Ganzheitliche Systemlösungen zur Bewältigung energiepolitischer Herausforderungen

Holistic system solutions to meet energy policy challenges

VGB-Conference / Essen / 23.09-2021 / Dr. H.-U. Thierbach / L. Brandau / A. Haite

Rely on good experience with

steinmüller engineering

The Engineers Company

Content

Introduction – Revolutions in Energy Providing Industry

First Revolution in Energy supply beginning 20th century

Until 20th Century

Power from Muscular Strength

Carl Baum (1941)

Ilya Jefimowitsch Repin (1872/73)

Sun Based Energy

Preußen (1902)-Wikipedia

20th Century –

Fossil Fuel Based Power

Power Station Reisholz

1908	3 x 5 MWel turbines
1918	75 MWel largest power station in the world
1920	Explosion of coal fired steam Generator

Foundation of VGB in Leuna

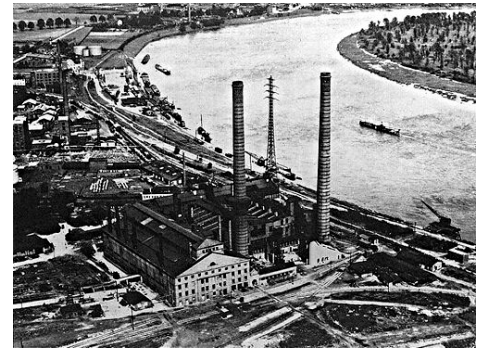
Power Station Boxberg unit Q

2000	1x 900 MWel
Hight Boiler Haus	160 m
Hight Cooling Tower	176 m

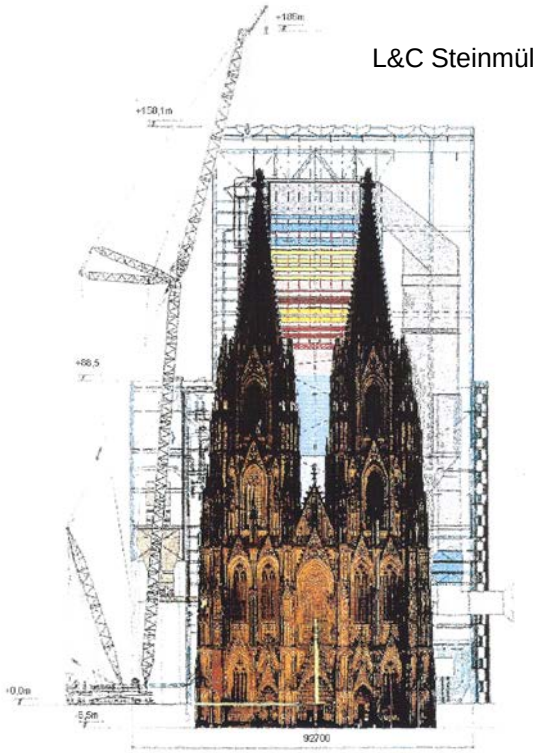
Sun Based Energy

Aggertalsperre (1929)

2,5 GWh /a (2,25 MWel)



KW Reisholz 1930 - Wikipedia



L&C Steinmüller

Introduction – Revolutions in Energy Providing Industry

First Revolution in Energy supply beginning 20th century

Example for illustration : 24 000 MWh = 24h operation of 1.000 MWel Power Station

Virtual Horse Power Station 1000 MW mech

Power : 1.000 MW mech → 1,360 Mio Horses

24 hours operation
4 horses/d to cover 24 hours(h) → **Total # horses** : **5,44 Mio**

Fuel : 10 kg hay/d per horse → 54.400 t hay/d
Volume flow : 90.700 m³/d → 1.200 Wagon/d (75 m³/ Wag)

Hay Consumption : 54.400 t/d → **20 Mio t/a**
Necessary farmland* : **2 Mio hectare (12% of total farmland)**

Farmland total in Germany	**16,60 Mio hectare**
Total land area of Germany	35,74 Mio hectare

*Harvest : 10 t hay per hectare per year

Hard Coal Power Station 1000 MW el ~ mech

Power : 1.000 MW el → 2.220 MW th (eff. 45%)

24 hours operation
Lower heating value 25 MJ/kg

Fuel : 89 kg/s coal → 320 t/h → 7.672 t/d
Volume : 9.025 m³/d →120 Wagon/d (75 m³/Wag)

Coal Consumption : **2,762 Mio t/a**
(2.4% of annual exploitation 1970)

Coal exploitation in Germany 1970 → **111 Mio t/a**

Introduction – Revolutions in Energy Providing Industry

Second Revolution in Energy supply beginning 21st century

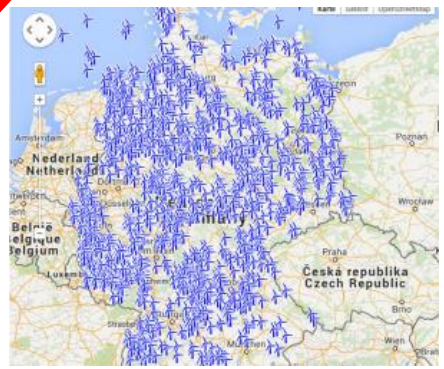
20th Century –
Fossil Fuel Based Power

KW Lünen / 12/2013 / 1 x 750 MWel

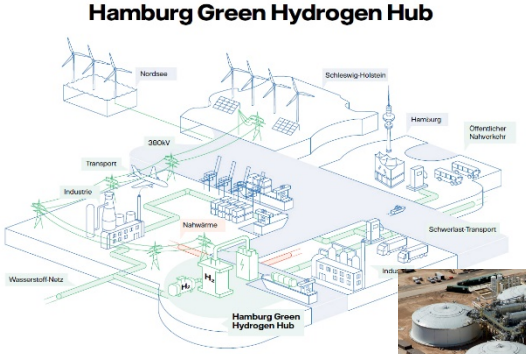
2015 → 2038 → 2050
Paris Klimaschutzvertrag

*
11.March 2011
Fukushima

21st Century
From fossil to **100% Sun Based Energy supply**



Commerzbank-Studie (2020):
Windkraft auf Expansionskurs



Wärme Hamburg (2021)

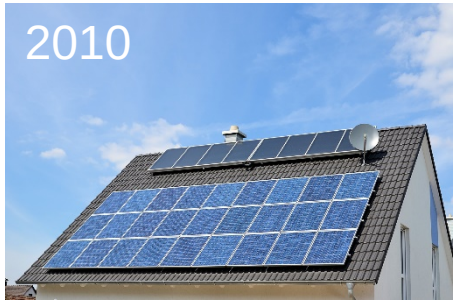
Solana CSP plant (US)

Sun Based Energy
Oil Crises 1973

Sonntags-
fahrverbot

Wikipedia

Kange Studio – stock.adobe.com



Umweltbundesamt

Solar PS10 Sevilla - Wikipedia

Wallenius Marine

Introduction – Revolutions in Energy Providing Industry

Second Revolution in Energy supply beginning 21st century

Example for illustration : 8 TWhel = 8000h operation of 1000 MWel Power Station (one year)

20th Century –
100% Hard Coal Based Power

Efficiency 46% (modern plant)
CO2-Emissions: 850 g CO2/kWhel
Source UBA 2017UBA 2017 - Daten und Fakten zu Braun- und Steinkohlen / https://www.volker-quaschning.de/datserv/CO2-spez/index.php

8 TWhel -> **6,9 Mill t CO2 per year**

100% German Power 2020 from Hard coal
→ **469 Mill t CO2 per Year (545 TWhel/a)**

Carbon footprint / Year (per person for living, food, heating, power, mobility)
2019/Germany 7,9 t CO2 per head
2018/China 6,8 t CO2 per head

21st Century - virtual 100% Onshore Wind Power

Utilisation	Efficiency	# 5MW Units*
50 % Direct consumption	100 %	400
20 % Battery	85 %	189
15 % HTS-Storage	45 %	267
15 % H2 Storage	25 %	480
Total Capacity		**1.336** -> 6.680 MW

*2.000 full load h/a / 29.715 Installed Onshore Wind Mills in Germany June 2021 with 55.772 MWel

Specific space consumption: ~30 m²/kW (wind park, 5MW mills, min. mill distance)
Source: Rotorblattspitze innerhalb oder außerhalb der Konzentrationszone: Welchen Einfluss hat dies auf den Flächenbedarf einer Windenergieanlage? Bernd Neddermann; DEWI – UL International GmbH, Wilhelmshaven, Eike Müller; Klimaschutzagentur Region Hannover GmbH, Hannover´, Juni 2015
Required area: ~ 200 km² ~ 28.000 soccer fields (Bundesland Bremen 419,4 km²)

Solar PV - Required space: ~200 km² (=20 000 hectare)
Required PV capacity: 13.360 MW (Full load hours/year: 1.000) // Specific space consumption: ~15 m²/kWpeak, ground-mounted PV

Germany 2020 : Power consumption = 545 TWhel (app. 23 %-total)
68 times 8 TWhel → **90848 windmills with total capacity 454 240 MWel**
→ **required area 1,36 Mio hectare** (8,2 % of German farmland)

Germany 2020
Final Energy = 2360 TWh / share of sun based 455TWh 19,3%
https://www.umweltbundesamt.de/themen/klima-energie/erneuerbare-energien/erneuerbare-energien-in-zahlen#uberblick

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III. Current & Future portfolio for new Energy Infrastructure

IV. Summary

Steinmüller Engineering Business Areas in the recent past

Engineering & Supply for conventional fuels power stations

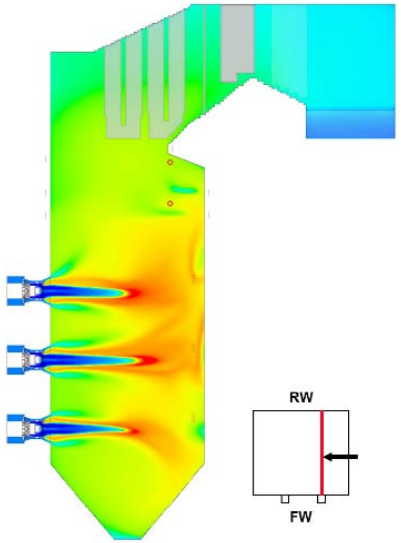
Dual-Fuel

RSM

SM V

- **Combustion Systems**
  - CFD calculation
  - Basic & Detail
  - Manufacturing
  - QA/QC
  - Erection advisory
  - Commissioning

- Type of work
  - Revamp
  - Upgrade
  - Modernization
  - Rehabilitation
  - Co-firing
  - Fuel conversion



Hard Coal

Lignite

Peat

Biomass

Oil

Gas

Substitute Fuels

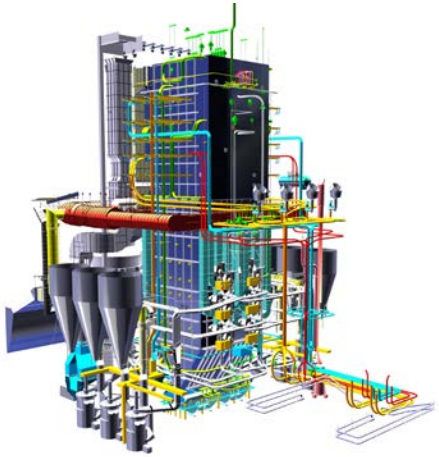
Steinmüller Engineering Business Areas in the recent past

Engineering & Supply for power stations and utility boiler

➢ **Flue Gas Cleaning**
- Selective Catalytic Reduction
- Selective Non Catalytic Reduction
- Fabric Filters
- Electrostatic Precipitators
- Wet FGD
- Semi Dry FGD
- Dry FGD

➢ **Engineering Services and Supplies**
- Concept Engineering
- Engineering & Supplies
- Process Design
- Mechanical Design
- CFD Simulation

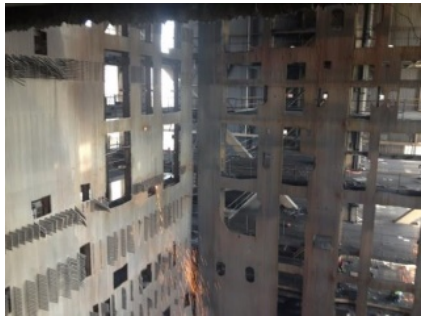
➢ **Steam Generation**
- All fuels
  - PF fired
  - CFB
  - Grate firing
- All boiler types
  - Tower-type
  - 2-pass
  - Multi-pass
- All parameters
  - Sub-critical
  - Super-critical
  - Ultrasuper-critical
- Chemical plant components
  - Process gas cooler
  - Ammonia
  - Waste heat boiler
  - Nitric acid
  - Caprolactam
  - HCN
  - Syngas cooler

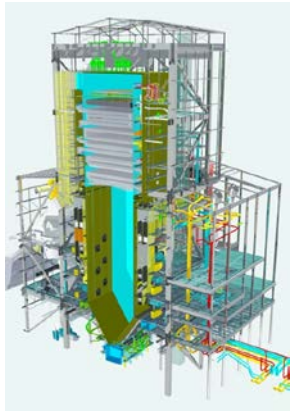


Steinmüller Engineering Business Areas in the recent past

Engineering projects for power stations

Site:	**PS Duvha Unit 3 (600 MW)**
Client:	Eskom (RSA) Bit. coal, designed in 1970s
Task:	Total re-engineering of the boiler (like-for-like) Reduction of NOx emissions
Scope:	Basic & Detail Engineering for: - Demolition concept - Pressure parts with modifications - Ducting - Firing system with new low NOx burners - PF piping - Main, primary & secondary steel structure - Steam piping & low pressure service Technical guarantees for NOx/CO emissions
Share:	Engineering Service 100%
Finalized:	**12/2019**

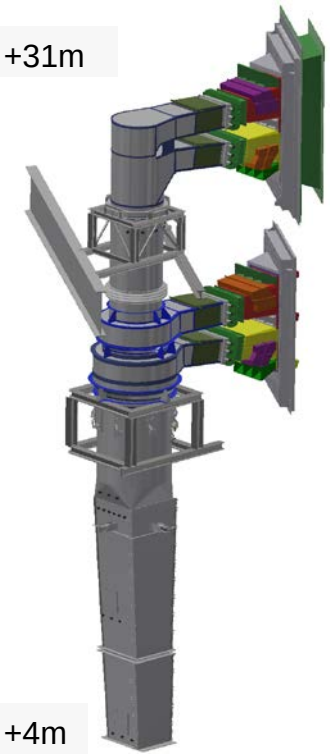




Site:	**TPP Stanari BiH (300 MW)**
Client:	EFT (Denmark/Serbia) Lignite, new-build
Task:	Owner‘s Engineer for a 300 MW CFB boiler
Scope:	- Design Review - Review of all technical documents of the EPC-contractor - Specification of quality assurance company - Review of quality manufacturing book - Workshop inspections - Witness of factory acceptance tests - Supervision of quality assurance on-site - Supervision during erection phase - Supervision during commissioning phase - Supervision during acceptance test
Share:	Engineering & Consulting Service 100%
Finalized:	**09/2016 (COD 2 month ahead schedule)**

Steinmüller Engineering Business Areas in the recent past

EP & EPC projects to meet emission levels



Site:	**PS Weisweiler unit G (600 MW)**
Client:	RWE Power AG Lignite, operated since: 1974
Task:	Implementation of BAT (EU-BREF), Reduction of NOx emissions
Scope:	Concept study, Basic and detail engineering, supply: - Low NOx Burner - Secondary air ducts - PF ducts erection & commissioning advisor Technical guarantees for NOx/CO emissions
Share:	Engineering 17%/ Supply 83%
Finalized:	**12/2020**

Site:	**PS Weisweiler unit H (600 MW)**
Scope:	see unit G
Status:	delivered, erection starts 10/2021

Site:	**PS Lippendorf unit R (933 MW)**
Client:	LEAG Lausitz Energie Kraftwerke AG Lignite
Task:	Implementation of BREF for SOx Conversion of the sump to agitator gassing Installation of additional tray level
Scope:	Approval engineering support Basic and Detail engineering FGC and auxiliaries Manufacturing and supply Erection and commissioning Technical guarantees for SOx emissions
Share:	Engineering 11%/ Supply 89%
Finalized:	**Block R Juli 2020**

Site:	**PS Lippendorf unit S (933 MW)**
Scope:	see unit R
Status:	delivered, trial operation 09/2021

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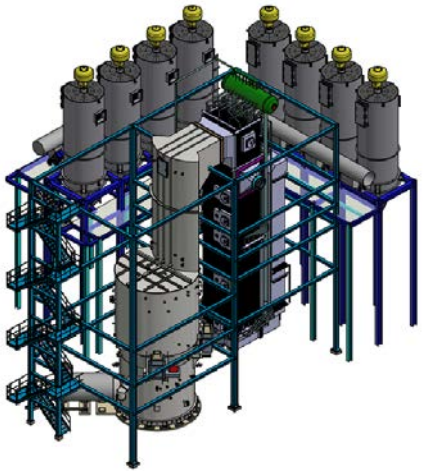
Current & Future portfolio for new Energy Infrastructure

EPC or EP execution & Consulting solutions

- **Combustion & Incineration**
  - Biomass, residues, coal-2-gas, co-combustion
  - Sewage sludge, waste



- **Air Pollution Control**
  - Industrial and Waste incineration
  - Dry and wet systems

- **Heat Exchanger**
  - Industrial application for waste heat recovery

- **High Temperature Energy Storage**
  - Molten salt, fixed bed (solids)

- **Consulting**
  - New system solution & Digital services

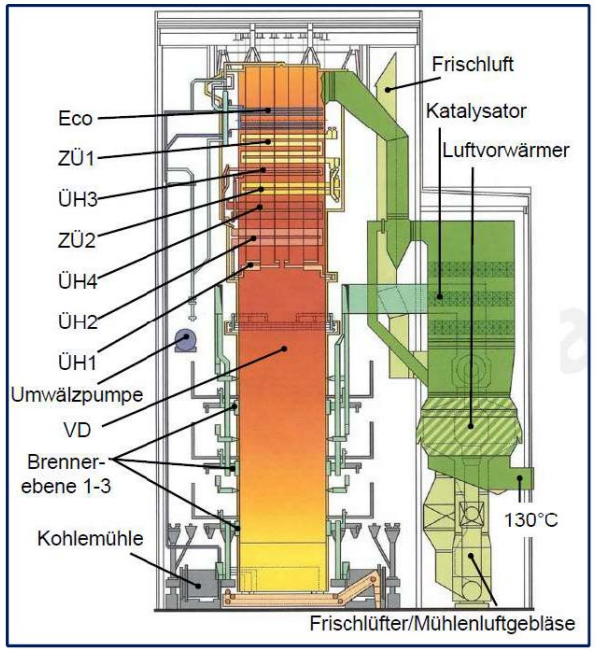
Current & Future portfolio for new Energy Infrastructure

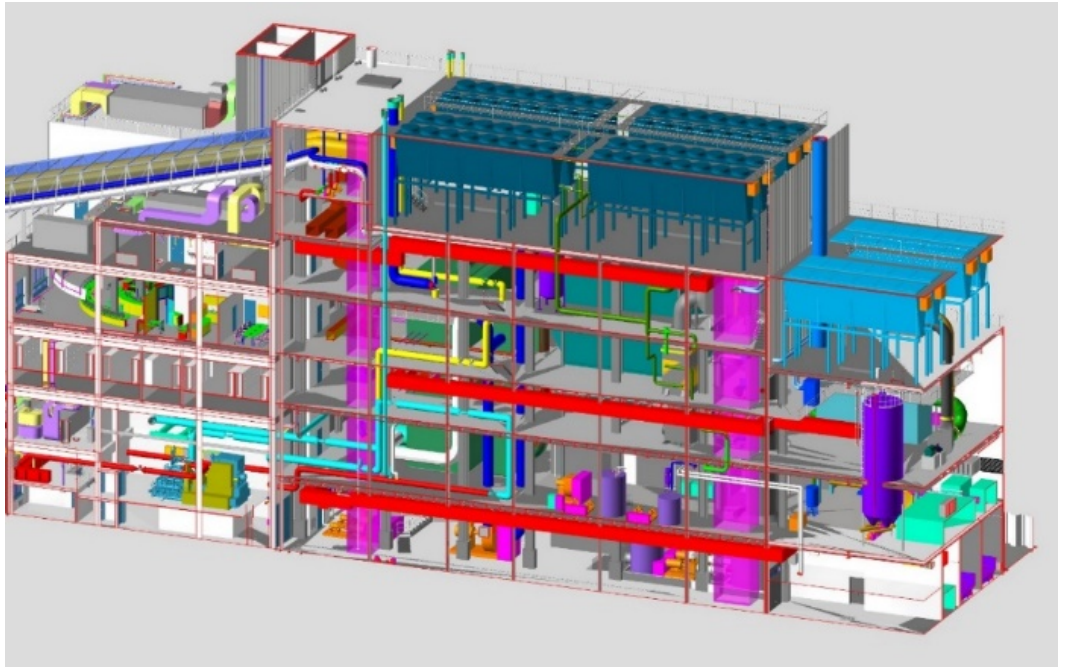
EP & EPC projects to serve future market demand

Coal-to Gas Conversion (Order status)

Site: **Herne 4 (510 MWel)**
Client: STEAG Energy

Task: Conversion from coal to gas firing
Scope: Basic and Detail engineering
Conversion firing system to natural gas
Conversion W/S-circuit to pure district heating operation, Adaption of DCS system
Erection and commissioning





Sewage Sludge Incineration (Offer status)

Site: **Germany (4,5 t/h DS)**

Task: EPC sewage sludge incineration plant
Scope: Sludge reception, -storage, -transport, -drying
incinerator, steam generator, BoP, Steam turbine,
Air pollution control, Auxiliaries, El., I&C, DCS
incl. control room, Boiler house steelwork
Technical building equipment
Erection and commissioning

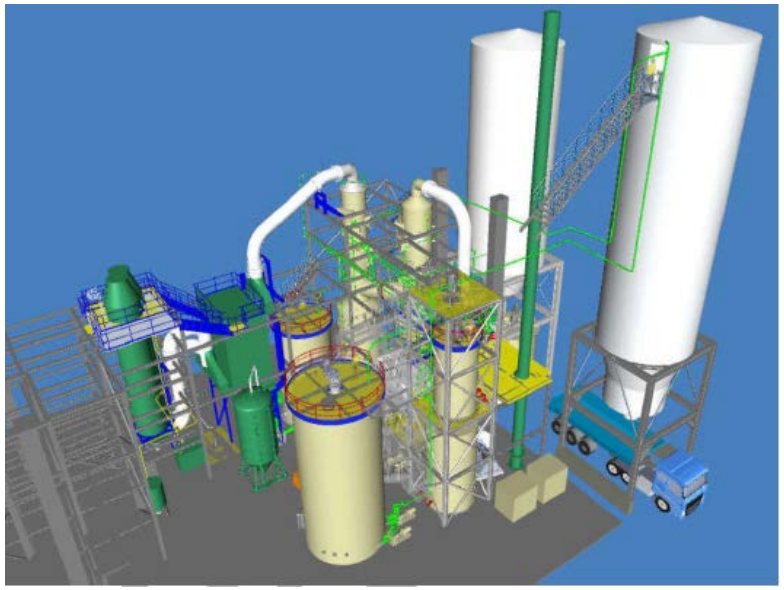
Current & Future portfolio for new Energy Infrastructure

EP & EPC execution to serve future market demand

APC-wet behind industrial furnace process (Order status)

Site: **Benelux**

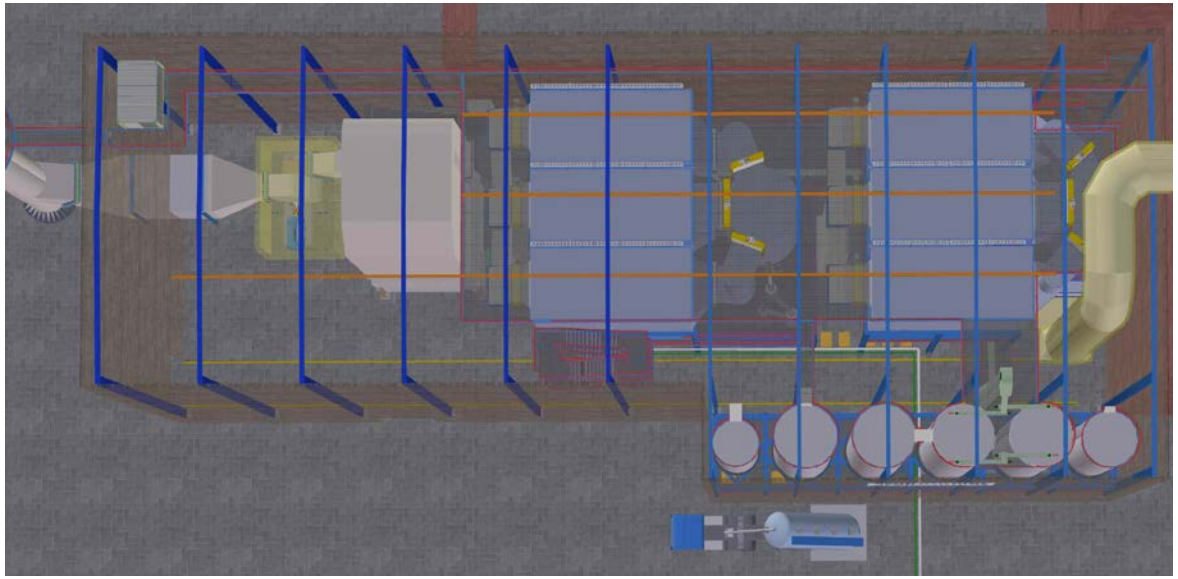
Task: EPC flue gas cleaning lot
Scope: Basic and detail engineering
Supply of spray cooler, activated carbon system, bag filter, 2-stage SO_2 scrubber, wet ESP,
Gypsum production,
Electrical and instrumentation
Erection and commissioning



APC-double dry with SCR-DeNOx behind combined waste and sewage sludge incineration (Offer status)

Site: **Germany 40 t/h waste + 1.84 t/h DS**

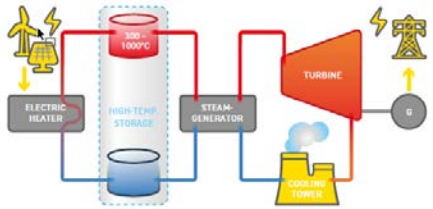
Task: EPC flue gas cleaning
Scope: Basis and Detail engineering
1st stage streaming reactor, fabric filter, recirculation
2nd stage CFB reactor, fabric filter, recirculation
CFB dry lime slaking installation, Tail end SCR DeNOx
heat extraction, erection and commissioning



Current & Future portfolio for new Energy Infrastructure

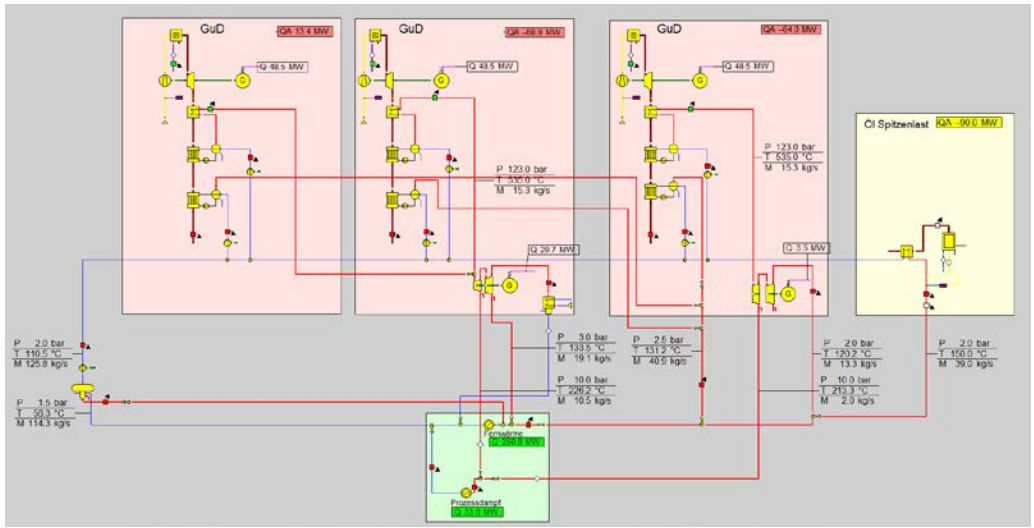
Engineering & Consulting to provide new system solutions

- **Engineering & Consulting**
  - Owners engineer
  - Engineering service
  - Plant flexibility
  - Feasibility studies
  - Life-time extension
  - Root cause analysis
  - Cost optimization
  - Relocation
  - Heat recovery
  - Power & Heat storage



- **Services**
  - Mercury Monitoring
  - 3-D-Scan
  - Digital Twin
  - Wireless Data Collection

- **Example: Replacement systems für CHP plants**
  - Technical consideration of CHP coal replacement options by gas turbine
  - Modeling of the CHP coal replacement plant
  - Modeling of heat load profile / annual cycle calculation
  - Cost analysis based on annual cycle calculation
  - Integration of waste heat/ thermal heat storage in CHP plants
  - Integration of high temperature storage



Current & Future portfolio for new Energy Infrastructure

Energy Storage Systems – Storage Need

Study on energy storage – Contribution to the security of the electricity supply in Europe

Final Report March 2020

Baseline: Recently agreed policies
1.5C: Keeping temp increase < 1.5C

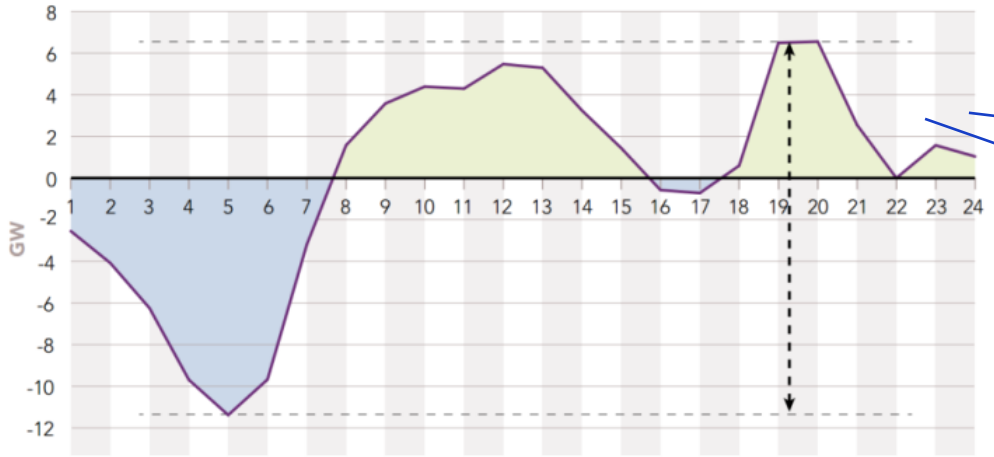


Figure 14 - Illustration of daily flexibility needs (the solid purple line measures the deviation of the residual load from its daily average for a given day). Source: RTE, Bilan prévisionnel de l'équilibre offre-demande, 2015

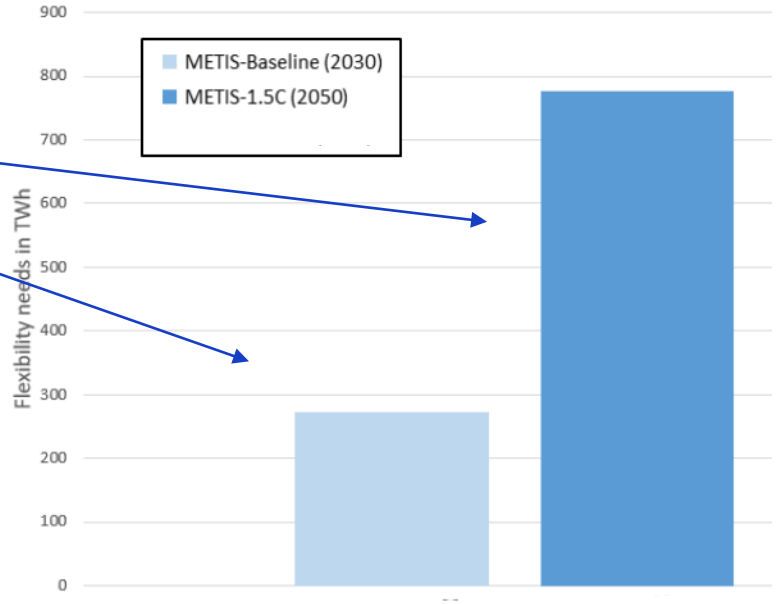


Figure 16 - Daily flexibility needs at EU28 level

Flexibility Need/year	~800 TWh_e/a (2050)
Flexibility Need/day	~2.200 GWh_e/d
Flexibility Need/day for Heat Storage Plant (HSP)	**~1.470 GWh_{th}/d** (30% share, 45% efficiency)

1000 MWel for 6 hours -> Storage 13 GWh_{th} -> 220.000 t Checker Brigs

Overall huge potential in Europe for energy storage in the upcoming years

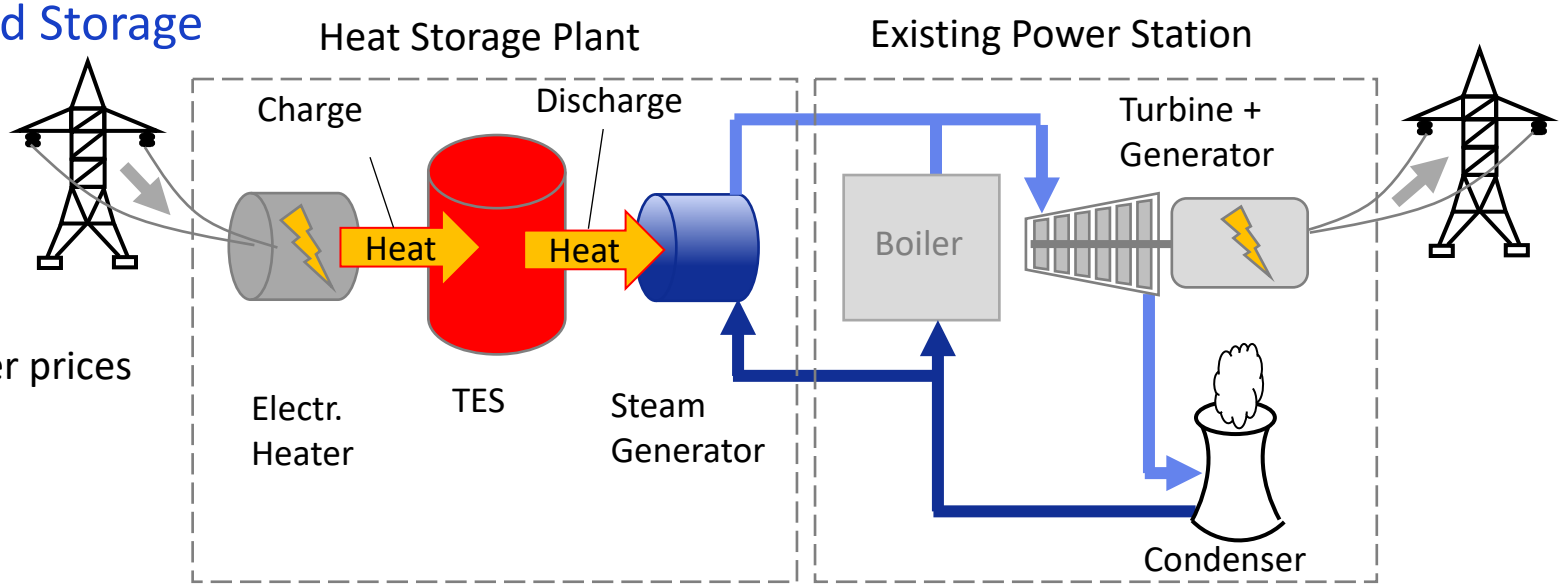
Current & Future portfolio for new Energy Infrastructure

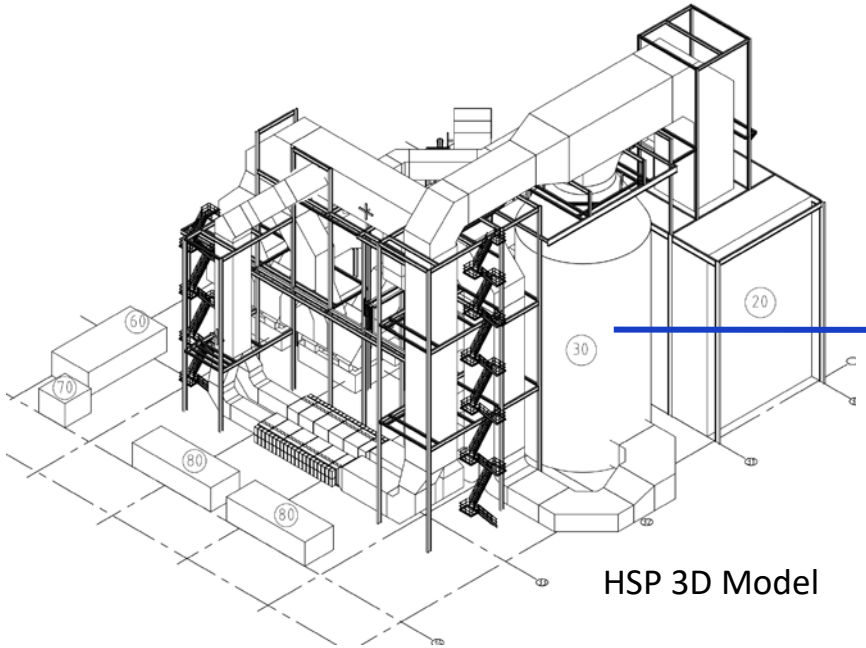
Heat Storage Plant (HSP) - Fixed Bed Storage

RWE

StoreToPower Study

- 2nd Life of Coal fired PS
- Charge: Surplus RE power stored as heat
- Discharge: Power generated at good power prices
- Steam parameters: 600/605°C, 270 bar
- Capacity: 500MWh
- Storage Medium: Checker Bricks





HSP 3D Model

Hot Stove Blast Concept, Source : Paul Wurth

Checker Bricks

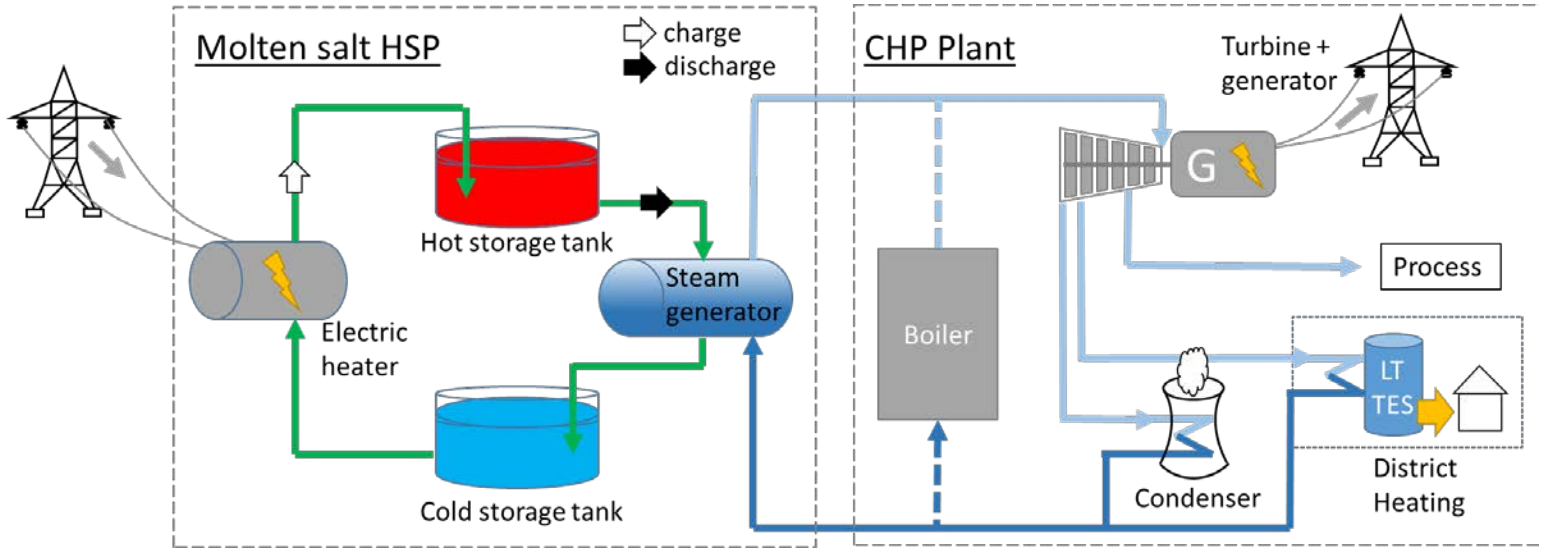
Current & Future portfolio for new Energy Infrastructure

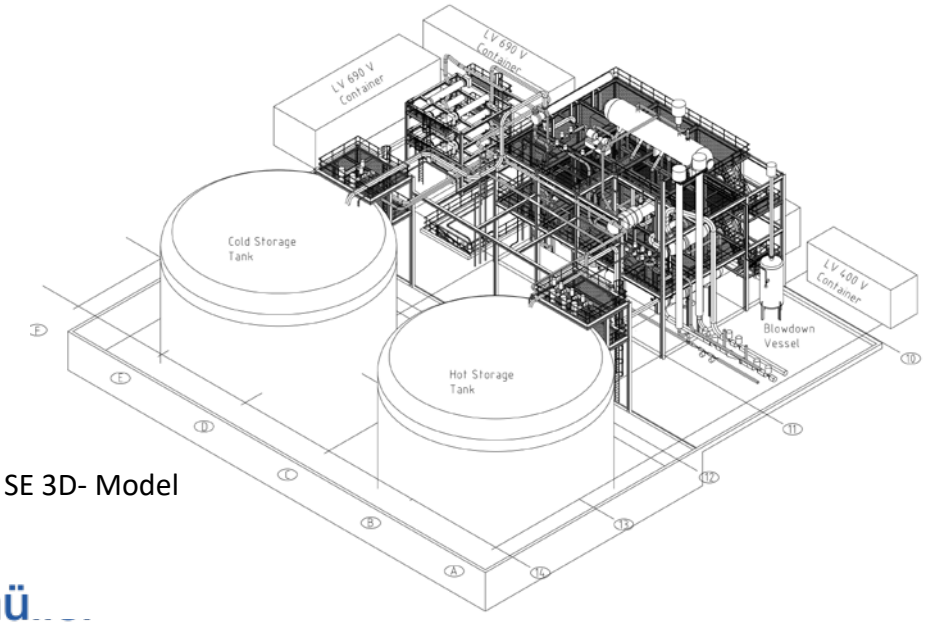
Molten Salt Storage Plant

IHI GROUP

Molten Salt HSP Study

- Surplus RE power stored as heat
- Discharge: Power generation, process and district heat
- Steam parameters: 525°C/170 bar; 210°C/16bar; 120°C/10 bar
- Capacity 500 MWh
- Storage Medium: Molten Salt





SE 3D- Model

Source: Solana CSP plant (US), Caldwell Tanks

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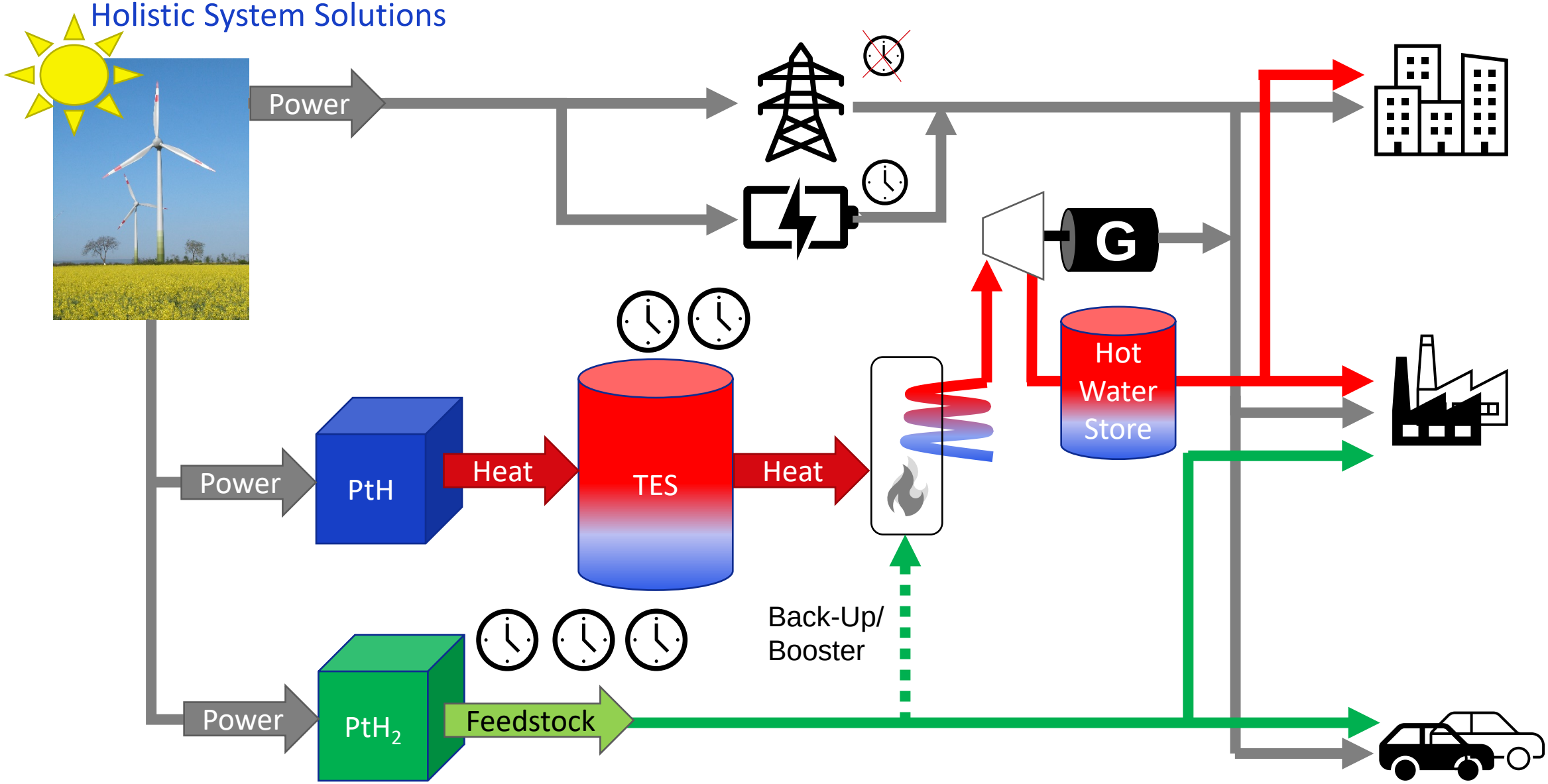
Current & Future portfolio for new Energy Infrastructure

Storage Systems Comparison

		Battery	Hydrogen + HtP	Carnot Battery
General	Ressources	- -	-	+ +
	Lifetime	o	+	+ +
	Development Level	+	o	+ +
	Pick Load	o	-	+
Power **to Power**	Efficiency	+ +	- -	o
	Economics	+	-	+
	Storage Duration	Shortterm (2-4h)	Longterm	Midterm (6-36h)
Power **to Heat**	Efficiency	o	-	+ +
	Economics	-	-	+ +
	Storage Duration	Shortterm (2-4h)	Longterm	Midterm (6-36h)

Current & Future portfolio for new Energy Infrastructure

Holistic System Solutions



Summary

- **Extensive restructuring of Energy Infrastructure is required**
- **Political decisions are crucial for development of new Energy Infrastructure**
- **Large challenge for transformation of operating and supply companies**
- **Development of complex new concepts for specific situations**
- **Storage solutions and their further development are essential for the successful transformation of the Energy Sector**