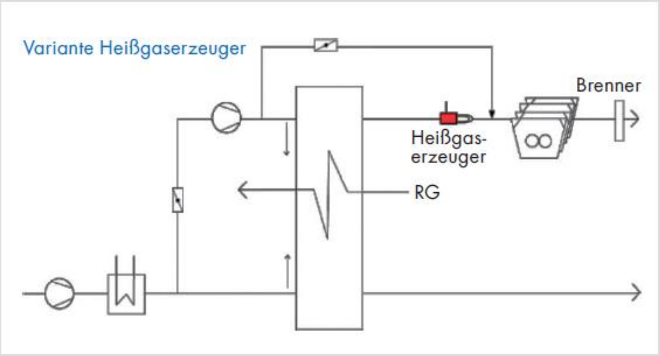
Fuel flexibility: Enhanced coal range by imported coal

POWERTECH

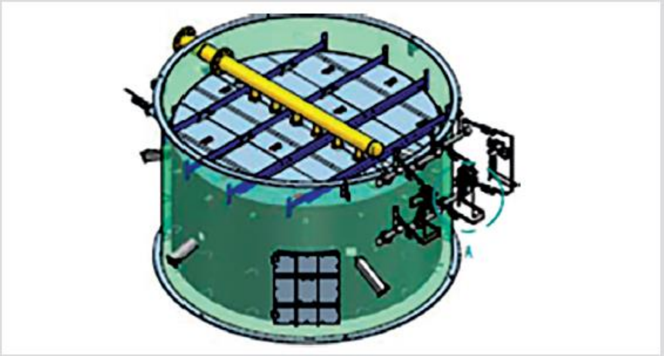
Typical challenges	Problem	Solution	Technical measure
Higher ash content	▪ Higher slagging ▪ Higher unburnt hydrocarbons ▪ Higher emissions	▪ Reduction of burning temperature ▪ Better air/coal mixture ▪ Optimize ESP	▪ Improve air distribution ▪ Modify burner flow by baffle plates ▪ CFD flow optimization ▪ SO3 dosing
Higher water content	Load restriction	Enhance mill pulverising and drying capacities	▪ Increase air flow to mill (shift secondary to primary air, flue gas recirculation) ▪ Increase mill air temperature (modify air2air preheater, install steam2air preheater or hot gas burner) ▪ Additives for water bond
Higher volatile content	Avoiding flashbacks at burner	Increase burner outlet velocity and coal/air flow pattern and mixture	▪ Change from rectangular to round shape of coal header ▪ Install guide and baffle plates
Varying (+/-) sulphur content	▪ Higher Corrosion (+) ▪ Higher particle emissions (-)	▪ Ensure oxigen content at burner side walls ▪ Improve FGD	▪ Install additional burner side wall air nozzles (modify secondary air system) ▪ Optimize pump scheme, additional nozzle layer

Fuel flexibility: Enhanced coal range by imported coal

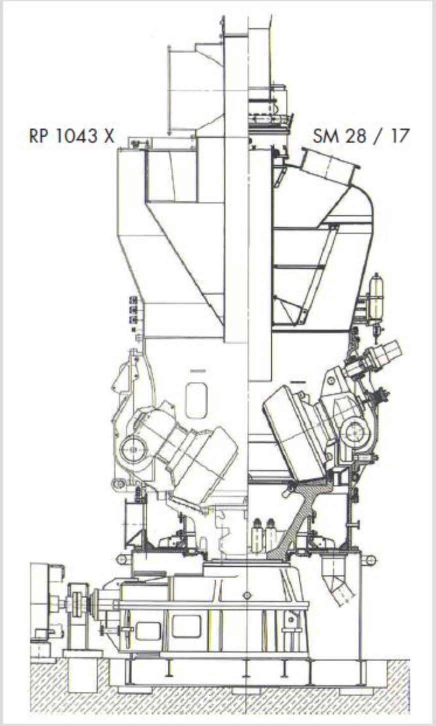
Enhance drying and pulverizing: Power Plant Weiher/Bexbach, 700 MW hard coal



Drying and pulverizing scheme

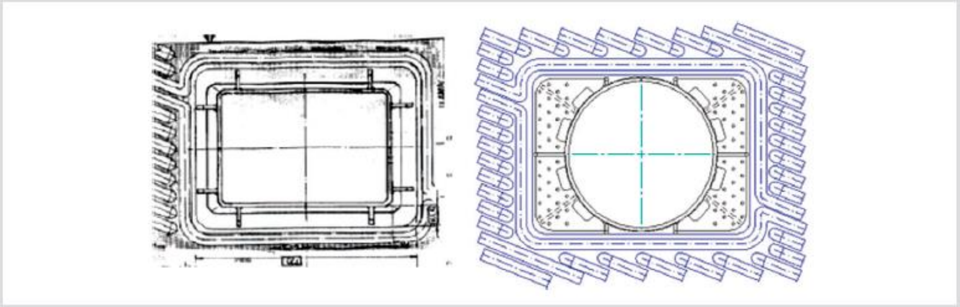


Additional hot gas generators



Enhanced mill capacity:
Power Plant Bergkamen, 750 MW hard coal

Improved burner geometry:
Power Plant Bergkamen, Bexbach



Source: STEAG/Alstom

Overview of Heat Storage

POWERTECH

- Heat storage
  - Thermal energy
    - Sensible heat
      - Liquid
        - Water
      - Solid object
        - Stone
      - Aquifer (Water, Stone)
    - Latent heat
      - Solid-liquid
        - Melting
      - Liquid-gaseous
        - Steam
  - Chemical energy
    - Heat of reaction

Liquid salts (commercial)

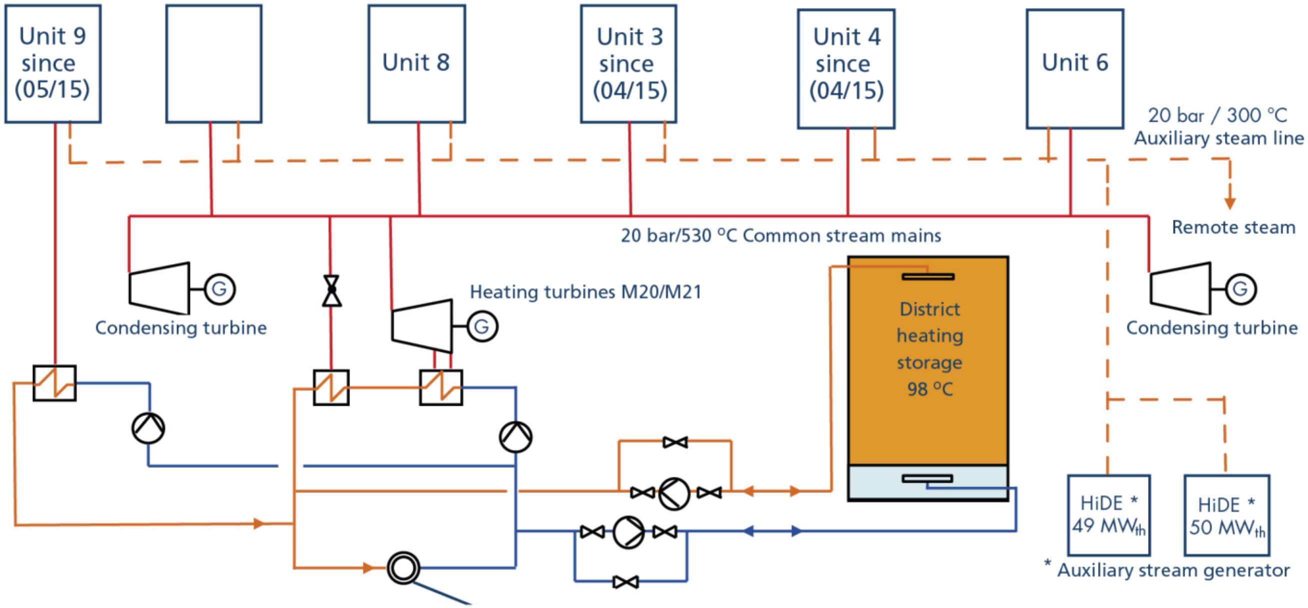
Steam storage (commercial)

Phase change materials (pre-commercial)

Solid materials (demonstration stage)

- Wide range of storage technologies for power plant applications available
- Adaptation for specific application necessary

Thermal Storage – Best Practice GKM Mannheim



Not-pressurized flat bottom tank (Hedbäck design):

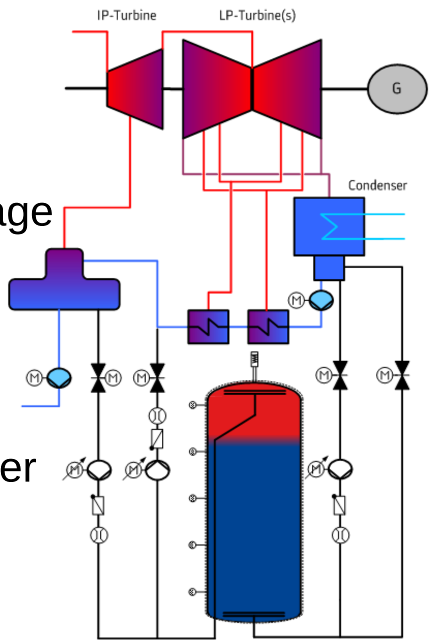
- Simple design
- Water/steam as medium
- Max. temperature < 100 °C
- High voluminas (> 1000.000 m³)
- High output and capacities
  up to 300 MW , > 2.000 MWh per tank)

Thermal energy storage

idea / concept

Storage of thermal energy in low load times

- thermal energy storage parallel to the LP-preheating route
- storage medium water
- particular storage design to avoid loss



operation

Loading of the storage

- cold condensate is heated by LP-preheater und is stored in the pressure tank
- reduction of the load because of additionally extraction of the bleeder steam

Unloading of the storage

- bypassing of the LP-preheater
- reduced extraction of the bleeder steam
- rising performance

Source: Vattenfall

Calculation Example

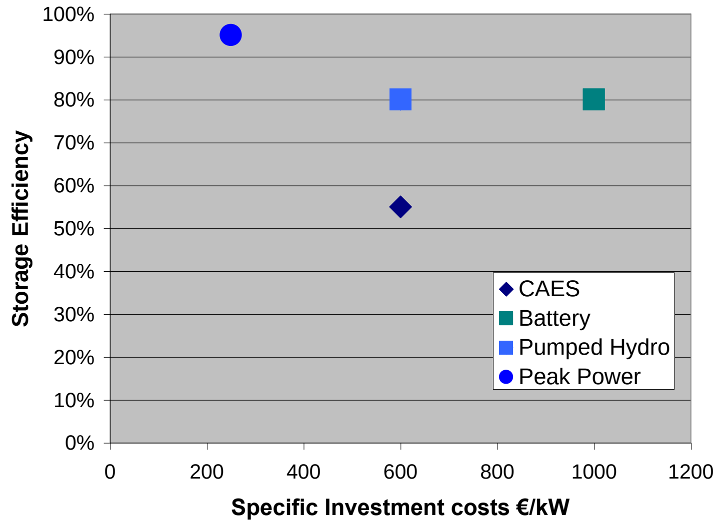
Benefit

- Max. Load: 660 MW → 690 MW (+4,5%)
- Min. Load: 264 MW → 244 MW (- 7,5%)
- Additional Primary/Secondary Control

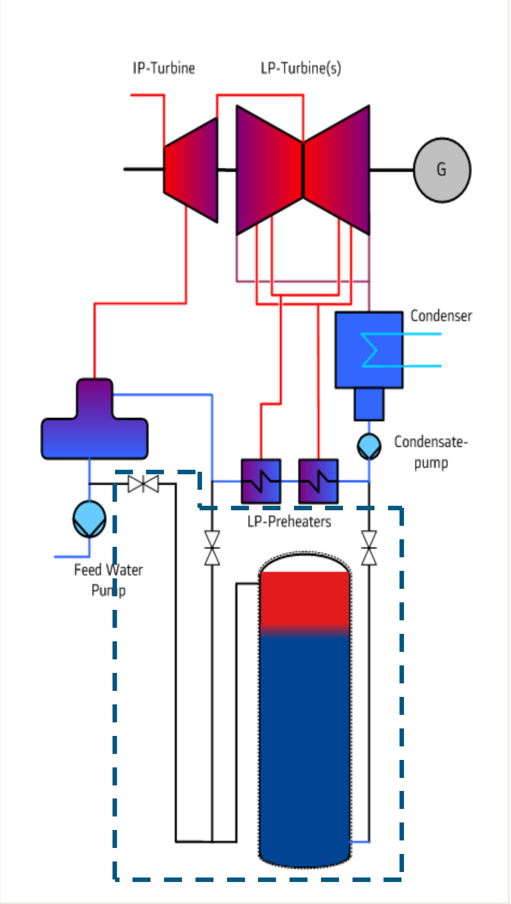
Heat Storage

- Volume for 1h : 1800 m³
- 5 Storage Tanks (D= 4,8 m; H = 24 m)

Comparison with other storage technologies



Peak Power Module

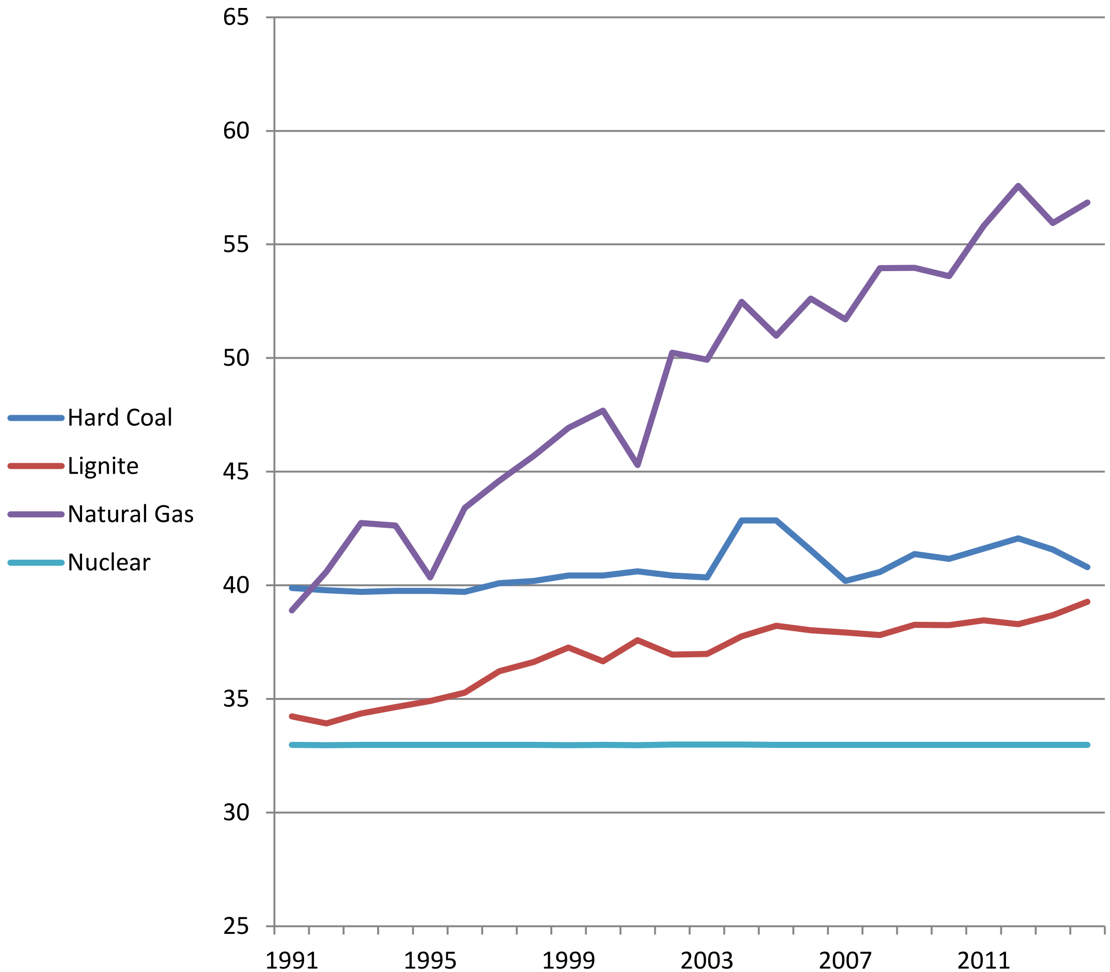


Condensate flow: 460 kg/s

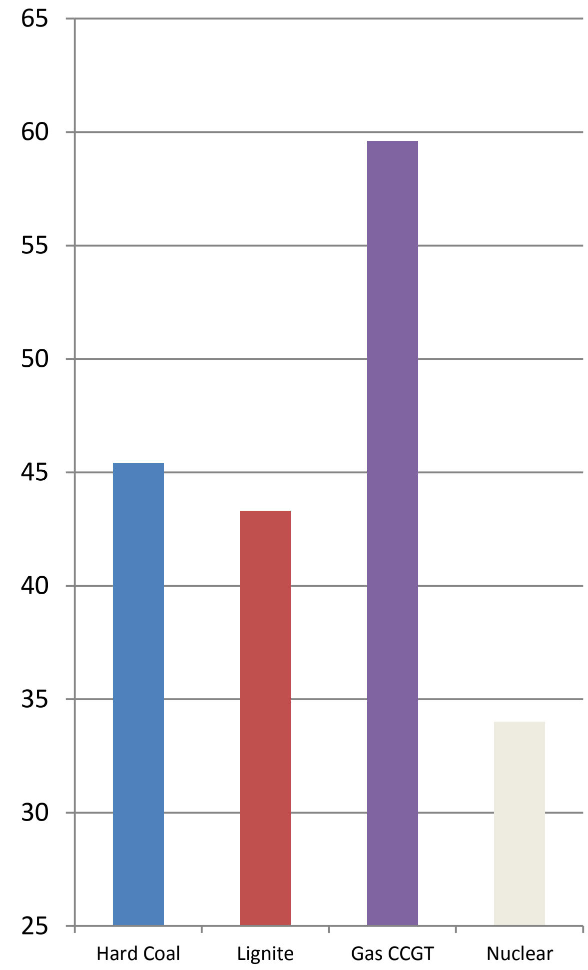
Condensate Temperatures 35 - 180 °C

Source: Vattenfall

Efficiency development in Germany



Average yearly operating gross efficiency (in %)



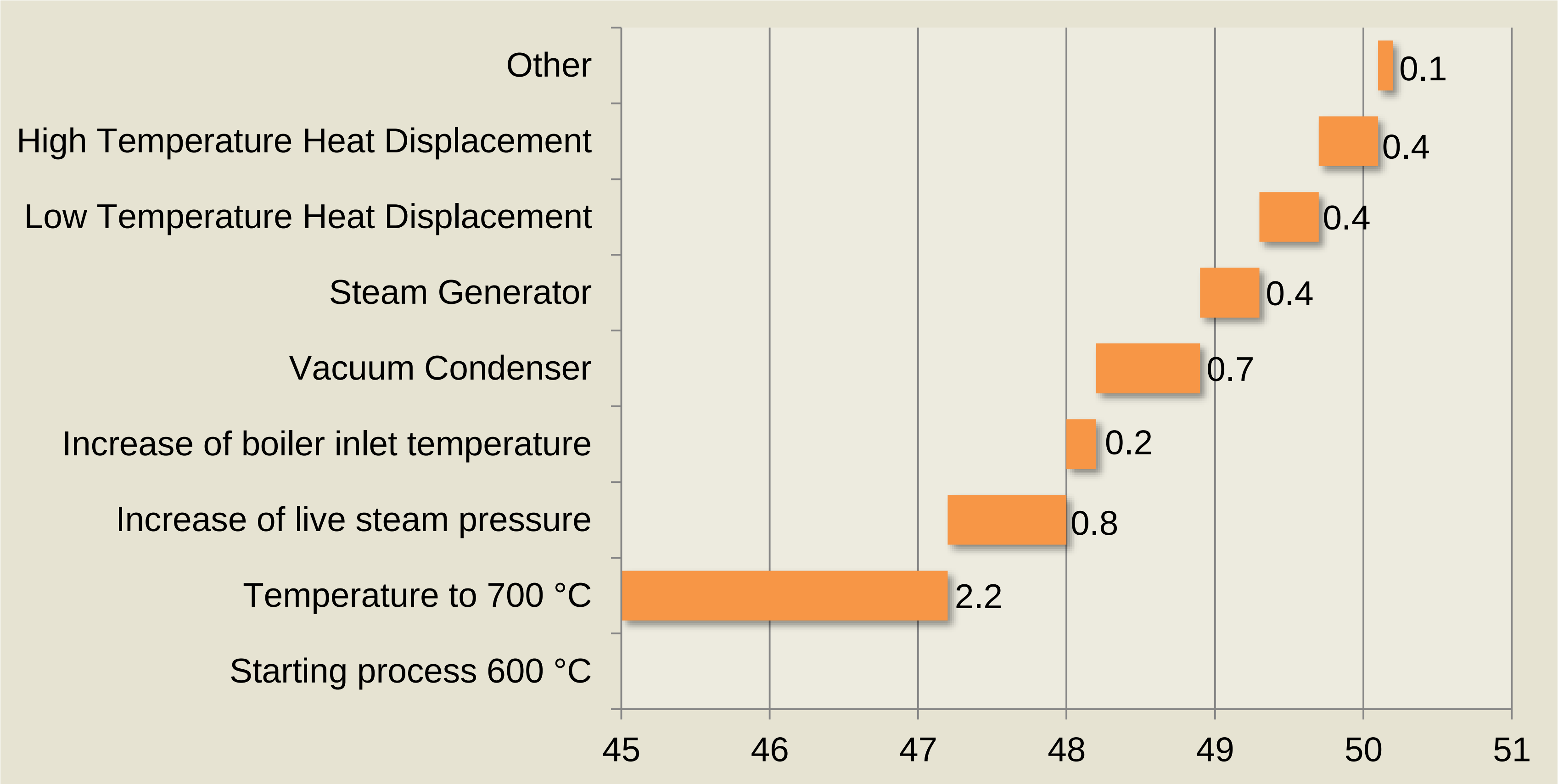
Best available technology
Average operating net efficiency (%)

Source: BMWi Energy Data 2014, VGB

What about efficiency in the future?

POWERTECH

Expected values for efficiency enhancement measures

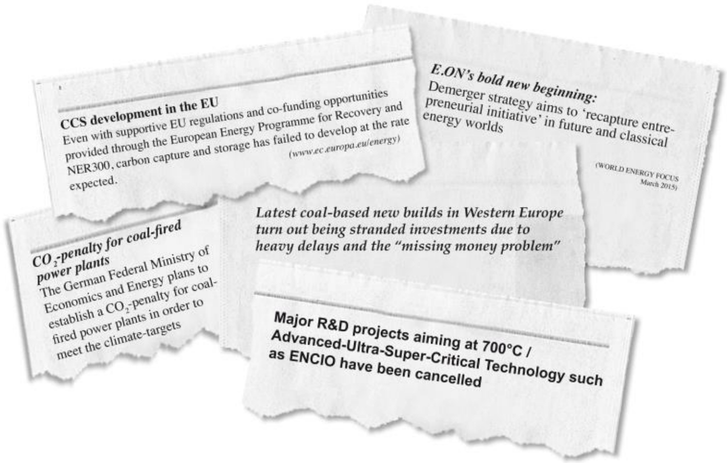


Only partly deployment of these measures is expected as there are low pay-off perspectives. Efficiency has lost its importance as a technology driver.

Efficiency-lighthouse project ENCIO terminated

POWERTECH

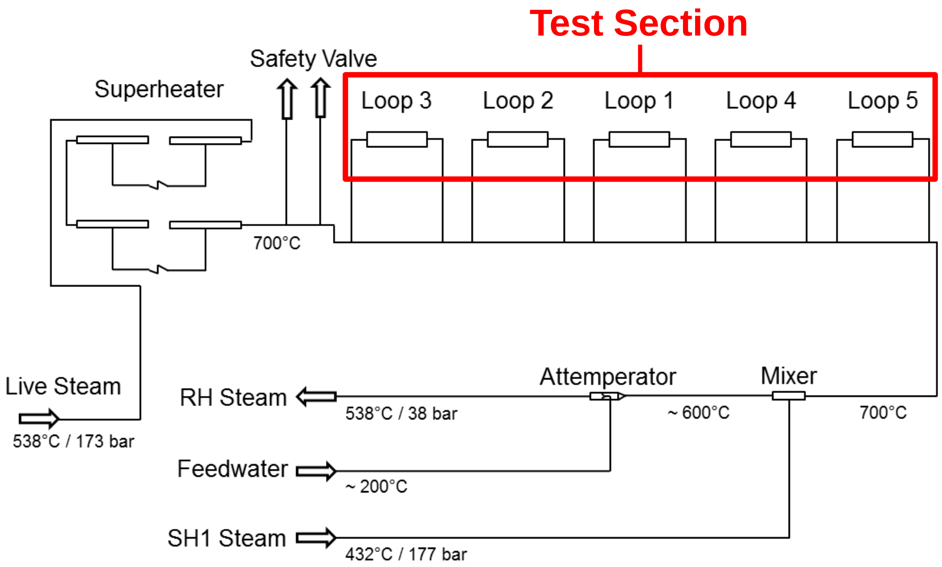
- Provide proof of design and material behavior of thick-walled components under operating conditions
- Close main technical open items derived out of the comprehensive analysis of COMTES700 (repair of service exposed Ni-based materials)
- Test of new developed materials (Alloy 617 occ) and manufacturing options to improve the reliability of weldments made out of Ni-based alloys
- Develop a life-time monitoring concept for pipes made out of Ni-based alloys
- Explore materials (HR6W) and manufacturing options (HIP) having the potential to reduce the investment cost of 700°C technology and improve the load change behavior
- Verify the technical conditions for achieving high efficiency and better environmental figures (lower emissions)
- Planned runtime of the project from July 1, 2011 - June 30, 2017



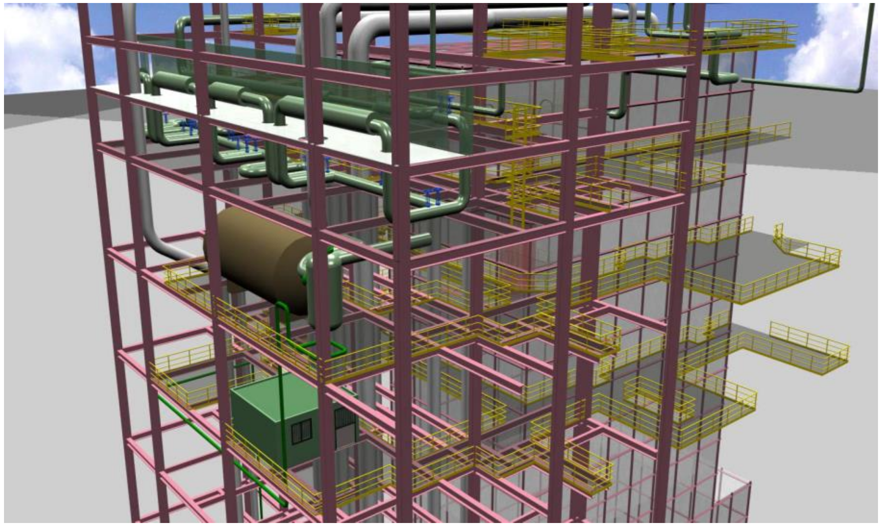
encio
European Network
for Component Integration
and Optimisation

Terminated in October 2013

P&I Diagramm



3D-View of the Test Facility at the Enel plant in Fusina, Italy



Test Loop	Scope
TL1	Development of pipe repair concept
TL2	Test of Hot Isostatic Pressing (HIP) parts and weldments
TL3	Test of different Ni-based alloys and weldments
TL4	Test of turbine cast material and weldments
TL5	Test of a life-time monitoring system

Two WPQR for repair are available (welding)

- Annealing at 1160°C, 1h / mechanised TIG / PWHT 980°C, 3h
- Annealing at 1160°C, 1h / manual TIG / PWHT 980°C, 3h

NDT recommendations for 50 mm wall thickness (testing)

- Penetration Testing on outer surface
- Ultrasonic Testing (mechanised) as volumetric testing
- Radiographic Testing not applicable for dimension (220 x 50 mm) on site with exc. of 60Co

Remaining open issues

- Does solution annealing still work at longer aging times ?
- Critical crack dimension and propagation ?
- Are micro cracks permitted ?
- Adjustment of relevant codes possible ?

ENCIO results for Test Loop 2 (HIP)

HIP Alloy 625

No evidence of a leak before break behaviour of components

- Material failed as HIP candidate

HIP Alloy 617 LCC (manufacturing)

Leak before break can be expected from integrity investigations

- A pipe could be successful manufactured

Remaining open issues

- Long term creep strength behavior
- Qualification of manual welding technology for field welding
- Prove of repair weld methods
- Qualify other product forms (T-pieces, valve bodies)
- Generate VdTÜV sheet

ENCIO results for Test Loop 3 (new materials)

POWERTECH

Alloy C-263

No evidence of a leak before break behaviour of components

- Particularly critical is creep crack growth behaviour

Alloy 617 occ (manufacturing and welding successful)

- First industrial heats and pipes are already produced w/o problems
- New VdTÜV data sheet 573 covers new Alloy
- WPQR for Alloy 617 occ / HR6W available

Remaining open issues

- Long term creep strength behavior of Alloy 617 occ
- Qualification of manual welding technology for field welding
- Prove if the modified chemical composition can be used w/o PWHT
- Prove if Alloy 617 occ can be repaired w/o pre-heating after operation (aging)

ENCIO results for Test Loop 4 (turbine cast material)

Alloy 625c

WPQR performed not successful material failed

- Cast had flaws of up to 3 mm (PT) but below LINAC detection level
- Coarse grain and cast structure are challenging for NDT
- Weld buttering applied to reduce risk of cracks due to shrinking
- After preheating cracks near buttering in base metal
- Weld passed NDT after PWHT 800°C, 4 hours
- Side bending tests failed in the base material at 40° bending angle

Remaining open issues

- Improved quality of Alloy 625c material
- Qualification of welding Alloy 617 occ/Alloy 625c and Alloy 625c/Alloy 625c
- Long term creep strength of improved Alloy 625c and cross weld creep tests with Alloy 617 occ or Alloy 625c

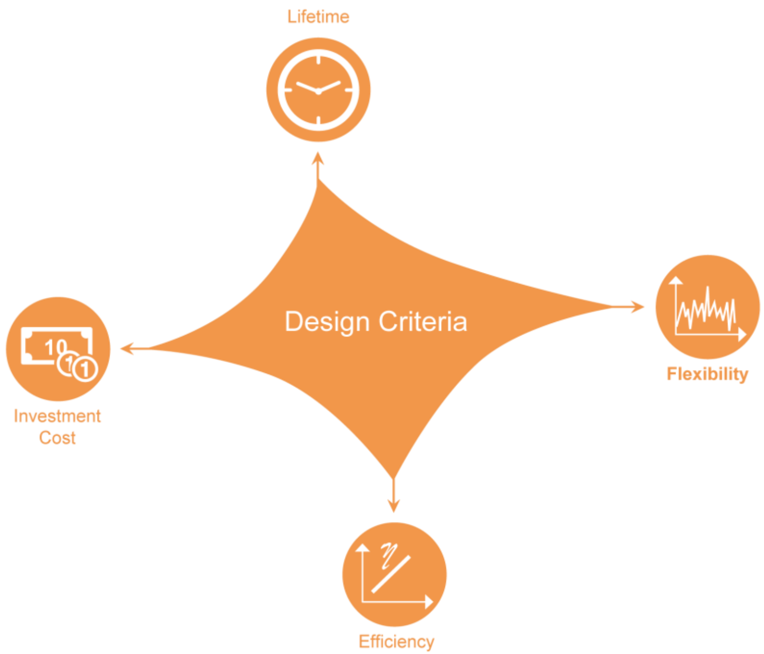
Reasons to terminate ENCIO in October 2013

- Technical problems inherent to R&D projects in which new materials and/or manufacturing methods are being developed resulted in a delay causing extra costs.
- The necessary additional investment of the financing generators was not considered as a maximum additional contribution.
- Due to tremendous changes within the European energy market, the ENCIO project parties could no longer cover these extra costs, which would far exceed the planned budget.
- In the light of the increasing political stigmatization of coal combustion in some European countries, the financial possibilities limit additional financial commitment from the industry.
- The project was thus terminated before the commissioning of the Test Facility.

encio
European Network
for Component Integration
and Optimisation

Summary

- → Europe's energy policy has initiated a change of paradigm for conventional power technologies
- → Flexibility has replaced efficiency as a technology driver
- → R&D activities towards 700deg technologies have been stopped or continue on lower level.



- → Flexibility has many facets: dynamics, operational flexibility, O &M, fuel, work flows and skills and licensing and permitting issues
- → Thermal storage is also an important option to increase the plant flexibility

Flexibility drives the technology development in European power generation. It has many facets ranging from design, optimized processes to storage options.

german cooperation
DEUTSCHE ZUSAMMENARBEIT

धन्यवाद

Thank you

for your interest!

Contact:
Dr. Oliver Then
Head of Power Plant Technologies
Deilbachtal 173
45257 Essen / Germany
Phone: +49 201 8128 250
Mobile: +49 172 292 8677
oliver.then@vgb.org

www.vgb.org