Strategic Perspectives

of

Clean Coal Technology

referring to

Efficiency, Cost and Regulatory Issues

Franz Bauer, VGB PowerTech e.V.

Introduction & Background

Future Requirements – Policy & Demand

Technology Perspectives

Economic Constraints

Conclusion

→*Political Targets in the EU 27*

Energy

- **20 % Efficiency Increase**
- **20 % Renewables in Energy Sector**
- **to be achieved in 2020**

and

- **de-carbonised in 2050**

Economy

? most powerful ⟺ de-industrylised ?

Environment for Clean Technologies for Coal

- Regulatory Issues
- Characteristics *coming* Demand Pattern
- Development Potential
- Environmental Impact
- Economic Constraints

➡ **Criteria for Setting Priorities**

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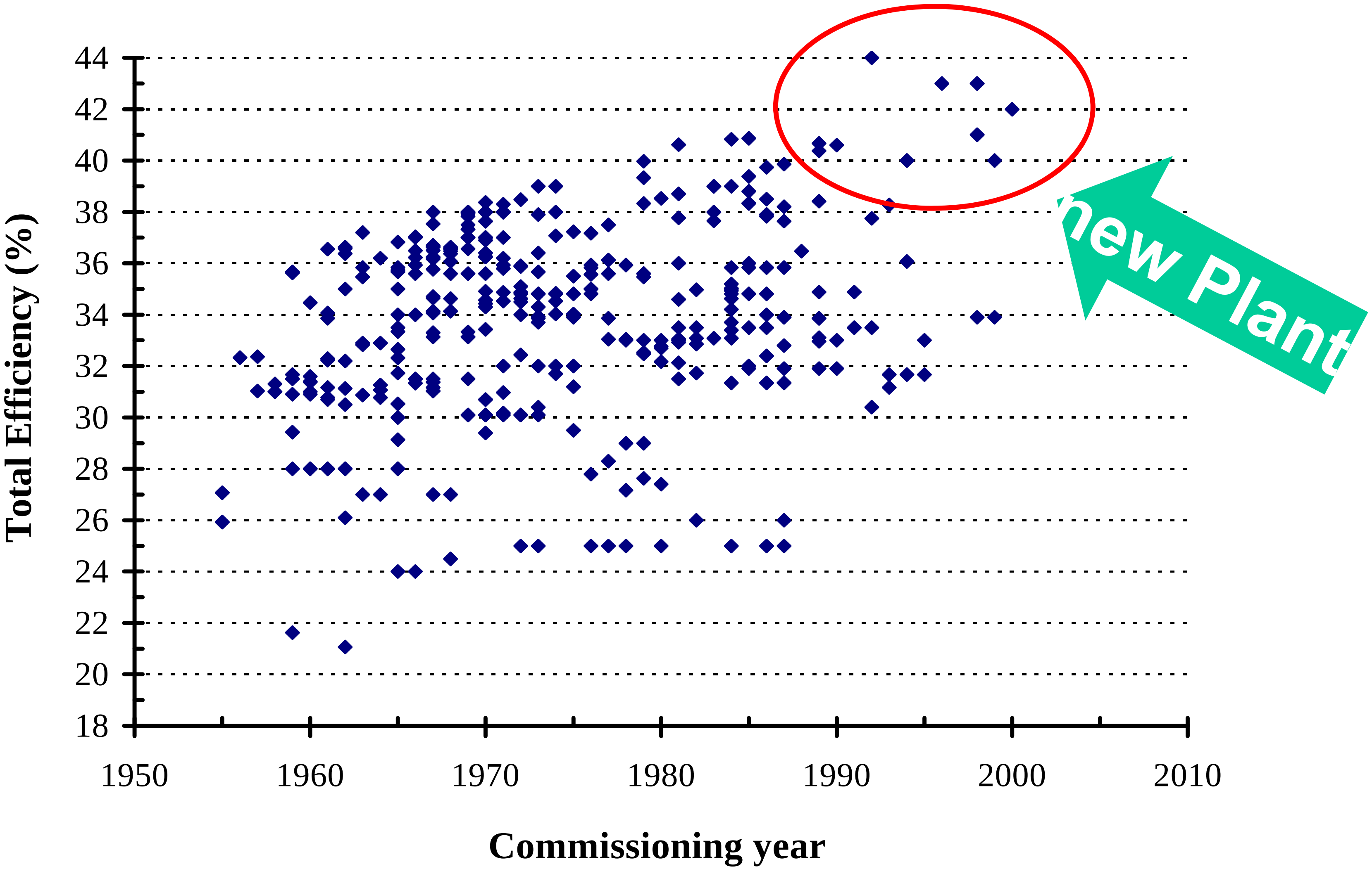
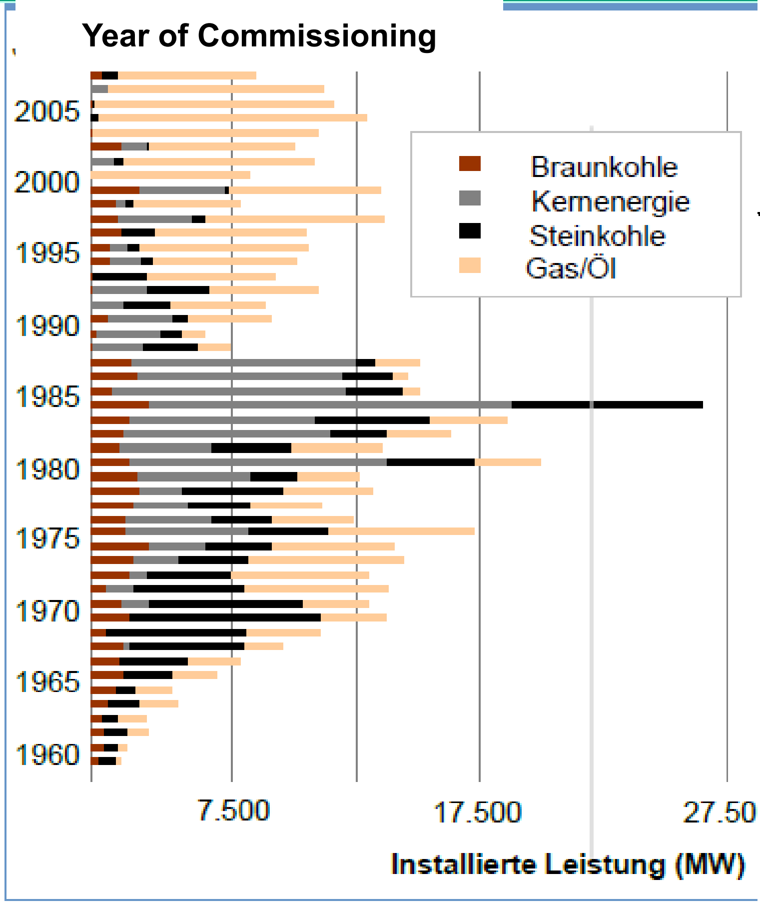
EU Situation →Fossil Power Plant Efficiency



the conventional Power Plant Fleet in the EU 27 *is aged*

→ Need for the build-up of new Power Plants

EU 27 Structure Power Plants in terms of Age



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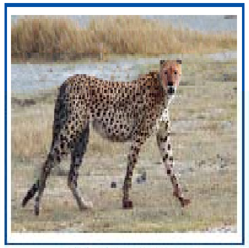
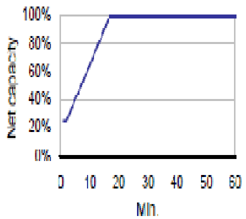
Flexibility of new Power Plants - Comparison

...are we able to cope with the challenge?

Sprinting



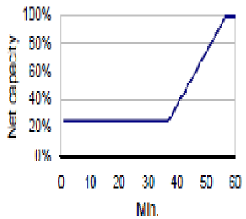
Ramp capacity CCGT Lingen



Gas capacities offer quick start-up capabilities. Partial load is expensive. Gas remains ideal to cover peaks, even in volatile markets.

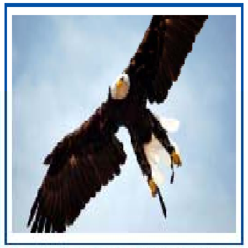
Lurking

Ramp capacity Hard-Coal plant Hamm

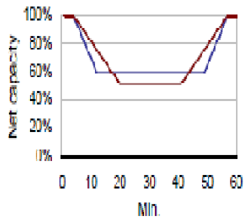


New coal capacities can be dispatched with 25% of rated output. The plants can profitably wait for high prices over a period of temporarily low demand.

Gliding, diving and rising



Ramp capacity Nuclear, e.g. Biblis, or New Lignite, e.g. Neurath



Although designed for the base-load regime, nuclear plants and new lignite plants can be dispatched flexibly, and they can be operated to provide partial load.

RWE The energy to lead

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Generation and Grid Interaction

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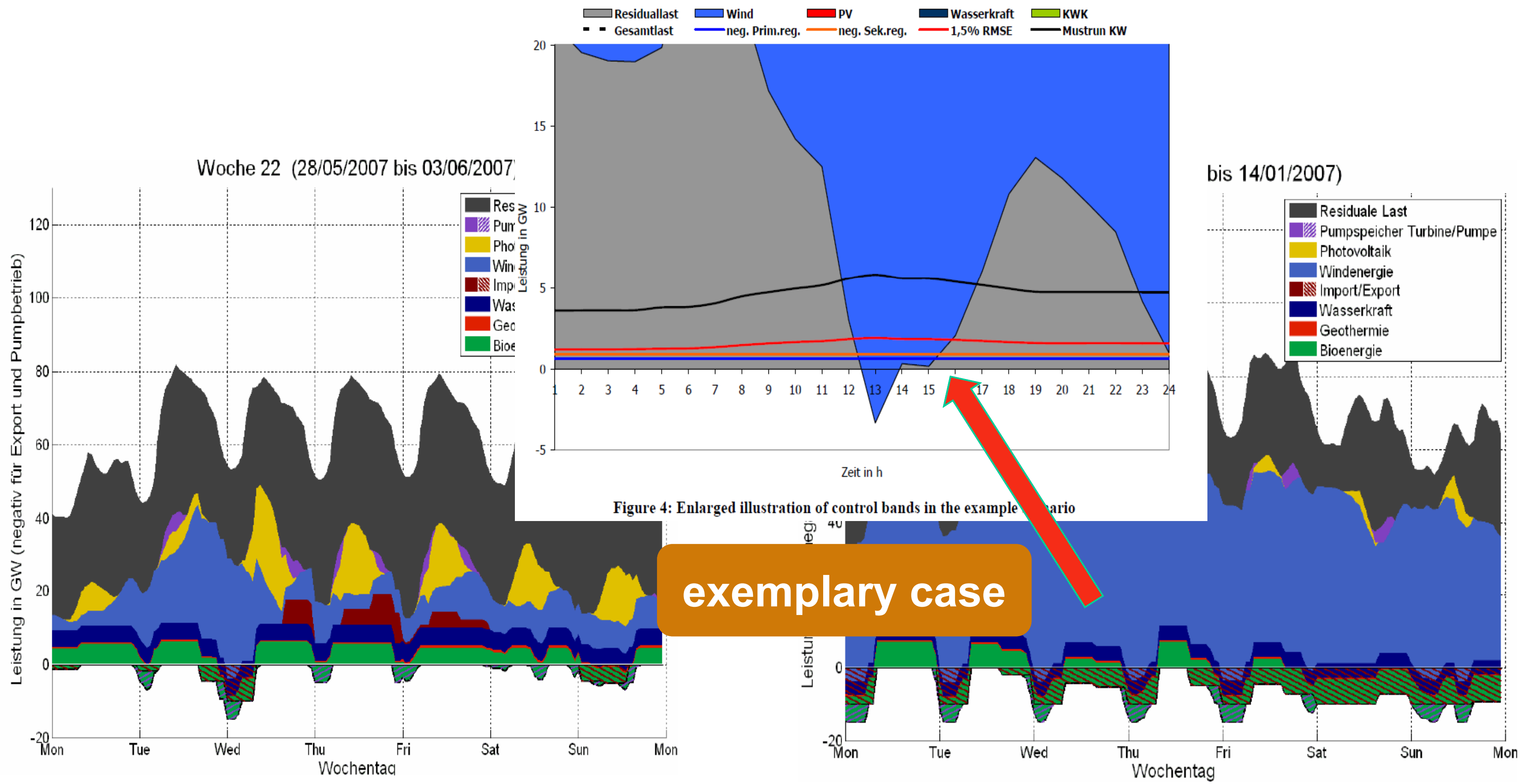
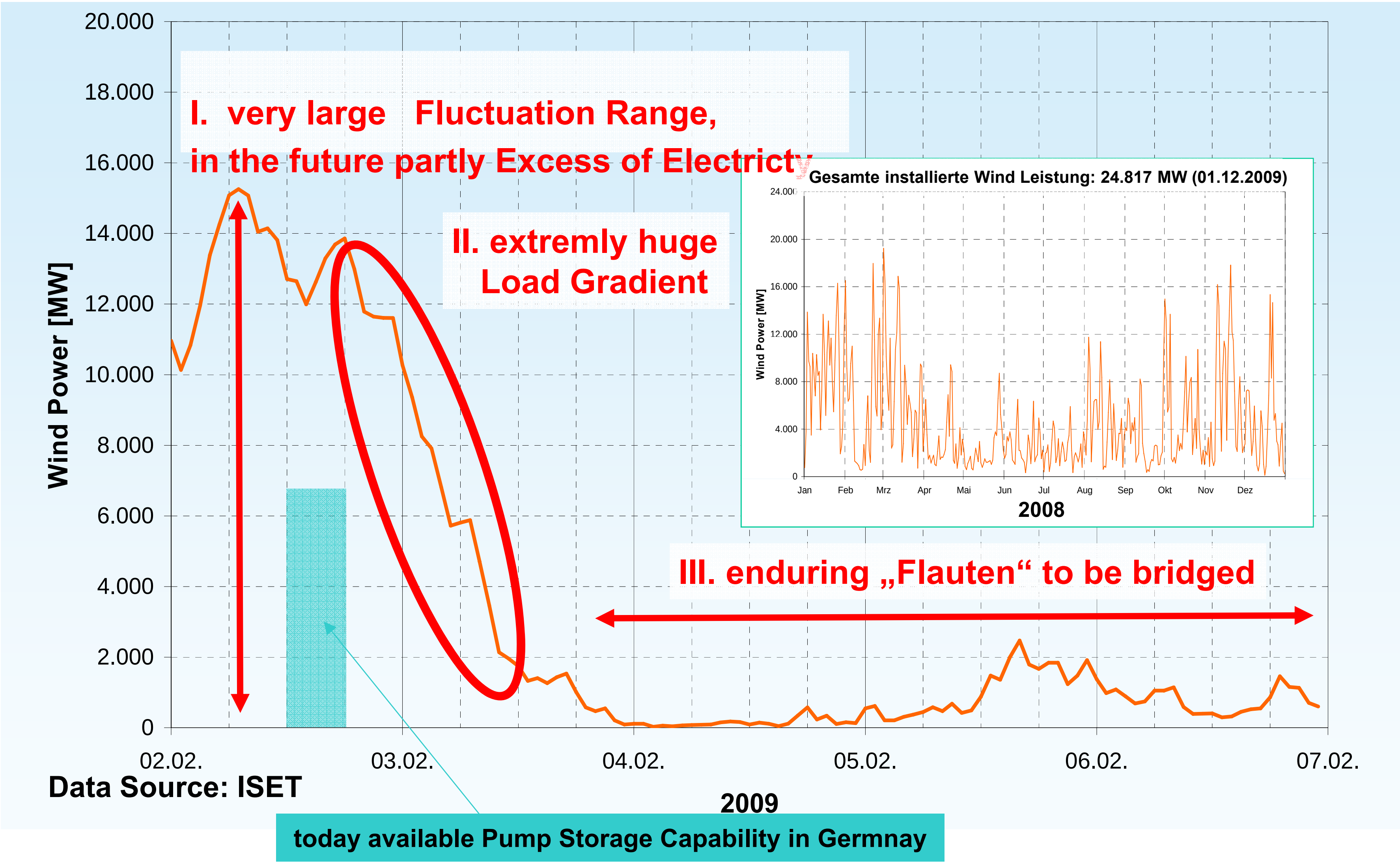
Examples for different intermitting Generation Input to the System for different wind conditions



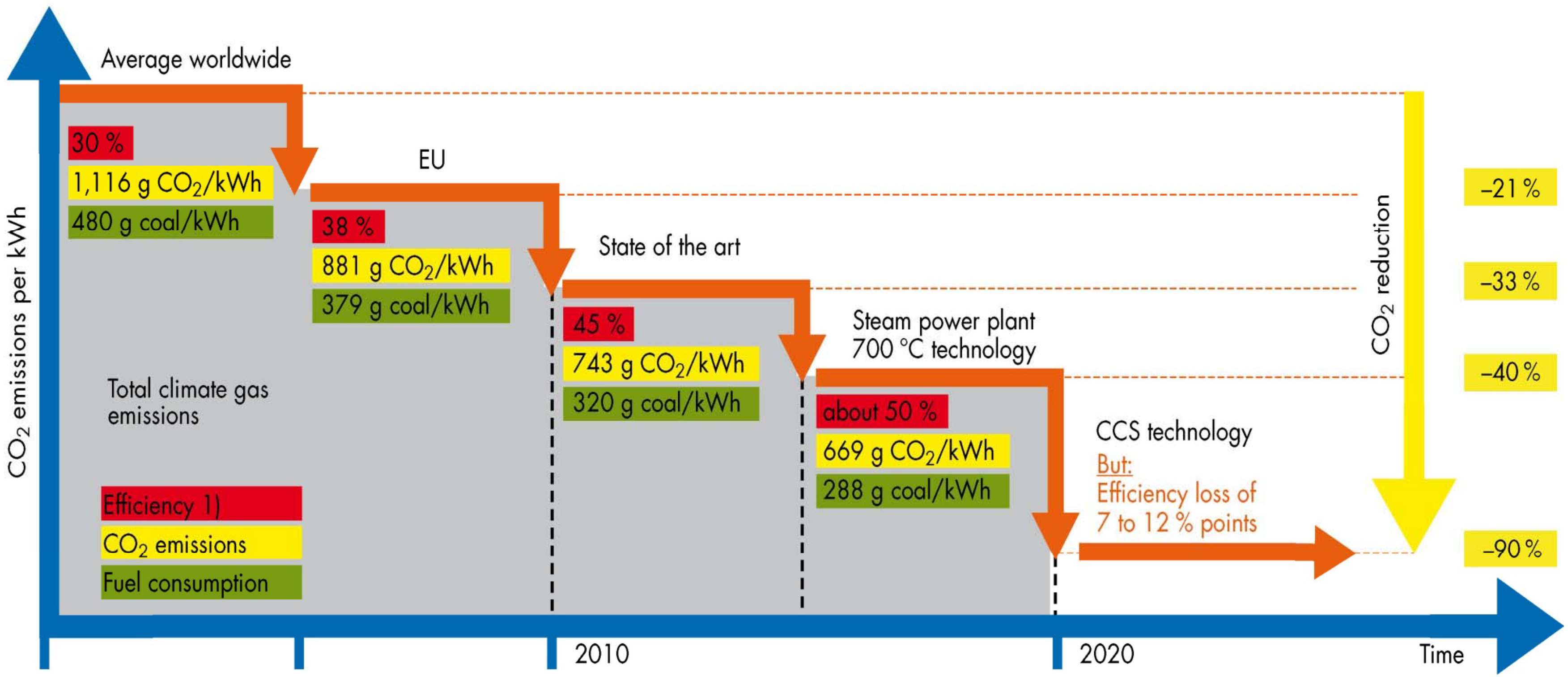
Source: Fraunhofer IWES

Challenges → Impact of Increase of RES for Supply System



CO_2 Efficiency, Emissions and Fuel Comsumption

CO_2 reduction potential of coal-fired power plants[1] by increased efficiency



1) Average data for hard coal-fired power plants

Power Plant Concepts – an Overlook

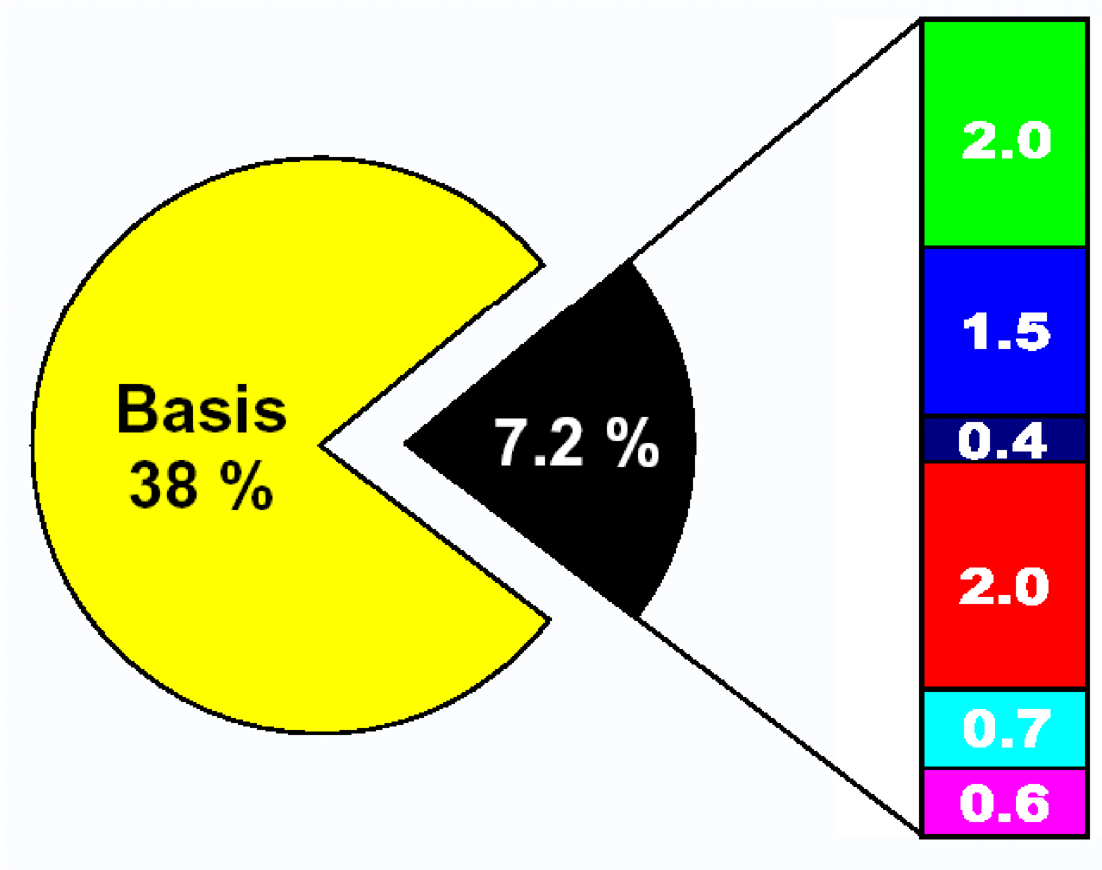
time of technical maturity & efficiency potential

Plant Concept	state of the art	2020	2025	2030+
Combustion				
conventional process	46	51	53	53+
CO_2capture by MEA in flue gas		38…42	39…43	..43+
Oxyfuel - cryo air separation		39…43	45…48	
Oxyfuel - membrane air separat				50+
CCGT				
conventional process	60	62	63	66+
CO_2capture by MEA in flue gas		48…52	51…55	56…60
O_2combustion - membrane air separat				61+
IGCC				
conventional process	43…46	50…52	54…57	62+
CO_2capture by methane combustion		42…46	47…50+	50…55
gasification - membrane air separat				

source Cooretec

Efficiency increase of Power Plants

Fraction of Efficiency increase in Coal fired Power Plants in the period of 1985 - 2000



Turbine efficiency

Kondensator pressure

Prozess optimisation (Fdw. preheating,...)

Steam parameter

Feedwater temperatur

Steam generator (Δp, P_{el}, $T_{Exhaust}$)

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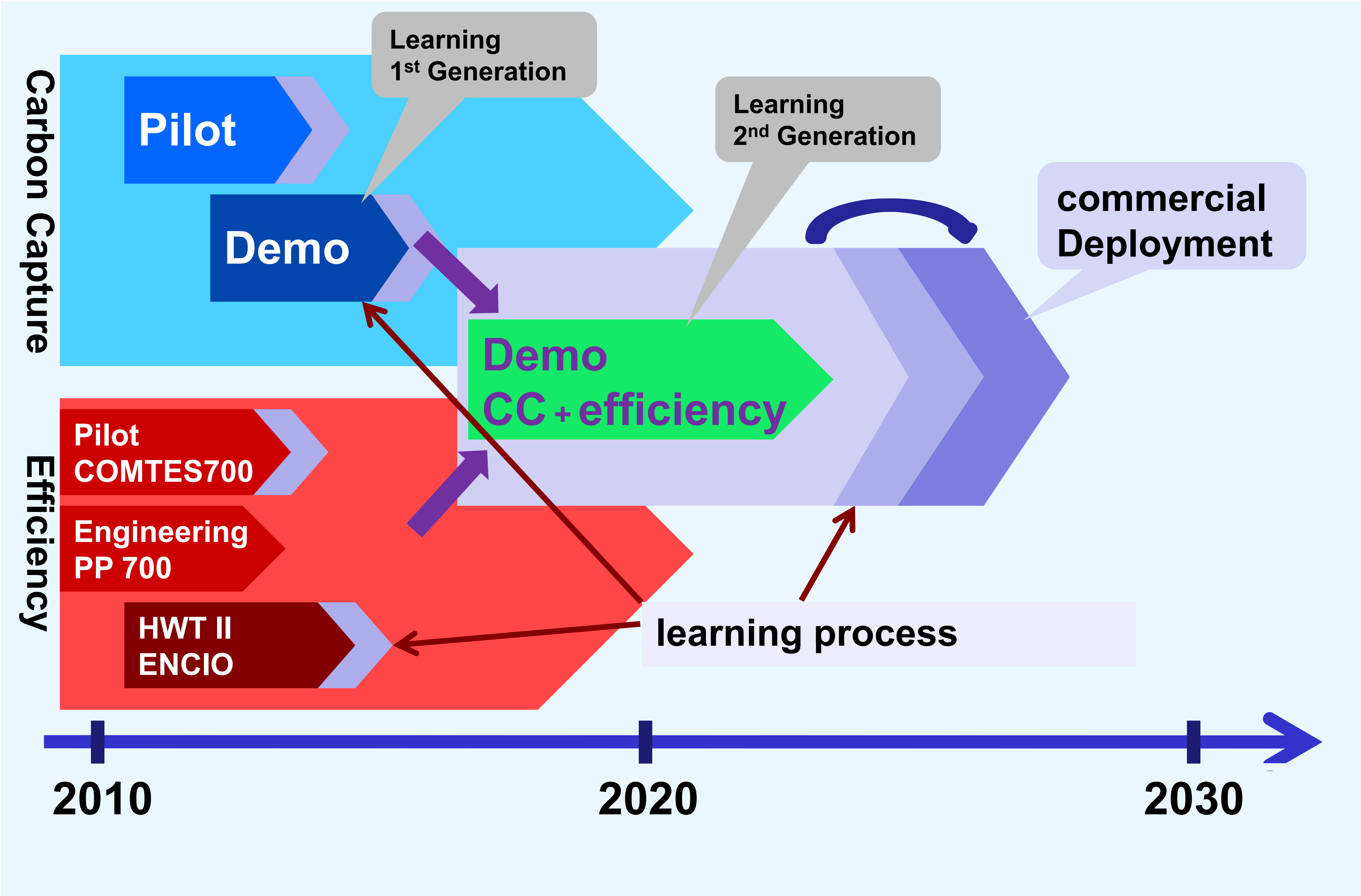
VGB Activities Technology Area

- Topics
  - future Requirements for Power Plants (flexibility & more)
  - System Stability - Integration RES into the Supply System
  - Scenario Analysis Energy Roadmap 2050
  - Consolidation 600°CMaterials (T24 and others)
  - COMTES+ for 700°C Technology
  - Emission Issues as Mercury, NOx and others
  - Utilisation of Biomass
  - Residuals as Gypsum and Fly Ash
- Organisation
  - embedded in the Committee Structure
  - activating Emax Steering Committee



Learning
1st Generation
Learning
2nd Generation
commercial
Deployment
Carbon Capture
Pilot
Demo
Demo
CC + efficiency
Efficiency
Pilot
COMTES700
Engineering
PP 700
HWT II
ENCIO
learning process
2010
2020
2030

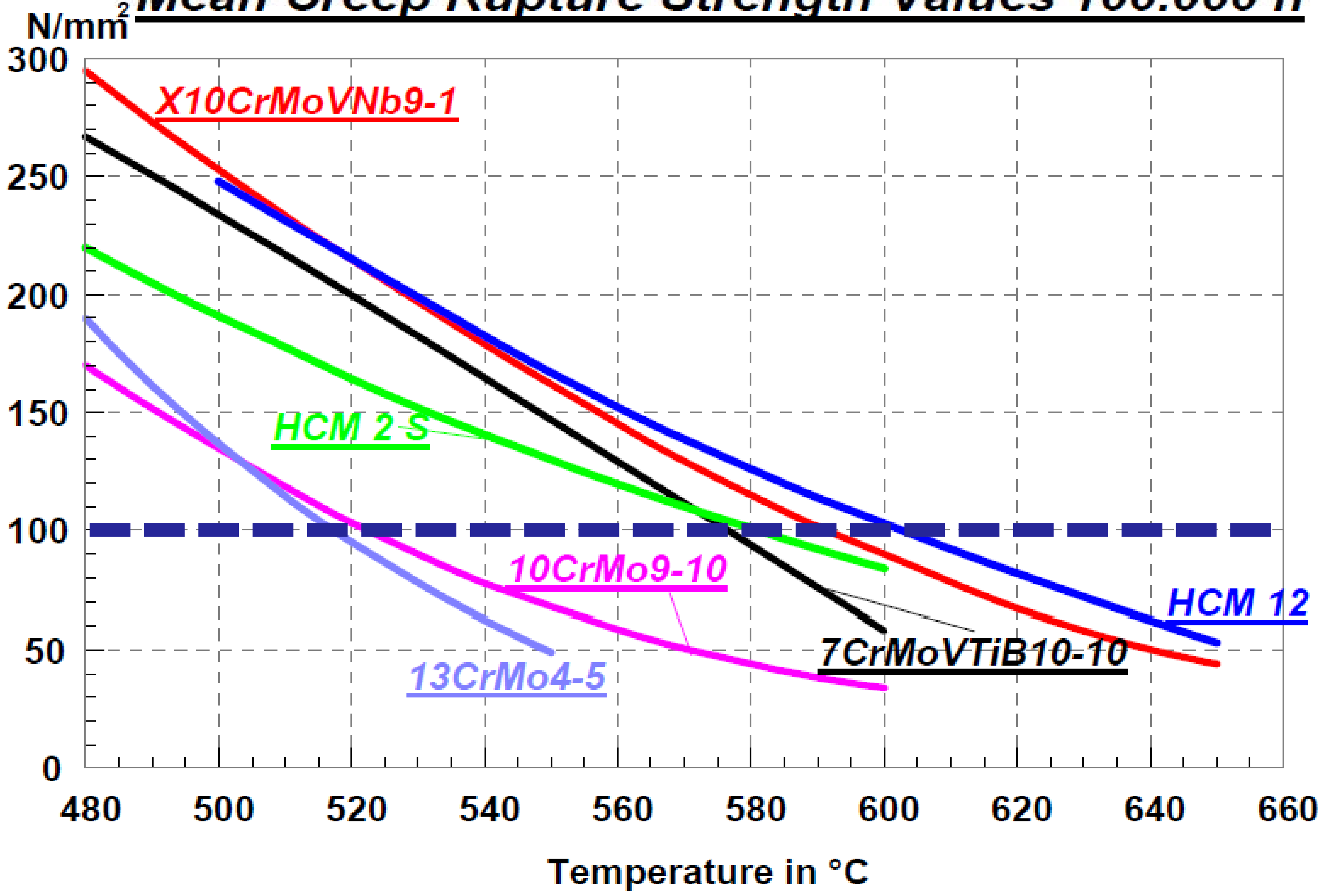
VGB Activities

in pursuing the Development of Clean Coal Technologies

- **Material Research**
- **NRW Reference Plant → *state of the art***
- **AD700/COMTES700 → component test**
- **COMTES+ →ENCIO & HWT II**
- **ZEP Technology Platform → CCS Issues**

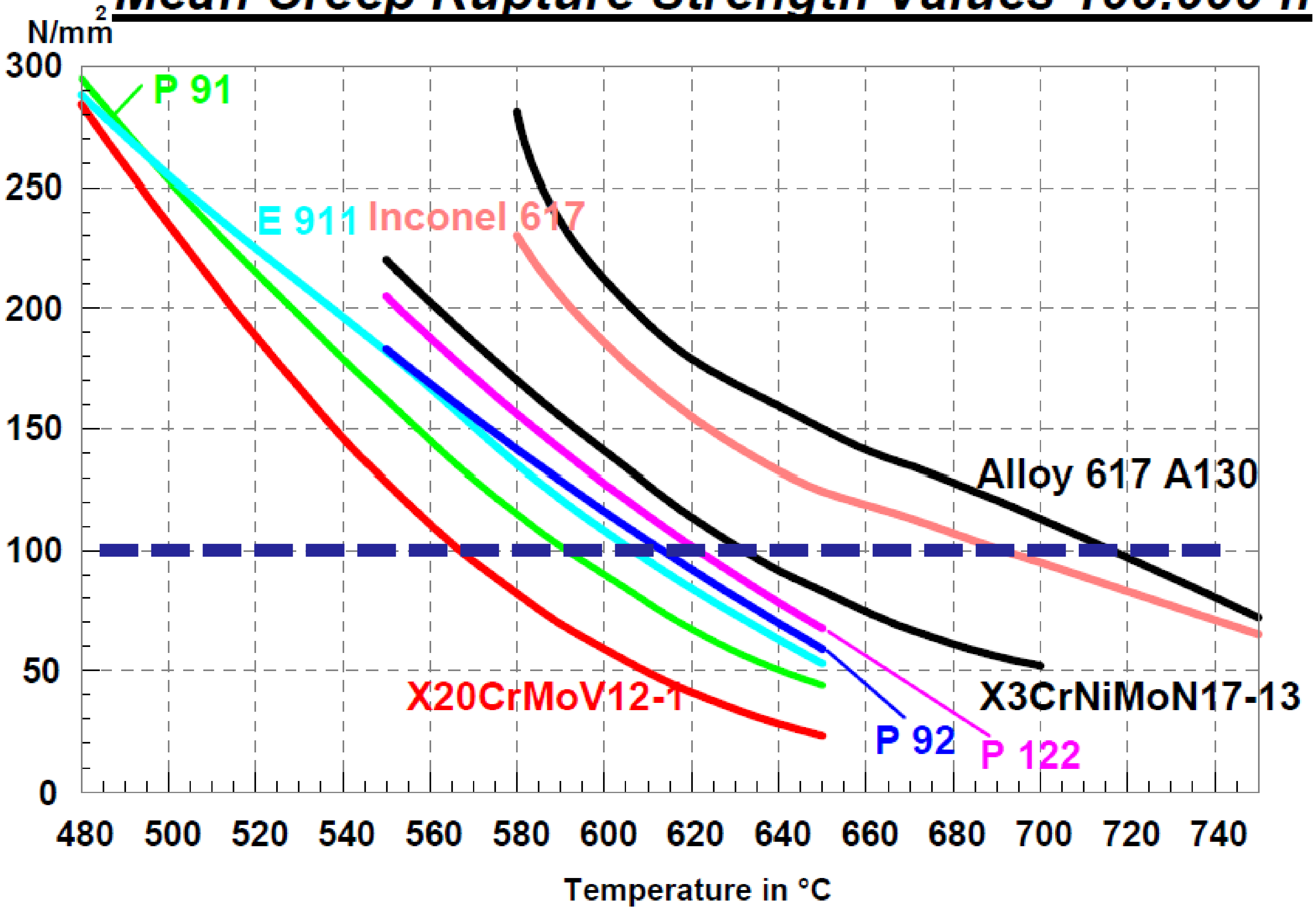
Materials for Waterwalls

Mean Creep Rupture Strength Values 100.000 h



Materials for Header and Piping

Mean Creep Rupture Strength Values 100.000 h



pulverised Coal Plant Technology

state of the art Technology → 600 °C

advanced USC/Ni Alloys → 700°C

NRW Reference Plant

principal Design Data

- Gross capacity:	600 MW
- Type of boiler:	Tower-type boiler with vertical tubes and steam coil air heater
- Heat recovery:	Utilization of mill air heat recuperation
- Flue gas discharge:	Discharge via cooling tower
- Turbine model:	H30-40 / M30-63 / N30-2 x 16 m^2
- Main steam parameters:	285 bar / 600°C / 620°C
- Condenser pressure:	45 mbar
- Generator:	Water/hydrogen cooling
- Feed water heating stages:	8 feed water heaters + external desuperheater
- Feed water final temperature:	303.4°C
- Feed water pump concept:	3 x 50% electric motor-driven feed water pumps, variable-speed drive with planetary gearing

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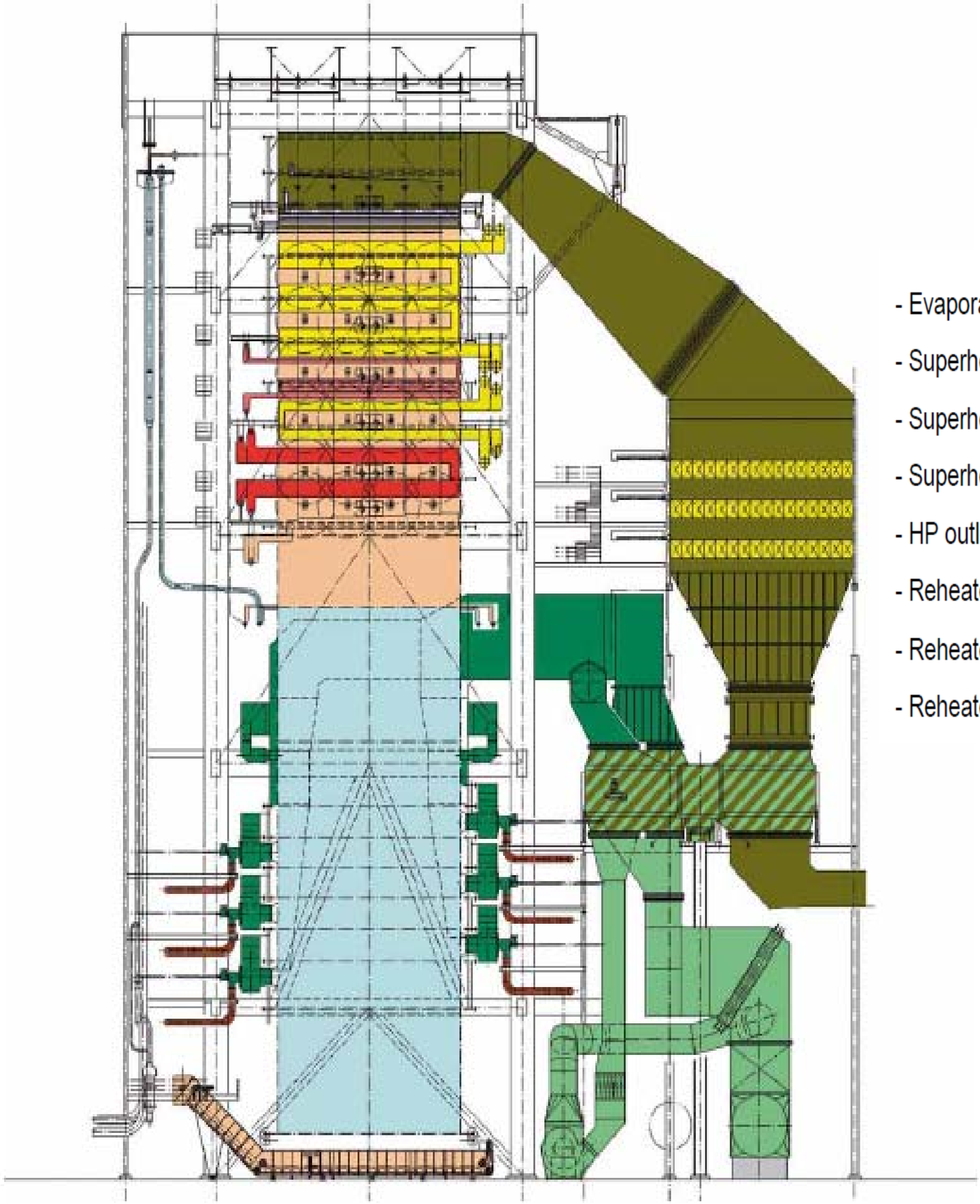
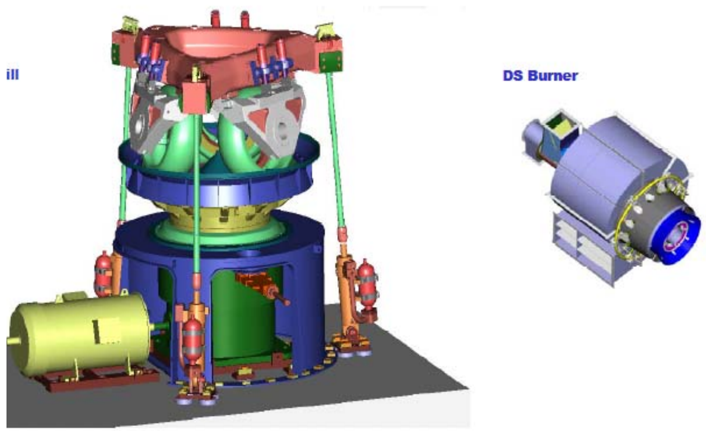


Figure 8.2: Tower boiler.

- Evaporator/superheater - vertical tubing	7CrMoVTiB 10 10
- Superheater Ü1 support tube partition	HCM 12
- Superheater Ü2	Super 304 H or TP 347 HFG
- Superheater Ü3	HR3C or AC 66
- HP outlet header	P92
- Reheater ZÜ1 Outlet	7CrMoVTiB 10 10, HCM 12
- Reheater ZÜ2	HR3C or AC66
- Reheater outlet header	P92



re 8.1: MPS mill and DS burner.

COMTES700 – Implementation into Boiler

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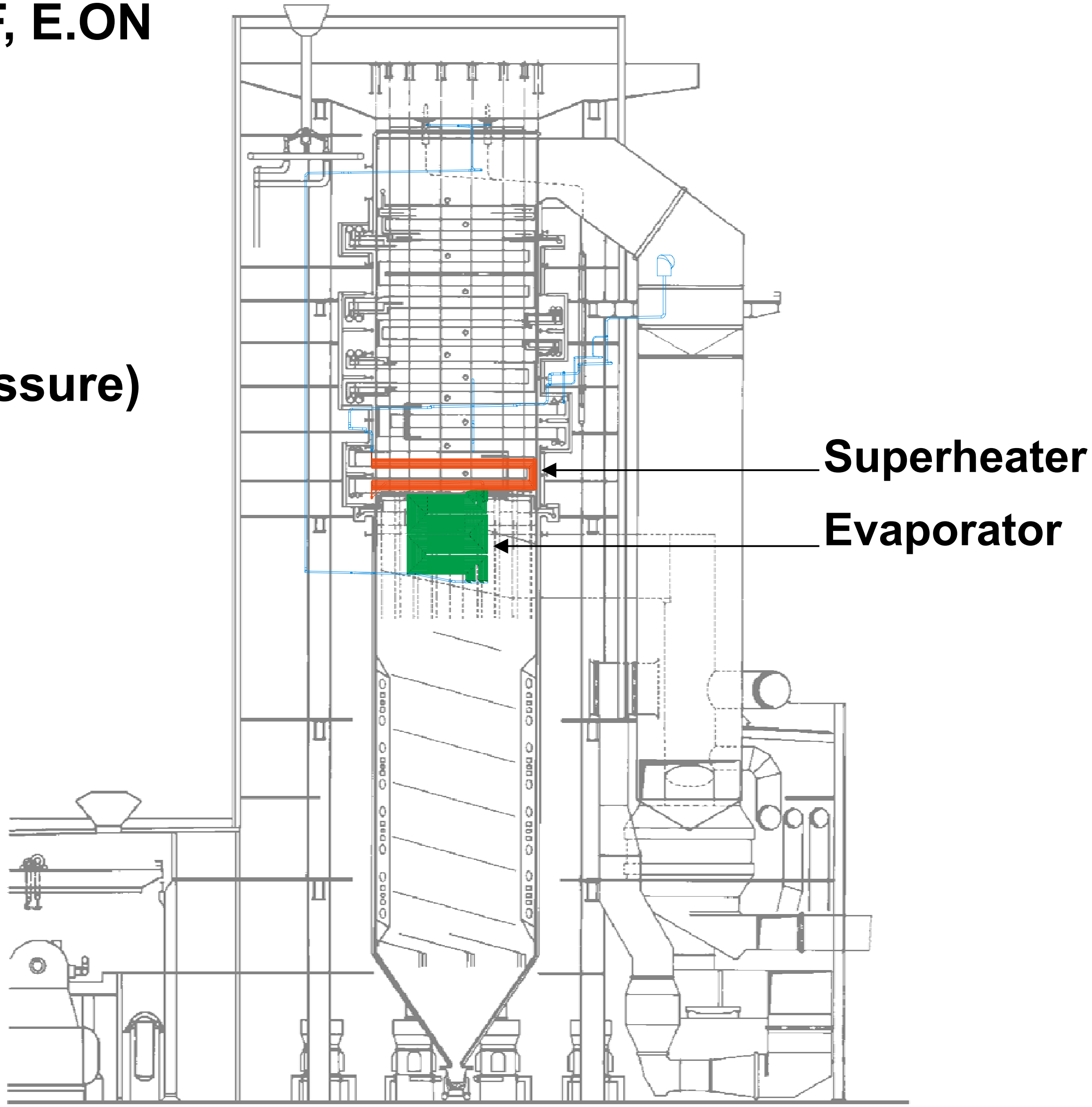
Host Plant - Scholven F, E.ON

- **Net output**
  - **676 MW**
- **Live-steam**
  - **220 bar (design pressure)**
  - **540 °C**
  - **625 kg/s (2,250 t/h)**
- **Reheater-steam**
  - **44 bar**
  - **540 °C**
  - **568 kg/s (2,044 t/h)**
- **Fuel**
  - **Hard coal**



Pre-Engineering Study PP 700

Principal Objectives & Tasks

- definition of reference case
- concentration on the 700 °C relevant issues
- implemeting the experiences (AD 700, Marcko, COMTES700)
- detailled analysis where necessary
- concept ready for Demo 700 PP
- inclusive credible parts for *capture ready*

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Condition for Investments in the Electricity Sector

→ influencing factors

- market regulations → PPA or spot market
- financing conditions
- cash flow
- licensing procedure
- infrastructure
- owner´s engineering
- project structure → turn-key or lot-wise
- supplier´s issues
- fuel prices → long term perspective

..which Perspective?
Politics - Investor

...*to analyze/evaluate → Options of different Policies*

Cost	**capex/opex as a f(time)**
Time Line	**when/what/how much**
RES subsidies	**cost (capex/opex)**

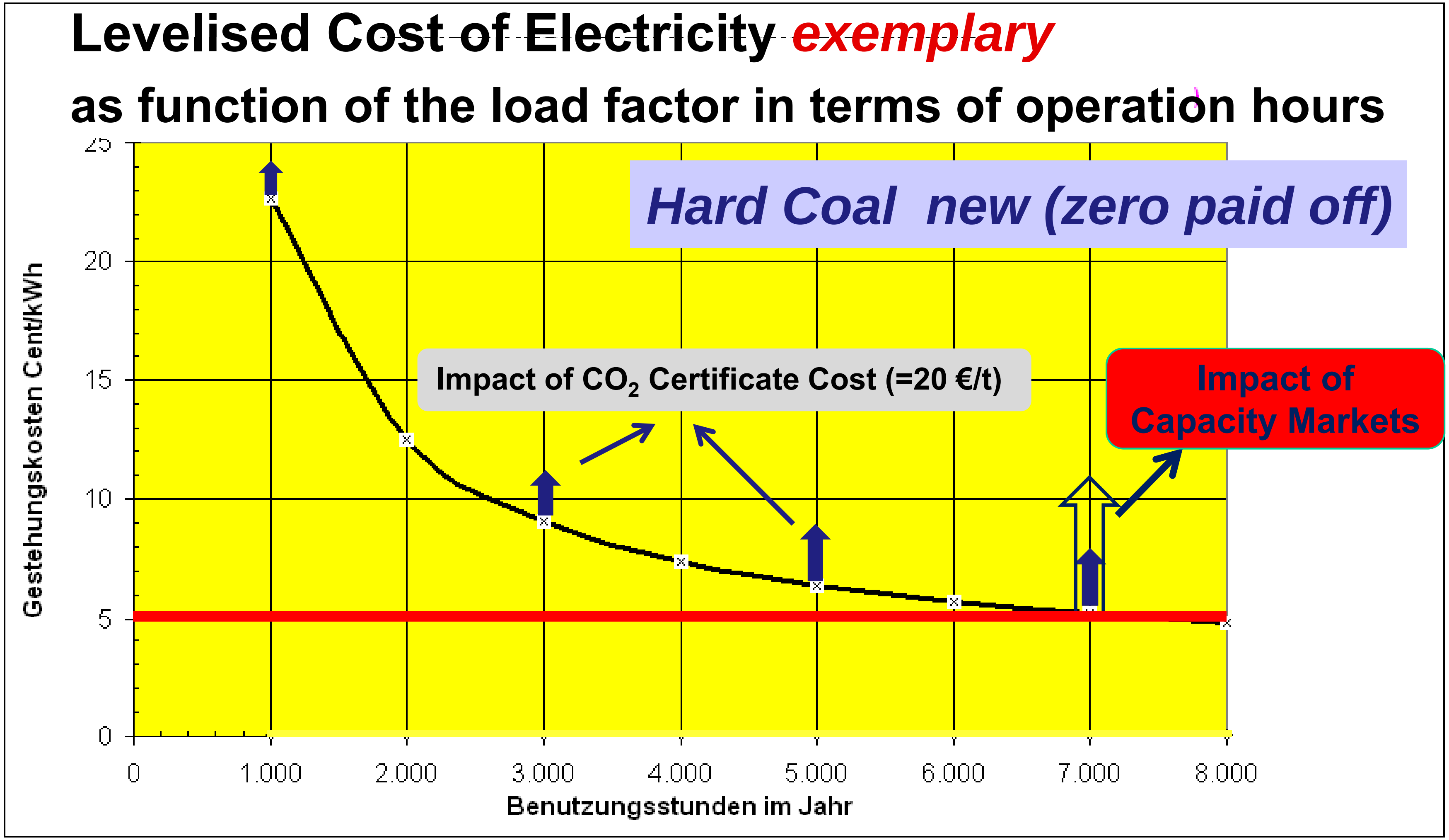
→ Obstacles = system stability/ transmission & distribution

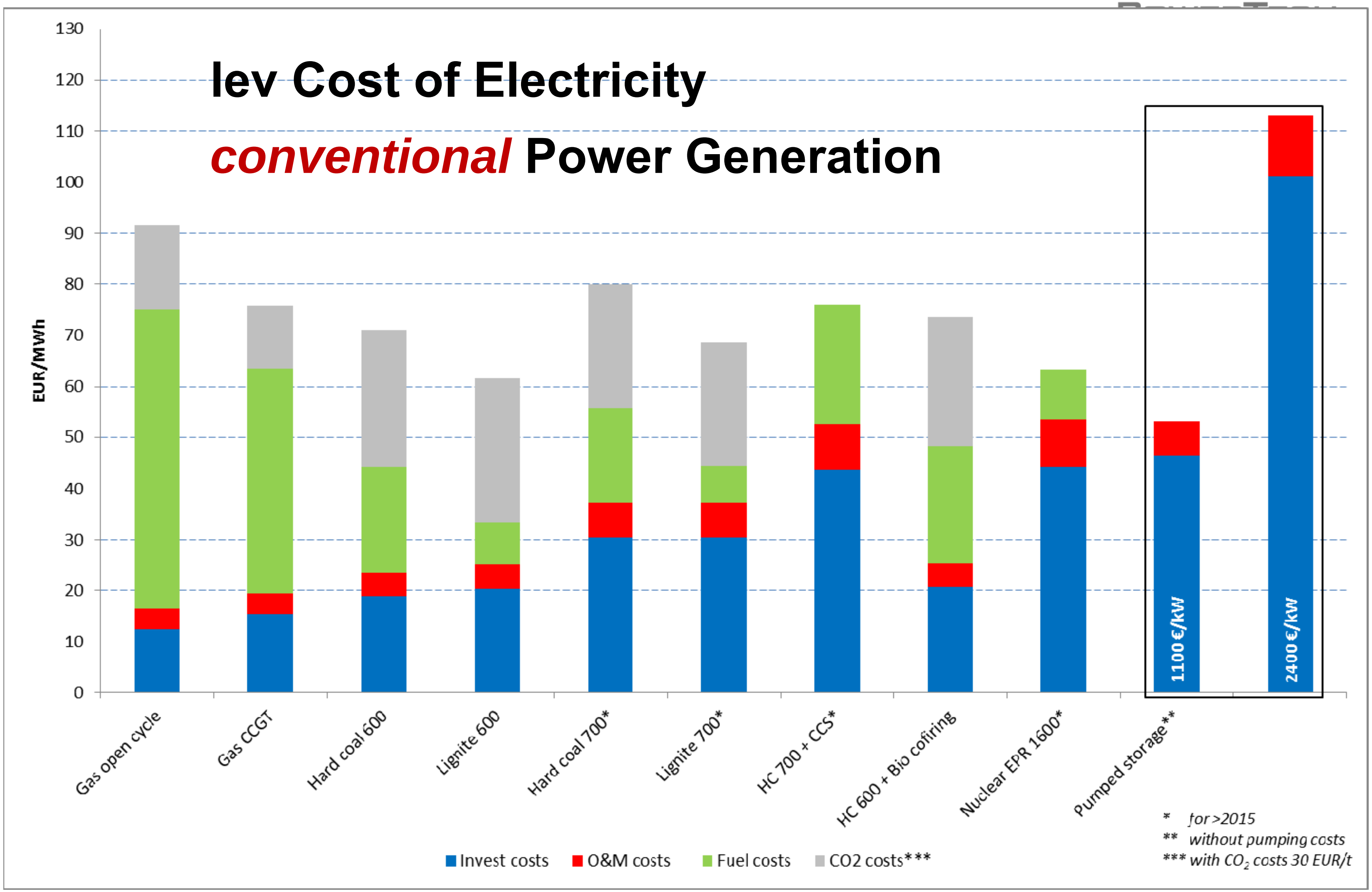
!to be identified!

GDP = Market Consequences

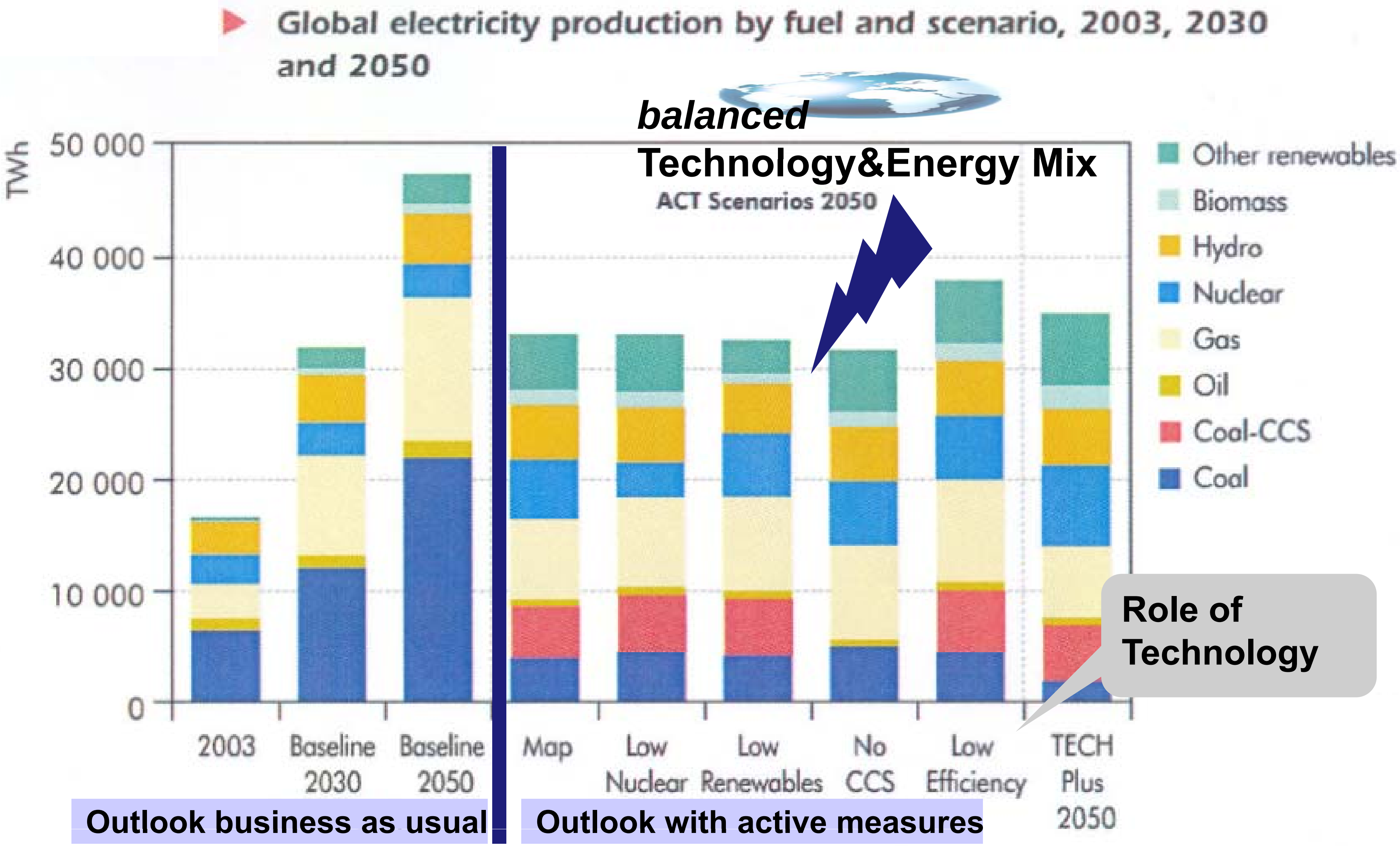
→ Cost! Security! Affordability! Sustainability!

Impact of low Load Factor on Generation Cost



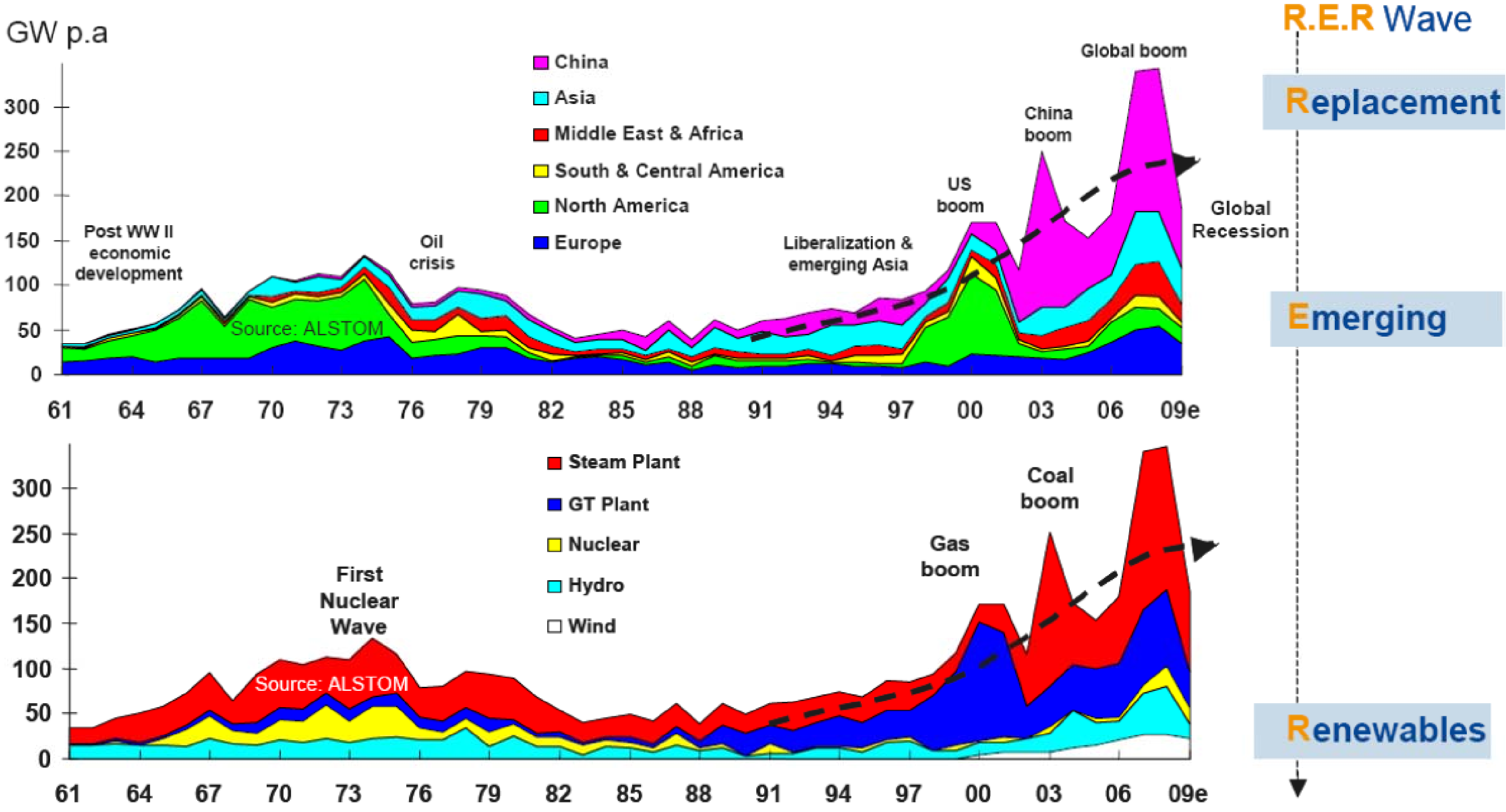


lev Cost of Electricity
conventional Power Generation
EUR/MWh
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1100 €/kW
2400 €/kW
Gas open cycle
Gas CCGT
Hard coal 600
Lignite 600
Hard coal 700*
Lignite 700*
HC 700 + CCS*
HC 600 + Bio cofiring
Nuclear EPR 1600*
Pumped storage**
Invest costs
O&M costs
Fuel costs
CO2 costs***
* for >2015
** without pumping costs
*** with CO_2 costs 30 EUR/t



IEA Energy Outlook 2006

Power Plant Trends
Diverse technologies and emerging markets



Drivers leading to the "triple" investment wave - R.E.R
Replacement in established markets + Investment in Emerging countries + Renewables

Conclusion

- ***even*** **in a RES-driven Power Generation**
  →Need for back-up Power Generation
- ***absolute Must*** **for R&D Activities for Coal**
- ***burden sharing*** **is the first Choice**
  →Cooperation
- ***Consistency*** **of Regulatory Framework**
  →basis for economic Viability


Thank you for your Attention