14th Annual Southern African Coal Conference

Clean Coal Technologies – Supercritical & Ultrasupercritical Technologies, Upgrades & Retrofits

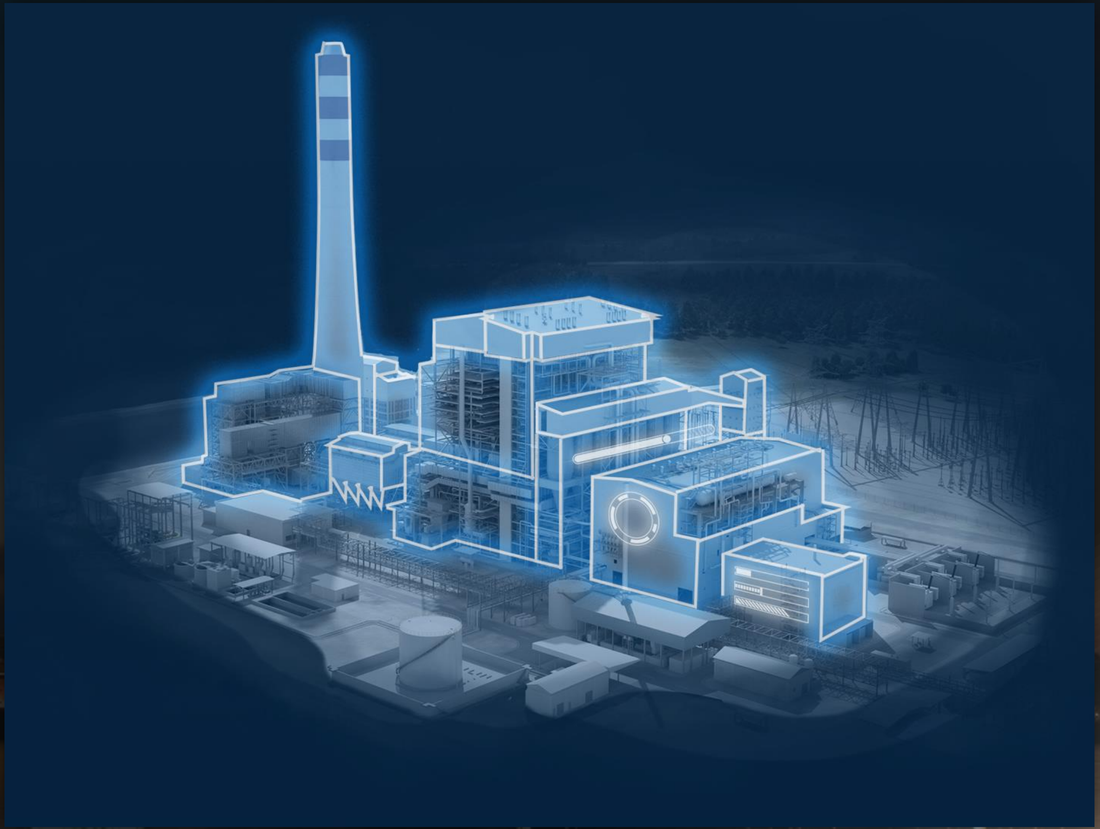
February 1, 2019

Contents

Clean Coal Technology

- The IEA (CIAB) describes CCTs as several generations of technological advances that have led to more efficient combustion of coal with reduced emissions of sulphur dioxide (SOx) and nitrogen oxide (NOx).

- The definition of clean coal technologies has been expanded to include efficiency measures designed to reduce emissions of CO_2 and carbon capture and sequestration technologies.

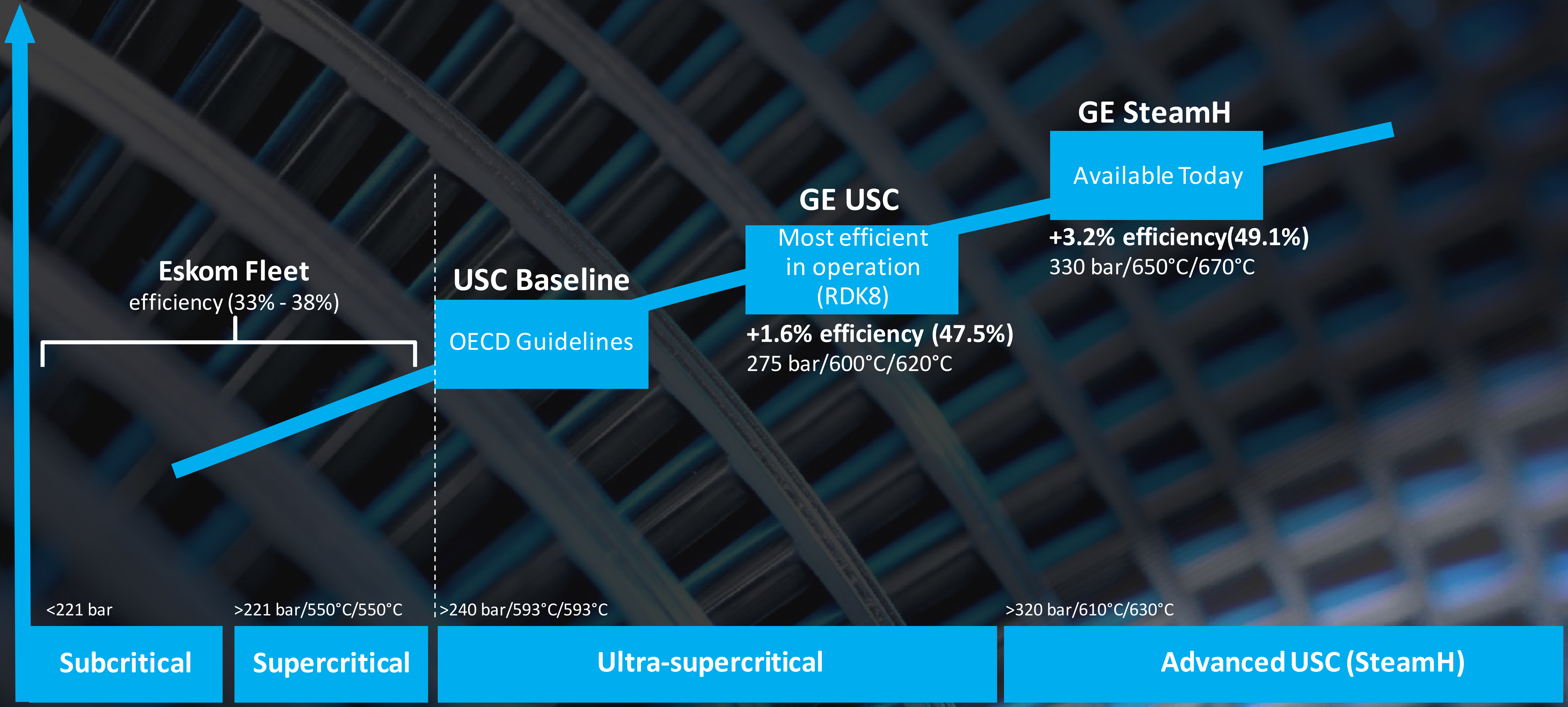


Take away: Supercritical and Ultra-supercritical technologies with higher efficiency, reduce CO2 emission from coal combustion

Technology Advancements

Leading efficiency, lower emissions and better economics.

Take away: There is huge opportunity to improve coal utilization in South Africa



CO_2 Emissions

Coal Plant Design, Performance & CO_2

Factors influencing CO_2 emissions

- Plant Efficiency
- Coal quality (CV, Carbon, Sulphur, etc.)
- Ambient conditions
- Cooling technology (Wet vs Dry Cooling)

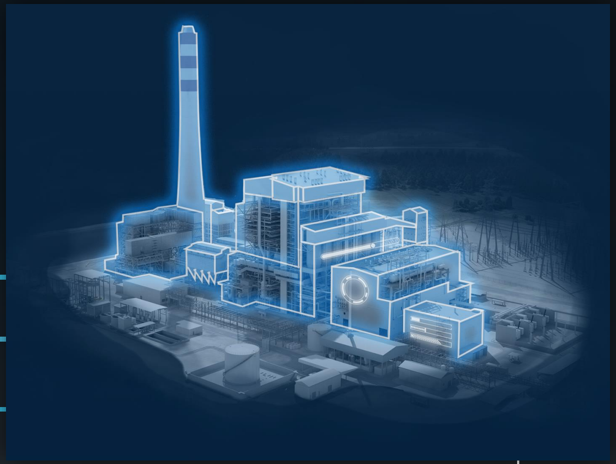
Relationship with CO_2 emissions

- Better coal quality → higher plant efficiency → lower CO_2 emission
- Lower ambient temperatures → higher plant efficiency → lower CO_2 emissions
- More effective cooling → higher plant efficiency → lower CO_2 emissions

Factors that improve plant efficiency will lower CO_2 emissions

Take away: Improved Plant Performance can be strategically used for CO_2 reduction

Coal Consumption & CO_2 Emissions



Plant Capacity	300MW gross		
	270MW net		
Coal Quality / CV	23.42MJ/kg (LHV)		
	Subcritical (35.9%)	Supercritical (38.7%)	Ultra-supercritical (40.6%)
		Delta %	Delta %
Coal Consumption (t/hr)	116	-7%	-12%
Coal Consumption (t/Yr)	863736	-7%	-12%
CO_2 (g/kWh)	842	-7%	-12%
CO_2 (Mt/Yr)	1.882	-7%	-12%

For a 300MW plant operating at the same condition and coal quality, as much as 200kt/Yr of CO_2 can be saved by changing technologies from subcritical to ultra-supercritical. Depending on the coal quality and specific efficiency, even greater CO_2 savings may be achieved. Refer to table below for 300MW case study

Steam Generation

Boiler Product Portfolio

Two Pass

Coal-Fired

100 MW — 1,350 MW *

* Oil-fired boiler : up to 1,000 MW

Tower

Hard Coal-Fired

Lignite-Fired

100 MW — 1,350 MW *

* Lignite tower boiler: up to 1,100 MW

CFB

100 MW — 660 MW *

* Up to 660MW for lignite, higher for hard coal

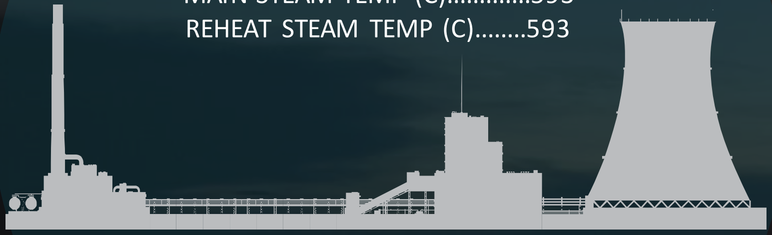
Discard and Ultrafine coals can be burned

		PC	CFB
Coal	Lignite B	●	●
	Lignite A	●	●
	Subbit. C	●	●
	Subbit. B	●	●
	Subbit. A	●	●
	Bit. High Vol. C	●	●
	Bit. High Vol. B	●	●
	Bit. High Vol. A	●	●
	Bit. Med. Vol.	●	●
	Bit. Med. Vol.	●	●
	Semi-anthracite	●	●
	Anthracite		●
	Meta-anthracite		●

References

Clean Coal Power Plants

Baseline Ultra-supercritical
(OECD Guidelines)
PRESSURE (bar)...........................240
MAIN STEAM TEMP (C).............593
REHEAT STEAM TEMP (C)........593



Malaysia
Tanjung Bin 4 1000MW

PRESSURE (bar)..270 *2016 Operation*
MAIN STEAM TEMP (C)..........................595
REHEAT STEAM TEMP (C).....................605

UAE
Hassyan 4 x 600MW

PRESSURE (bar)..280 *2020 Operation expected to begin*
MAIN STEAM TEMP (C)..........................600
REHEAT STEAM TEMP (C).....................610

Poland
Opole 2 x 990MW

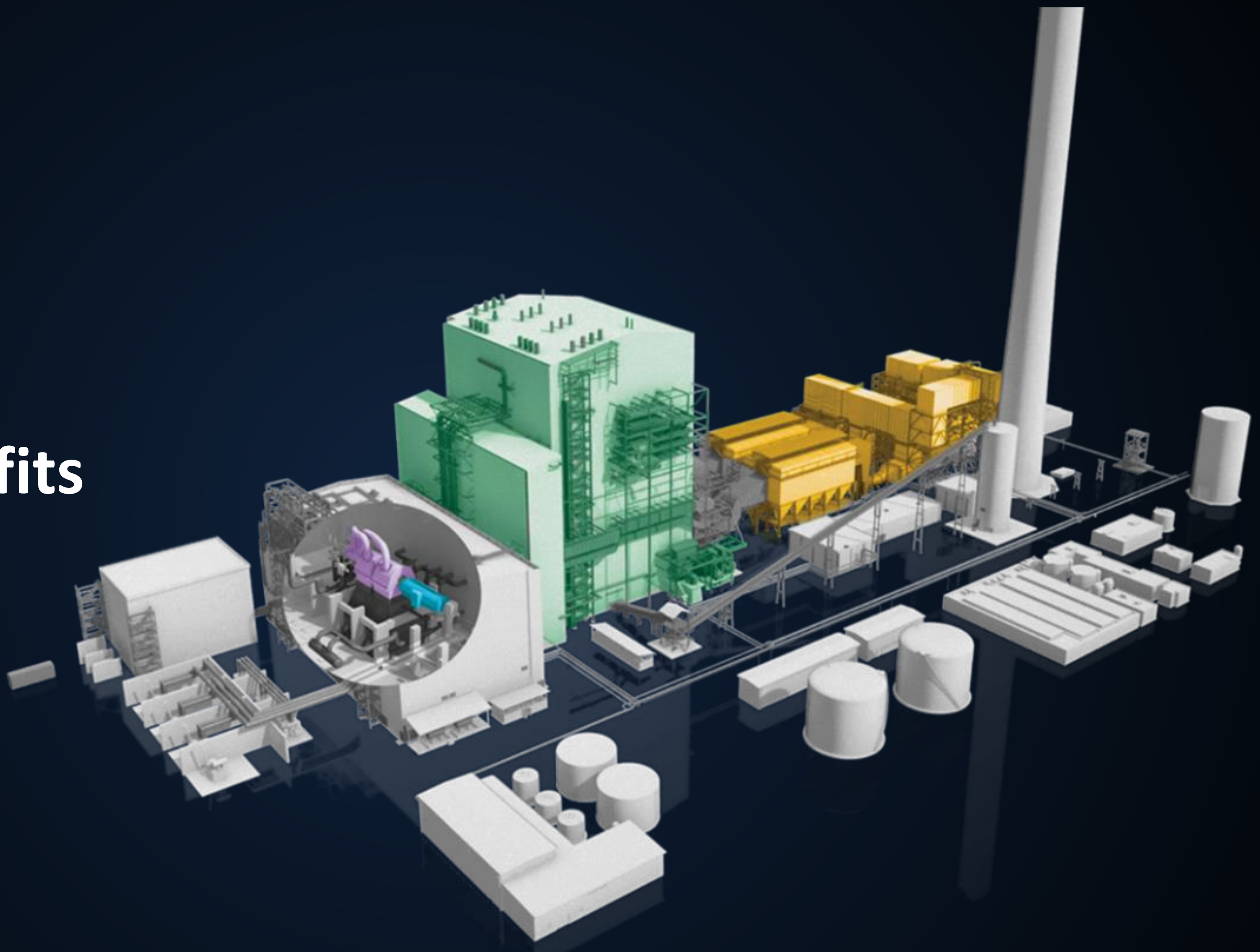
PRESSURE (bar)..250 *2018 Operation expected to begin*
MAIN STEAM TEMP (C)..........................600
REHEAT STEAM TEMP (C).....................610

Germany
RDK8 1 x 900MW

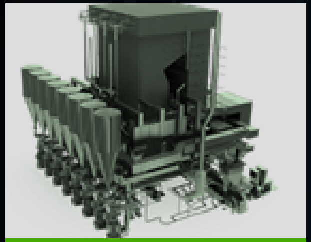
PRESSURE (bar)..270 *2014 Operation*
MAIN STEAM TEMP (C)..........................600
REHEAT STEAM TEMP (C).....................620

Emile Huchet – France (UFC)
Seward – USA, Baima – China, Khanyisa – South Africa (Discard Coals)

Upgrades & Retrofits



Upgrades & Retrofits – Improvements & Optimization



Boiler

Boiler
- Replacement of creep/ wear affected components
- Modernized firing system
- Emission control devices
- Upgraded materials

Steam Turbine

Steam Turbine
- Turbine Modules
- Creep affected components
- Fatigue affected components

Generator

Generator
- Component replacements
- Stator rewinds
- Rotor rewinds
- Excitation system upgrades

ECS

ECS
- ESP optimization
- ESP to FF conversions
- FGD retrofits

NOx + Efficiency/CO_2

Life Ext.

PM + SOx

Up to ≥ 95%
NOx removal

Up to 99.9%
Particulates removal

Reduction in
CO_2

Up to > 99%
SOx removal

Up to 10%
Improvement in efficiency

Upgrades & Retrofits – Turkey Case Study

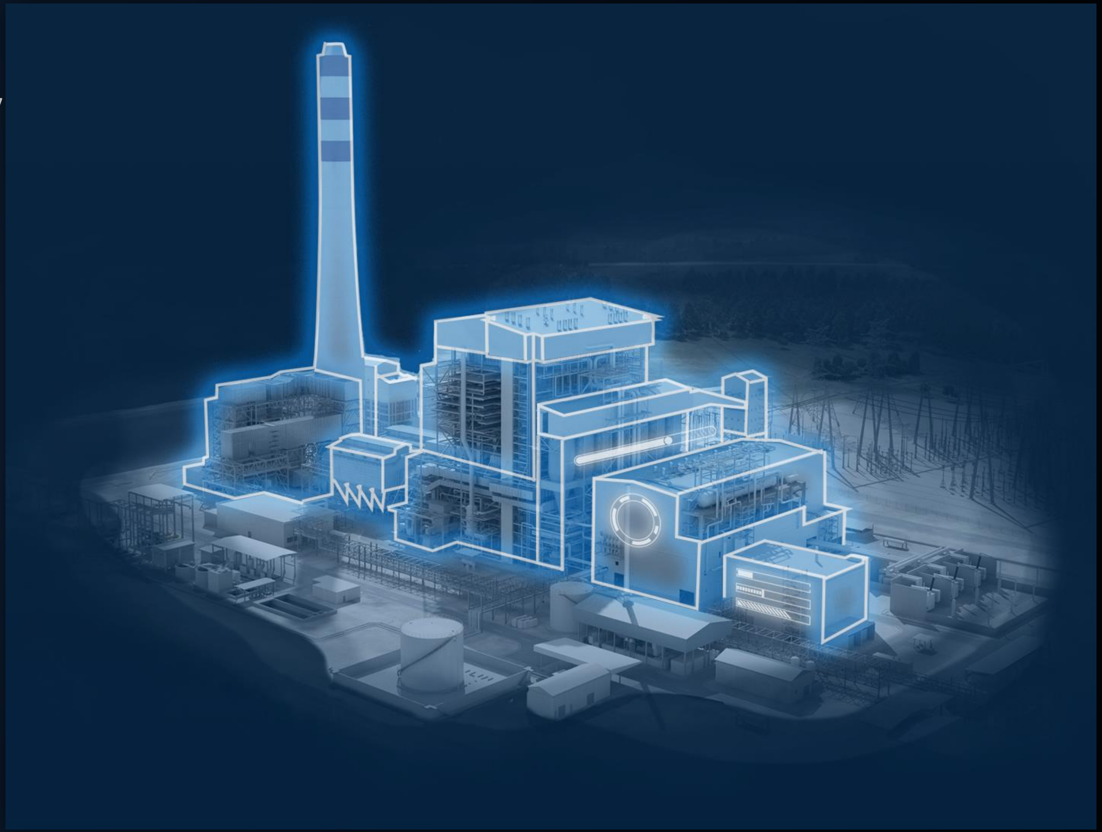
Drivers for U&R

- Average age of the coal power plant fleet is from 10yrs to > 25yrs
- New emission legislation requiring all existing power plant to comply by 2019.
- Fuel (lignite) changes impacting plant performance

Main Plant Equipment Impacted by U&R

- Boilers (LNBs & SNCR systems) - Efficiency, CO_2 & NOx
- STG – Efficiency, Power output & CO_2
- Environmental Control Systems: FGDs, ESPs & FFs – SOx and PM

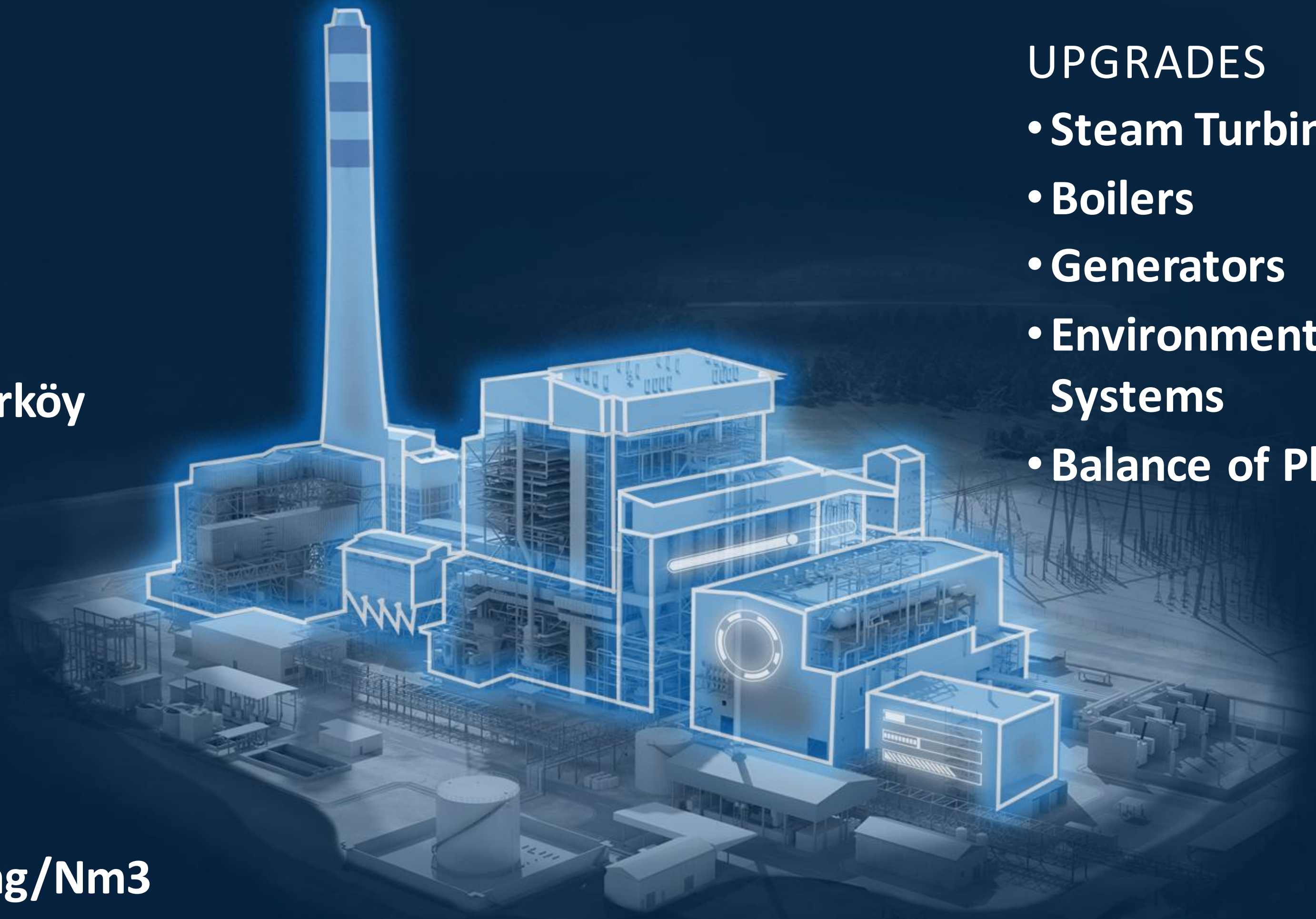
Take away: Fuel changes over the lifetime of the plant can be accommodated where applicable with U&R



YENIKöY & KEMERKöY – TURKEY

2 x 210MW / 3 x 210MW

GE & partner selected to perform U&R



PERFORMANCE TARGETS

- Output ↑ by 55 MW at Yeniköy
- Output ↑ by 142.5 MW at Kemerköy
- Total plant efficiency ↑ by 5%

UPGRADES

- Steam Turbine
- Boilers
- Generators
- Environmental Control Systems
- Balance of Plant

ENVIRONMENTAL TARGETS

- NOx ↓ below 200 mg/Nm3
- Particulate Matter ↓ below 40 mg/Nm3
- SOx ↓ below 320 mg/Nm3

LIFECYCLE

- Power equipment lifetime extended by 20 years
- Installation competed by 2020