Grosskraftwerk Mannheim AG

Operating a coal fired power plant in a flexible market environment

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Seminar on Adaption of Thermal Power Plants to Fluctuating Renewable Energies
The German Experiences (VGB POWERTECH / IGEF / EEC / CEA)

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Mit Energie überzeugen

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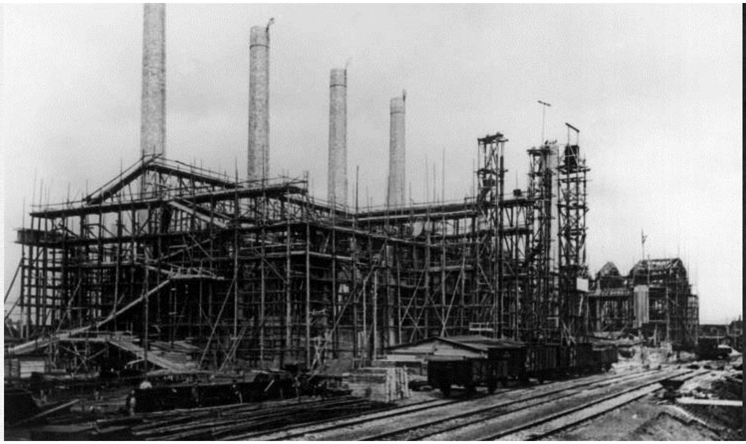
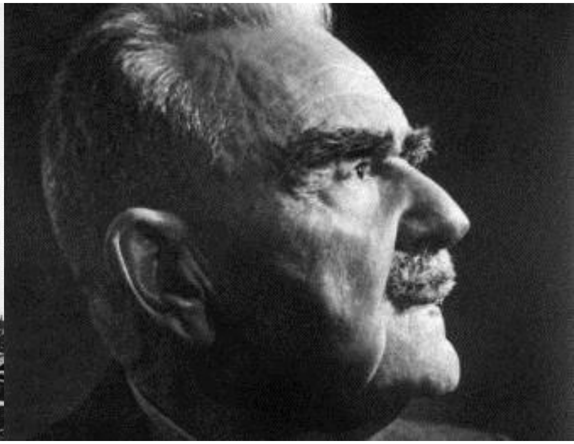
2. Actual situation in Germany („Energiewende“)
3. Optimization of the GKM Power Plant
4. Conclusions

GKM history: the beginnings





1921

GKM is founded on 8th of November

Start of construction work at a good location: close to town of Mannheim and directly sited at river Rhine; start of electricity generation in 1923

Mastermind: Dr. Karl Friedrich Marguerre, Executive Direktor

GKM founded 1921…new unit 9 in erection (2013)…

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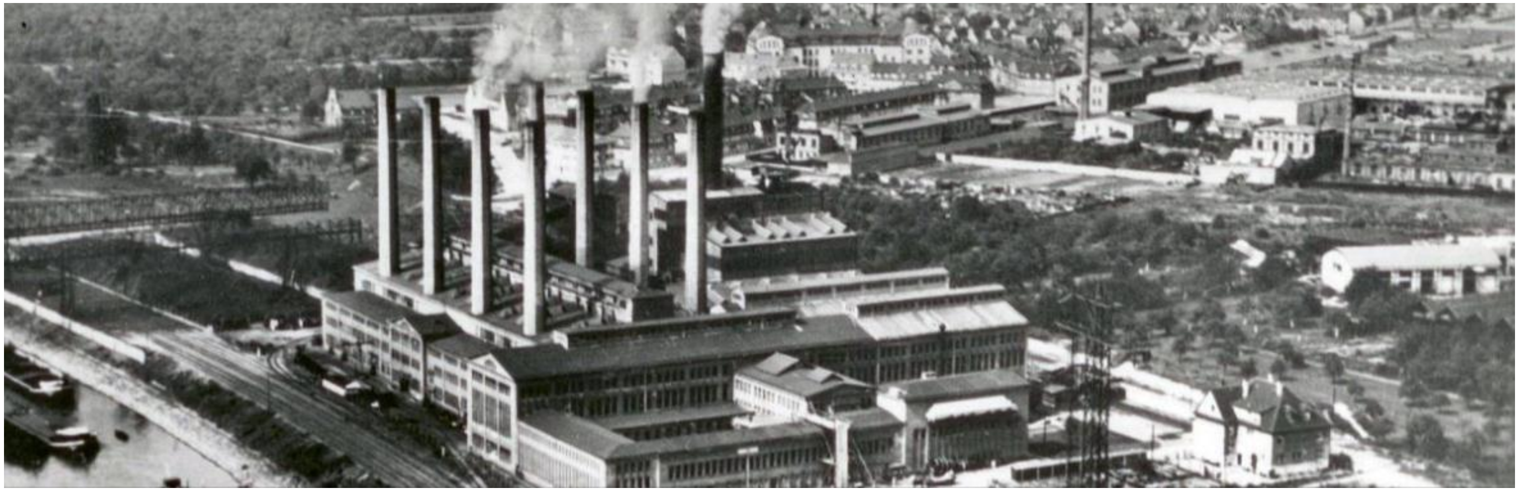
1926



2013

GKM plant today

CHP process (combined heat and power) in GKM

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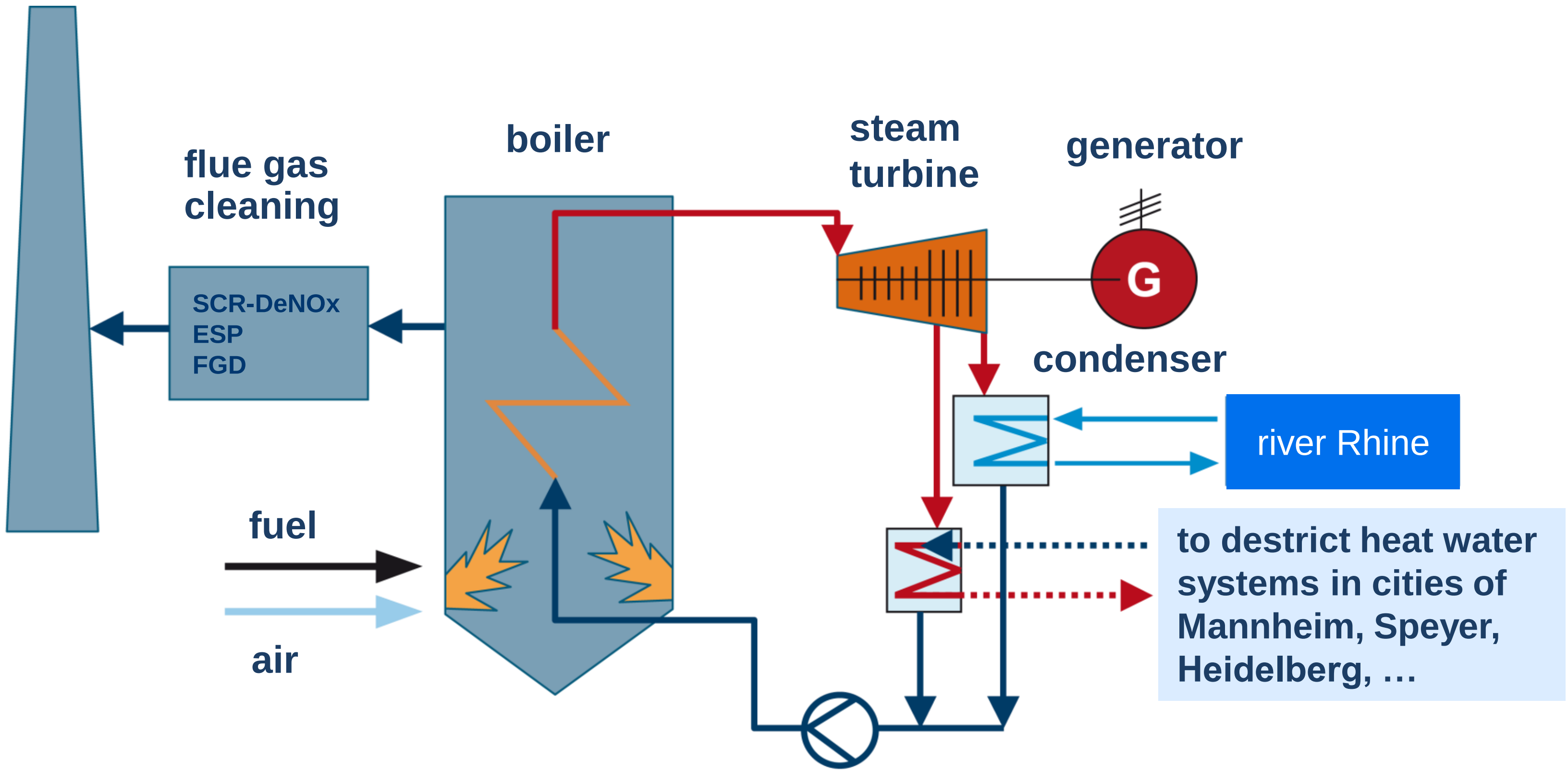
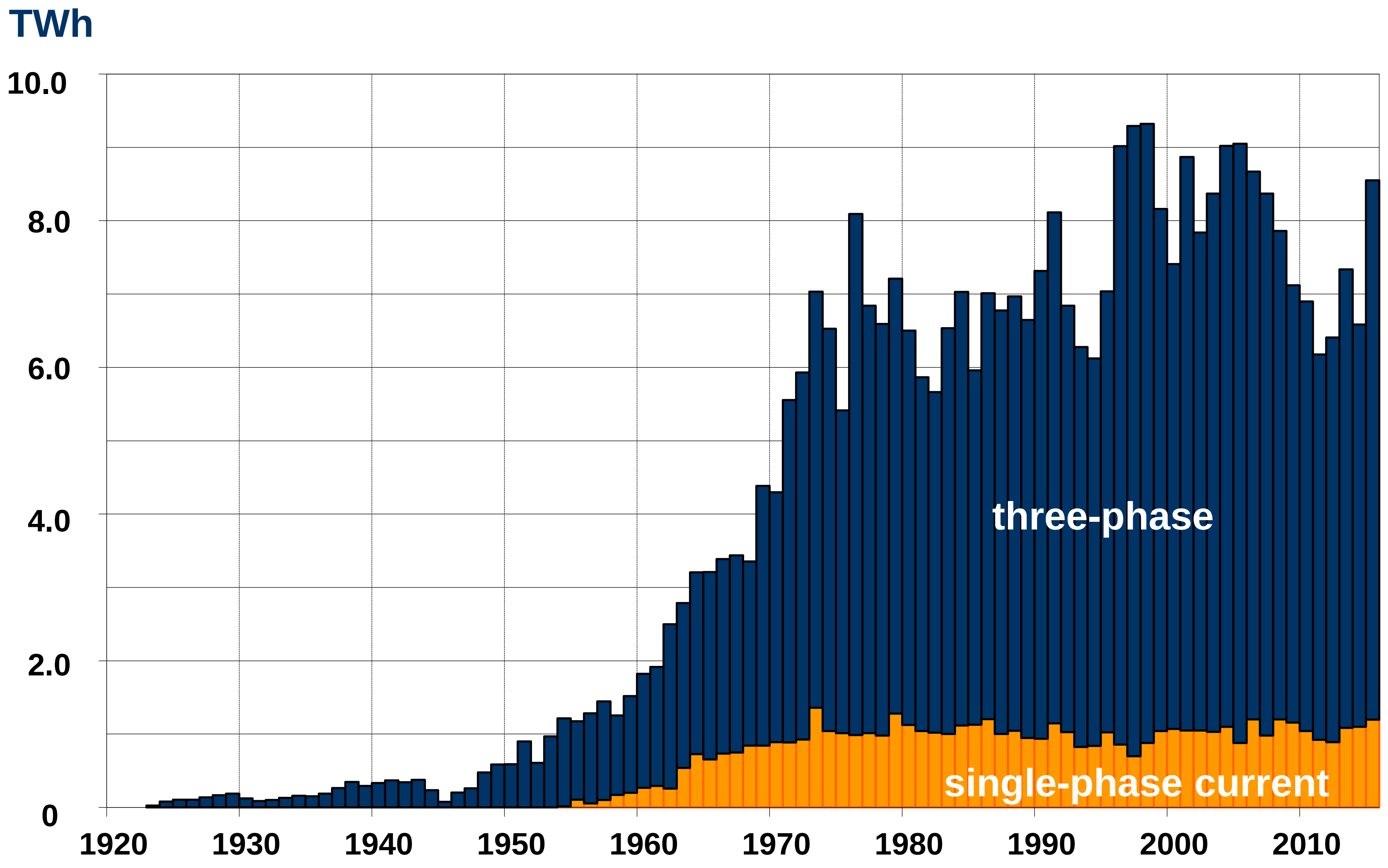


GKM power generation (electricity) since 1923



Efficient generation of electricity and district heat

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energy for share holders and German Railway: reliable, cost-effective and friendly to environment

50 Hz three-phase alternating current
(to the share holders of GKM AG)

RWE Generation SE **(40 %)**
EnBW AG **(32 %)**
MVV RHE GmbH **(28 %)**

16.7 Hz single-phase alternating current

DB Energie GmbH
(German Railway)

District heat
(hot water)

MVV RHE GmbH
Mannheim

GKM plant in 2016

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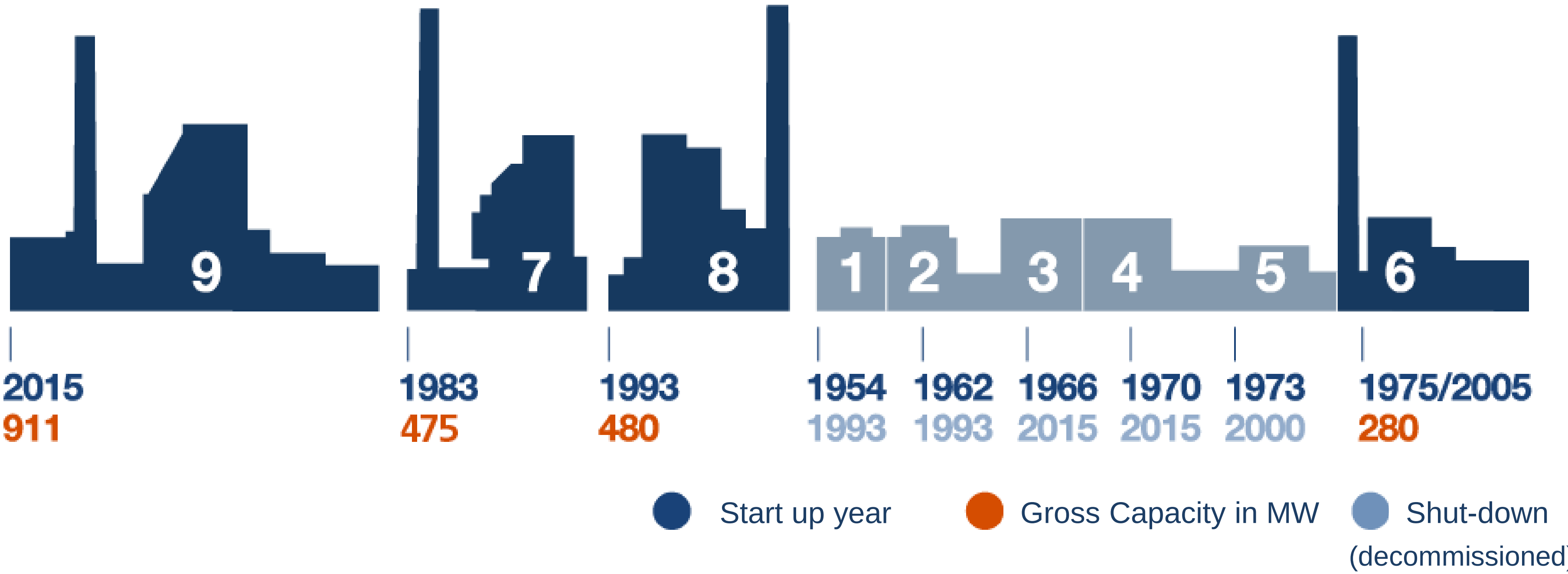
GKM plant: installed capacity: 2.146 MW_{el} (units 6,7,8,9)



GKM plant overview

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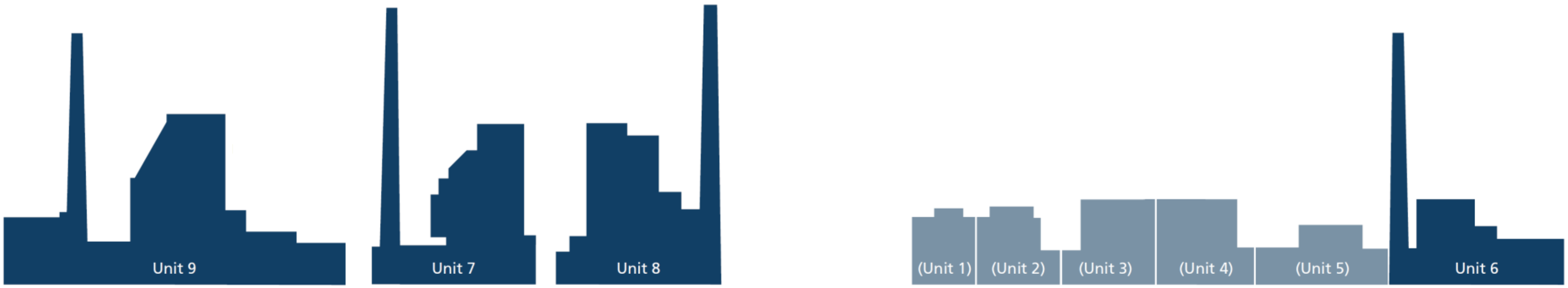
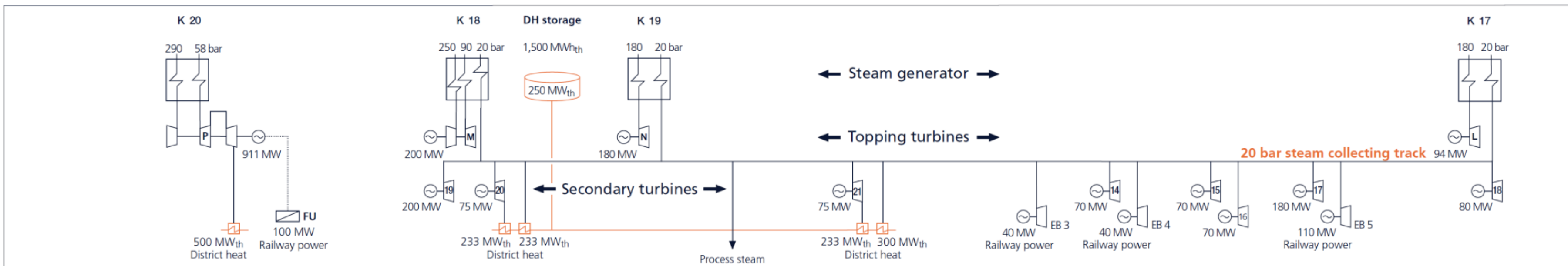


2015	1983	1993	Commissioning	Closed 1993	Closed 2015	Closed 2000	1975/2005
911 MW	475 MW	480 MW	Gross unit capacity				280 MW



Flow sheet of GKM unit 6

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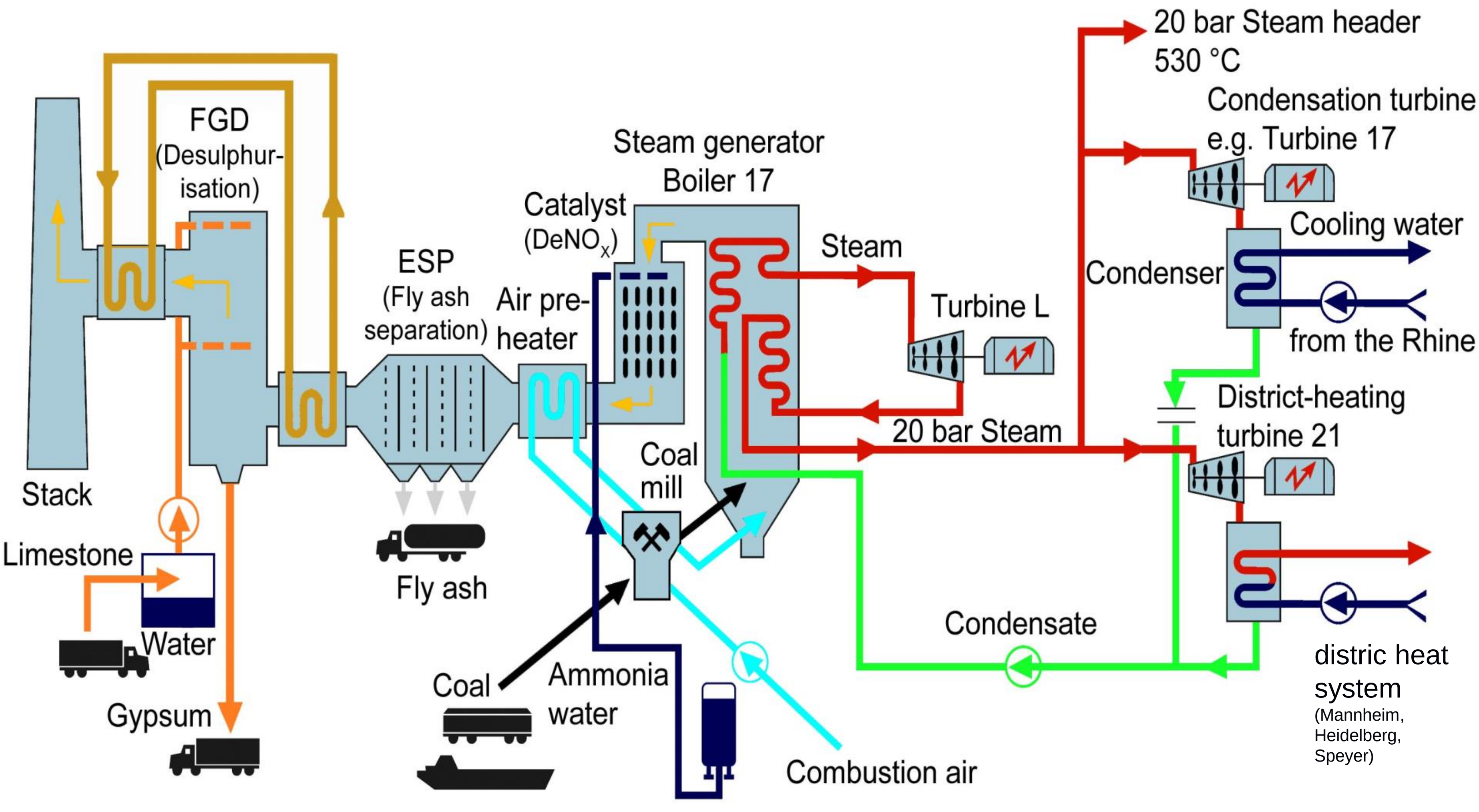

New unit 9

Unit 9 / bituminous coal / state of the art technology

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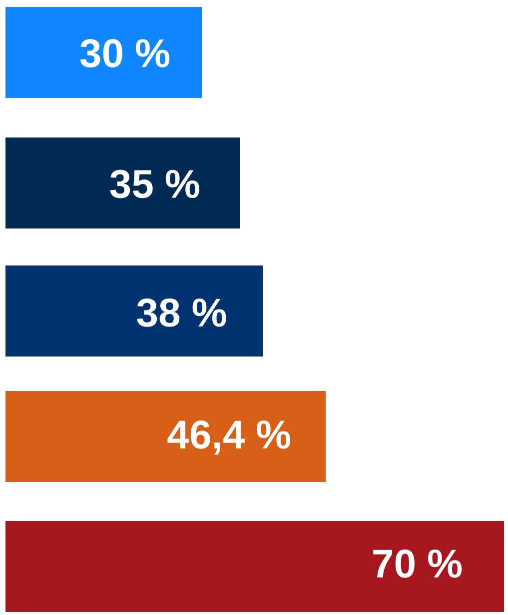
net efficiency of coal-fired power stations



worldwide

Europe

Germany

GKM unit 9 (ultra super critical)

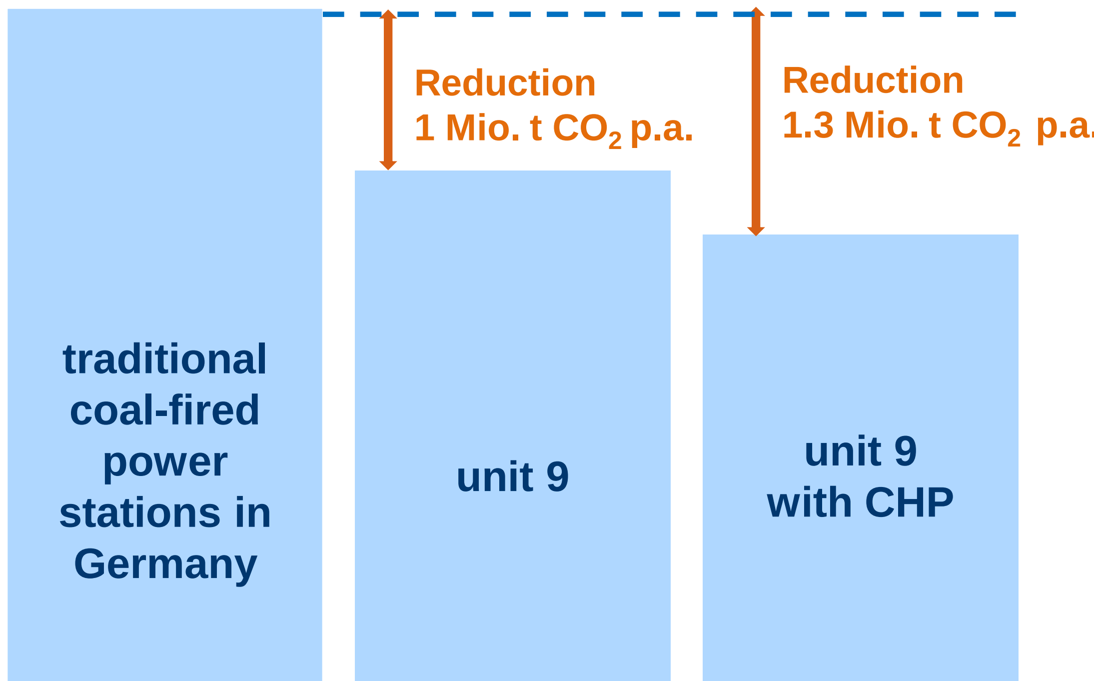
Fuel utilization efficiency unit 9 with CHP

Unit 9 – contribution to CO_2-reduction

CO_2-emissions of old and new bituminous coal-fired power stations

new unit 9

essential contribution to reduce CO_2-emissions in Germany



Facts and figures

Commissioning / start of commercial operation	1^{st} May 2015
Investment volume	1.2 bil. €
Gross output	911 MW_{el}
Electrical net efficiency	46.4 %
District heat generation with CHP	500 MW_{th}
Fuel utilization for CHP	70 %
Railway electricity (16.7 Hz) (per transverter)	100 MW

Boiler of unit 9 / SCR DeNOx / air preheater

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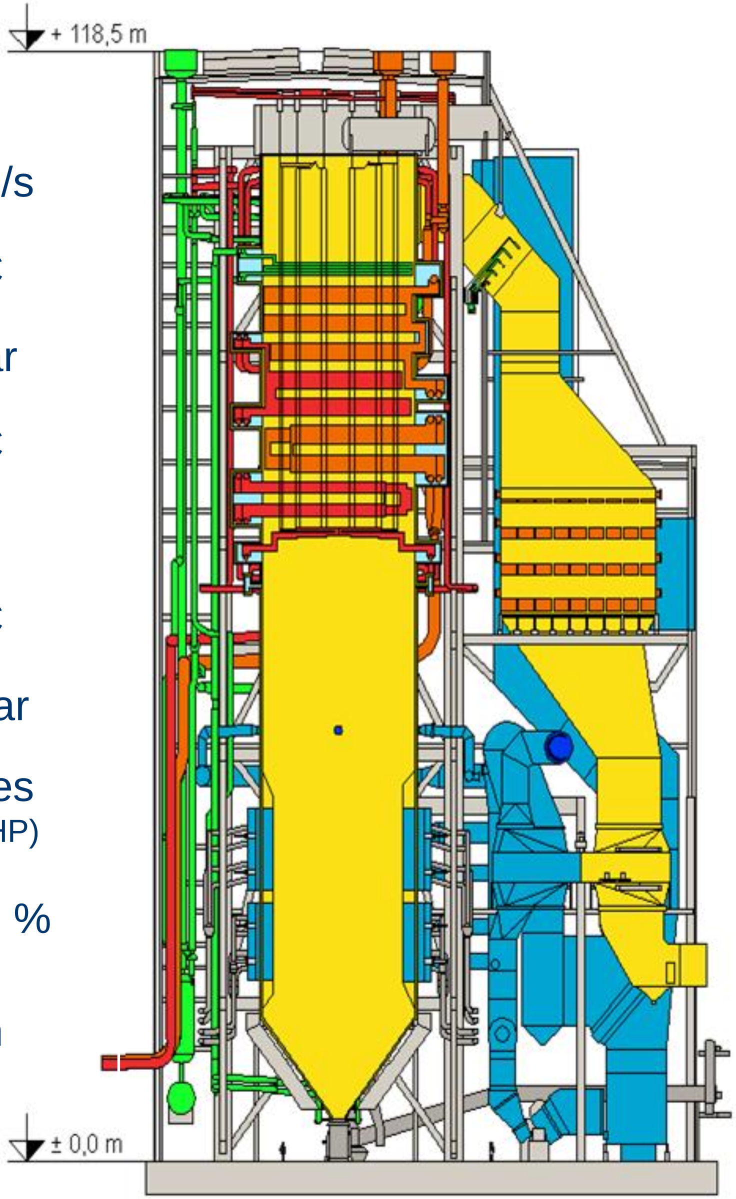
Design data

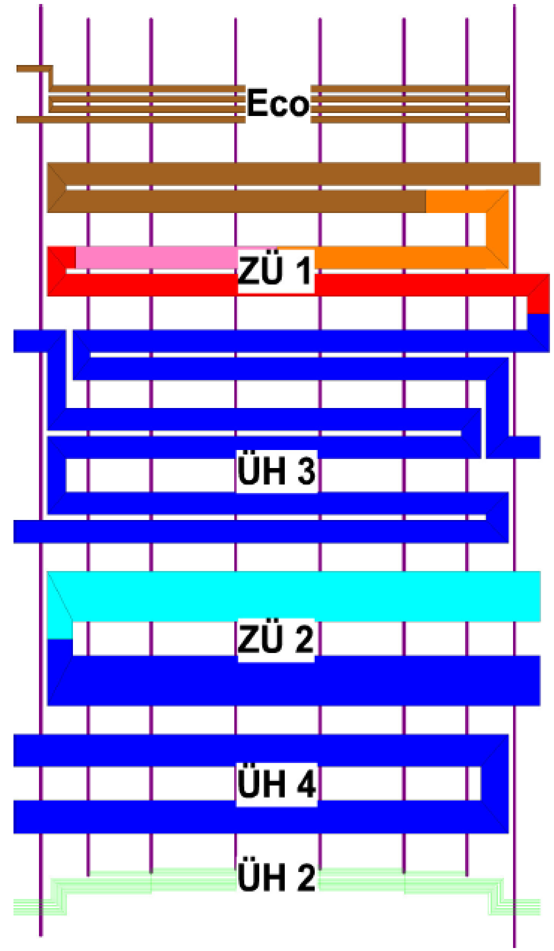
Life steam flow	663 kg/s
Life steam temperature	600 °C
Life steam pressure	290 bar
Reheat steam temperature	610 °C
Reheat steam pressure	58 bar
Feedwater temperature	309 °C
Condenser pressure	31 mbar
Preheater	9 stages (6 LP 3 HP)
Bowl mills	4 x 25 %
Coal amount	240 t/h



Boiler unit 9 / material concept / heating surfaces

Heating surfaces

- 16 Mo 3
- 13 CrMo 4-5
- 7 CrMoVTiB 10-10
- 10 CrMo 9-10
- X 10 CrMoVNb 9-1
- VM12-SHC
- Super 304 H
  Shot blasted
- HR3C



Unit 9 – flow sheet

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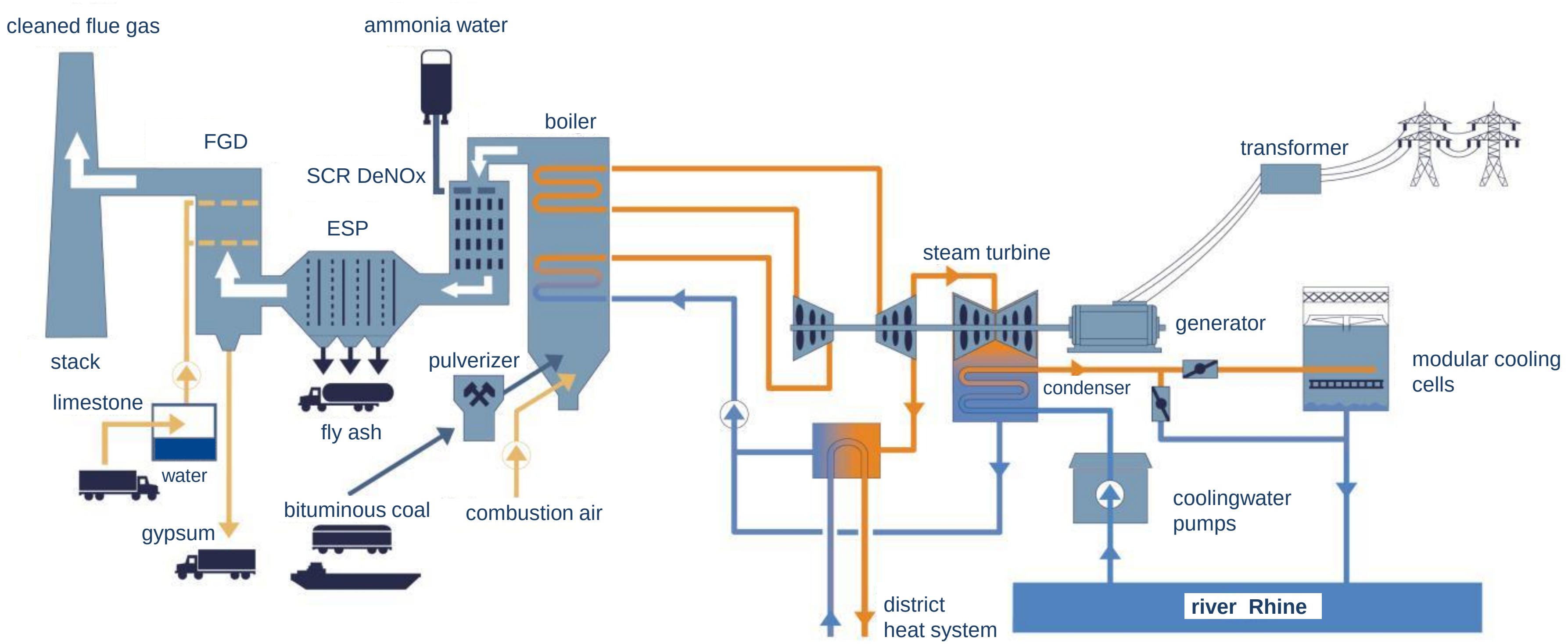
combined heat and power unit 9 (CHP)



Unit 9

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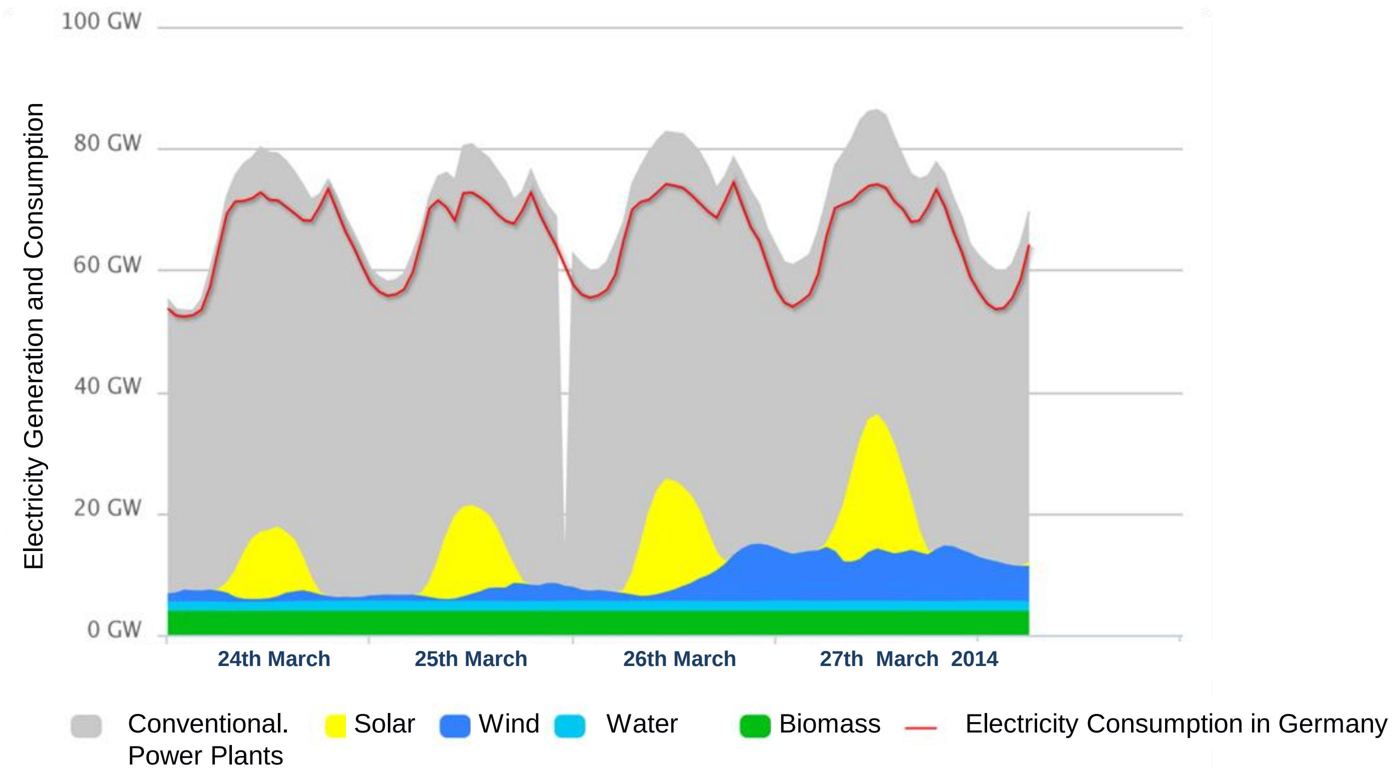
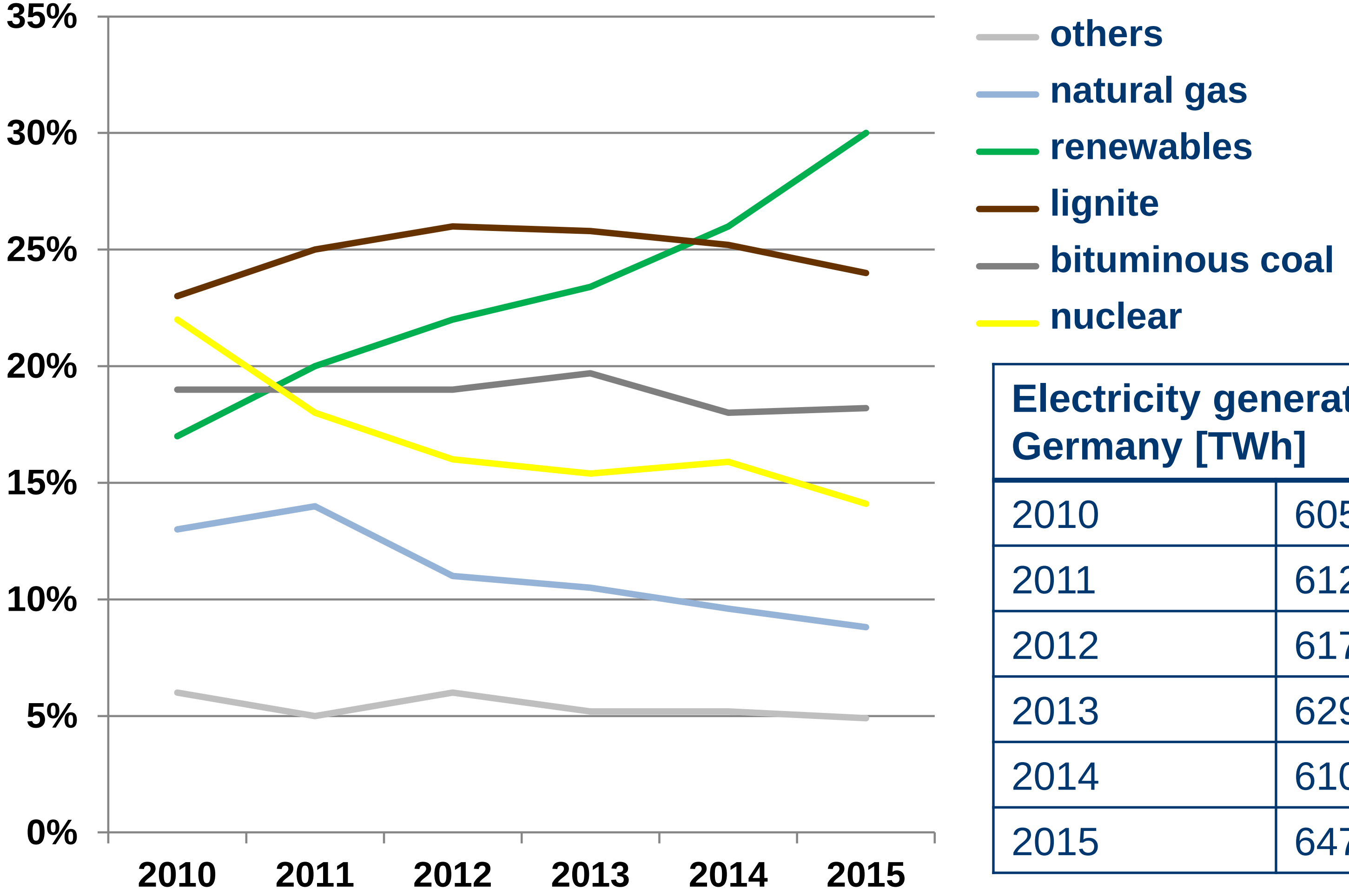
Electricity generation / actual situation in Germany (example)



- **fluctuating generation of renewable energies (RES)** here wind and solar (PV)
- remarkable **export of electricity from Germany to neighbour-countries** during high generation of wind- and solar-power („surplus/excess energy“)

Eletricity generation in Germany since 2010



Electricity generation in Germany [TWh]	
2010	605
2011	612
2012	617
2013	629
2014	610
2015	647

source: Amprion GmbH

RES*: installed capacity und generation in Germany since 2011 (here: wind and solar power)

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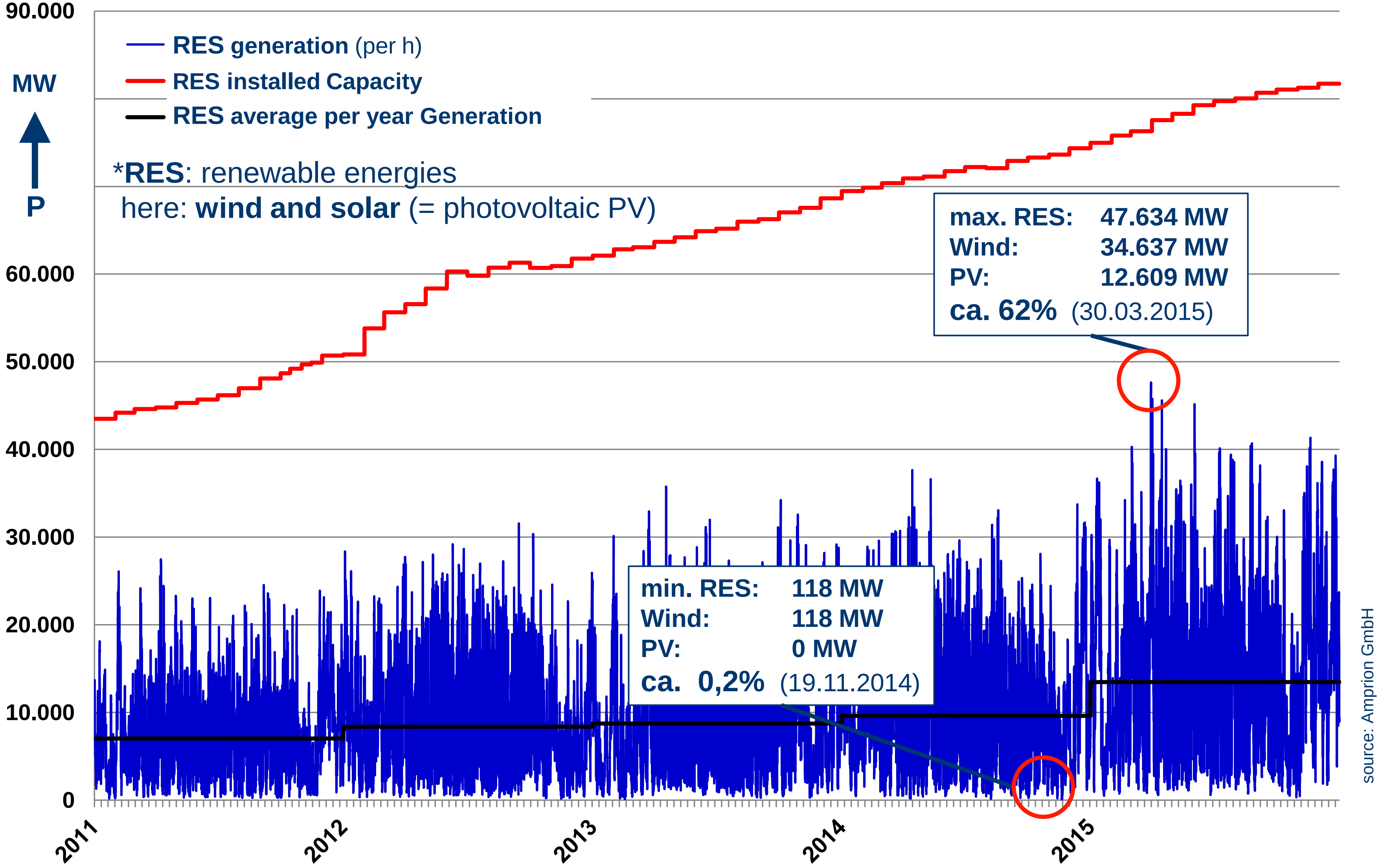

Development of EEX-prices vs. RES generation in Germany since 2011

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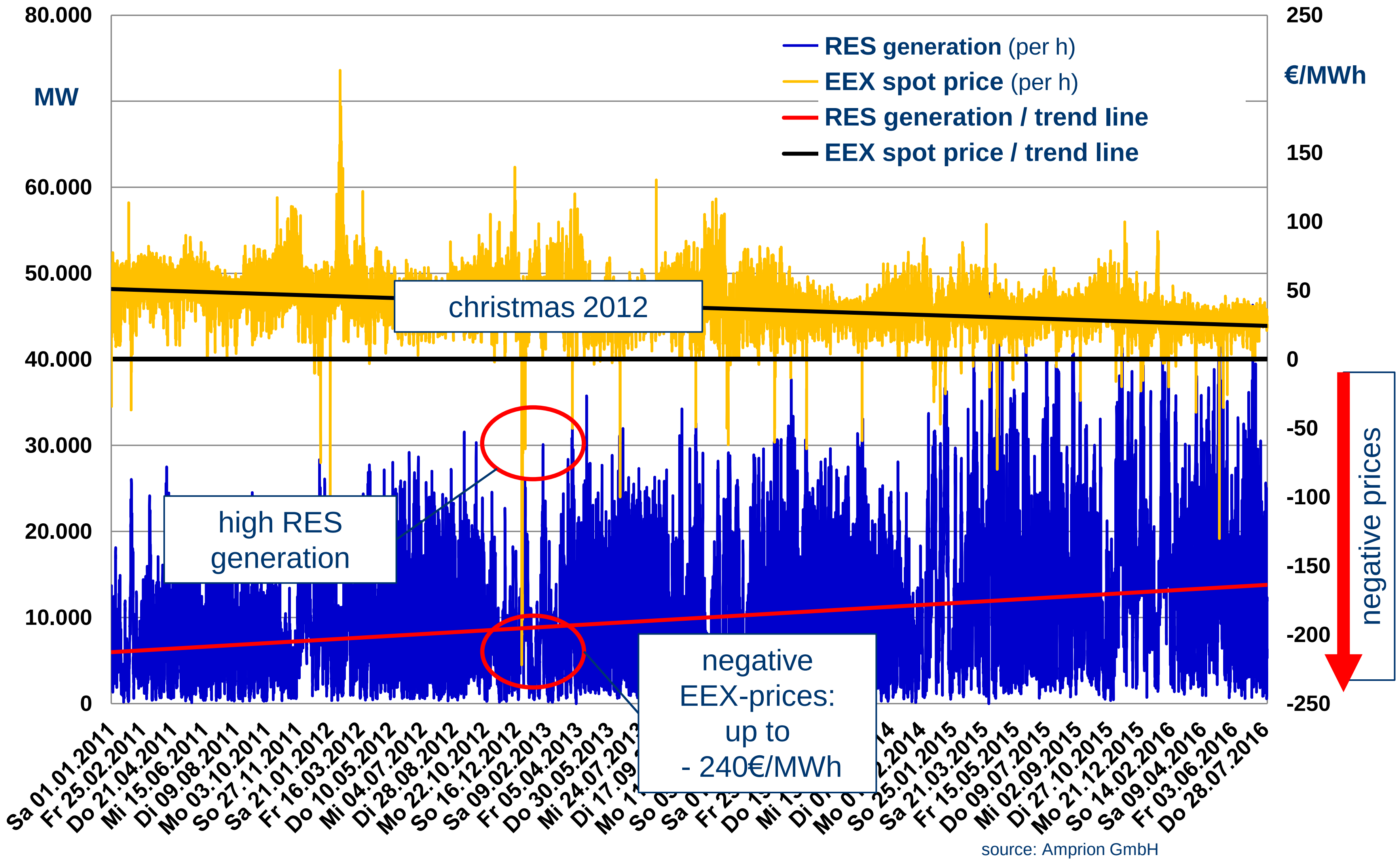

source: Amprion GmbH

EEX-price 2015 for electricity (hourly) in Germany
(wholesale / spot market)

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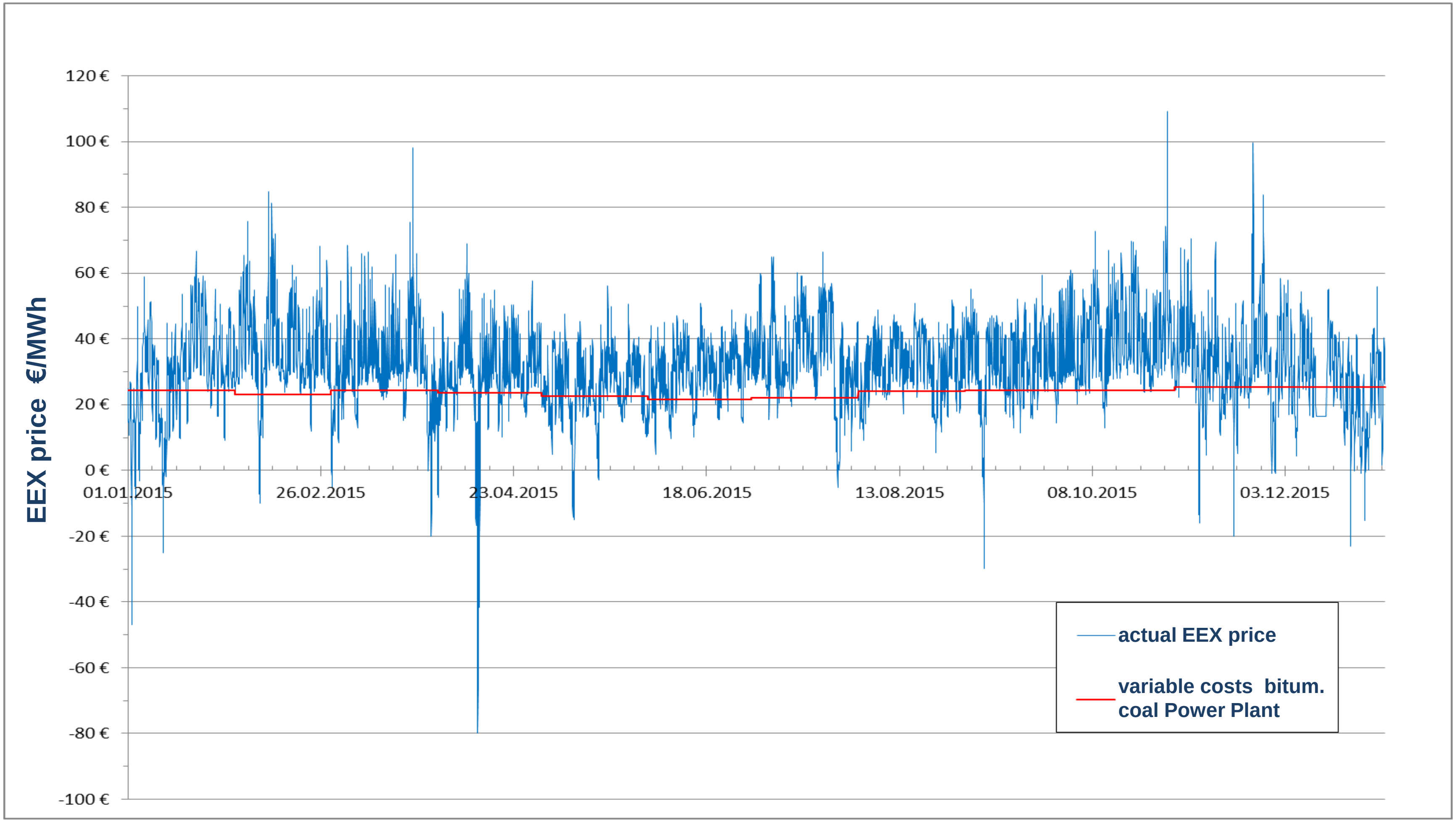

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GKM plant / daily operation in 2007 vs. today

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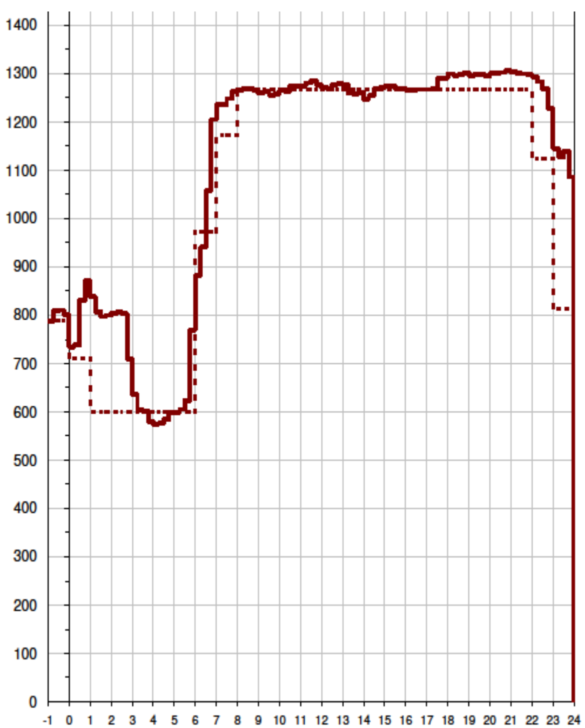
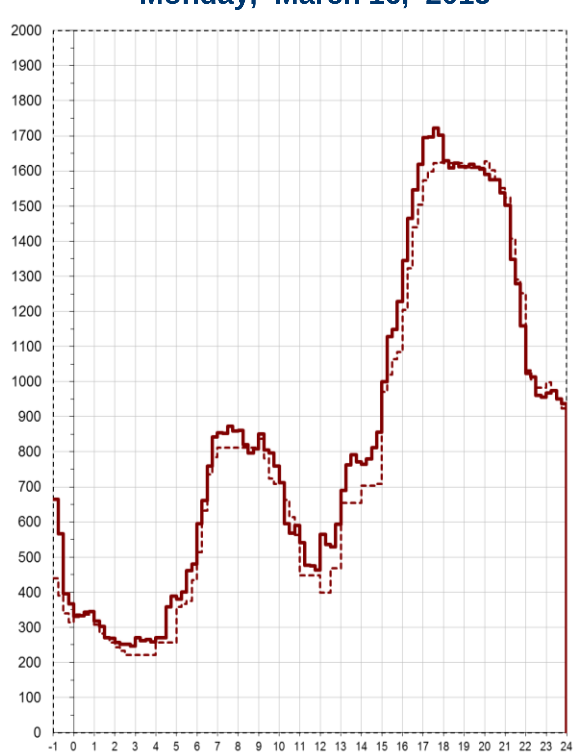
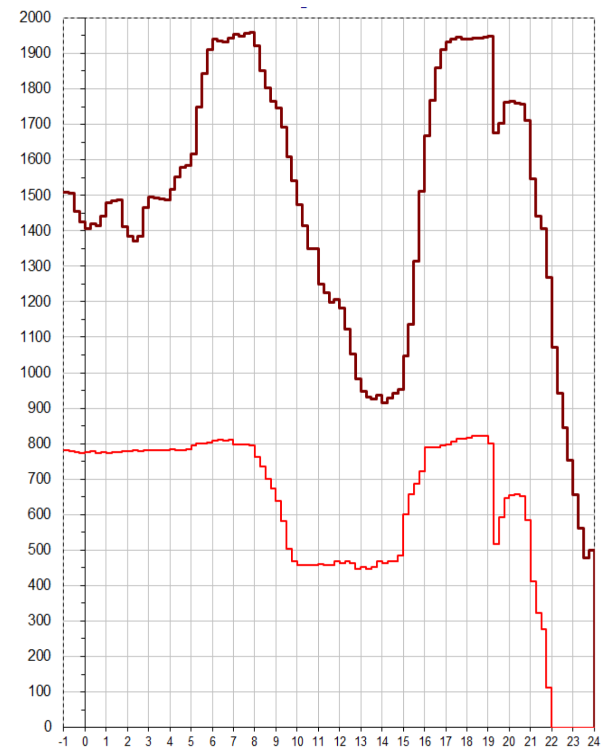
GKM Operation in 2007 and today (planned and real output)

Wednesday, March 21, 2007



Monday, March 16, 2015

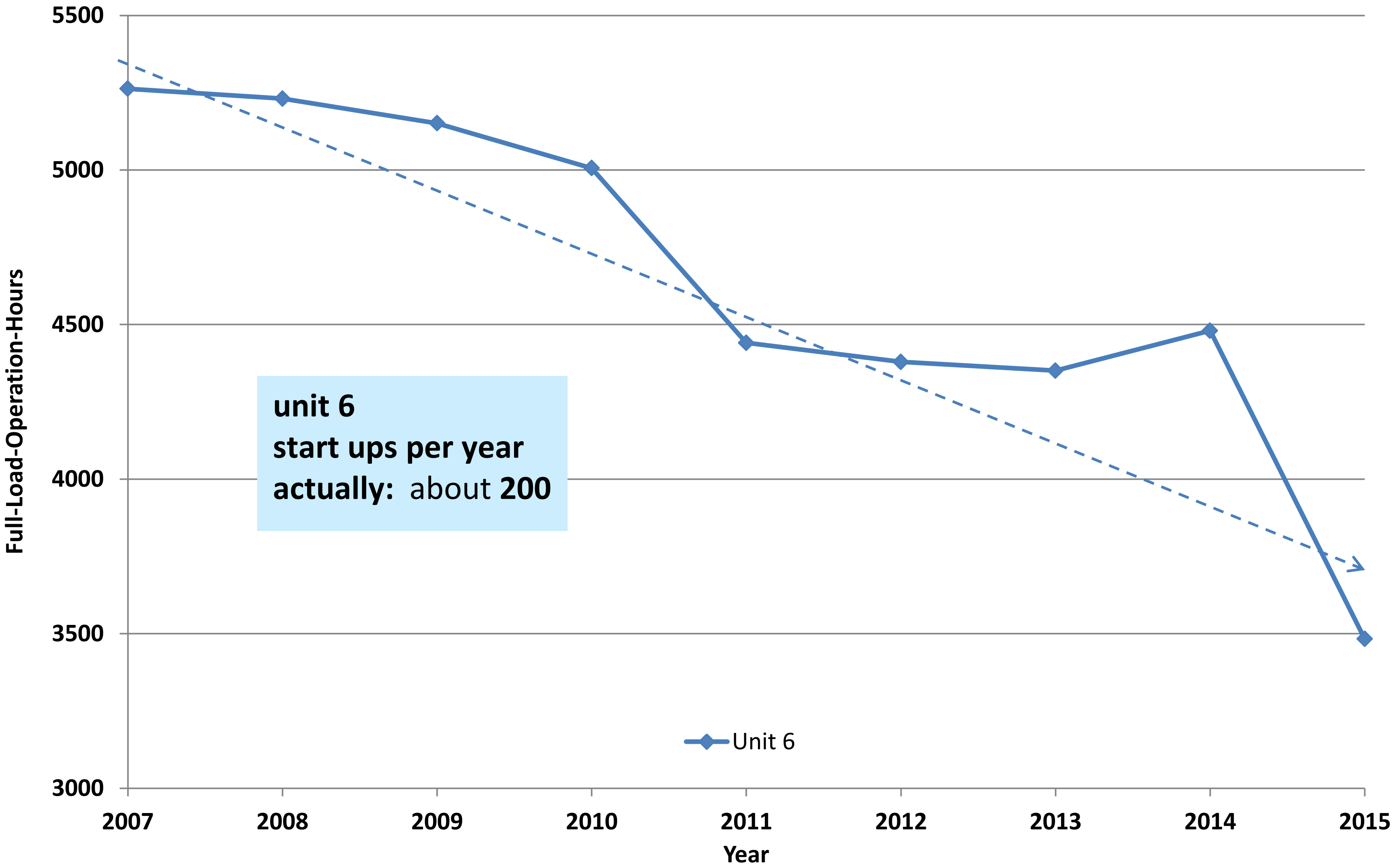




—— real output ---- planned output („day ahead") —— generation of unit 9

today's requirements in electricity market mean high demands on equipment and personell in GKM: high flexibility in load changes and timing

Full-Load-Operation-Hours of unit 6 (decreasing operation time because of increasing generation of RES in Germany)



unit 8 / load diagram (typical example)

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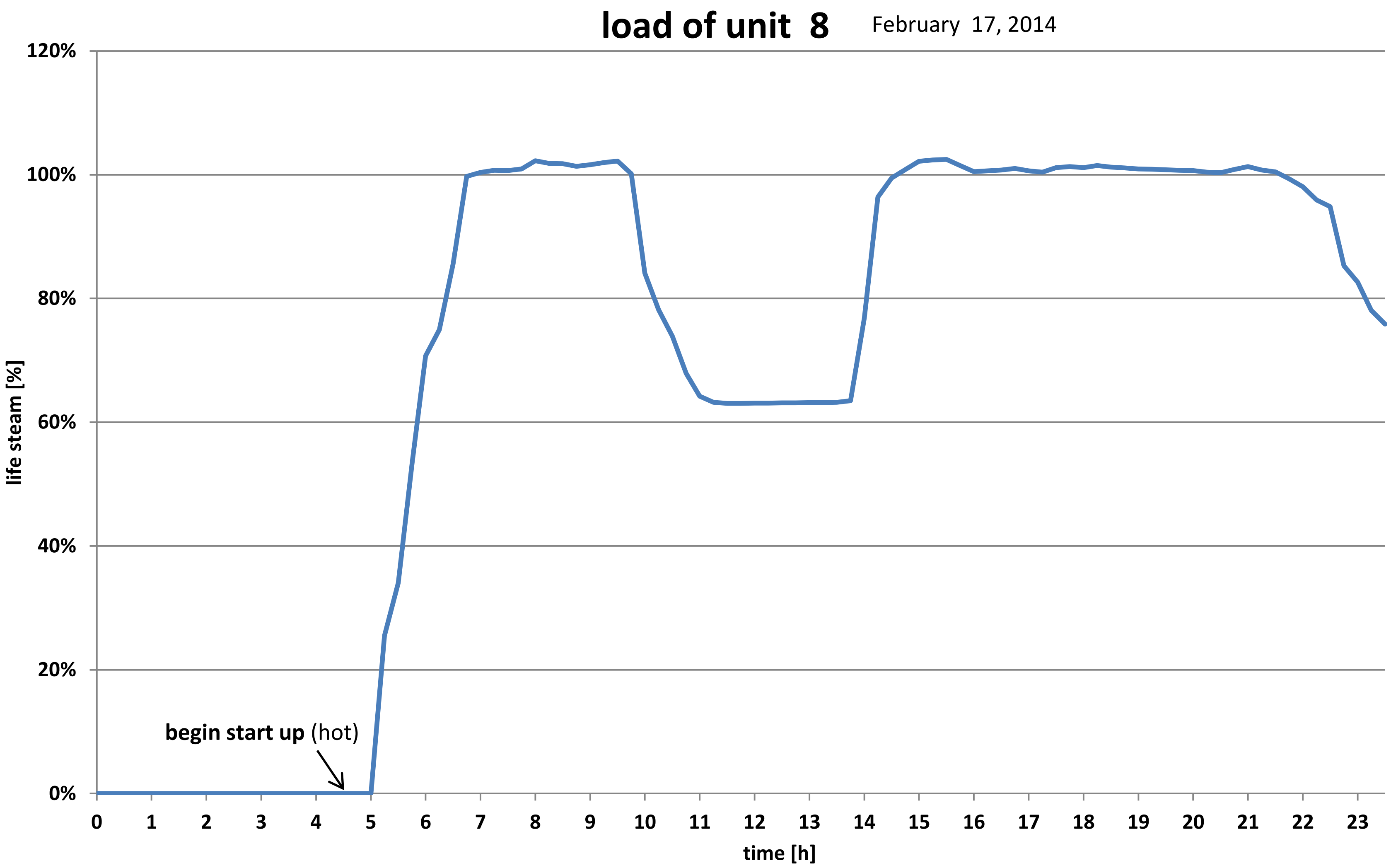

typical start up diagrams of unit 8

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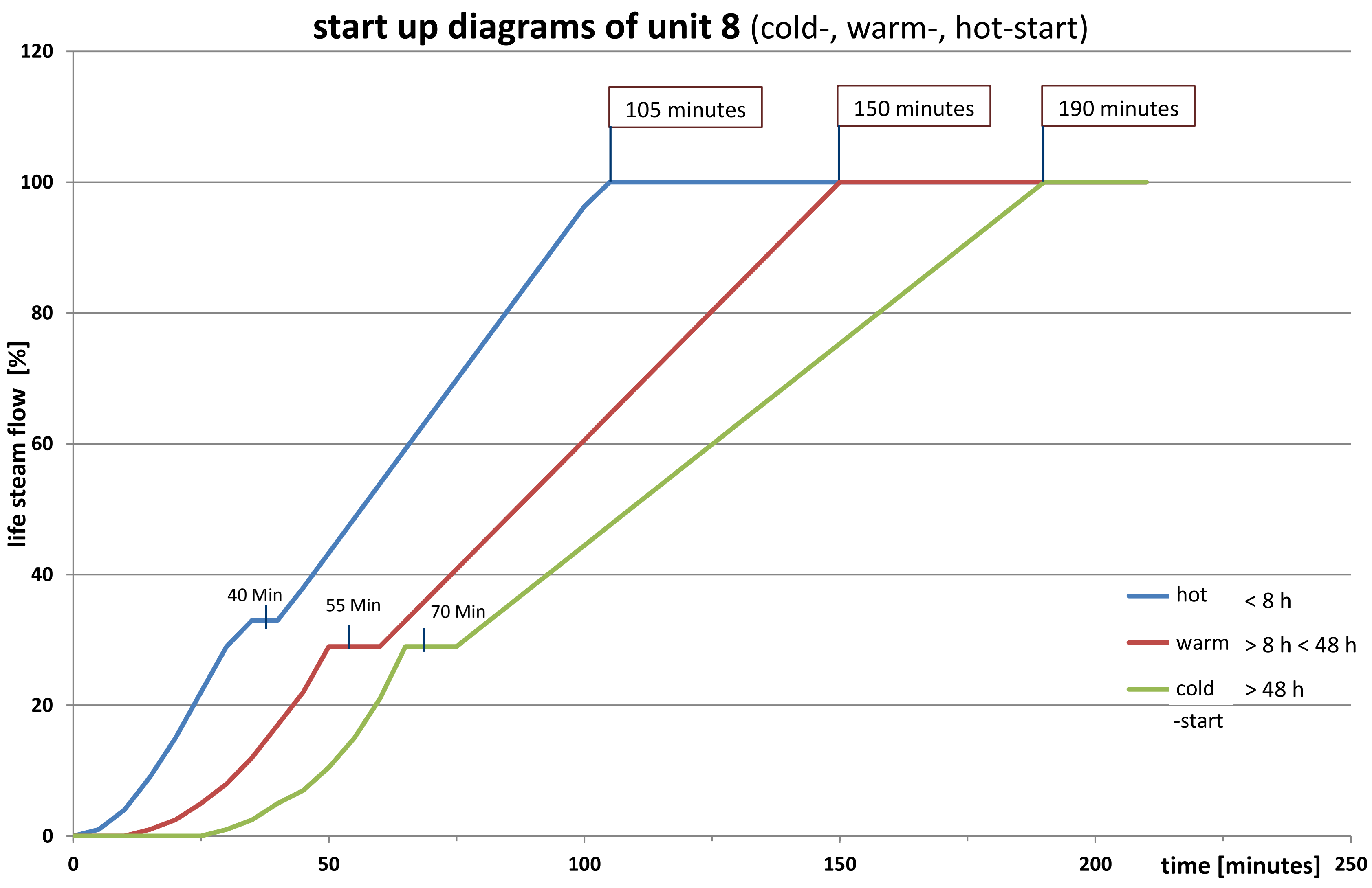
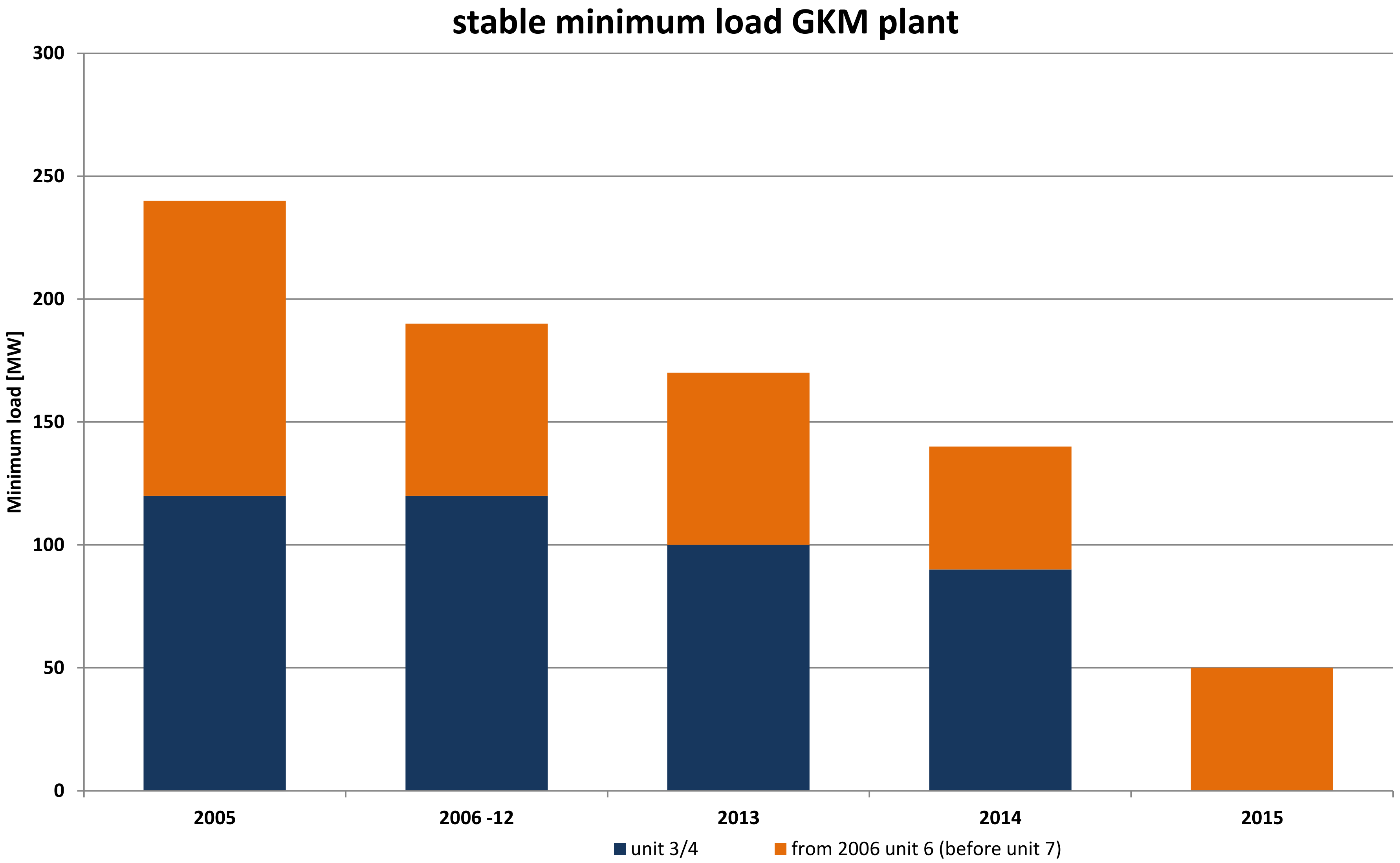
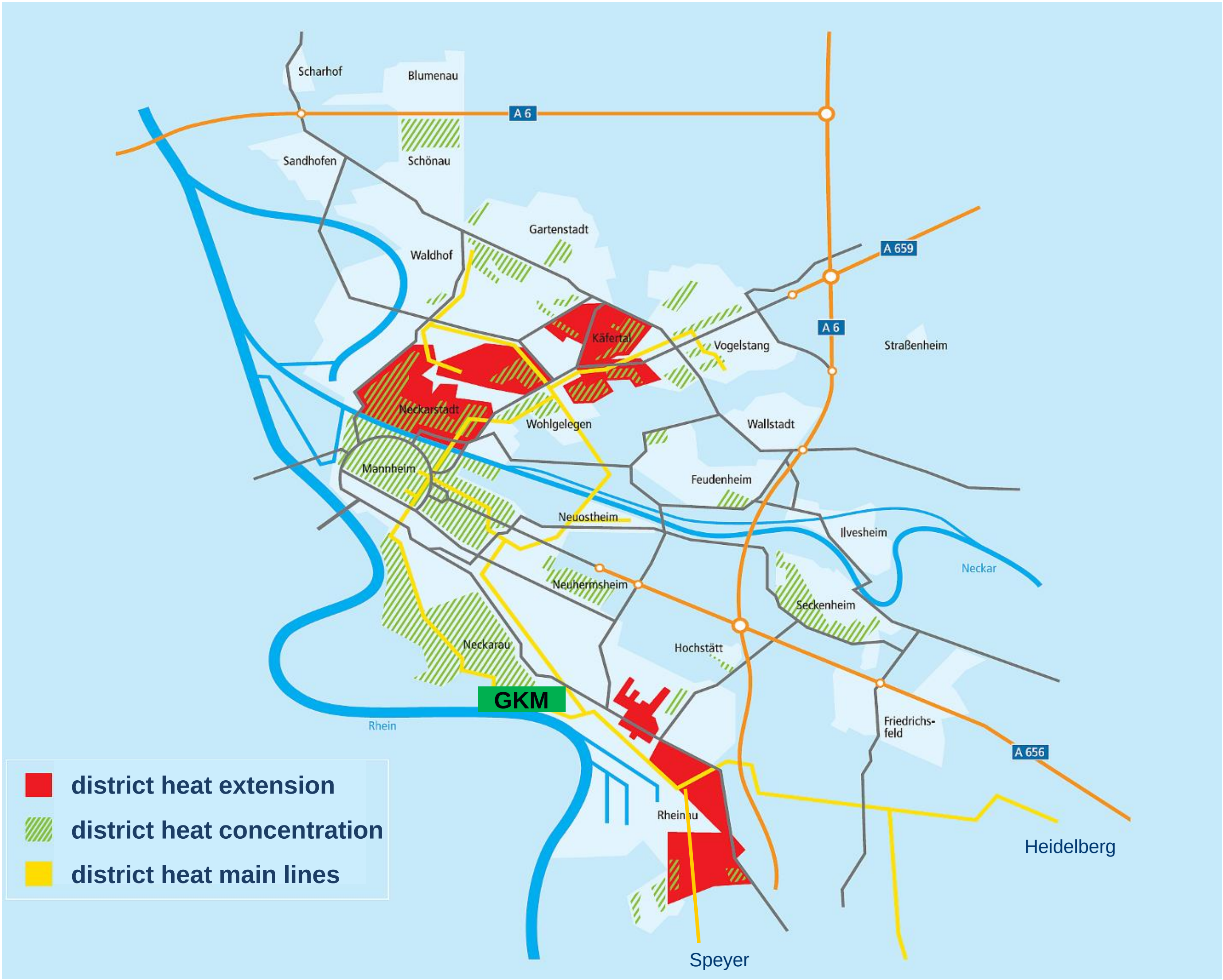


GKM / reduction of minimum load 2005 vs. today

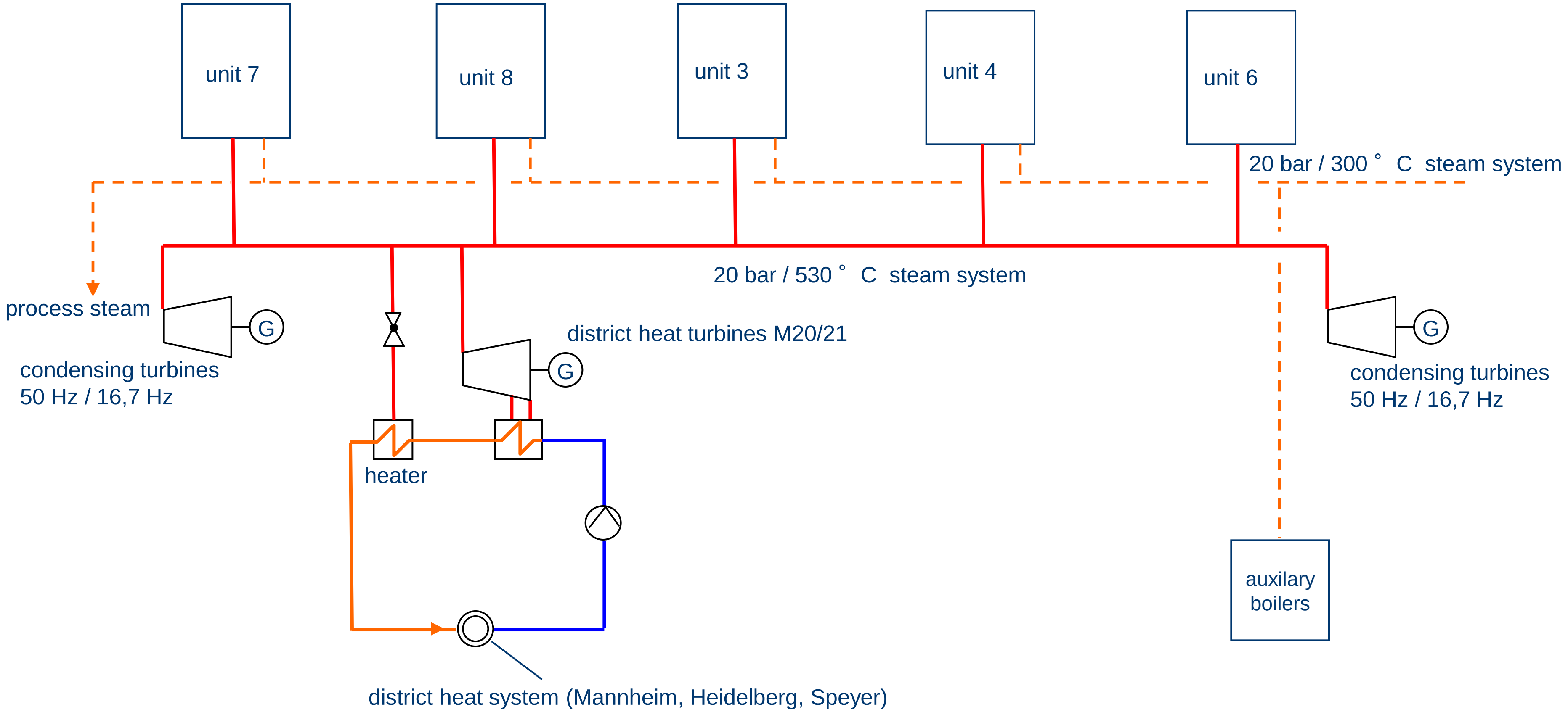


Mannheim district heat system / GKM CHP Plant



GKM Plant / district heat system until 2013

GKM „2-units-operation“ necessary at minimum load because of need for secure supply of district heat system (until end of 2013)



task / functions of new GKM heat storage system

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Load demands on CHP Plant GKM

- 50 Hz Electricity Generation for RWE, EnBW, MVV
- 16,7 Hz Electricity Generation for DB Energie
- Distric Heat Generation and **secure supply** of Mannheim, Heidelberg and Speyer

Situation at German Eletricity Market

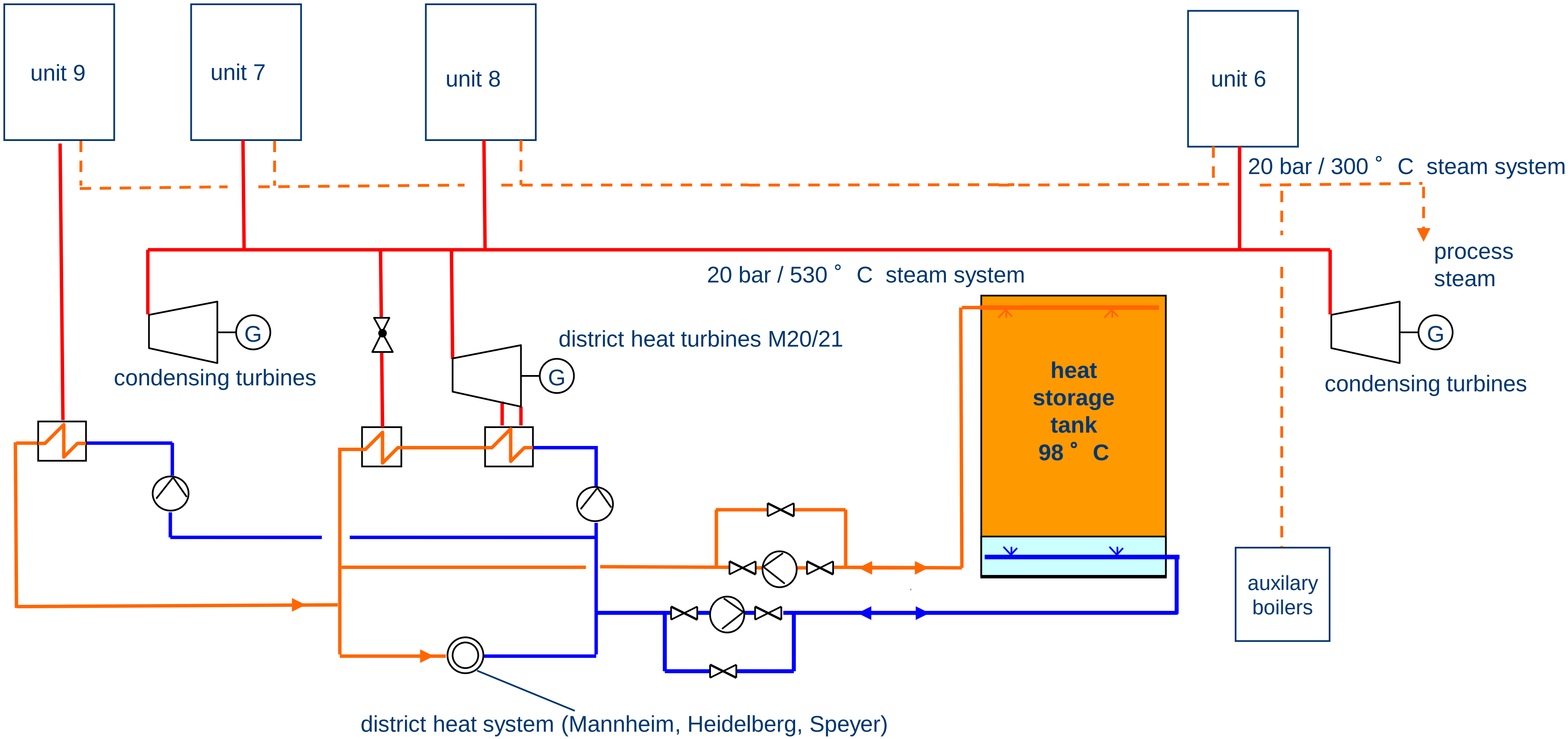
- GKM Plant Load corresponding to EEX Prices (Spot-Market „day-ahead and intraday“): volatile and often not fitting to district heat energy consumption

Functions of new heat storage system in GKM

- in times of low EEX Prices the GKM Electricity Generation must be as low as possible (minimum technical load)
- **the new heat storage tank enables GKM to operate only 1 unit during minimum load (instead of 2 units before)**
- during minimum load the heat content in the tank is sufficient to supply the district heat nets at least for 2 hours
- additionally the heat storage tank is used to optimize the plant operation depending on EEX Prices (e.g. **charging at night, discharging by day**)

GKM Plant / district heat system since 2015

GKM „1-unit-operation“ possible at minimum load / if district heat load < 250 MW (since heat storage system finished: end of 2013)



new heat storage system enables GKM CHP plant to reduce the minimum load significantly

technical data GKM heat storage system

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Heat storage tank ("system Dr. Hedbäck")

diameter tank	m	40
cylindric height tank	m	36
storage capacity	m³	43.000
max. flow to / from tank	t/h	6.200
max. storage water temperature	°C	98
effective heat storage capacity	MWh	1500
max. load (water flow)	MW	250

Hedbäck storage system can also be used for **cold water storage**

GKM heat storage tank completed (September 2013)

operation of heat storage tank (7 days, example)

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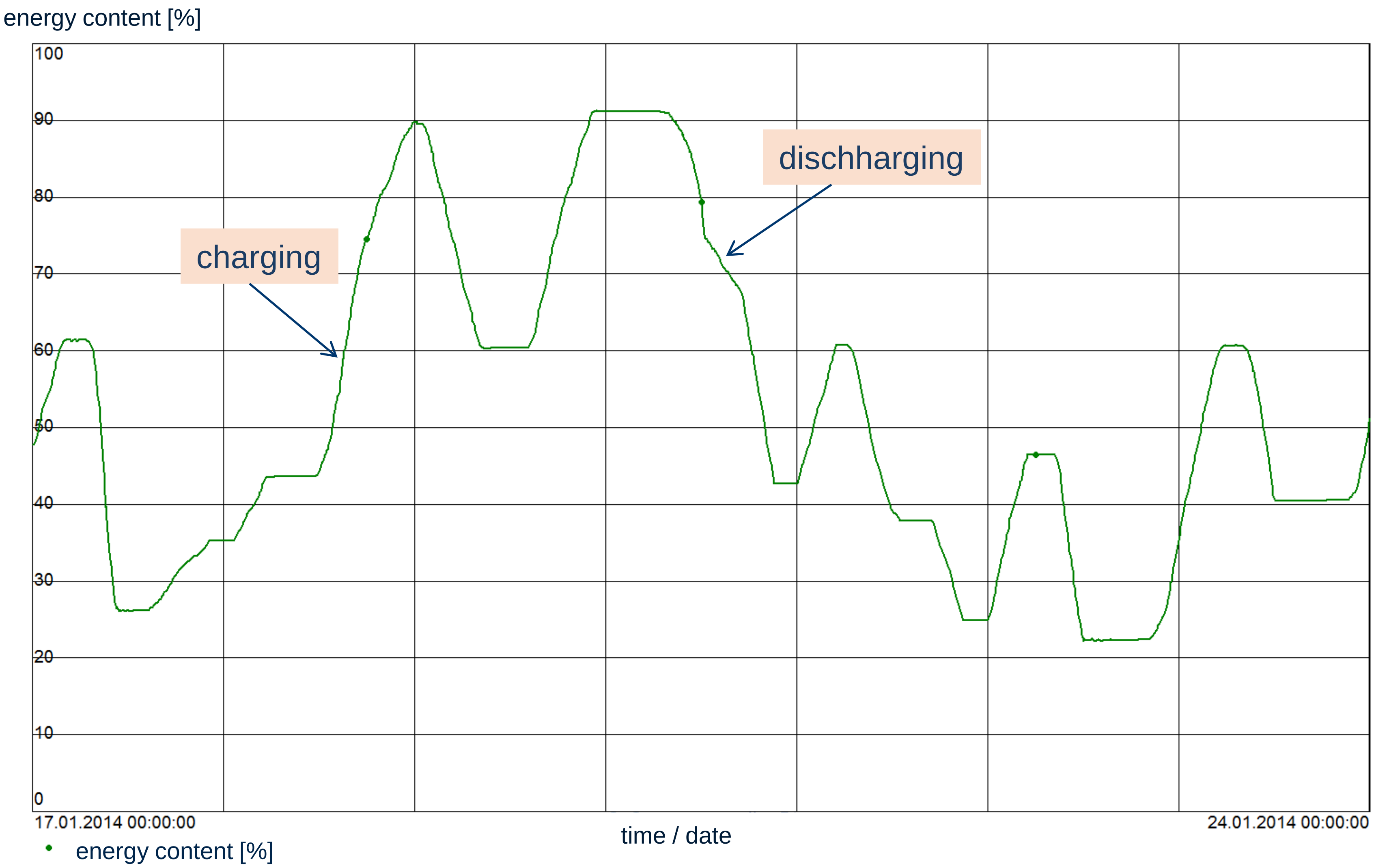

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Conventional Power Plants / GKM situation

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Actual situation of conventional Power Plants in Germany / „Energiewende“

- increasing and high capacities of „renewables“ **RES** (esp. solar (PV) and wind) for electricity generation with **fixed and governmental garanteed compensation**
- since more than 4 years **decreasing and volatile EEX Prices**

Situation at GKM

- GKM Plant **load is corresponding to EEX Prices** (Spot-Market „day-ahead and intraday“), production volume and operation hours of units are decreasing
- need for permanent Distric Heat Generation and **secure supply**
- power plants **„struggle with economics“**
- new heat storage system enables GKM to operate **only 1 unit** during minimum load (instead of **2 units before**)
- significant **reduction of minimum load** of all GKM units and **„must run“ generation**
- increase of efficiency by **new unit 9** and **decommissioning of old units 3 and 4**
- permanent measures to **improve load flexibility**

Technical quality and reliability

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basic needs for Conventional Power Plants

- good and proven **design** in detail
- proper **equipment** / components
- adequate **erection** and installation
- realization of **high automatization with eletronic/digital control systems** for each unit and the whole plant
- **commissioning by qualified teams** including checks of all systems / functions
- **process optimization** under real operational conditions, esp.
  - training of start up (cold, warm, hot) and stops of the units
  - load changes in the complete range (min. to max. load, quick start and stop)
  - tests of all types of failures
  - defined conditions during time when „plant is not in operation“
- **highly qualified and motivated staff for operations, maintainance, optimization** and different supporting tasks (purchase, finances, contracts, insurance, risk-management, personnel, ….)

Operations and maintenance aspects

- realistic, professional **planning of power plant operation and maintenance** including outages/overhauls
- **qualified dispatching (load/generation planning) „day ahead“, „intraday“, redispatch measures,… till the „last moment“** (= time of production)
- **highest flexibility to fulfill the needed functions („market driven“)**

Criteria / Monitoring

- high **efficieny** / low enegry losses
- **low emissions** (i.e. good work in „Environmental-Health-Safety“ fields)
- secure, good **technical functions**, high reliability in operations
- **availibility to the right time** (looking after the „market situation“: esp. EEX prices and customer´s demands)
- **economic aspects** (remaining competitive)

GKM unit 9

Thank you for your attention.

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