Measures to improve the flexibility of RWE's lignite power plants as a reliable partner of the energy transition

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Indo-German Energy Forum – Task Force Flexibility
November 30, 2018 – New Delhi, India

Powering. Reliable. Future.

RWE

Agenda

Preliminary remarks on flexibility

Measures to improve flexibility

What if things went wrong?

Realizing an 80% Renewables feed-in Scenario in 2050: What is required for this at least?*

Needed installed (nominal) capacity wind + PV in a low consumption scenario [500 TWh/a]: 200 GW

500 TWh/a	80 %	8760 h/a	7 GW	20 %	200 GW
electricity consumption, low scenario	share of renewable energies	average 24/7 feed-In	generation from run-of-river and biomass	Annual full-load hours, no fluctuation	

Needed storage performance for electricity from wind + PV: 100 GW

200 GW	75 %	50 GW	100 GW
installed capacity wind + PV	maximum output of nominal capacity REN (as observed in grid)	grid load **Feeded by 100% REN,** **All conv. power plants switched off!**	

Needed installed reliable capacity (in particular for long-term backup): 80 GW

90 GW	10 GW	7 GW	90 %	80 GW
Annual peak load in grid	5% of installed wind + PV (at winter high)	generation from run-of-river and biomass	availability of reliable capacity of conv. PP	

Massive expansion of electricity storage is essential

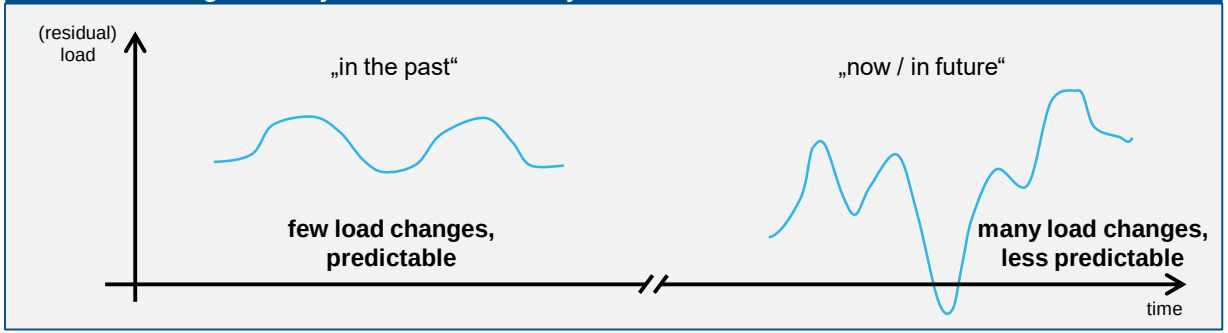
Even with 100% flexibility of conv. Power (i.e. zero feed-in) and other benevolent assumptions...

However, other reliable capacity, e.g. conventional generation, is still required for longterm backup.

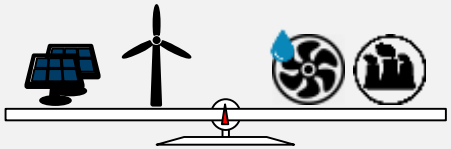
*all values roughly rounded

Flexibility: curve flank sufficiently designed in the market?

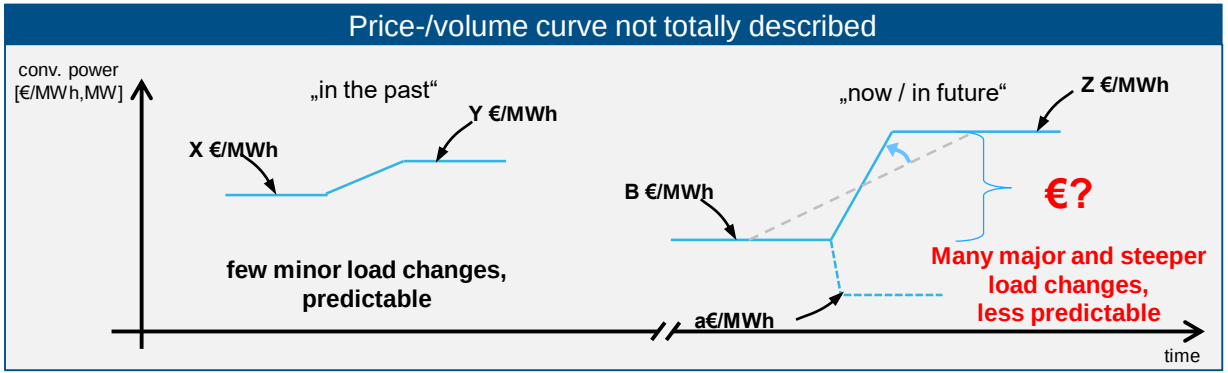
Significantly increased volatility due to variable feed in of wind + PV



Compensation essentially provided by conventional and pumped storage power plants*



Price-/volume curve not totally described



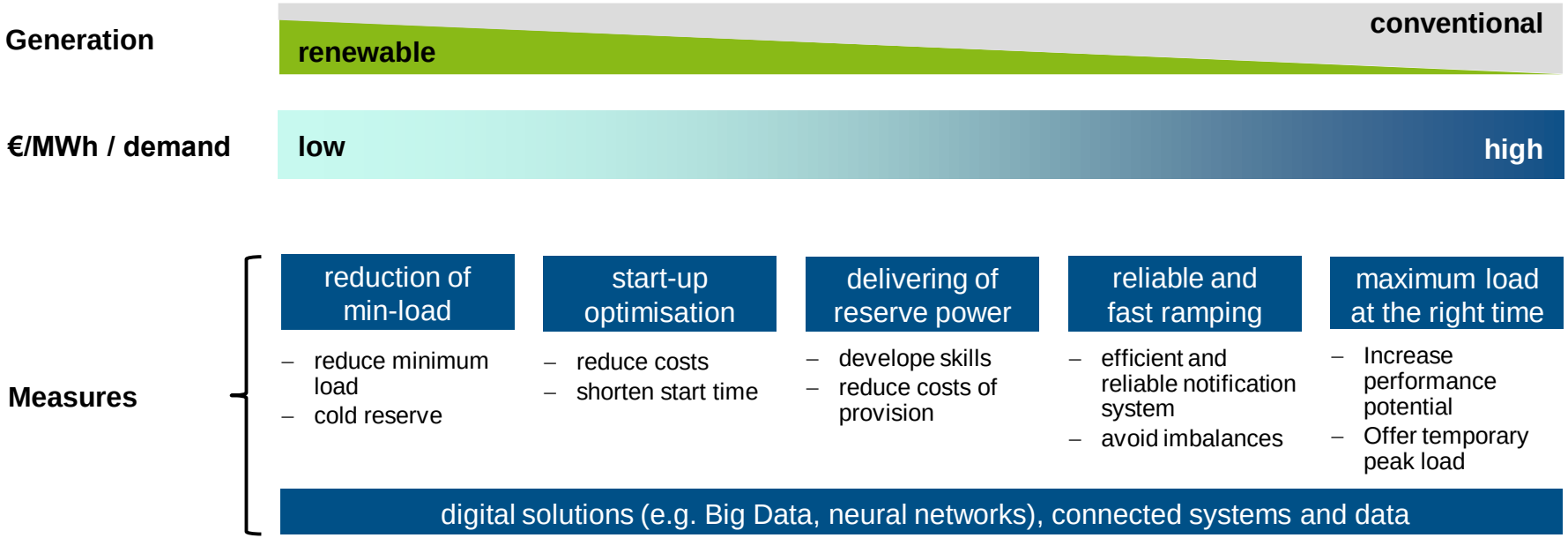
Market incentives for
- **flexible operation**
- **storage technologies**

sufficient?

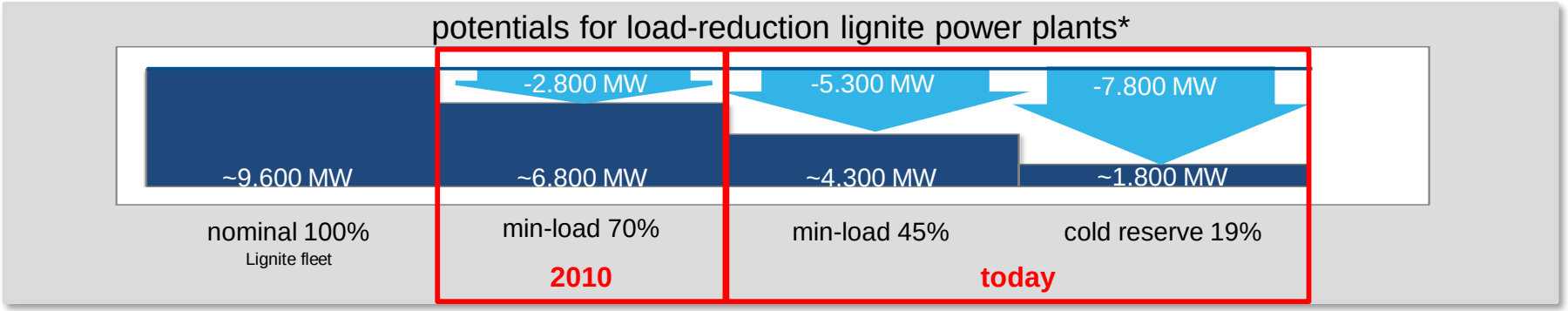
*perspectively electricity storage, power to gas, etc

Measures to improve flexibility

Flexible power plants remain vital part of the foreseeable energy-transition



Demand-oriented use of various options for load reduction



Nearly doubling the load-reduction-potential to minimum load (70 → 45%):

- Load change of ± 5,300 MW within < 60 min. using standard gradients**

Further load reduction by using the full cold reserve potential to ~19% of nominal capacity

- Reduction of generation by a further 2,500 MW by maximum shutdown of units (only must-run remaining)

Ongoing efforts to further optimize the potential for load reduction

Load-reducing potential increased significantly.
The fluctuating feed-in of renewable energies can be compensated in a wide range.

* without Frimmersdorf P/Q („Sicherheitsbereitschaft“ since 10/2017)
** less excessive stress and wear, compared to fast gradients

Start-up optimization

Goals:

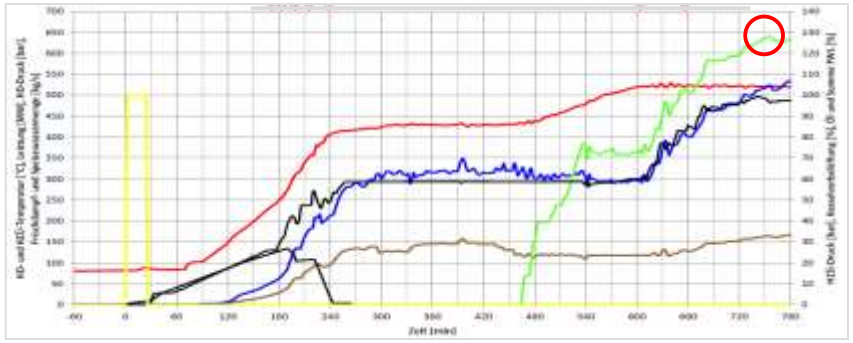
- Minimizing the costs and duration of start-up
- Increasing the reliability for dispatch

Approach:

- Detailed, systematic process analyzes
- Identification of action priorities
- Ensuring sustainability

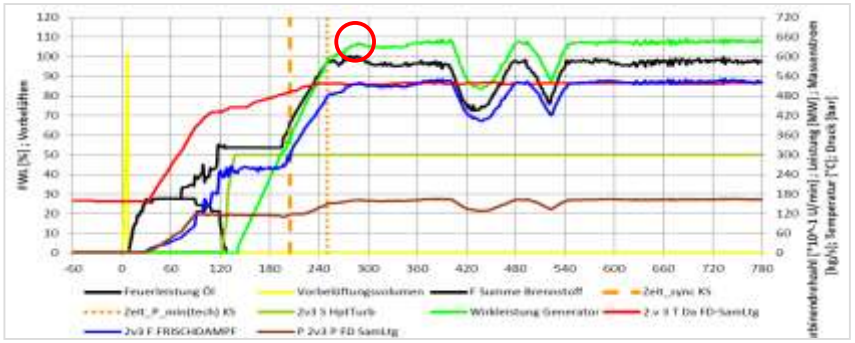
Cold-start 2010:

- Max-load after > 10h
- High consumption of ignition-oil



Cold-start 2017:

- Max-load after < 5h
- Ignition-oil ~ 50%

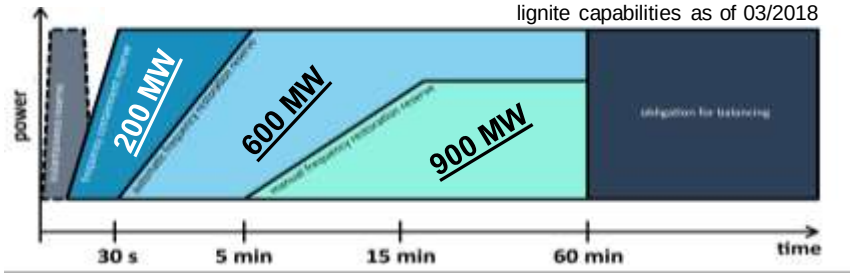


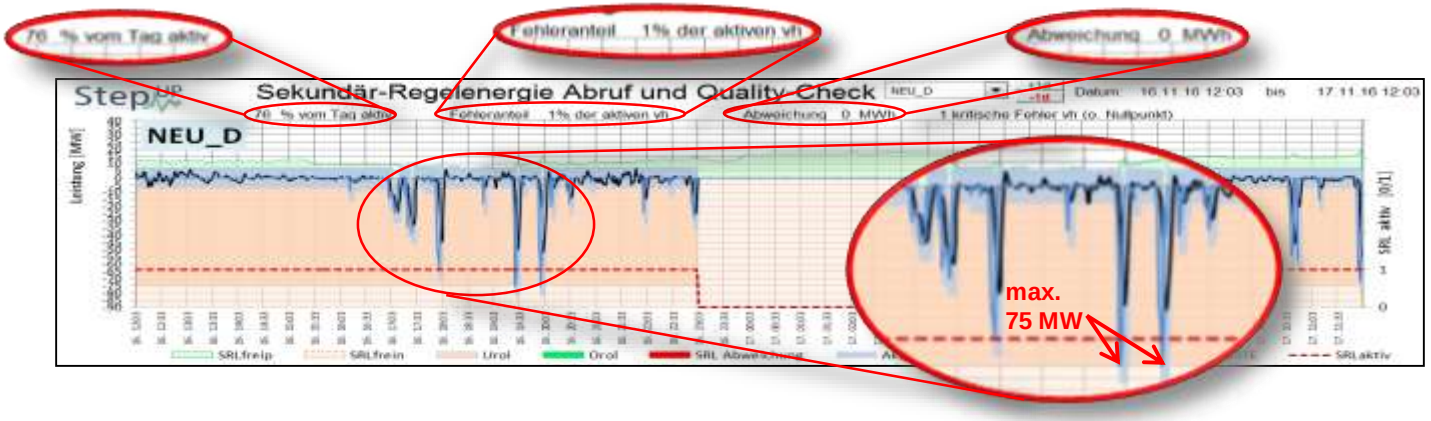
Time and ignition-fuels for start-up reduced by 50%

Delivering balancing and reserve power

The balancing and reserve power is a unique feature for lignite at high renewable generation and may offer a "second pillar“ in the market

- Skills for the provision of reserve power have been significantly expanded.
- Costs for provision of reserve power are continuously reduced.



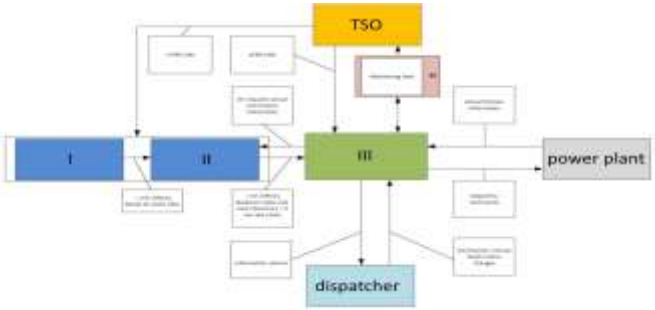


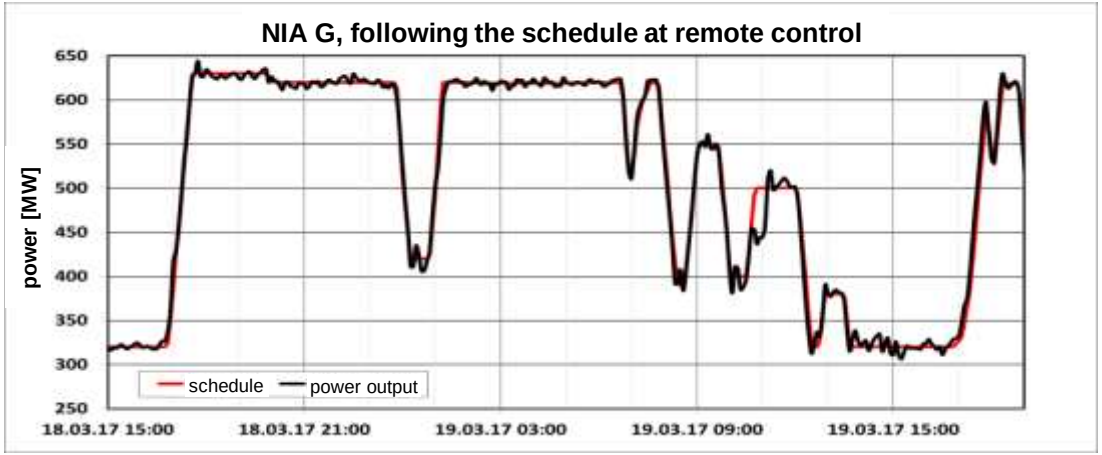
Reliable and substantial provision of requested reserve power.

Automated remote control enables flexible plant operation

Beginning in 2011, an IT-supported remote control of the units by the dispatcher was gradually built up:

- Units follow the schedule automatically
- Automated call of reserve power
- Currently 16 of 18 units connected





Efficient, automated process reduces costs due to imbalance and allows a fast reaction to market requirements

(Disponible) Performance maximization

Approach:

1. **Determine the capacity of units as best as possible and optimally utilize them:**
   maximum production in "normal operation"

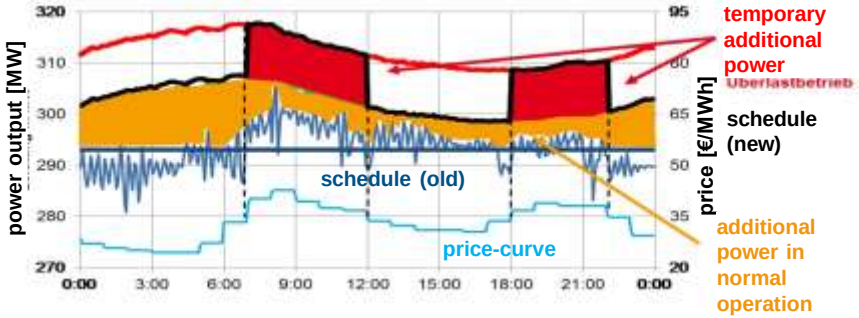
   ➡ **> 200 MW** (compared to 2011)

2. **Scheduling performance-influencing processes to meet intraday variations of electricity demand:**
   product "peak load" (e.g. shifting heating surface cleaning, exploiting technical plant boundaries).

   ➡ **> 70 MW** (compared to 2011)

To realize the performance enhancement potentials different technical and organizational tools are used:

- process-quality-optimization-system
- market-oriented control
- temperature-compensation
- peak load
- and other



Current needs of market are optimally met by flexible plant operation

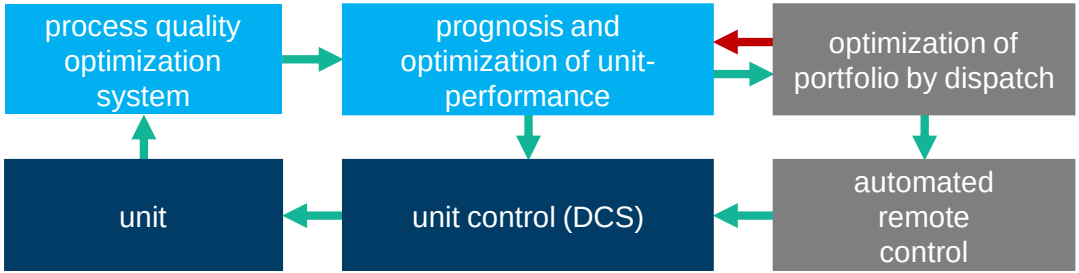
Forecasting and market-oriented control with a Big Data solution *

Approach:

- Forecasting maximum and minimum deliverable power due to technical parameters and extrinsic factors (price-curve, outside temperature…)
- Automatic power plant operation including retrieval of reserve power via remote control
- Closed, automated process between power plant and dispatch

Advantages:

- Linking technical-operational and market-related information
- Optimized use of potential on the electricity market
- Increased reliability supports balancing group management

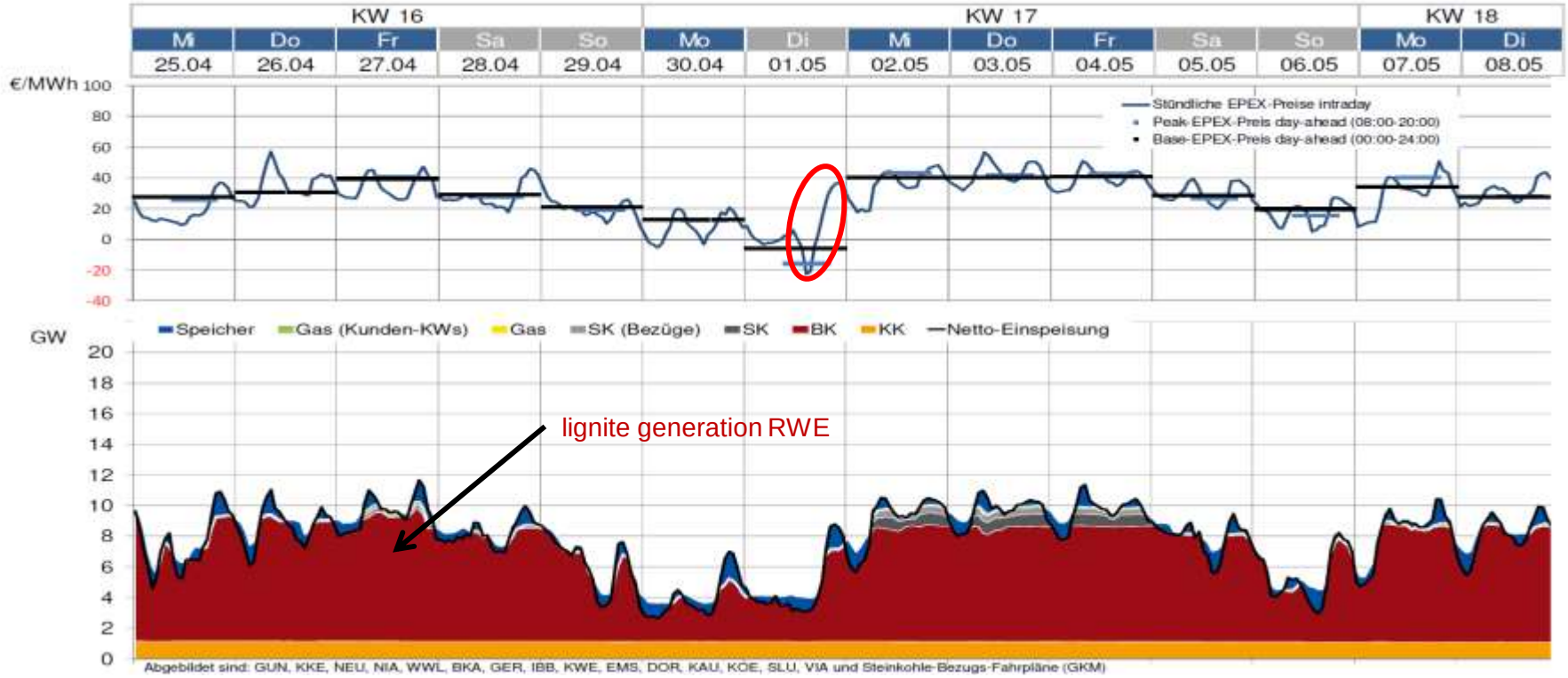


High benefit through additional functions:

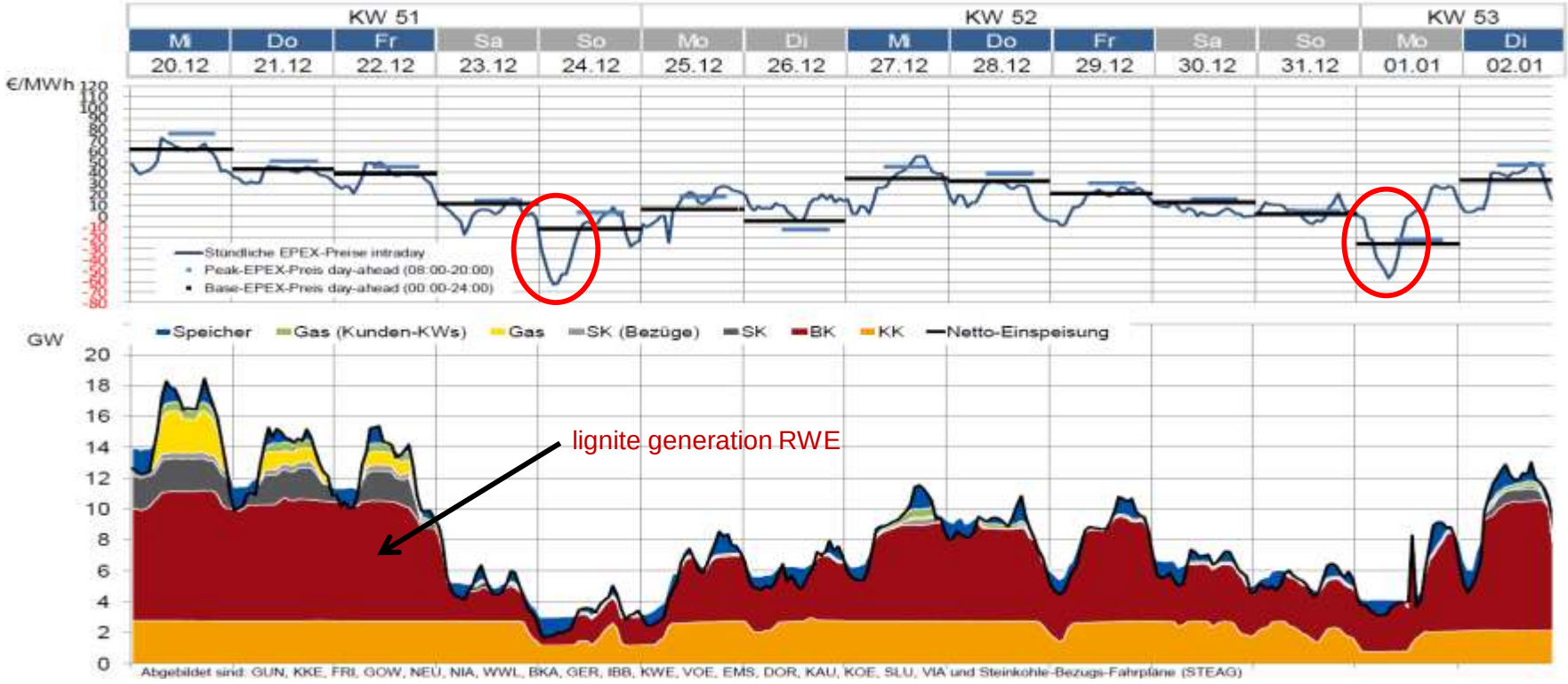
- Forecast of min-load (district heating Weisweiler)
- Consideration of operating strategies
- Intra-day update/ re-optimization
- and other…

* patented

Flexible operation of lignite power plants at typical public holiday in spring 2018

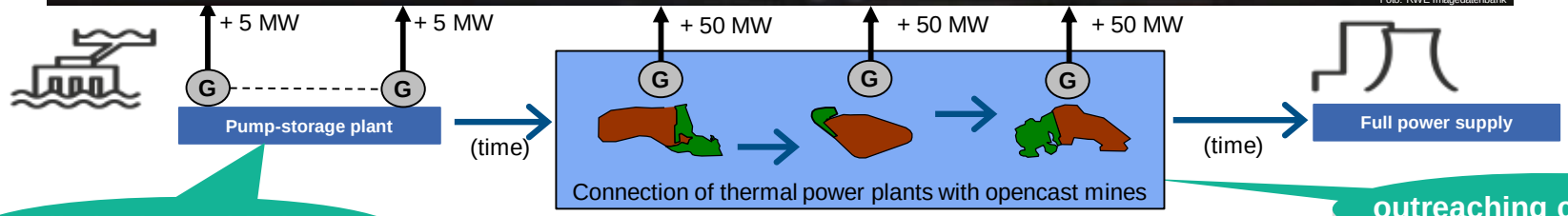


Flexible operation of lignite power plants at Christmas 2017



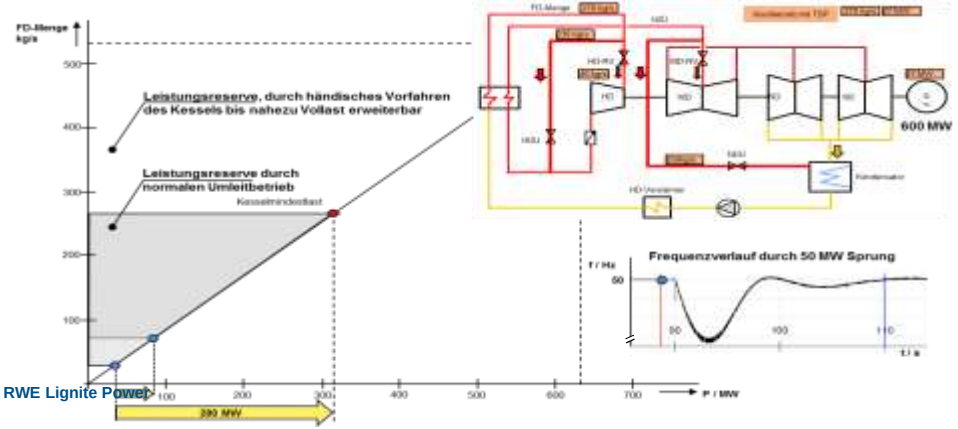
What if things went wrong?

Grid-Recovering Capability from isolated operation



limited capabilities

- capacity
- endurance (duration)
- robustness at load jumps



outreaching capabilities

- capacity
- endurance (duration)
- robustness at load jumps

Thank you very much for your attention