



Flexibility options – from power plant technology to latest storage solutions

- 1. Introduction of STEAG**
- 2. Why do we need flexibility?**
- 3. Flexibility options:**
 - a. Improvement of efficiency**
 - b. Compliance to new environmental requirements**
 - c. Optimisation of low load and start-up**
 - d. Operation and Maintenance**
 - e. Storage solutions**
- 4. Conclusion**

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WE are STEAG.

Our facts and figures



- **WE** are specialists in the generation of electricity and heat on the basis of a wide variety of technologies, and for the marketing of electricity and heat;
- with 9 hard coal fired and 2 refinery power plants in Germany, and 3 hard coal fired power plants in Colombia, Turkey and the Philippines;
- with more than 200 distributed generating facilities on the basis of renewable sources, for energy supply to industry and heat supply;
- with an installed capacity of 8,200 MW in Germany and 1,950 MW abroad;
- with a workforce of 5,920;
- with total sales of EUR 3.6 billion and EBITDA of EUR 399.2 million in 2015;
- with an investment volume of around EUR 219.3 million in 2015.



WE are STEAG Energy Services. The Technical Competence Center of STEAG



Revenue € 167 million

(consolidated)

Employees 1,615

(consolidated)

as of Dec. 31st, 2015



STEAG Energy Services

Energy Technologies



Design, site supervision and commissioning of power plants

Plant Services



Operation & Maintenance, catalyst management and -regeneration, personnel services

Nuclear Technologies



Decommissioning and dismantling of nuclear plants, safety, radiation protection and realization of final disposal sites

System Technologies



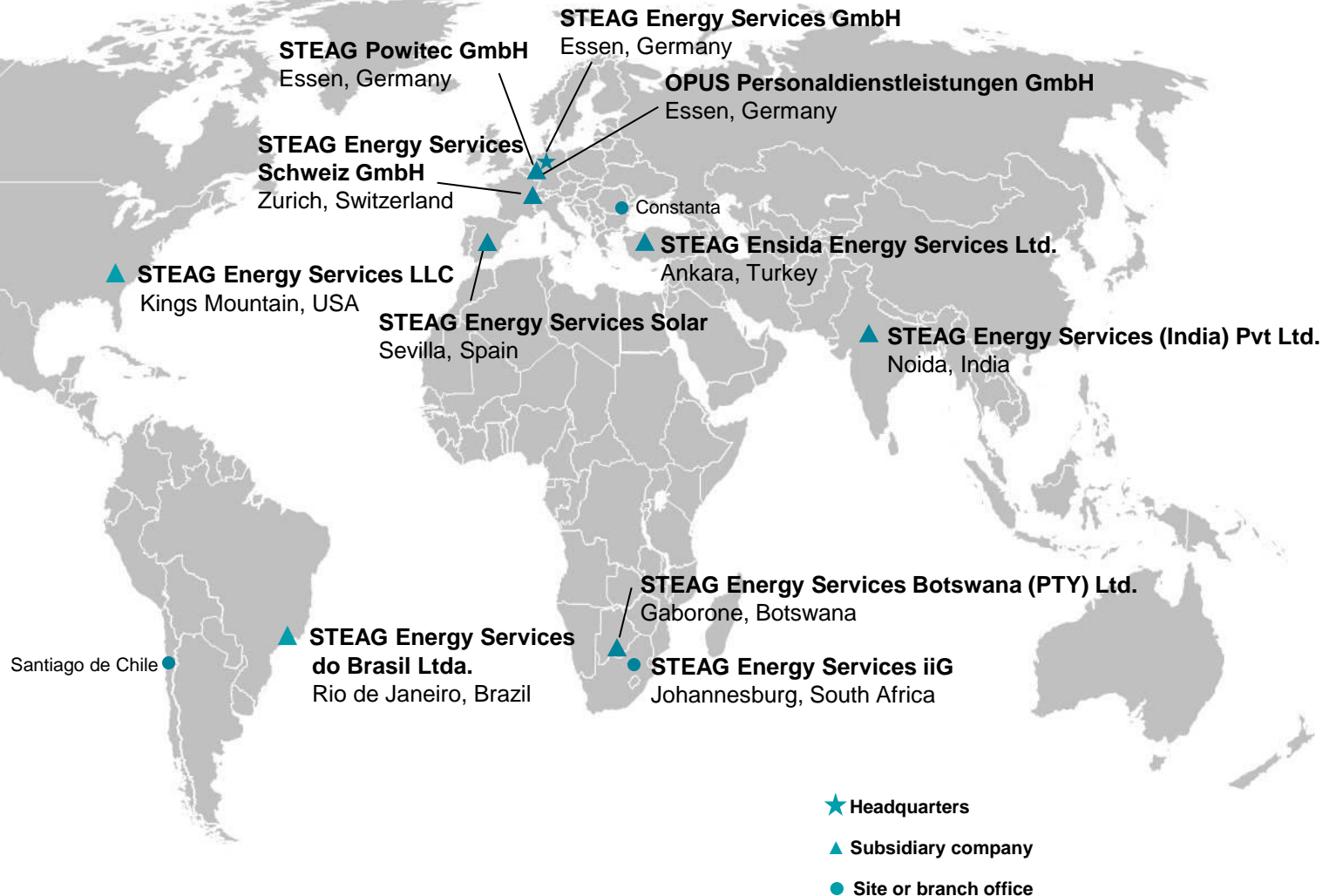
Energy Management Systems, process optimization by sensor-based solutions, user trainings

Information Technologies

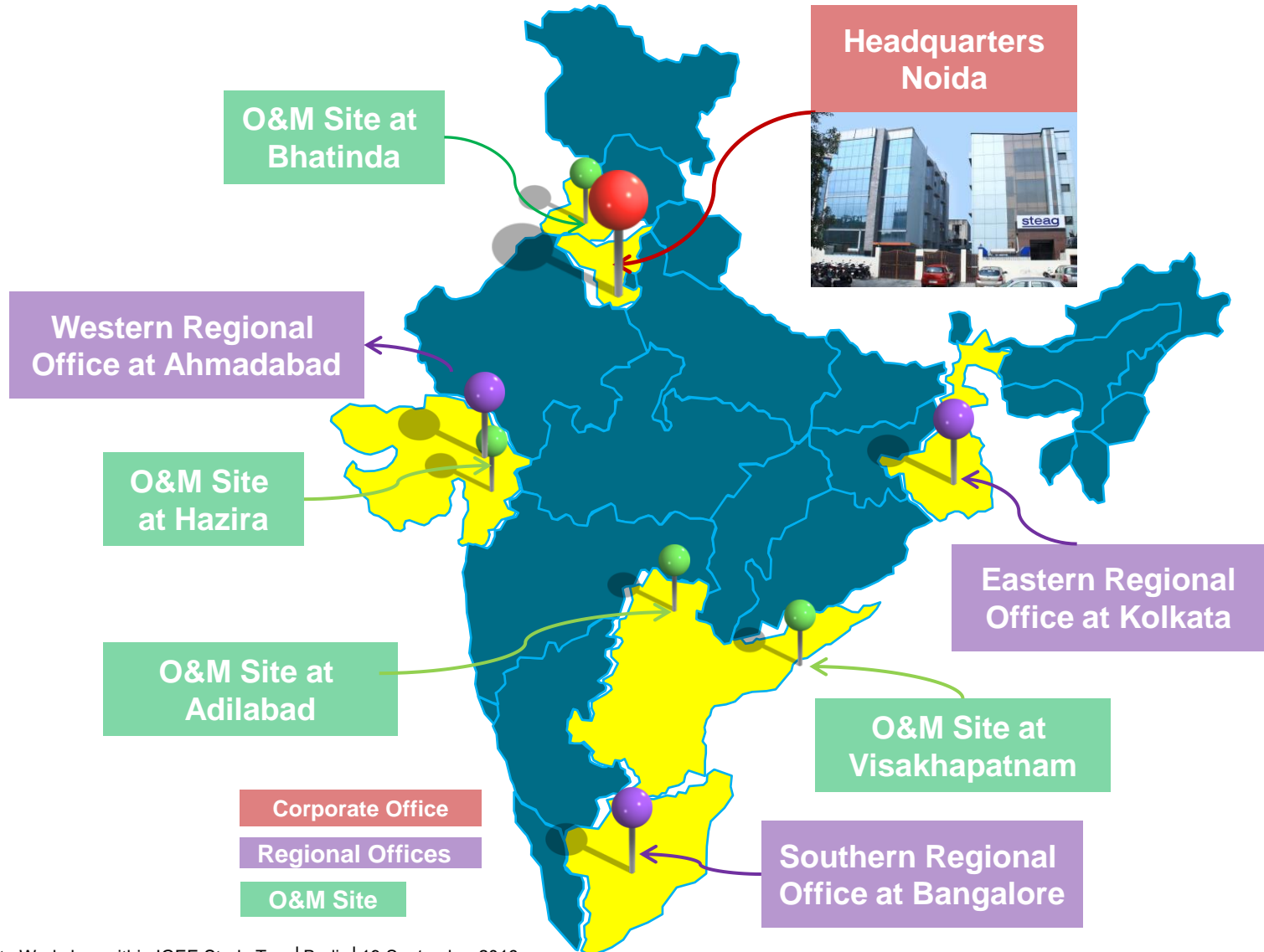


Operation Management Systems, Communication Technologies, Site IT

WE are STEAG Energy Services. Your Partner worldwide



WE are STEAG Energy Services. Your Partner in India



1. Introduction of STEAG

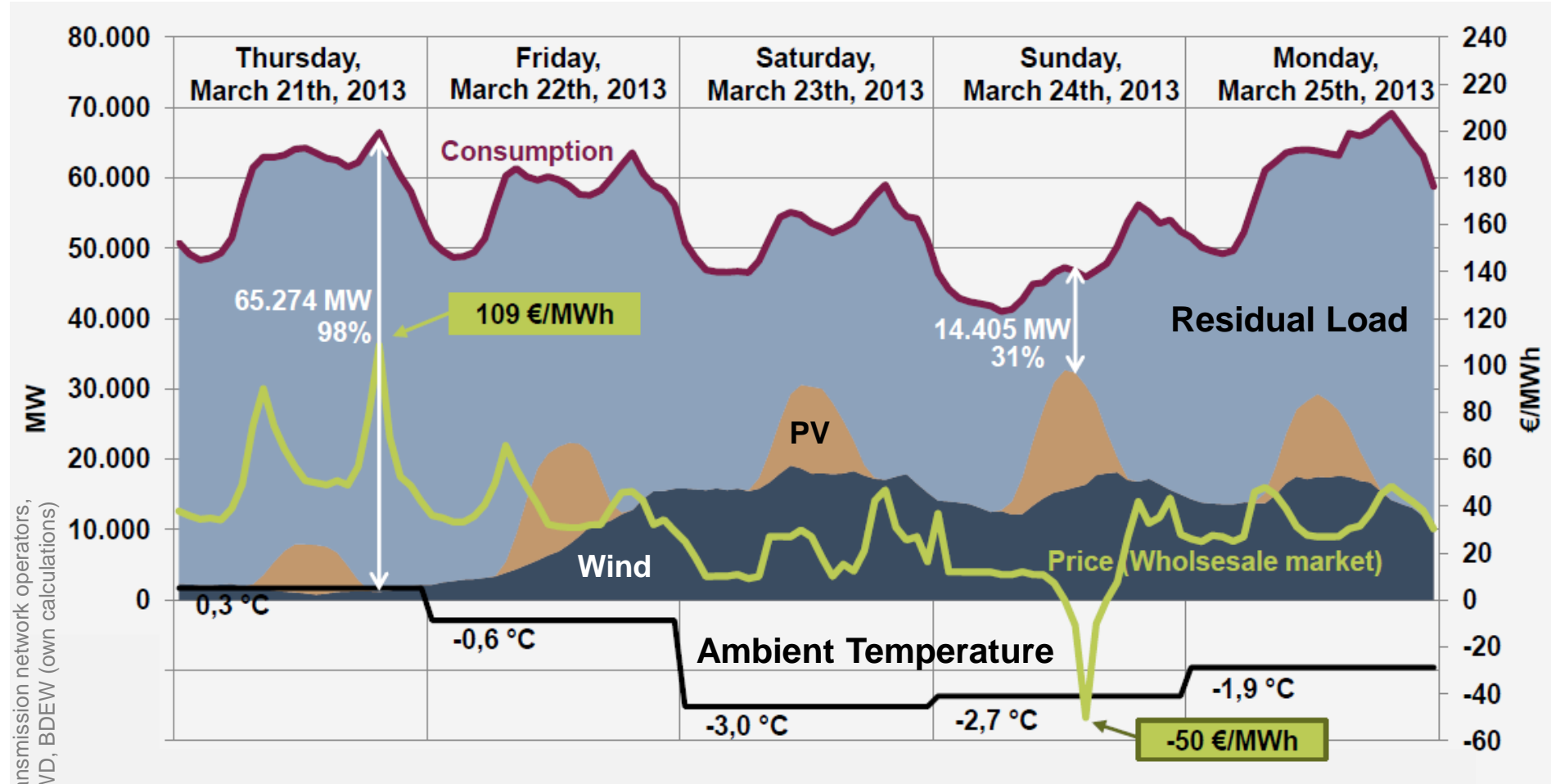
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Renewables and conventional power plants feeding into the German grid

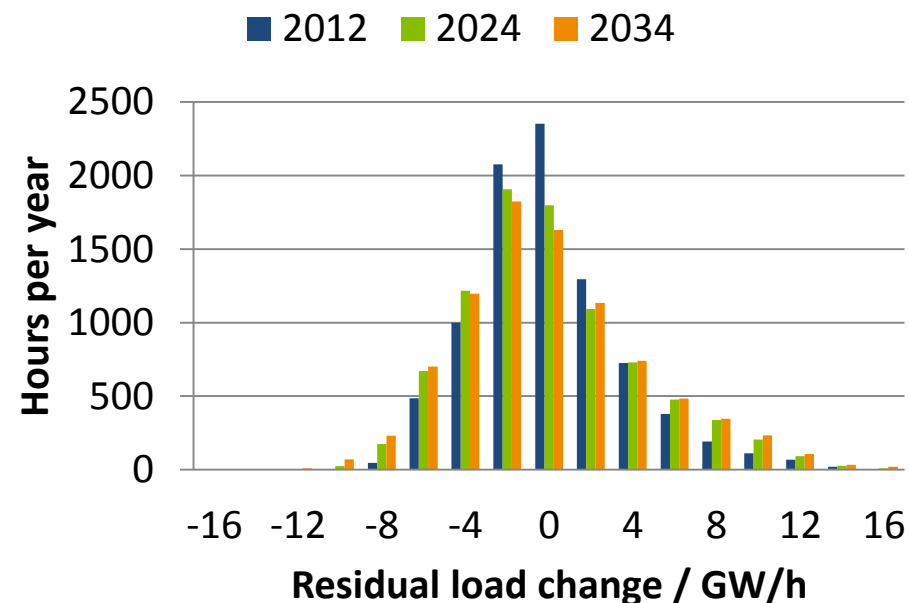
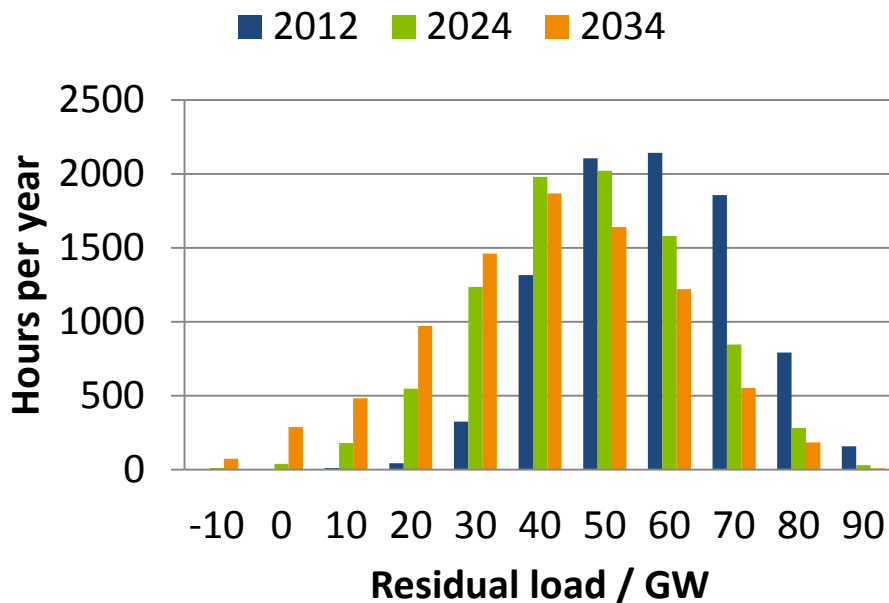


Ref.: Transmission network operators, EEX, DWD, BDEW (own calculations)

Residual load in Germany

- Dispatchable energy sources cover the residual load

$$P_{\text{Residual}} = P_{\text{Total}} - P_{\text{PV}} - P_{\text{Wind, onshore}} - P_{\text{Wind, offshore}}$$



- Flexible capacity (reduced minimum load and optimized start-up) by thermal power plants are still necessary

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Flexibility Options

Target		Driver
a	Improvement of efficiency	Ageing and competition
b	Retrofit of flue gas treatment	Compliance to new environmental requirements
c	Optimisation of low load and start-up	Rising renewable and fluctuating feed-in
d	Optimisation of Operation and Maintenance	Competition
e	Storage solutions	Rising renewable and fluctuating feed-in

Driver / Motivation to change

- Competitiveness due to new market player / economy

Targets

- Efficiency and the state-of-the art technology
- Fighting comfort, laxness and habits
- Establishing improvement processes

Reference Projects

- IGEN Program in India: assessment of 85 units from 100 – 210 MW, mapping of power plant efficiency, training of operators, engineers and energy managers over 7 years
- Energy Efficiency program of Eskom in South Africa: evaluation of 38 GW in 87 units
- Multi-retrofit of a 500 MW supercritical coal fired power in Germany



Driver / Motivation to change

- More stringent environmental legislation

Targets

- Compliance concerning air / water emissions
- Mainly PM, SO_x and NO_x

Reference Projects

- STEAG power plants built until the end of the 80ties
- STEAG/RWE new FGD Voerde 2x 760 MW
- ISKEN (Turkey) SCR 2x 660 MW
- Pego (Portugal) FGD & SCR 2x 311 MW
- West Burton (UK) FGD 4x 500 MW



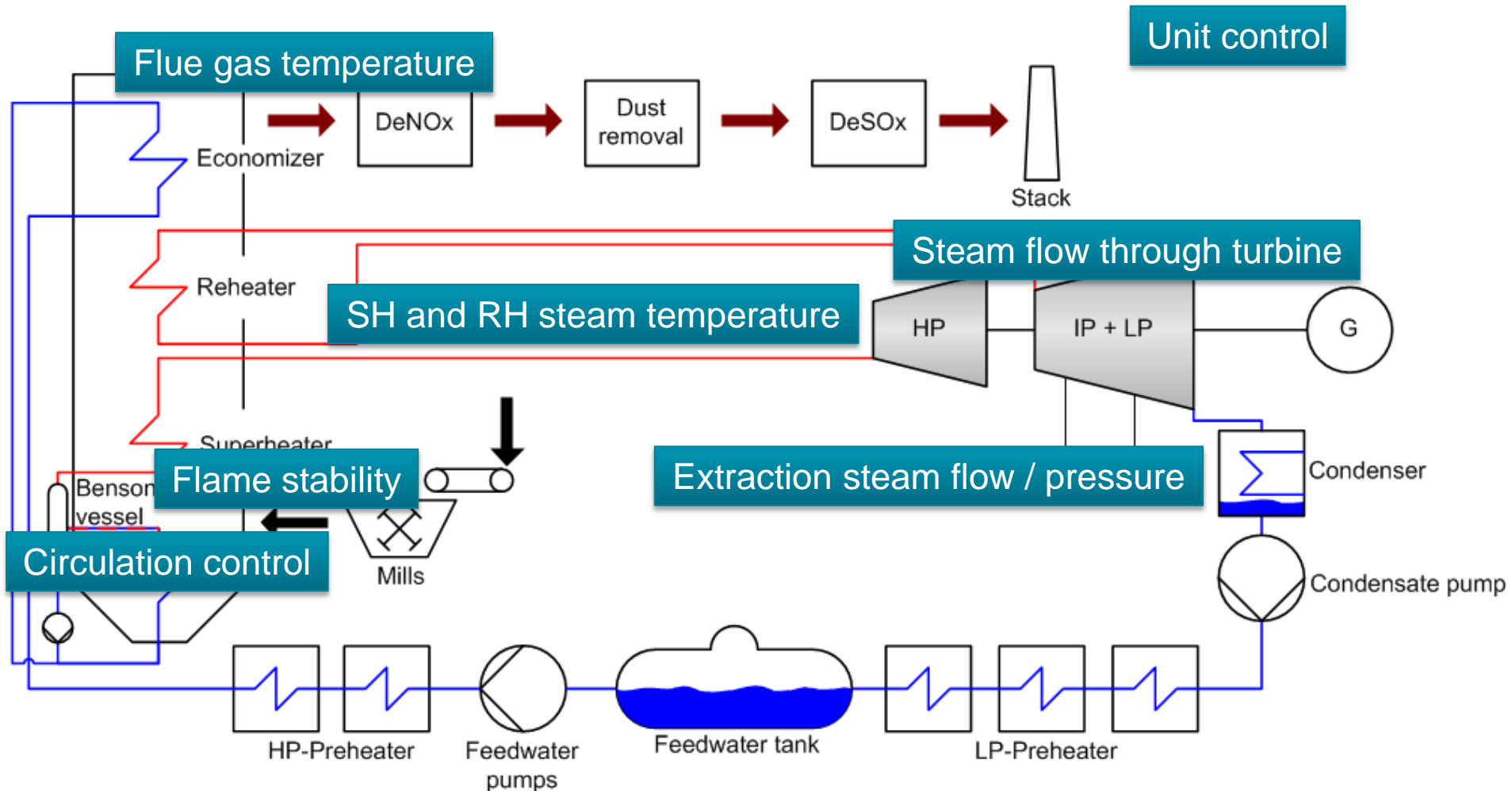
Coal fired power plants are designed

- for base load operation: 6.000 – 7.000 h at full load, but
- future scenario: 1.500 – 4.000 h at full load with a lot of starts

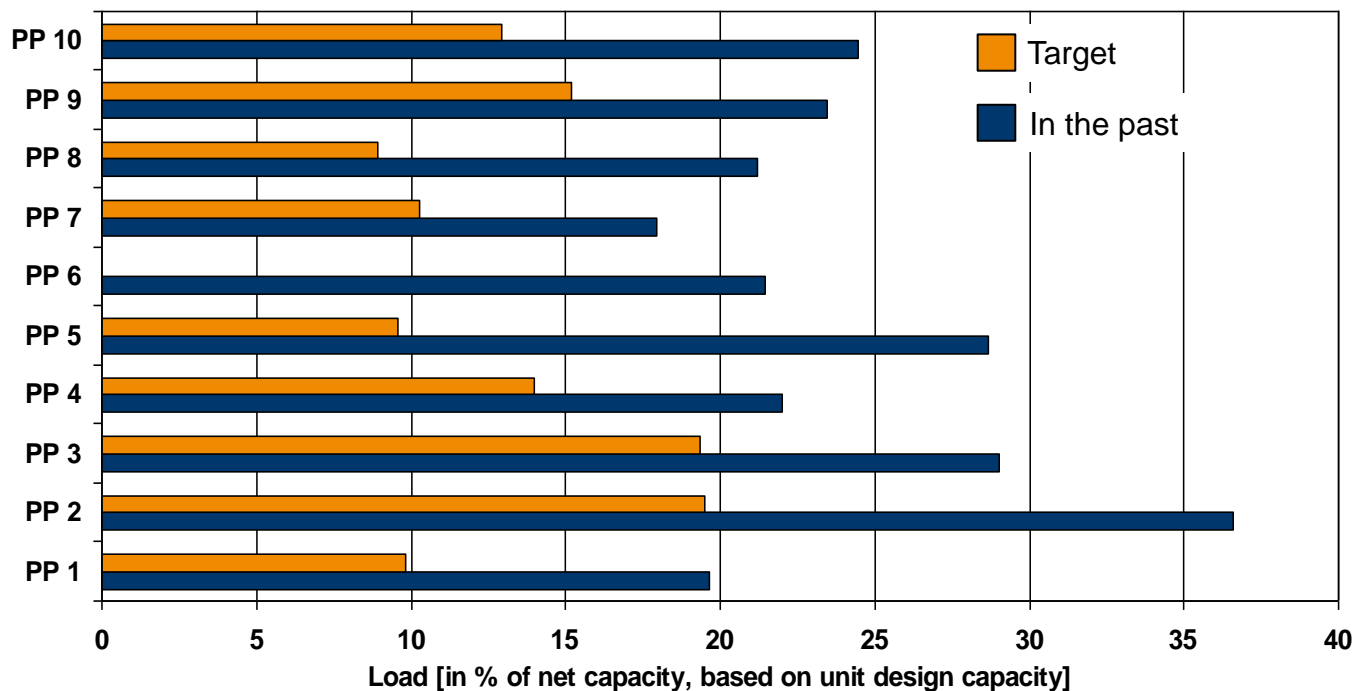
Improvement of flexibility:

- Reduction of start-up times and costs
- Reduction of minimum load
- Identification of limiting components
- Evaluation and optimization of components and aggregates

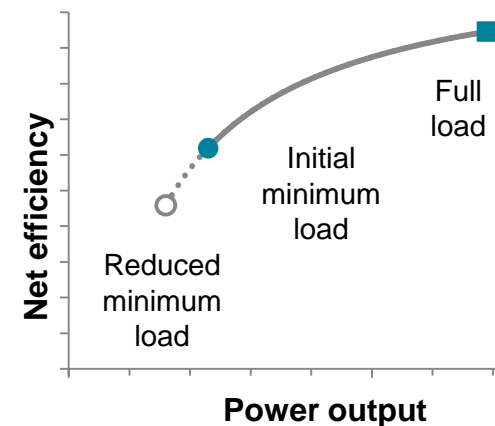


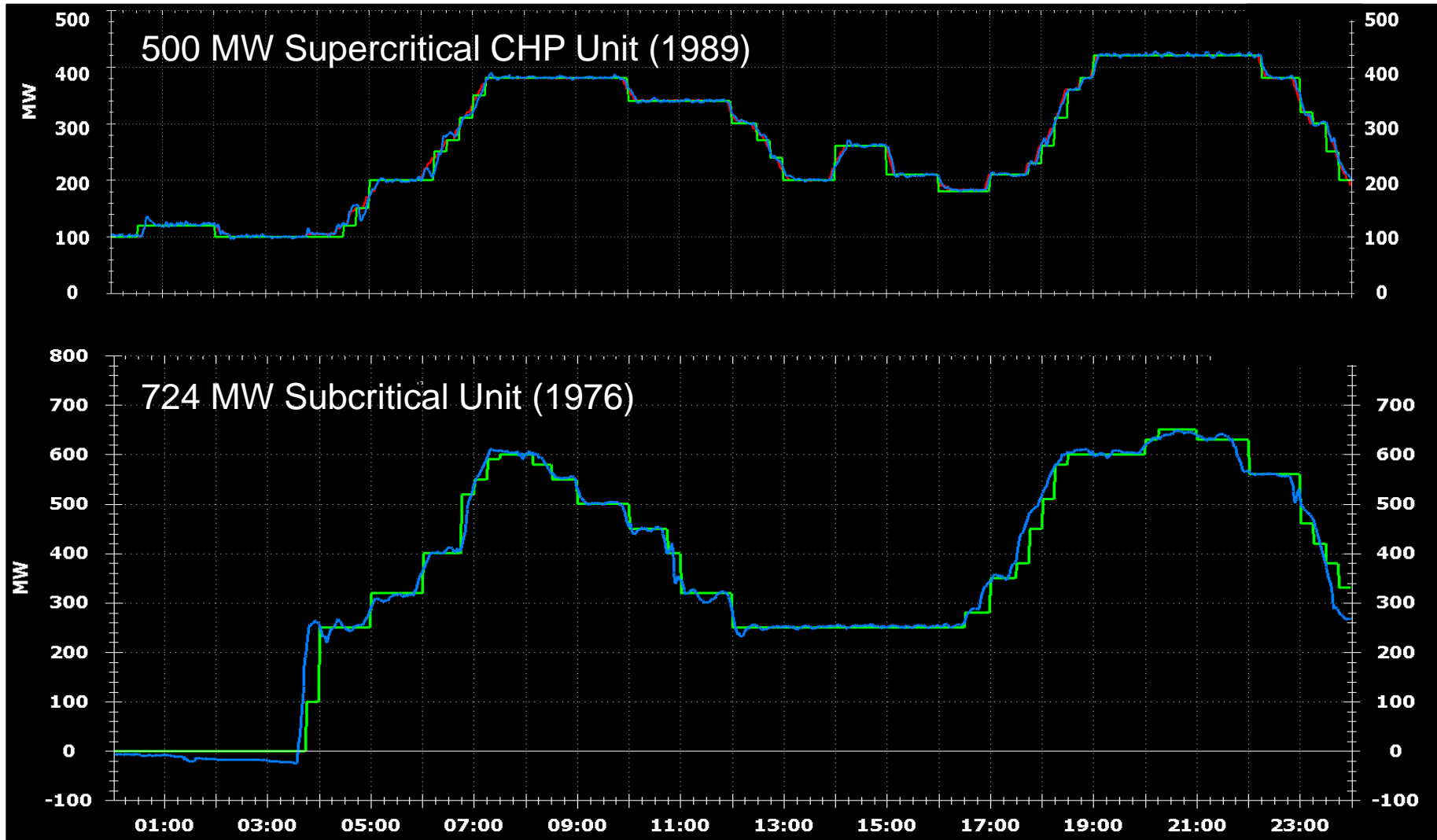


- Big potential beyond the initial design



- Reference plants in Germany built between 1970 – 1990
- But reduction of load will decrease efficiency





Plant performance

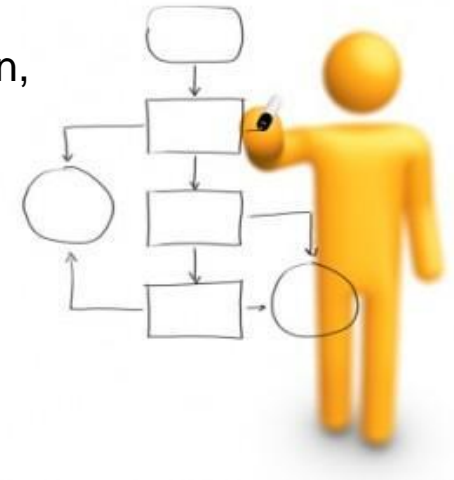
- Increase of level of automation
- Empowerment and skills transfer to operating staff
- Implementation and use of energy and operation management systems

Improvement of processes

- Evaluation of best-practice procedure, e.g. for start-up, shut-down, overhauls etc.
- Harmonization of organizations and processes within the fleet

Central administration and asset management

- Streamlined and effective reporting
- Reduction of overhead costs





Energy management system: SR-Systems

- Optimisation potential regarding efficiency and availability.
- Predictive maintenance and early warning system for changes in process conditions and component health.
- Lifetime consumption monitoring for frequent load changes.



Computerized maintenance management system: SI[®]/PAM

- Planning, control, execution and documentation of maintenance.
- Intelligent basis for economical preventive and condition-based maintenance strategies and documentation.
- Utilization directly onsite using RFID/Barcode and mobile devices.



„Virtual / Augmented Reality“

- Interface to computerized maintenance management system.
- Diagnosis with borescope, drones, robots, etc..
- Remote diagnosis by experts from headquarters.

Flexibility

e) Storage solutions

Estimated Day	Estimated Production in GWh	Storage Demand in GWh of 10% of generated wind power
January 2030	1.000	100
June 2030	240	24

	Electro Car „V2G“	Pump Storage Goldisthal	Hydrogen Electrolysis
Storage Capacity	30 kWh/Car	8.5 x 10 ⁶ kWh/PS	5 kWh/m ³ H ₂
Storage Power	4 – 6 kW/Car	500 MW/PS	5 MW/Unit**



Day in January	4.2 Mn Cars*	12 PS (level 0%)	830 Units 20 Mio. m ³ H ₂ (5.3% admixture)
Day in June	1 Mn Cars*	6 PS (level 0%)	200 units 4.8 Mio. m ³ H ₂ (2.8% admixture)

*units available on the grid the entire day (car availability 80%)

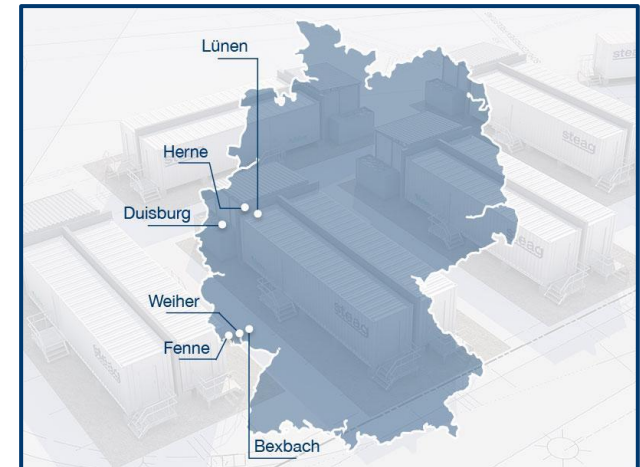
**estimated electrolysis reference plant

Investment in large battery systems to provide 90 MWe/1 PC in total:

- Project costs in total: about 100 Mio. €
- No subsidies
- Erection at 6 STEAG sites in Germany using existing grid connections
- Containerized solution to have the option of relocation

Fast realization

- Start of erection April 2016
- Commercial operation of all units end of 2016



Flexibility

e) Storage solutions

Lünen



Herne



Walsum



Bexbach



Fenne



Weier



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Market and environment require flexibility, i.e.

- able to change to cope with variable circumstances,
- capable of being changed or adjusted to meet varied needs.

Coal fired power plants

- are not rigid dinosaurs,
- can be adapted to new market,
- can be operated as flexible partner to secure growth of the renewables and must secure the stability of electrical grids.

Battery systems

- offer interesting solutions for grid stabilization and renewable feed-in,
- but have limits concerning mass storage of energy.



STEAG has experienced engineers to support you in your flexibility.

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