SteamH (A-USC)

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A Digital Industrial Company

~300,000 people operating in ~180 countries

POWER | AVIATION | RENEWABLE ENERGY | BAKER HUGHES GE | HEALTHCARE | TRANS. | LIGHTING | CAPITAL | DIGITAL

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We are GE Power

Providing technology, solutions and services across the entire electricity value chain from the point of generation to consumption.

STEAM POWER SYSTEMS

GAS POWER SYSTEMS

POWER SERVICES

ENERGY CONNECTIONS

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Future of Coal Power Generation

Using the right mix of technologies that are smarter, cleaner and more sustainable.

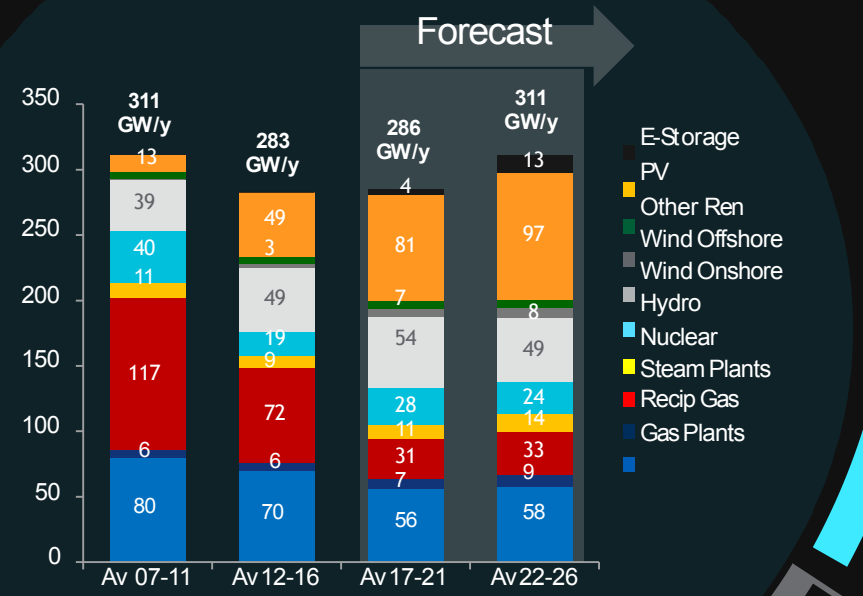
TODAY

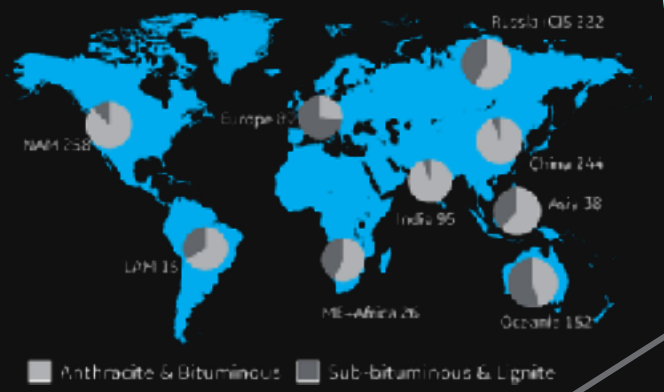
Today, 40% of the world's electricity is produced from coal and we predict that amount will decrease only slightly to 30% over the next decade.

FUTURE

The reality is that many countries have huge energy needs that, because of economic and local resource dynamics, will need stable energy that can be supplied by coal.

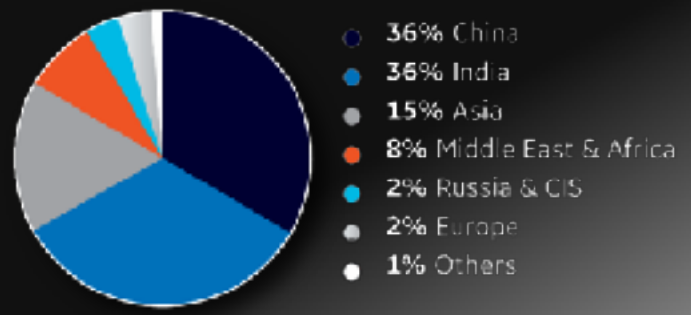
10 Year Orders Forecast by Plant Type





GLOBAL COAL RESERVES

Note: Reserve figures in billion tons



COAL FORECAST DEMAND OVER THE NEXT DECADE

With nearly 900 billion tons of reserves, coal remains a self-sufficient and affordable means to produce power and provide energy security. This includes using coal as a source of ancillary power in response to intermittent renewable energy sources.

RESOURCES

GE continues to push the limits of our best-in-class steam technology even further. As the economics of power generation have become tighter and regulations become even stricter, GE's technology is ready to respond to growing demands.

GE DIFFERENCE

Our goal is to help countries meet their energy and economic development goals given their local needs. In most countries, this requires an energy mix that includes renewables, gas and coal power generation.

ENERGY MIX

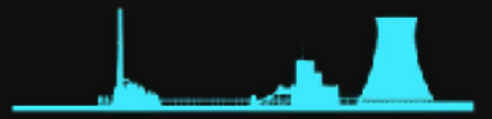
Raising the Bar on Cleaner Coal

Meeting & exceeding the highest industry standards and regulations

GE plants surpasses the benchmarks set by OECD for pressure, temperature & emissions requirements, delivering higher efficiency coal plants with less impact on the environment. See below how this baseline USC plant compares to plants using GE's USC technology.

Baseline USC (OECD Guidelines)
PRESSURE (bar).....240
MAIN STEAM TEMP (C).....593
REHEAT STEAM TEMP (C).....593

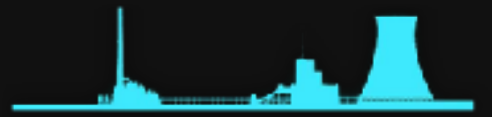
Tanjung Bin 4 1000MW



PRESSURE (bar).....270
MAIN STEAM TEMP (C).....595
REHEAT STEAM TEMP (C).....605
EFFICIENCY INCREASE (% pts).....1.07

2016 Operation

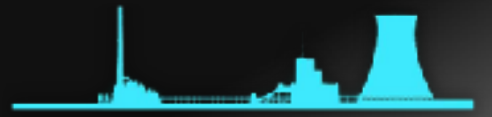
Hassyan 2400MW



PRESSURE (bar).....280
MAIN STEAM TEMP (C).....600
REHEAT STEAM TEMP (C).....610
EFFICIENCY INCREASE (% pts).....1.57

2020 Operation expected to begin

Opole 1800MW



PRESSURE (bar).....250
MAIN STEAM TEMP(C).....600
REHEAT STEAM TEMP (C).....610
EFFICIENCY INCREASE (% pts).....0.82

2018 Operation expected to begin

RDK8 900MW

PRESSURE (bar).....270
MAIN STEAM TEMP(C).....600
REHEAT STEAM TEMP (C).....620
EFFICIENCY INCREASE (% pts).....1.60

2014 Operation

The GE Difference

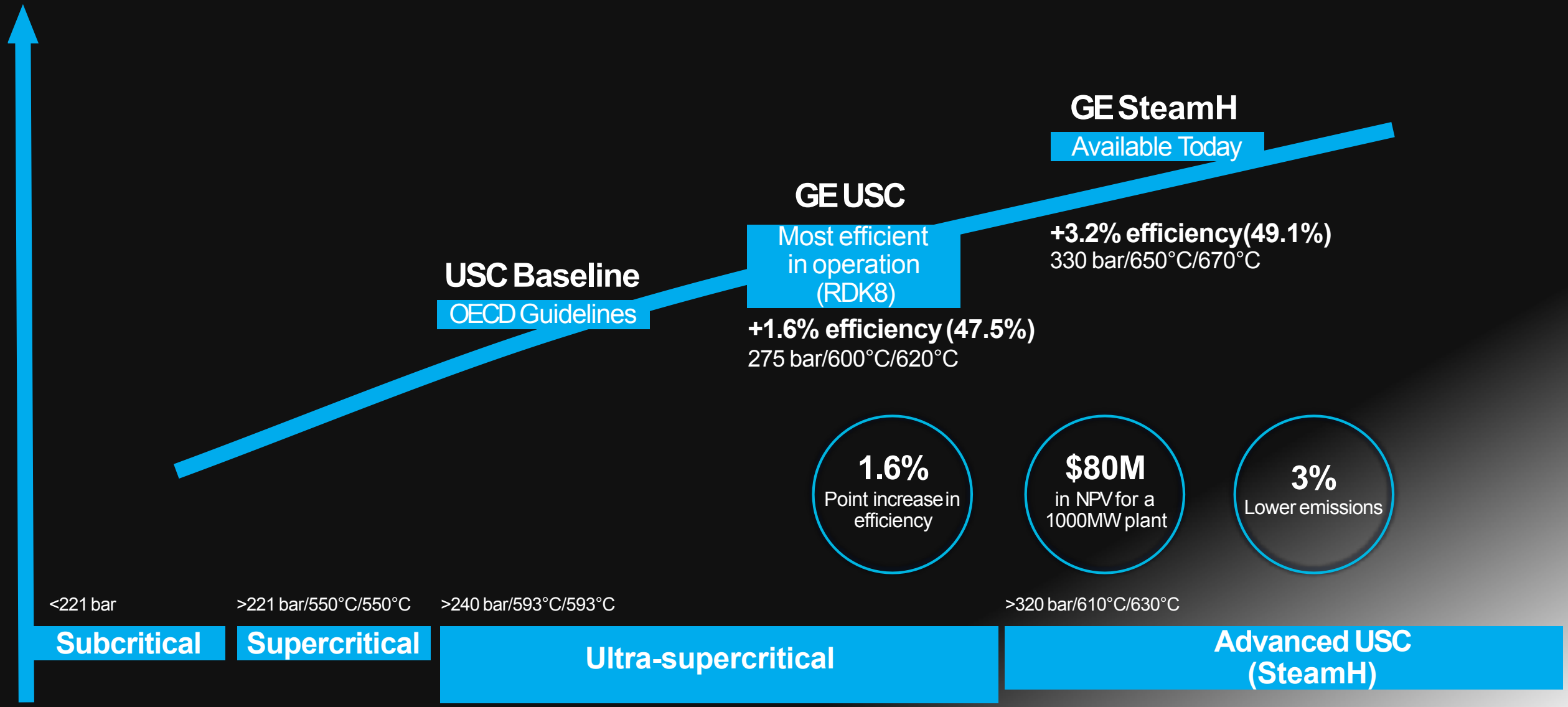
1.25%pts
better efficiency than OECD standard

950,000 tons
CO_2 reduction per year

500,000
cars off the road

Technology Advancements

Leading efficiency, lower emissions and better economics.



SteamH (A-USC)…

What is it?

- 660MW to 1,100MW plant at 330bar/650 ºC/670 ºC max conditions
- 1.6% pts better than today's best; 49.1% @ RDK8 conditions
- Based on the proven USC design with key components upgraded
- In 2017 SPS Product Catalog …engaging with customers & others

How did we get here?

- GER/EU & US programs since late 1990s …GE (ALSTOM) participated
- Extensive testing …boiler & piping (HR6W)>30,000h, ST (A625)>20,000h
- Identified key components …headers, steam piping & STHP/IP
- Recognized better economics & easier customer acceptance at 650 ºC

…able to deliver to a customer with the same level of confidence as USC

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Operating USC Power plants

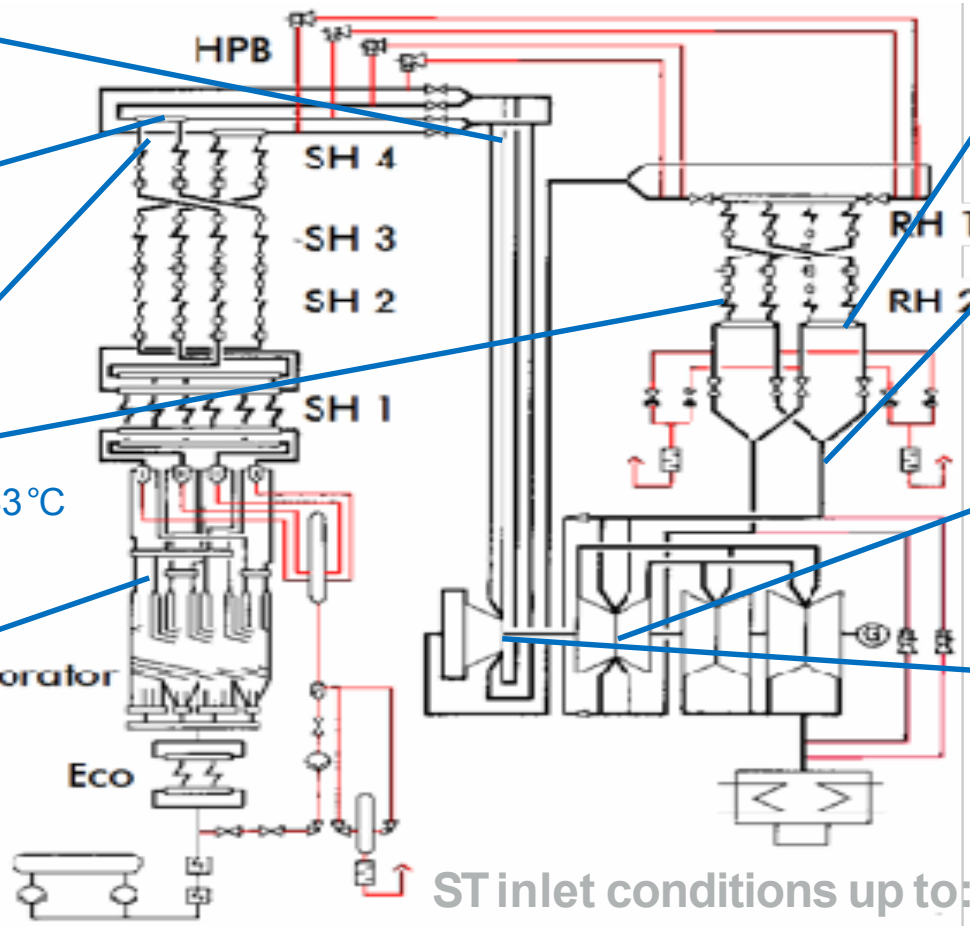
Material selection

LS Piping
315 bar/605°C
P92

SHO Header
315 bar/605°C
P92

SH/RH Tubes
315 bar/605°C, 63 bar/633 °C
Stainless steels

Membrane wall
335 bar/480°C
T23/T24



RHO Header
63 bar/633°C
P92

HRH piping
63 bar/633°C
P92

IP ST Inlet
60 bar/630°C
FB2/CB2

HP ST Inlet
300 bar/600°C
FB2/CB2

ST inlet conditions up to: 320 bar/600°C/630°C

P92 & FB2/CB2 were the bottlenecks for steam parameters increase

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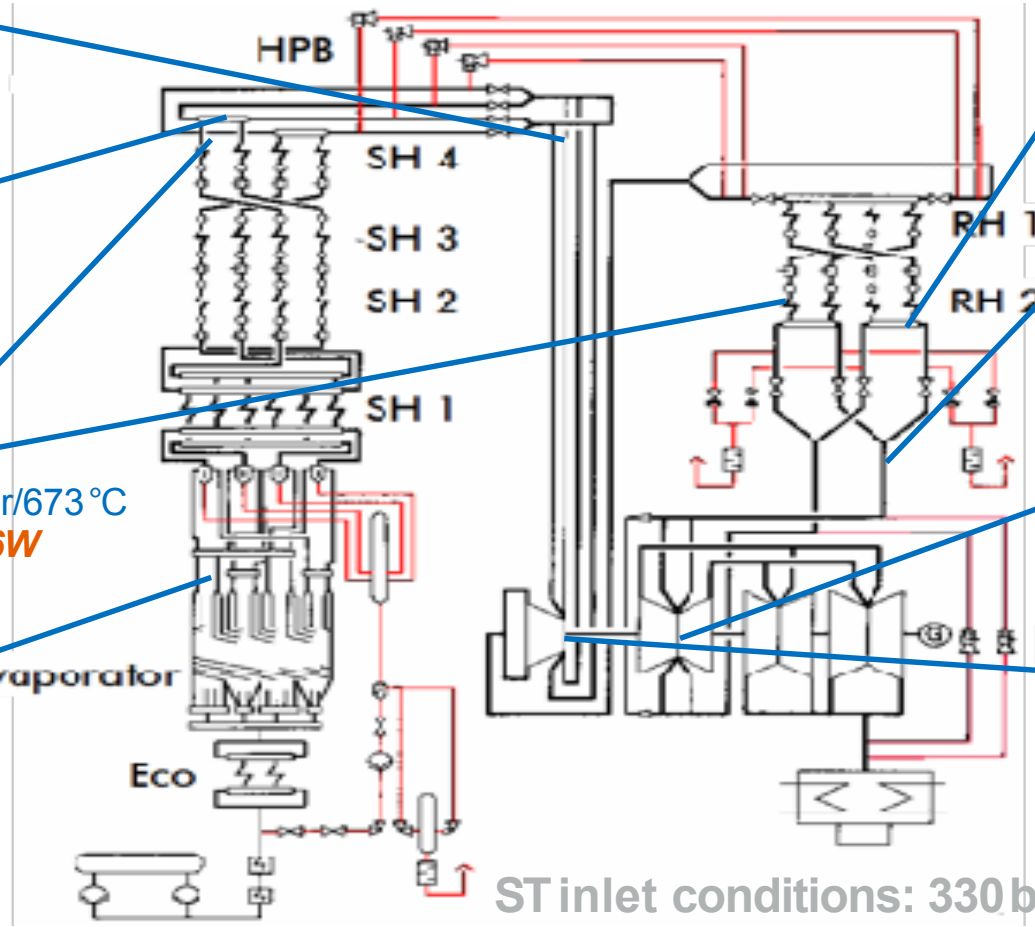
SteamH Power plant
Material selection

LS Piping
345 bar/655°C
HR6W

SHO Header
345 bar/655°C
HR6W

SH/RH Tubes
345 bar/655°C, 74 bar/673 °C
Stainless steels/HR6W

Membrane wall
365 bar/500°C
T23/T24



RHO Header
74 bar/673°C
HR6W

HRH piping
74 bar/673°C
HR6W

IP ST Inlet
70 bar/670°C
A617(F)/A625(C)

HP ST Inlet
330 bar/650°C
A617(F)/A625(C)

ST inlet conditions: 330 bar/650°C/670°C

HR6W & A617/A625 for boiler outlet headers & LS piping are the material enablers

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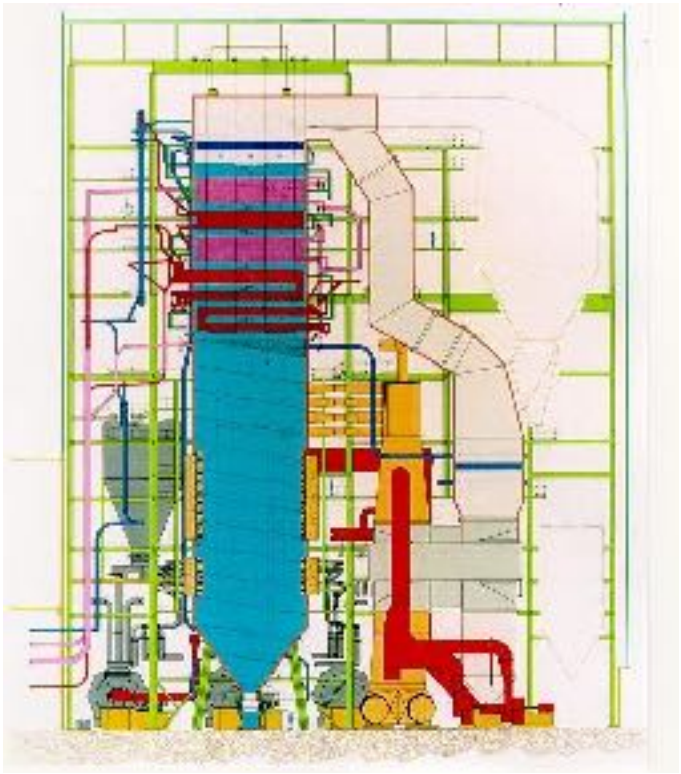
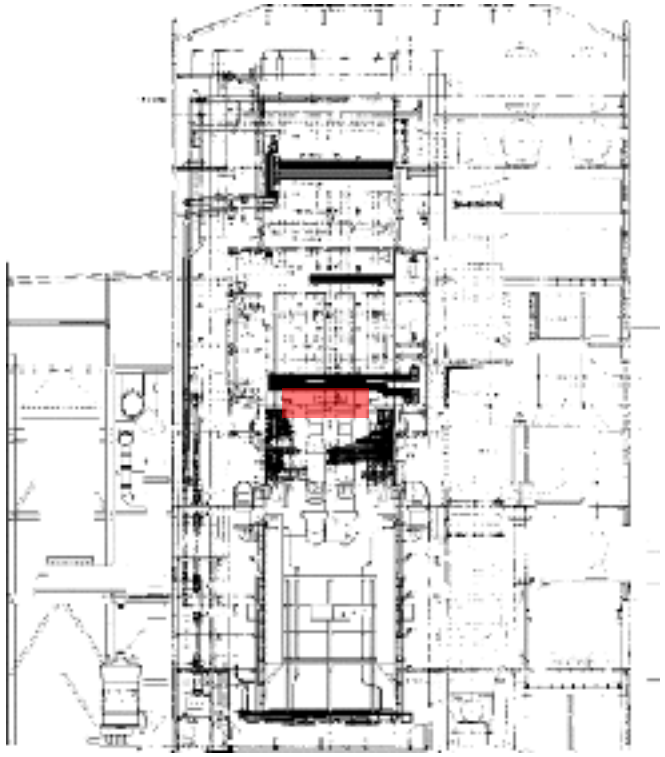
HR6W Operating experience

Esbjerg Phase 4 720°C



Operation hours 32,000h

GKM HWT I 725°C



Operation hours up to 15,000h

- Range of tested operation temperature for HR6W 630 °C– 690 °C
- Typical SH/RH tube dimensions

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HR6W Operating experience ..details

Program	Test Type	Steam Parameters	No. of Samples	Sample Dimensions	Test Duration (hrs)
Esbjerg Phase 4	Test loop	640C – 675C	4	38 OD. 8.8WT	32,000
GKM HWT 1	Test loop	630C – 690C	8	38 OD. 8.8WT	5,000 – 15,000
GE Testing	Weld creep test: HR6W with HR6W weld filler	625C 650C 700C	24	Samples taken from pipes 220 OD. 50WT 216 OD. 38WT	3,000 ongoing. Since October 2016

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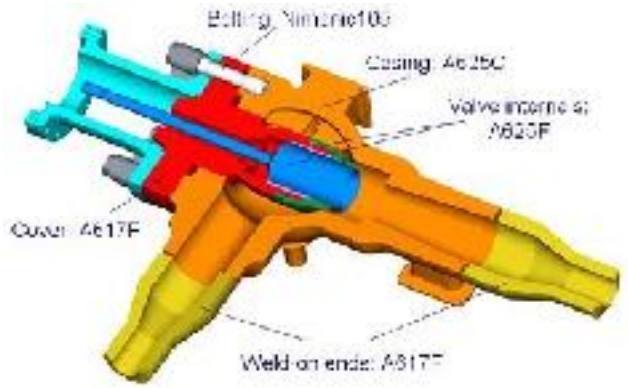
Alloy625 Operating experience

- 700°C Valve Service Demonstration COMTES700 project
- **Alloy 625** casting for valve chest
- Successful demonstration of a full-scale steam turbine valve for service at 700 °C at Scholven F Power Station in Germany between 2005 to 2009
- Total Run time ~21,000 h; Run time at 700 °C ~10,000 h



Full scale operation under life conditions

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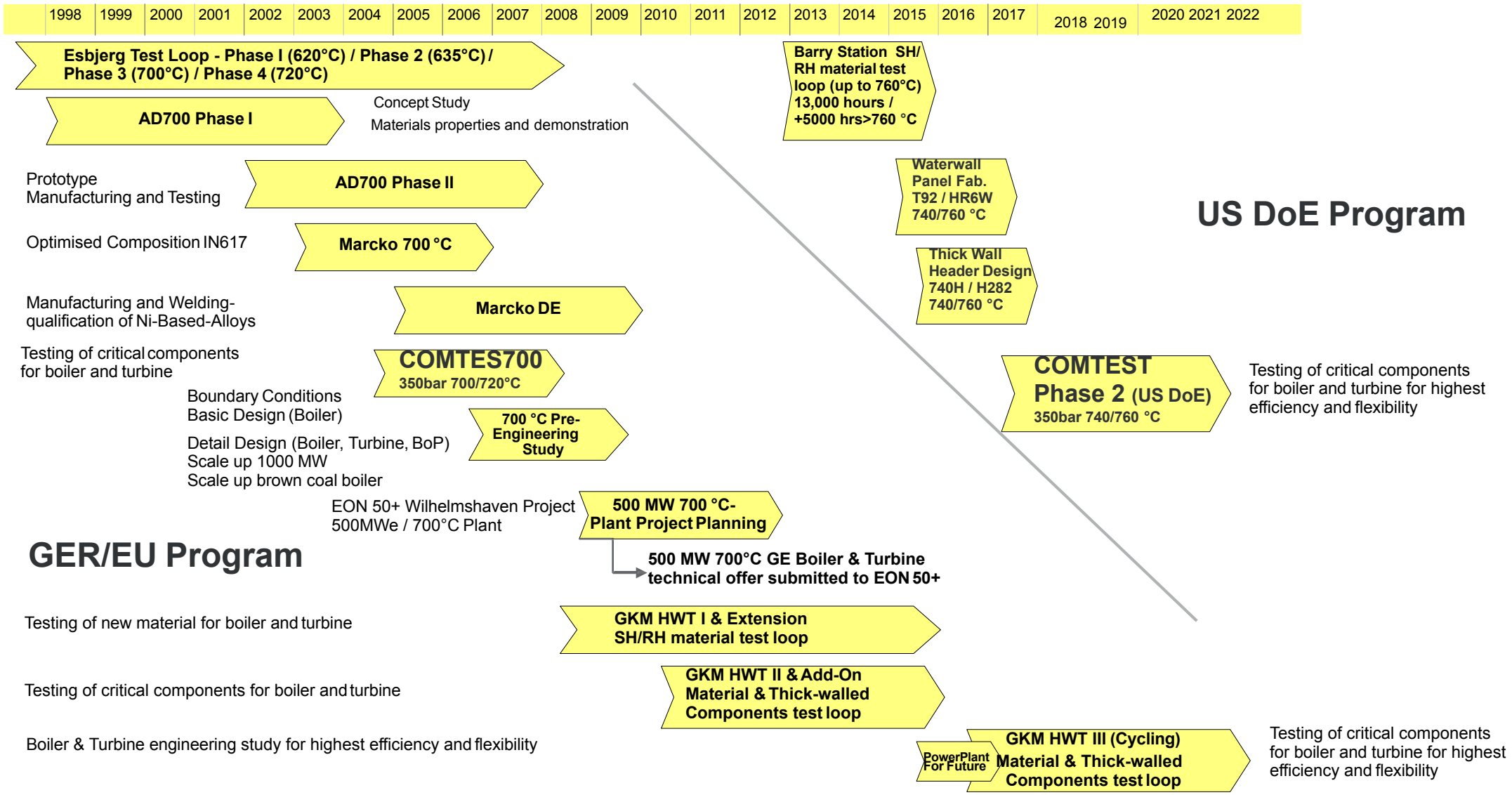
GE participating in major GER/EU & US programs



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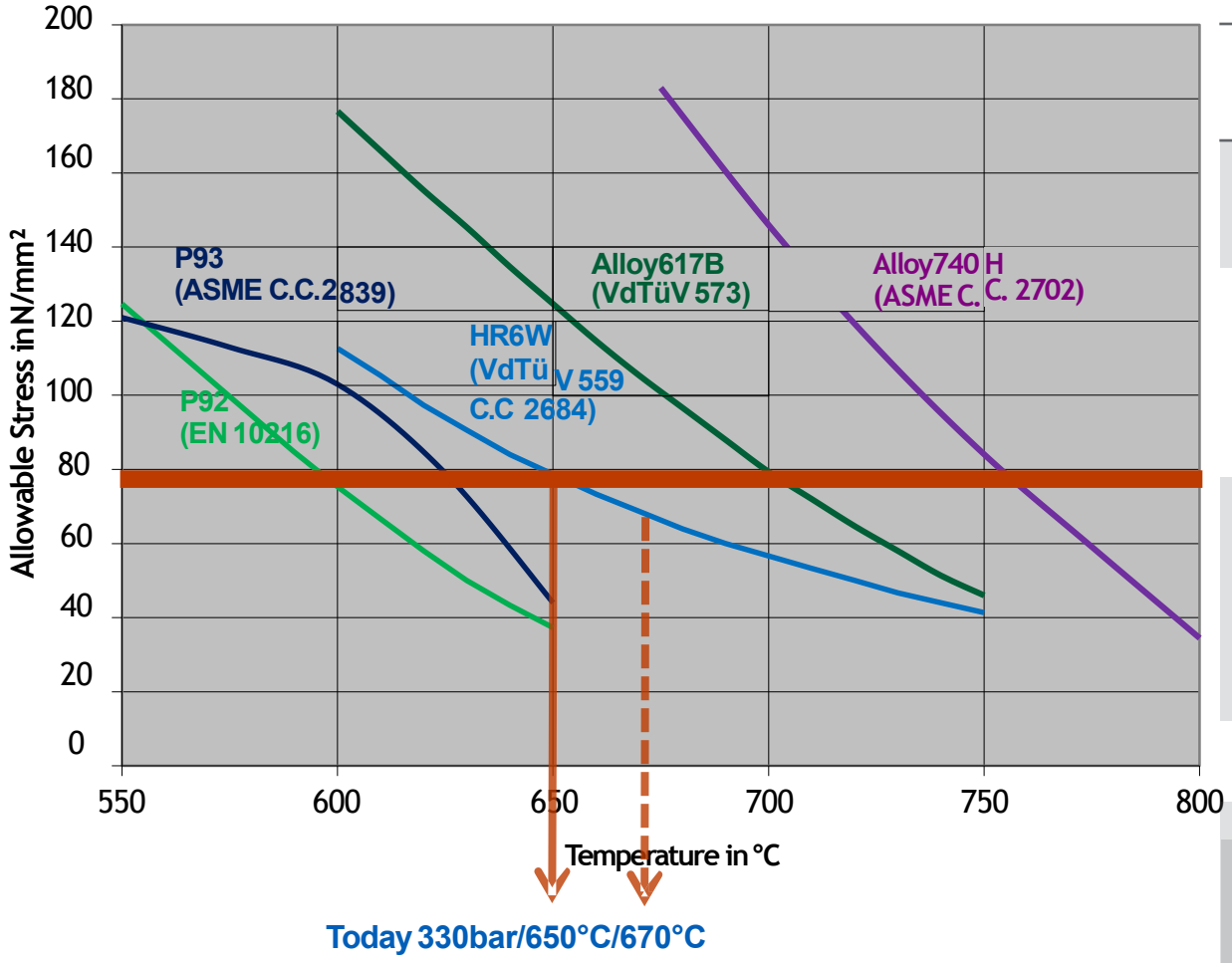
Piping & headers material selection

HR6W selected for best fit at 650°C/670°C



Material	Development Status	Benefits
P92	Qualified	▪ State-of-the-art 9% Cr-steel ▪ Used in all USC power plants
P93 & MarBN	▪ Base materials developed ▪ Further qualifications needed	▪ New 9% Cr-steel with higher creep strength than P92 ▪ Potential to save piping/header costs for USC power plants
HR6W	▪ Base materials developed ▪ Further qualifications needed	▪ High creep strength Ni-Fe alloy, which allows to move to higher steam conditions at 330 bar/ 650°C/670°C @ST inlet ▪ Easier fabrication & cheaper than Ni-Co alloys
A617B	Qualified	▪ High creep strength Ni-Co alloy, which allows to move to higher steam conditions above 350bar/700°C/720°C @ST inlet
A740H	▪ Base materials developed ▪ Further qualifications needed	

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HRW6 & Ni617 Codes and standard

Code cases on track . . status October 2017

Grade		Boiler Pressure and Vessel Code	Piping Code	Seamless Pipe and Tube	Forge/Valves	GTAW Welding Material	SMAW Welding Material
HR6W (UNS N06674 /-)	ASME	CC 2684-3 (2014-11 / 800°C max)	CC Q4 2018 or PMA	ASTM B167 – R2016	ASME SB-564 : N06674	Available not code driven	
	EN	VdTÜV 559/2 12.2012	VdTÜV 559/2 12.2012	VdTÜV 559/2 12.2012	CC Q4 2018 or PMA		
Ni617B (UNS N06617 / 2.4673)	ASME	ASME II Part D	ASME B31.1 (760°C max)	ASME SB 167 : N06617	ASME SB 564 : N06617	ASME II Part C. A5.14: ERNiCrCoMo 1	ASME II Part C. A5.11: ENiCrCoMo 1
	EN	*EN 13445-10:2015 : only 2.4663(Ni617)*	*VdTÜV 573*	*VdTÜV 573*	PMA	EN ISO 18274:2010: S Ni6617	EN ISO 14172:2015 Ni 6117

Ongoing HR6W codes development, ready for the first A-USC Plant

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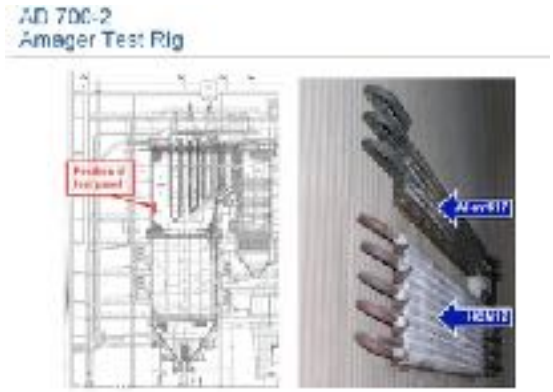
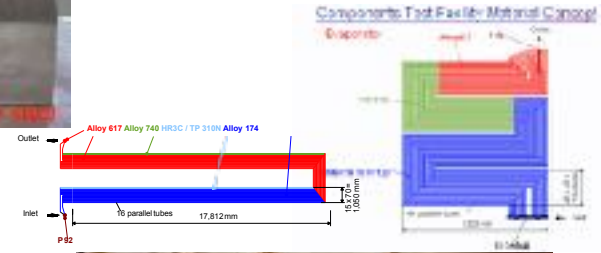
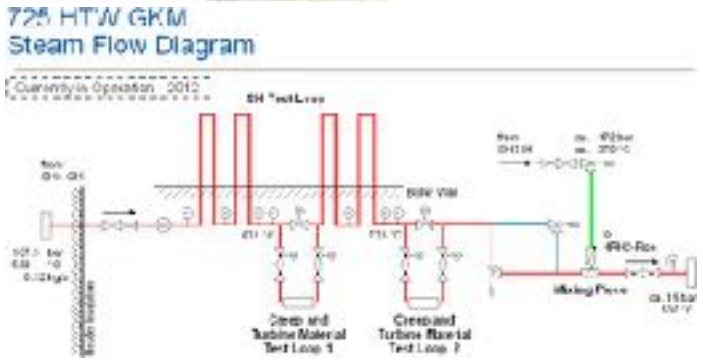
Material development programs &manufacturing trials







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SteamH (A-USC) Power plant

- The highest customer value coal fired plant
- Best power plant system design
- Well defined interfaces for fast and predictable construction
- Plant designs across a broad range of capacity & configurations

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