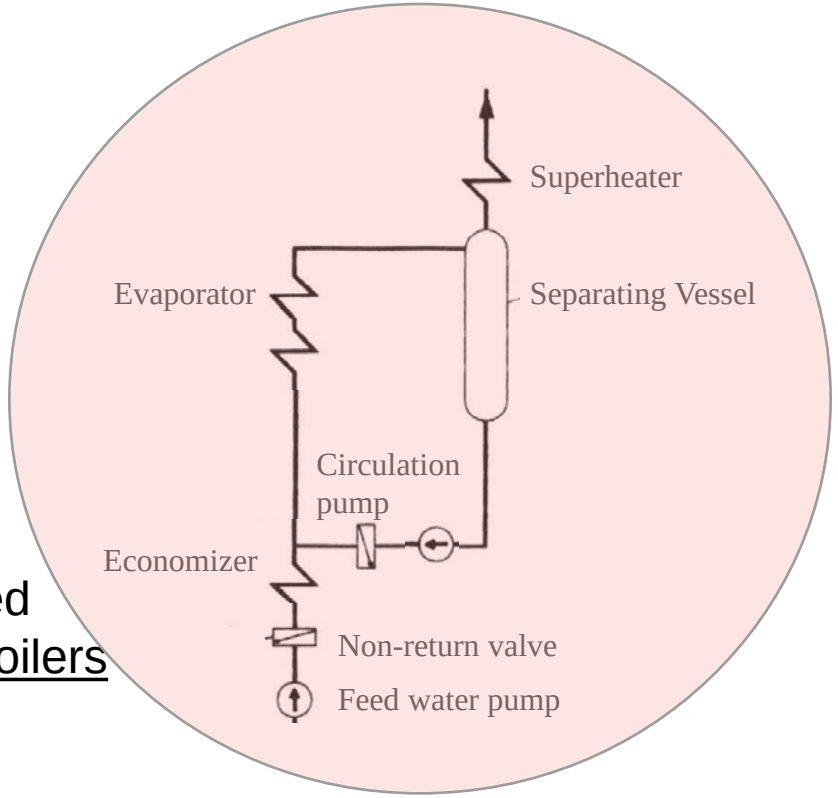
The main functions of the fossil-fired power-plants

1. Part of the base load
2. Save the net frequency

1 Motivation → main frequency stability

The challenge of the grid relating to the renewable is:

The permanent re-establishment of the deranged balance of the supply and the consumption of electric energy

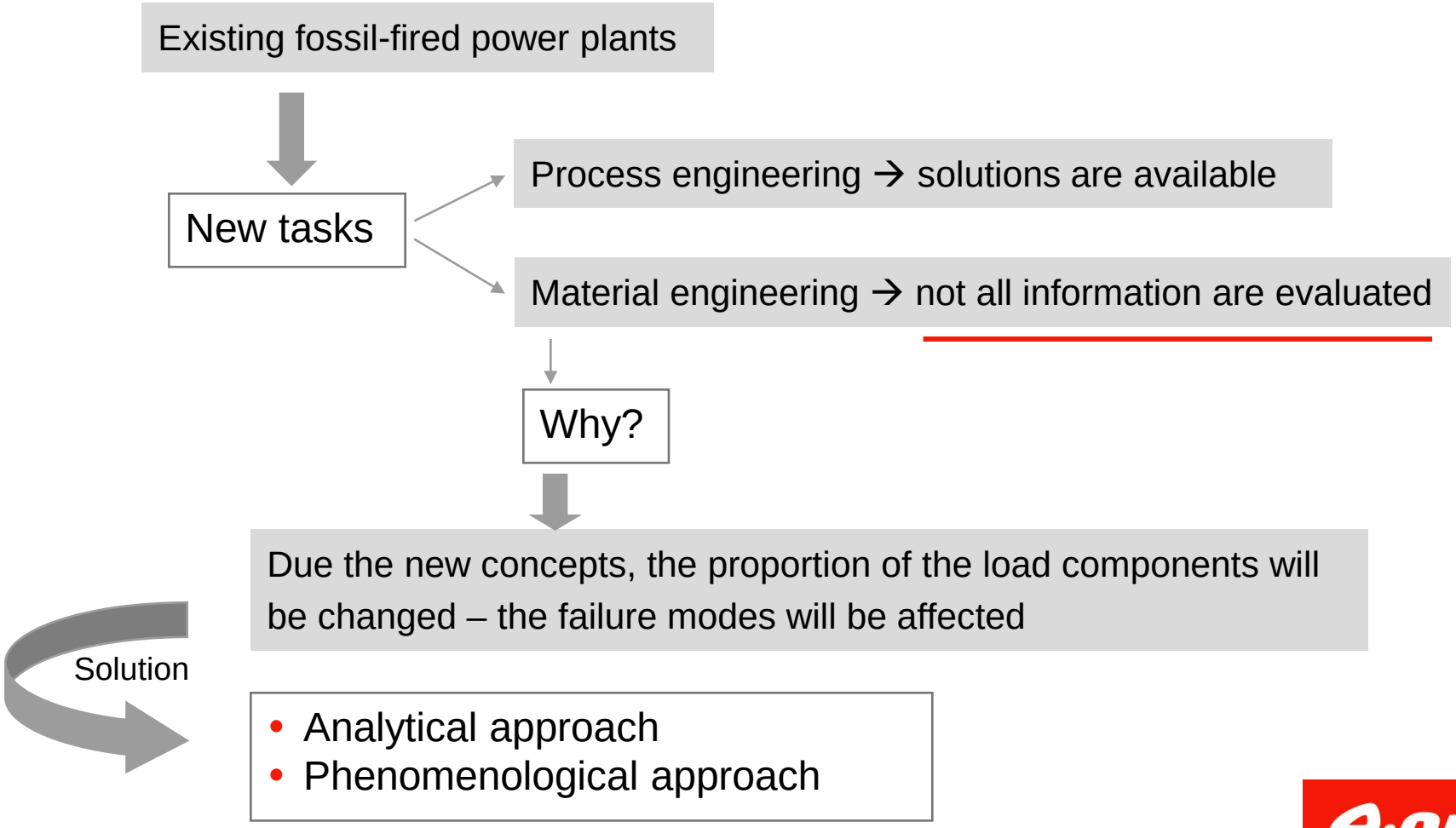


Since 1970 in Germany: all newly constructed coal-fired power plants)* are <u>once-through boilers</u>

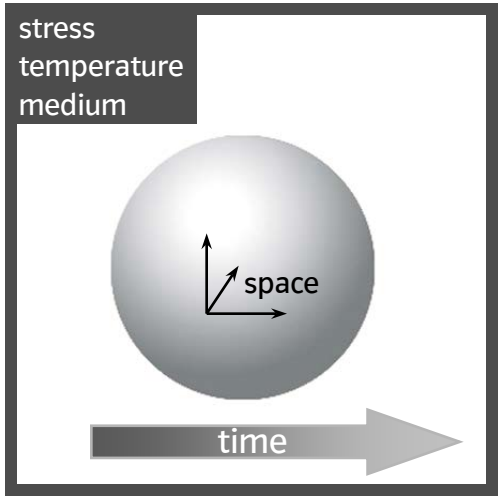
*(capacity>200MW)

- Sliding-pressure operation
- Steam end temperature is nearly constant over a wide pressure range
- Higher gradients at start and stop ramp

2 More flexibility – new questions as to the material engineering



2.1 Analysis - the analytical approach



(Level and gradient in space and time)

reducing

to the dominant mechanisms

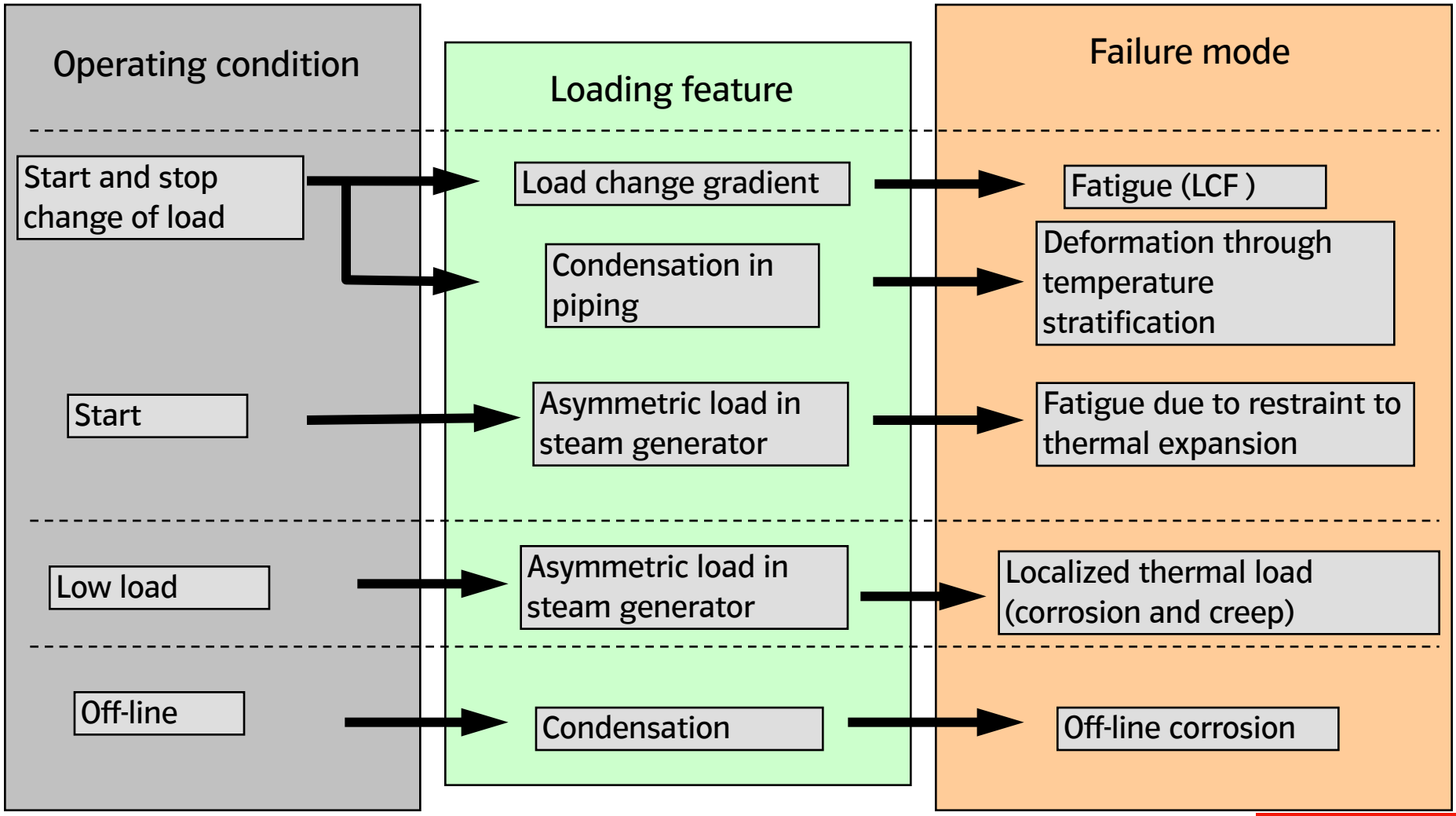
Characteristic of the load

- Load level (force- or strain-steered)
- Local stress-description
  (tensor and gradient)
- Time-dependent stress description
  - Dynamic (gradient)
  - Number of cycles
- Level of temperature
- Environment medium (corrosive reactions)

+ Variable parameter:

The material will be changed under the exposure.

2.1 The analytical approach: operation – loading – failure mode



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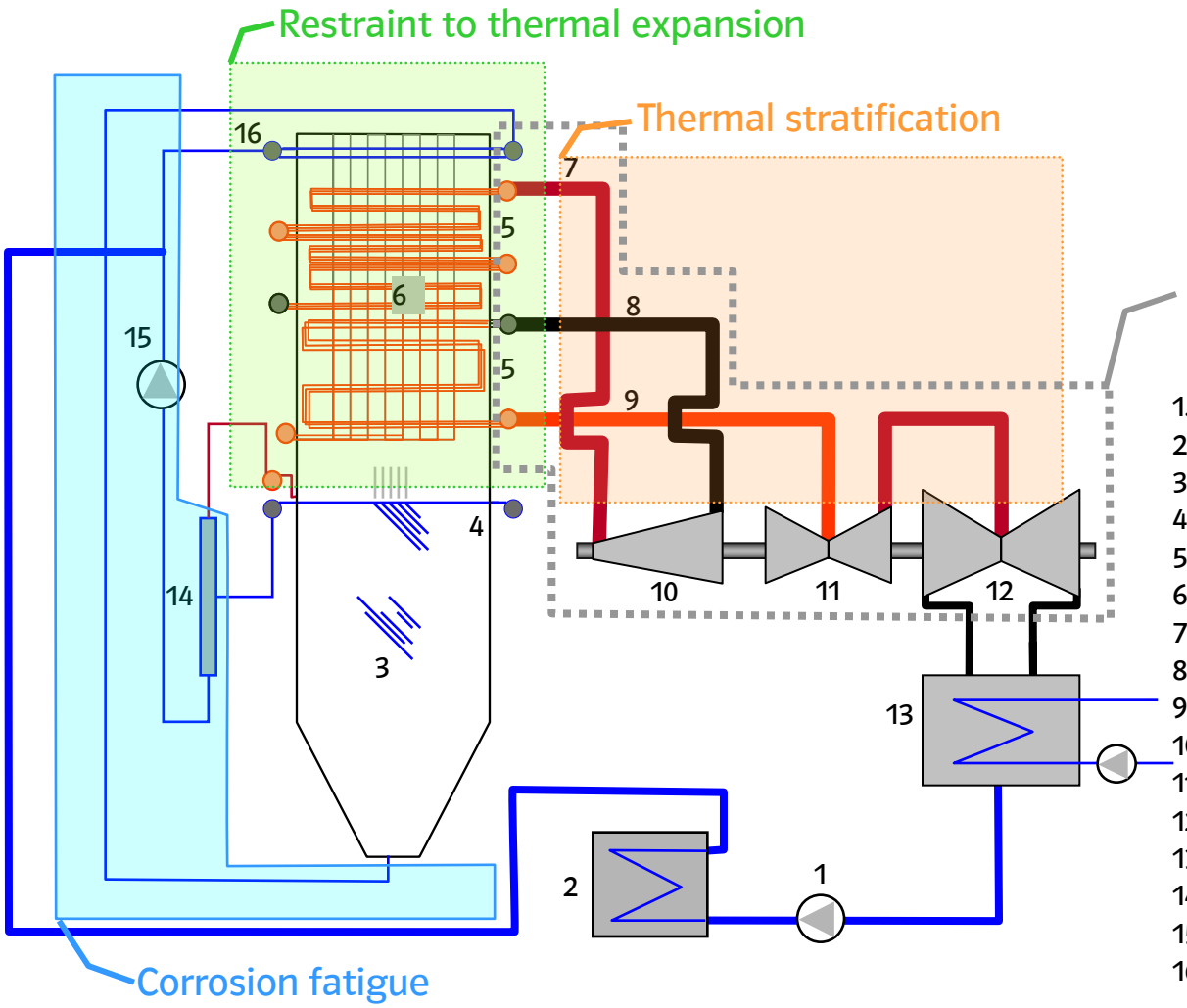
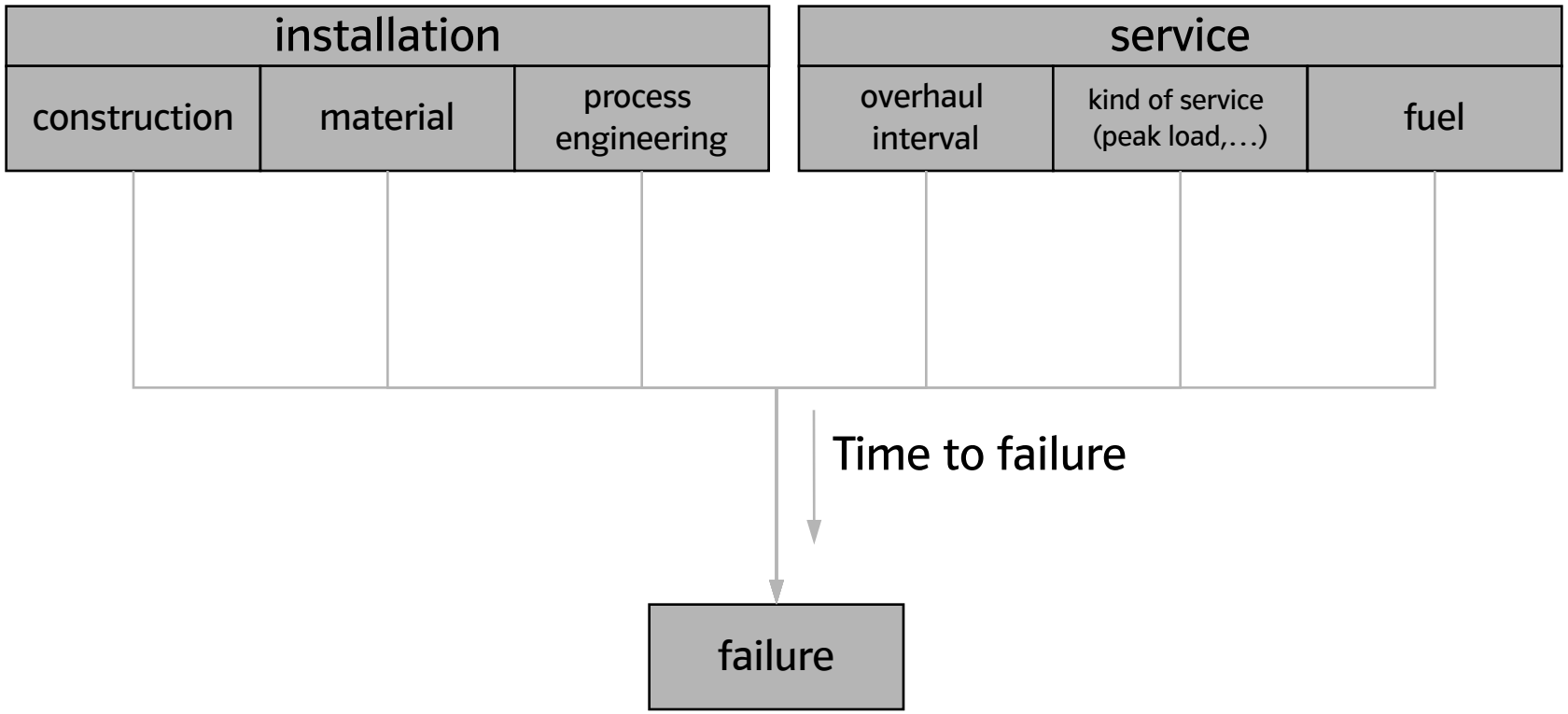


1. Feedwater pump
2. HP preheater
3. Evaporator
4. Transition inclined-/ straight-membrane
5. Header
6. Superheater / reheater
7. Main steam piping
8. Cold reheat piping
9. Hot reheat piping
10. High pressure turbine
11. Medium pressure turbine
12. Low pressure turbine
13. Condenser
14. Separating vessel
15. Circulating pump
16. Economizer

2.2 Analysis - the phenomenological approach: tool to analyse the failure – repair relation



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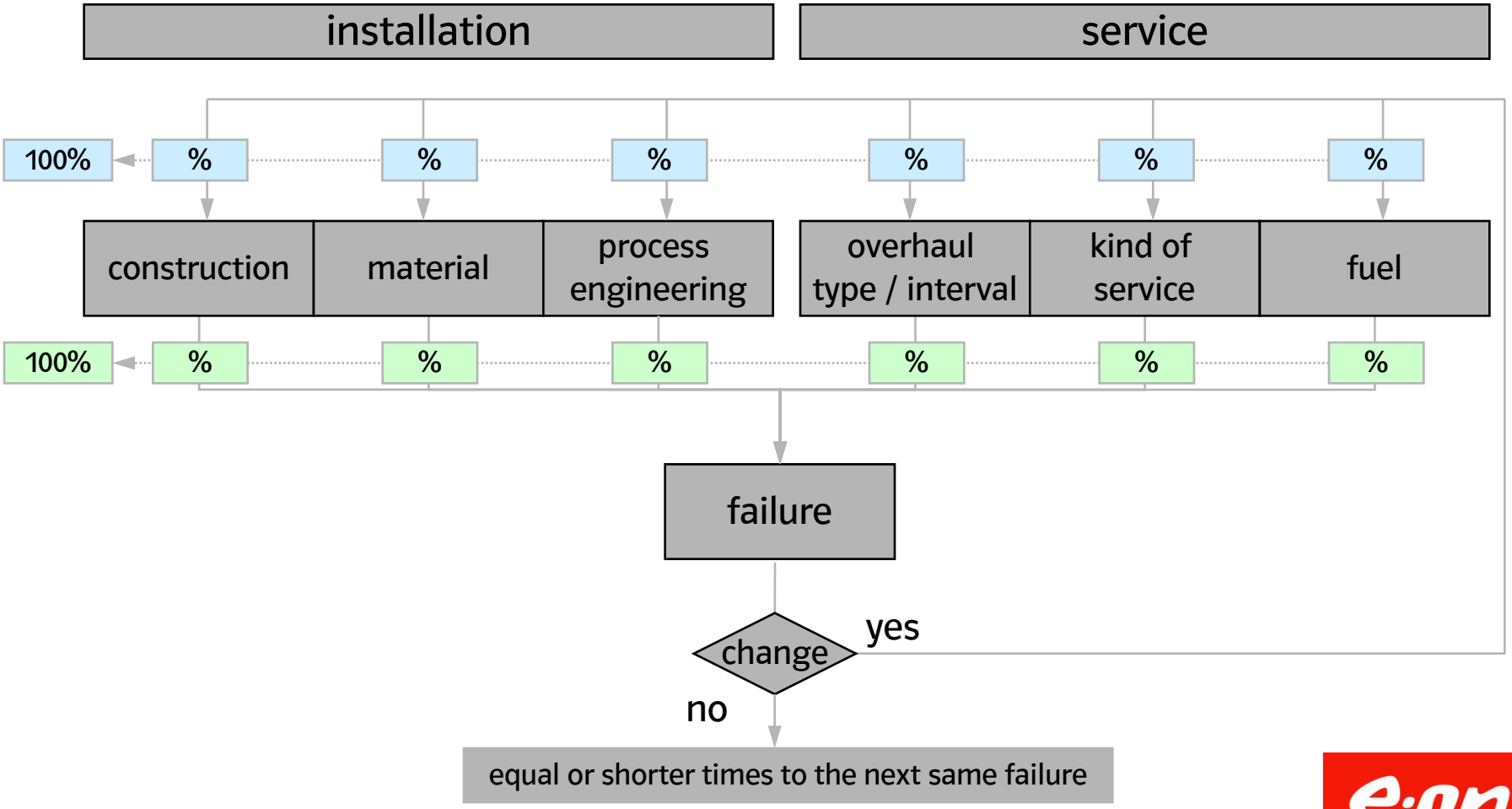

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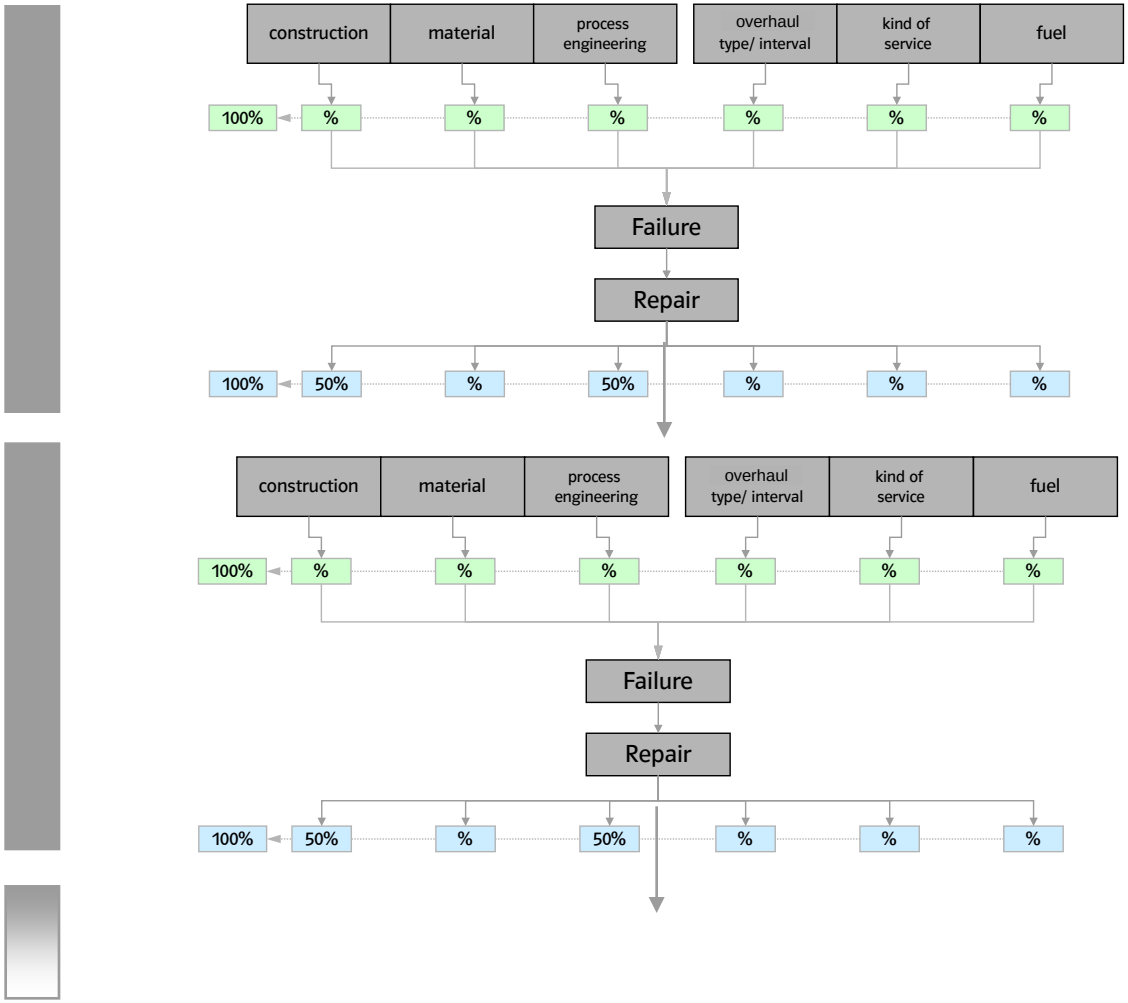


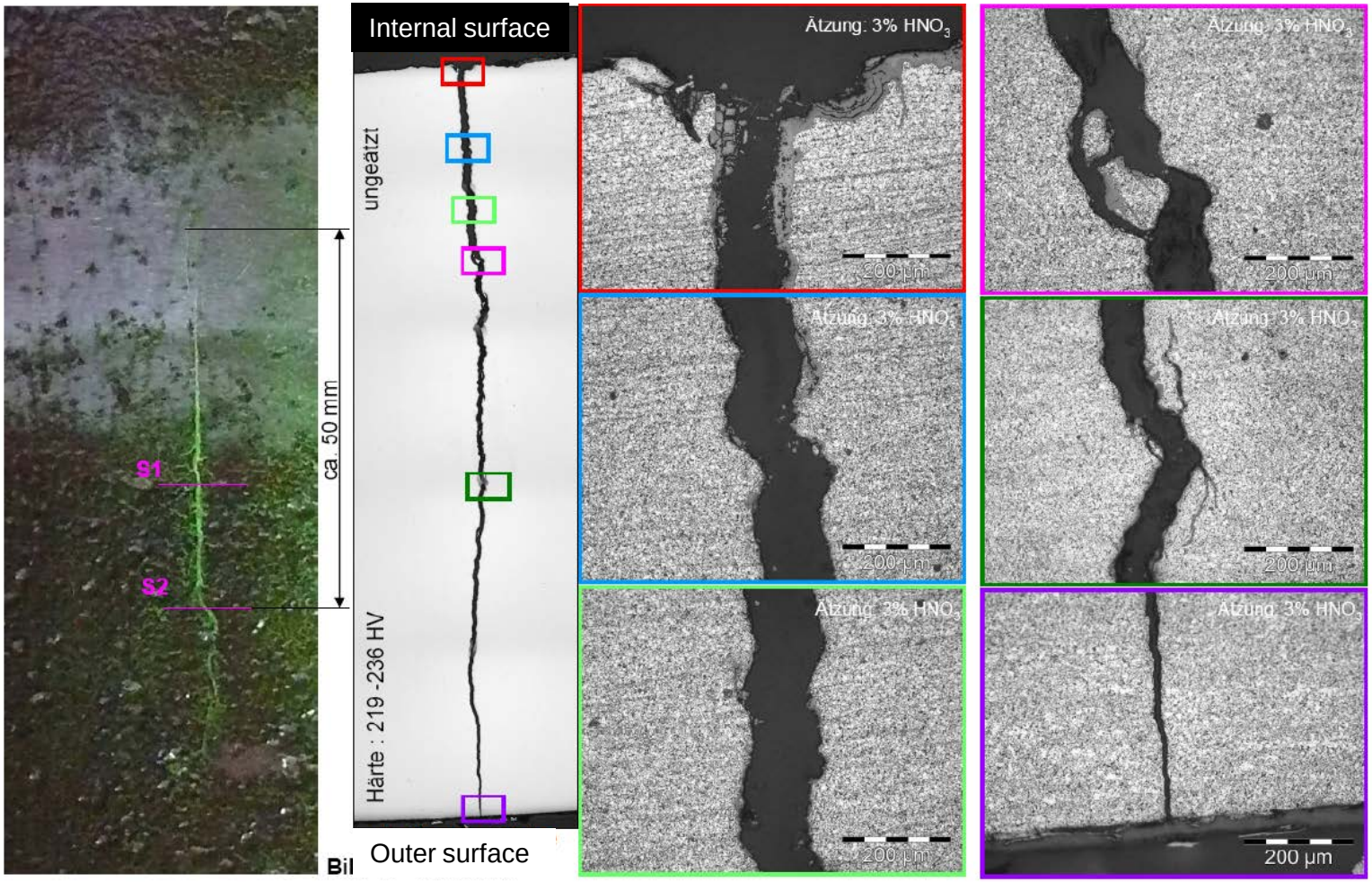
3 Example: failure in the circulation system

The circulation system is in respect to the net efficiency the best way to operate in natural sliding pressure also at very low boiler loads.

Many start-stop-cycles in the last years

Corrosion fatigue cracking

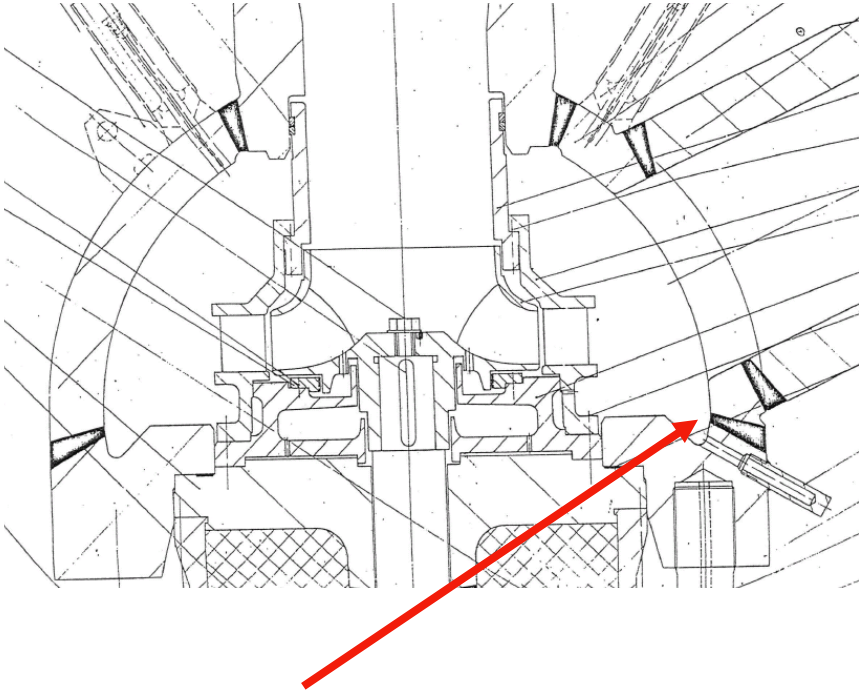
3 Example: failure in the circulation system



Corrosion fatigue cracking

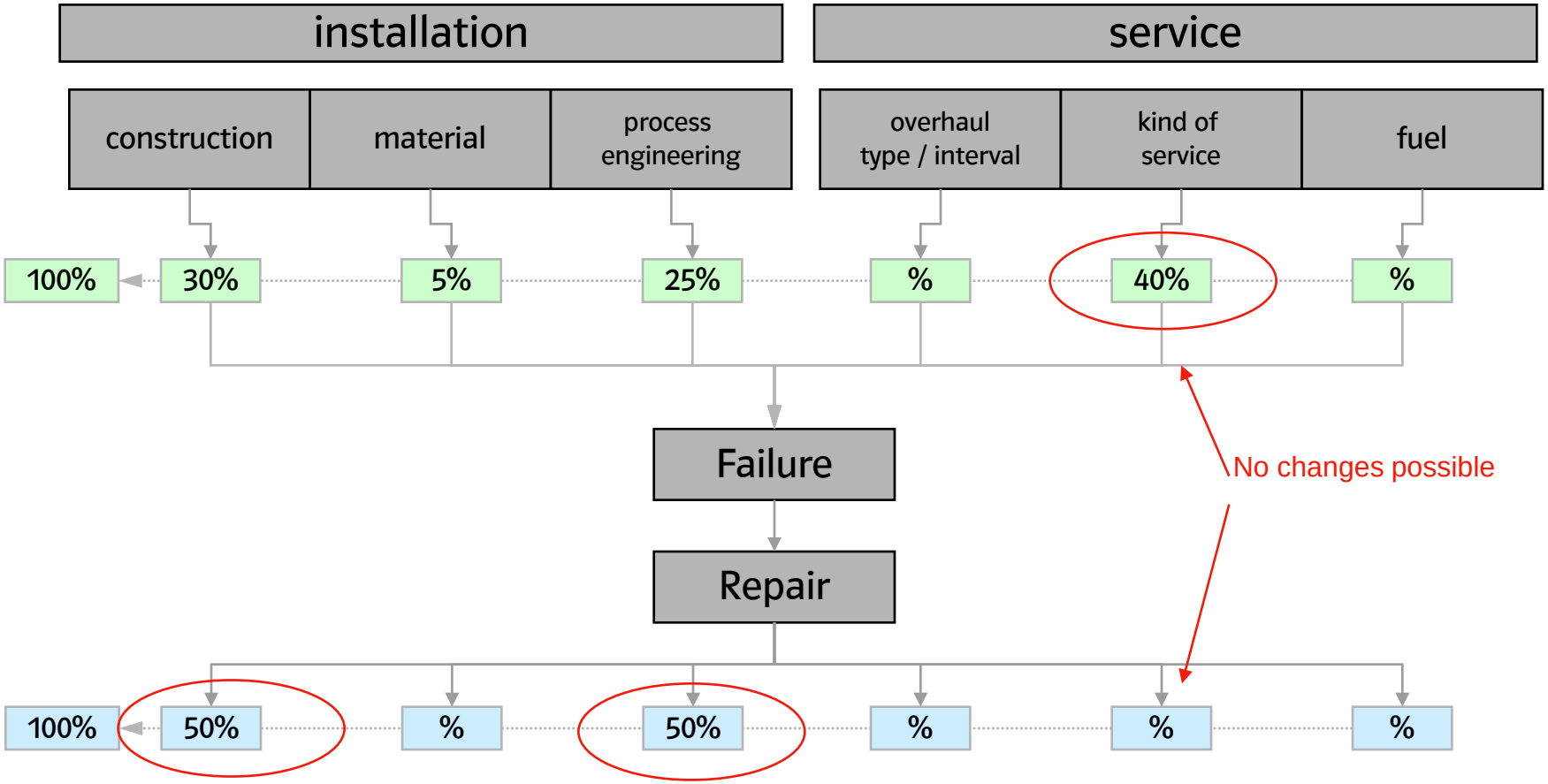
3 Example: failure in the circulation system

Many start-stop-cycles in the last years

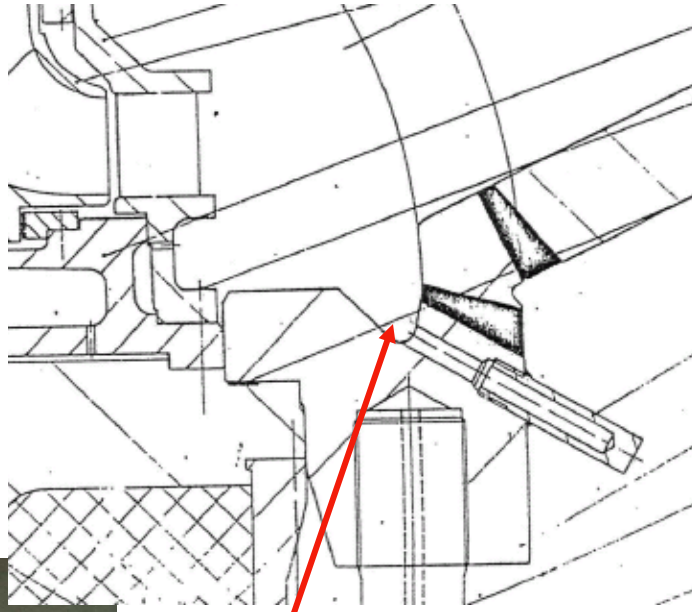


Corrosion fatigue cracking and LCF in the circulation pump

3 Example: interpretation of the failure and the tasks



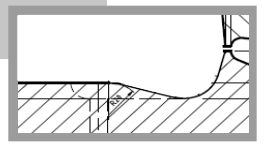
3 Example: reduce failure probability - design modification



Repair of the case, as an alternative variant to a new piece:

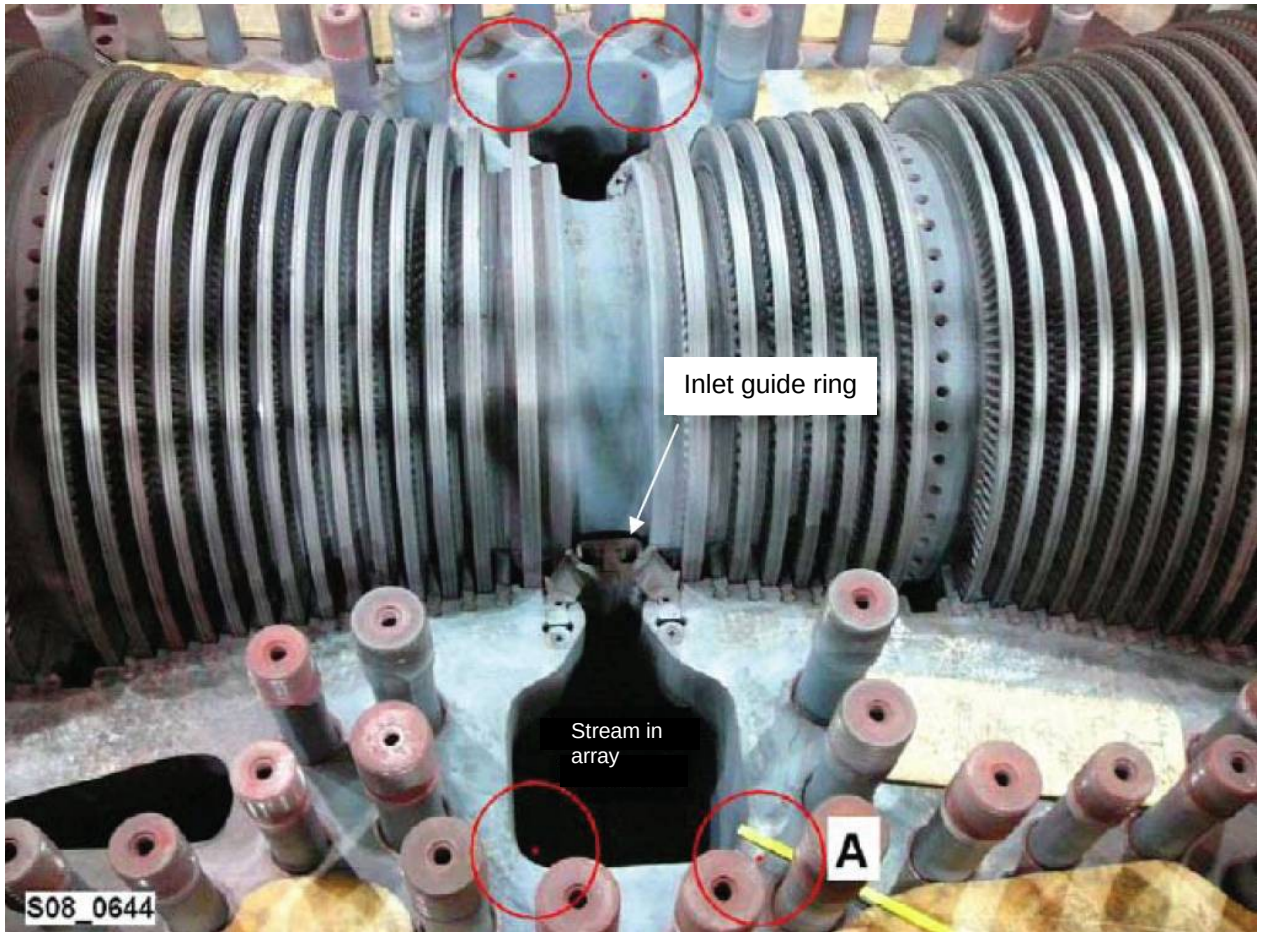
Reduce the possible delay time and costs

There are changes in the design



4 Further examples:

frequent and high thermal gradients lead to LCF

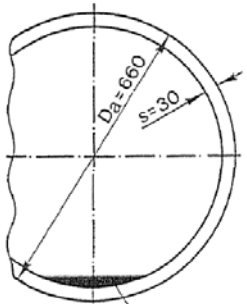


[Nothdurft , 2010]

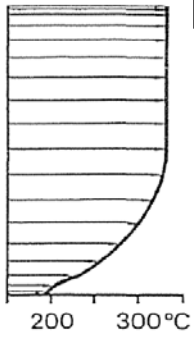
4 Further examples: thermal stratification

Hot state:
Thermal stratification

Cross Section of Pipe



Course of Temperature



Condensate

[Gillessen; 1992]

Cold state:
Visible deformation

Additional bending at fix points

Creep damage

The piping can be affected by thermal stratification due the ramp up and down.

5 Résumé

- **The higher impact of the renewable energy sources, especially wind, leads to a significant change of the load behaviour for the power plant components.**
- **Each fossil-fired power plant reacts in a very individual manner to the changed operation behaviour. It is, therefore, proposed to evaluate the influence based on the faults that have occurred. They should be analysed and strategies will then be developed to prevent further issues.**
- **When analysing, there are two different ways:**
  - **The analytical approach**
  - **And / or the phenomenological approach**
- **The phenomenological procedure is described using an example “repeated failure in a circulation system”**
- **For an optimal improvement to prevent further failure, it is recommended to develop a holistic strategy which employs all technical disciplines (design, process engineering and material engineering)**