Strategies of Satisfying CO_2 Emission CAP for AUSC Units Without CCS

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1 CAP For CO_2 Emission BY EPA

2 Efficiency Improvement of USC Unit

3 USC Unit with CHP/CCHP

4 Hybrid-firing with Biomass

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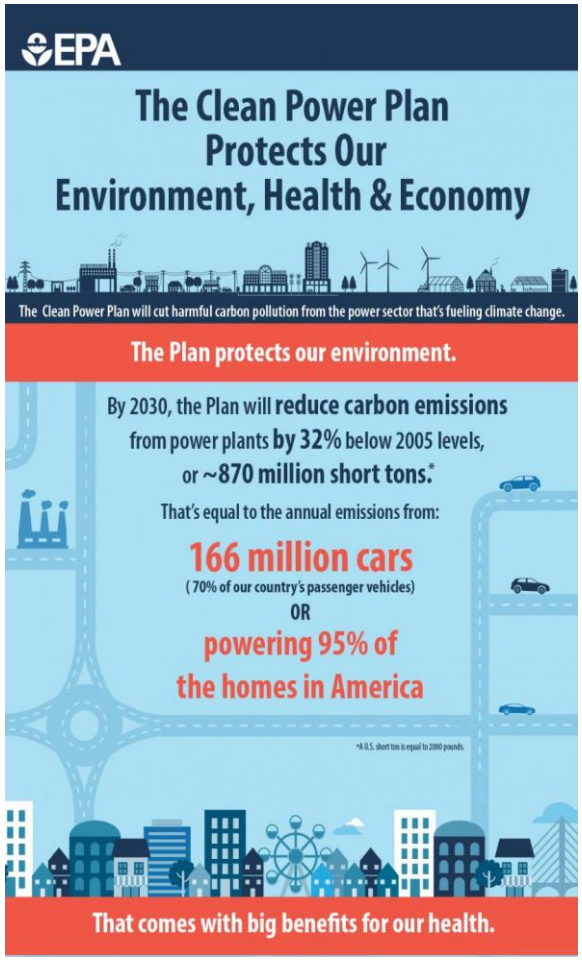
CAP For CO_2 Emission By EPA

- CPP(Clean Power Plan) of Obama administration aims to decrease the emission of greenhouse gas to handle climate change issue.
- CPP stipulates the CAP of CO_2 emission of all sorts of fossil-fired power plant.



CAP For CO_2 Emission By EPA

EPA: Gas Emissions from New, Modified, and Reconstructed Stationary Sources: Electric Utility Generating Units

Newly Constructed Fossil Fuel-Fired Steam Generating Units	**1,400 lb (635 kg) CO2/MWh-gross**
Reconstructed Fossil Fuel-Fired Steam Generating Units	**1,800 lb (816 kg)CO2/MWh-gross for sources with heat input > 2,000 MMBtu/h**
	2,000 lb (917 kg)CO2/MWh-gross for sources with heat input ≤ 2,000 MMBtu/h

CAP For CO_2 Emission By EPA

The gross/net standard coal consumption should be 230/225 kg/MWh in yearly average, i.e. 53%/55% in gross/net efficient.

Mass fraction of carbon of standard coal kg/kg 0.768

Oxidation factor of coal 0.98~0.99

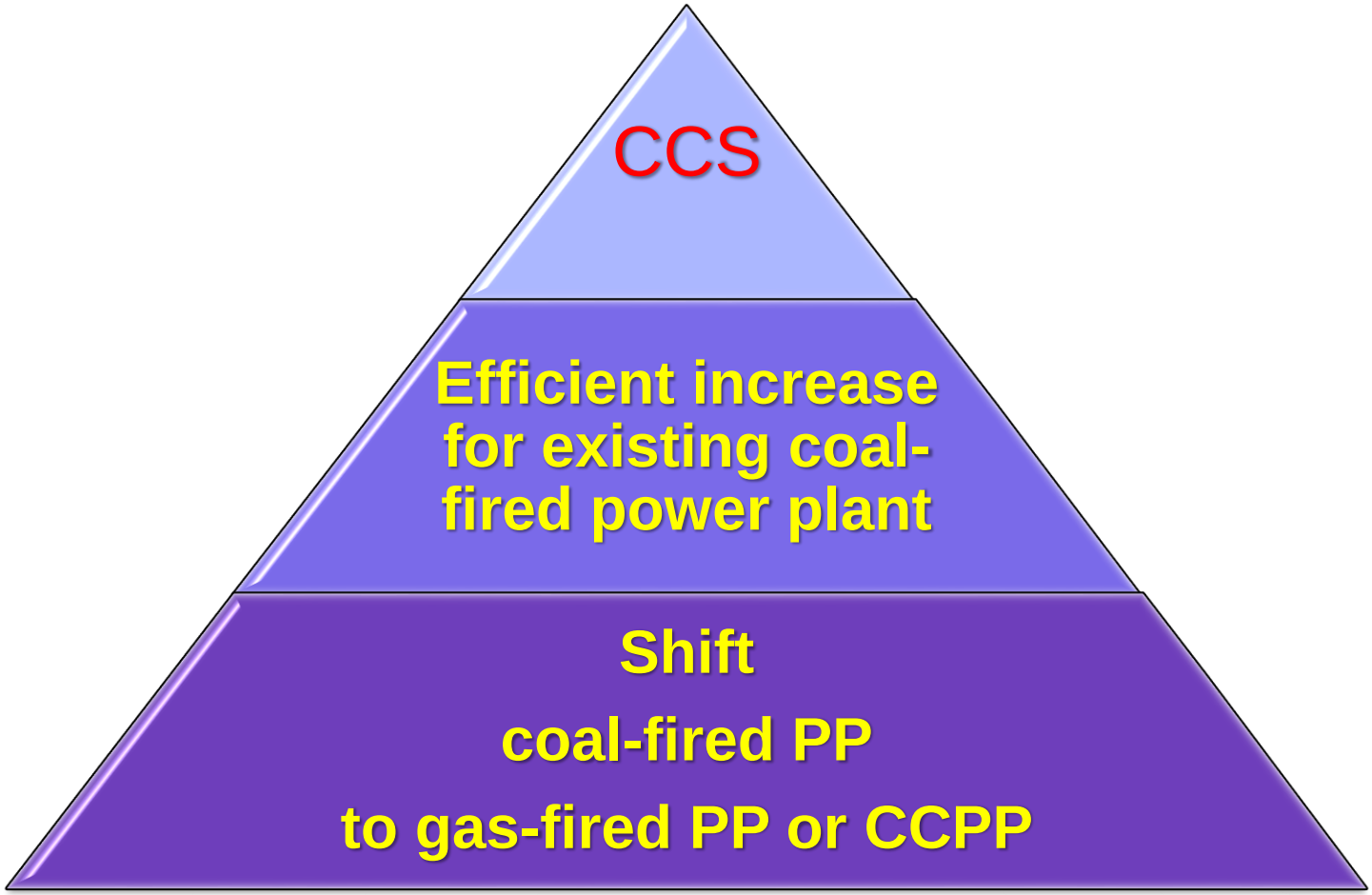
$$E=b\times k_c\times k_o\times 44\div 12$$

Standard coal consumption rate kg/MWh

molecular weight of Carbon and Oxygen

CO_2 emission rate kg/MWh

CAP For CO_2 Emission By EPA



COST of CCS for 2X600MW units

CCS Capacity	Investment of capture device	Electricity decline by capture device	Electricity decline by conveying device
5%	61.5 m$	1.42%	0.7%
25%	308 m$	7.1%	3.6%
50%	492 m$	12.7%	6.4%
100%	862 m$	22.6%	11.3%

CAP For CO_2 Emission By EPA

EPRI's Question

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Can Future Coal Power Plants Meet CO_2 Emission Standards Without Carbon Capture & Storage?

October 2015

Yes!

- USC with temp. up to 1125 ℃
- USC (29MPa/593 ℃ /621 ℃)+14% Steam Extraction
- IGCC
- US CO_2 Brayton Cycle
- Fuel Cell

CAP For CO_2 Emission By EPA

Our Key

3R Vision

- Reasonable for technology
- Realistic for cost
- Reliable for operation

Road Map

- AUSC with efficient improvement tools
- USC with CHP/CCHP technology
- Hybrid combustion with coal and biomass

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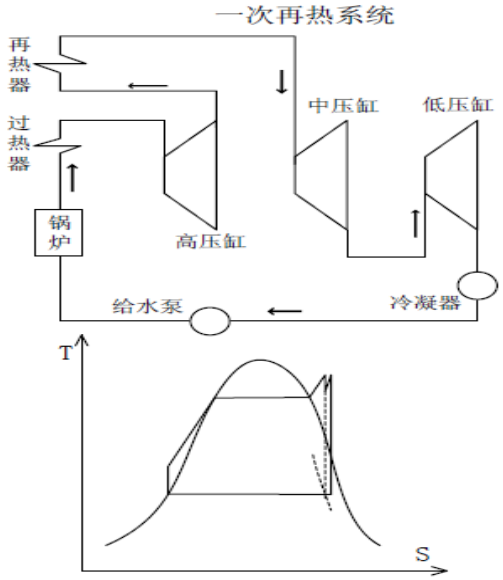
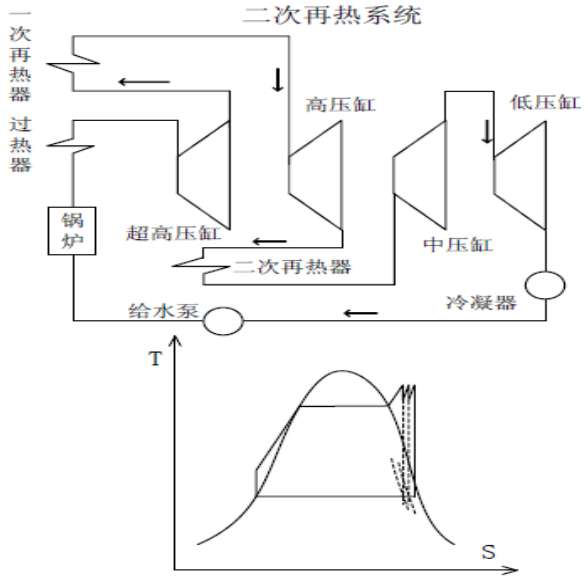
Efficiency Improvement Tools

Double Reheat

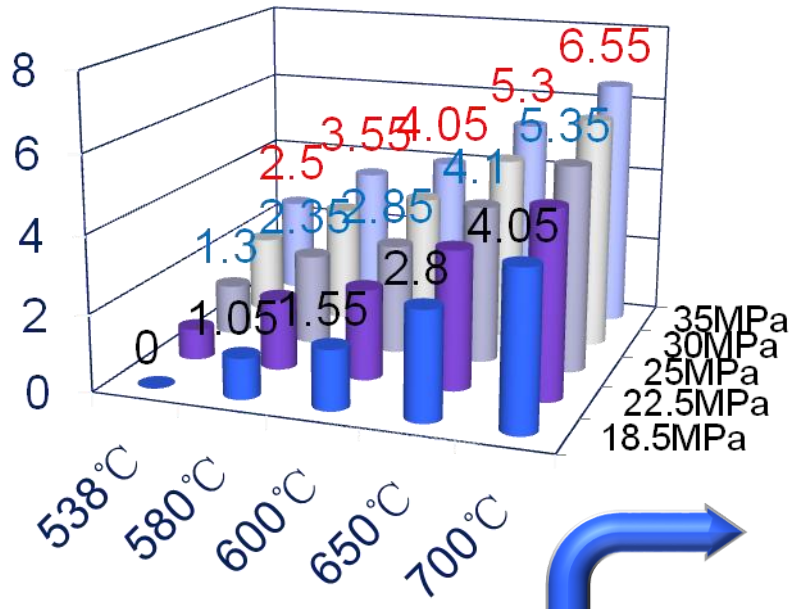


Single reheat system



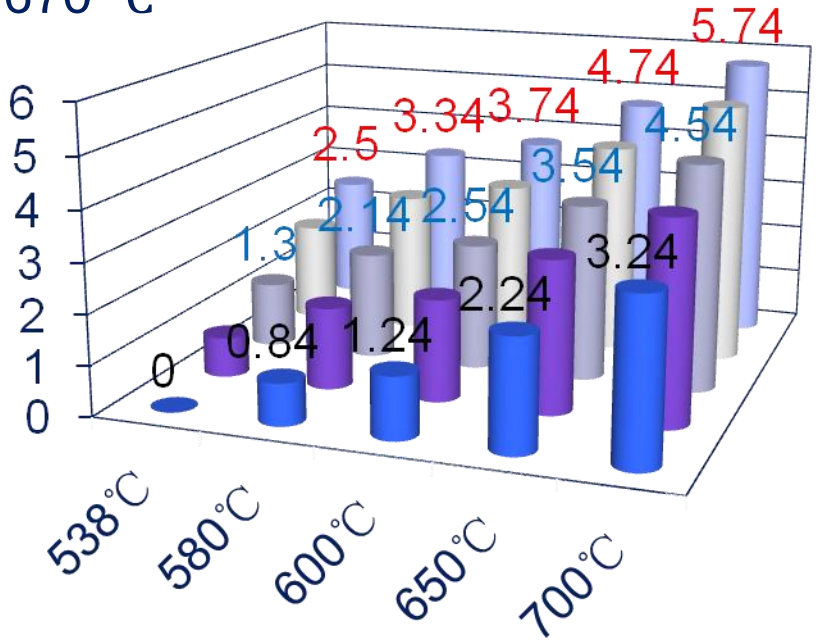
Double reheat system

1.5%~2.0% increase



40MPa/700 ℃/720 ℃ /720 ℃
42.5MPa/760 ℃/760 ℃ /760 ℃

35MPa/650 ℃
/670 ℃ /670 ℃



35MPa/615 ℃/630 ℃ /630 ℃

31MPa/600 ℃/600 ℃ /600 ℃

1000MW USC DR turbine (35MPa/615 ℃/630 ℃ /630 ℃), tandem compound with VHP+HP+IP+3LP

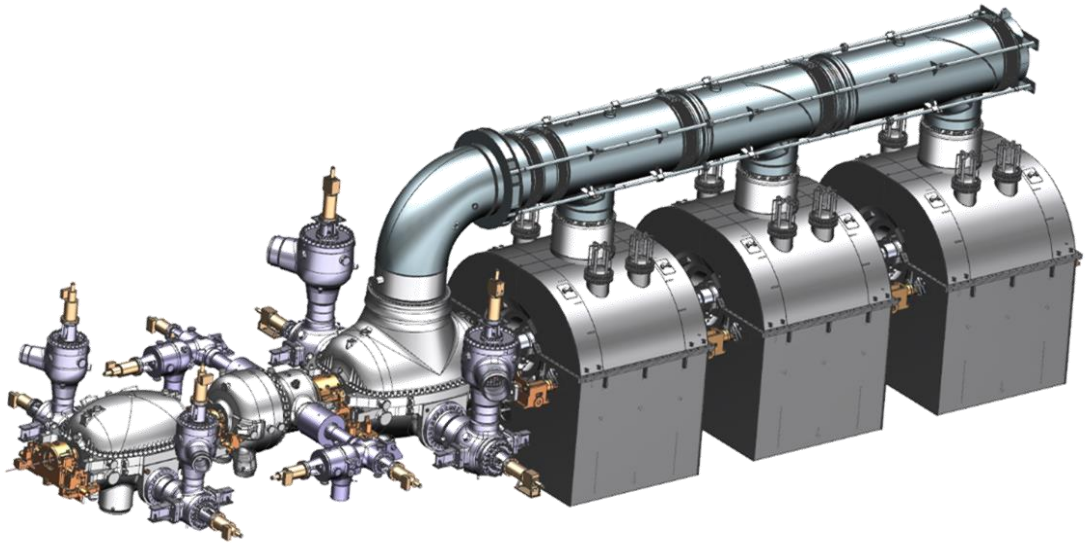
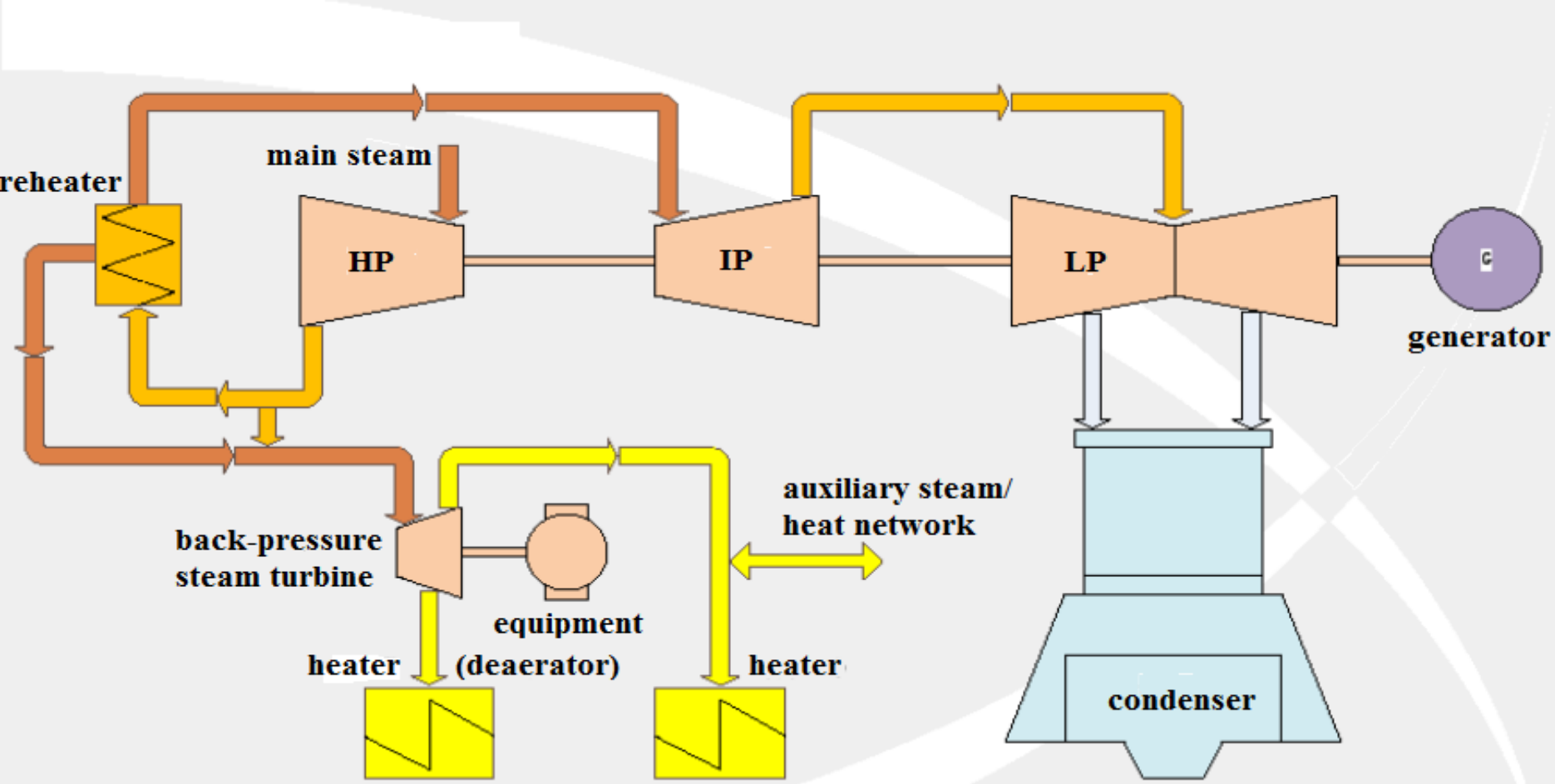


Fig. from Shanghai Electric Group Co. Ltd

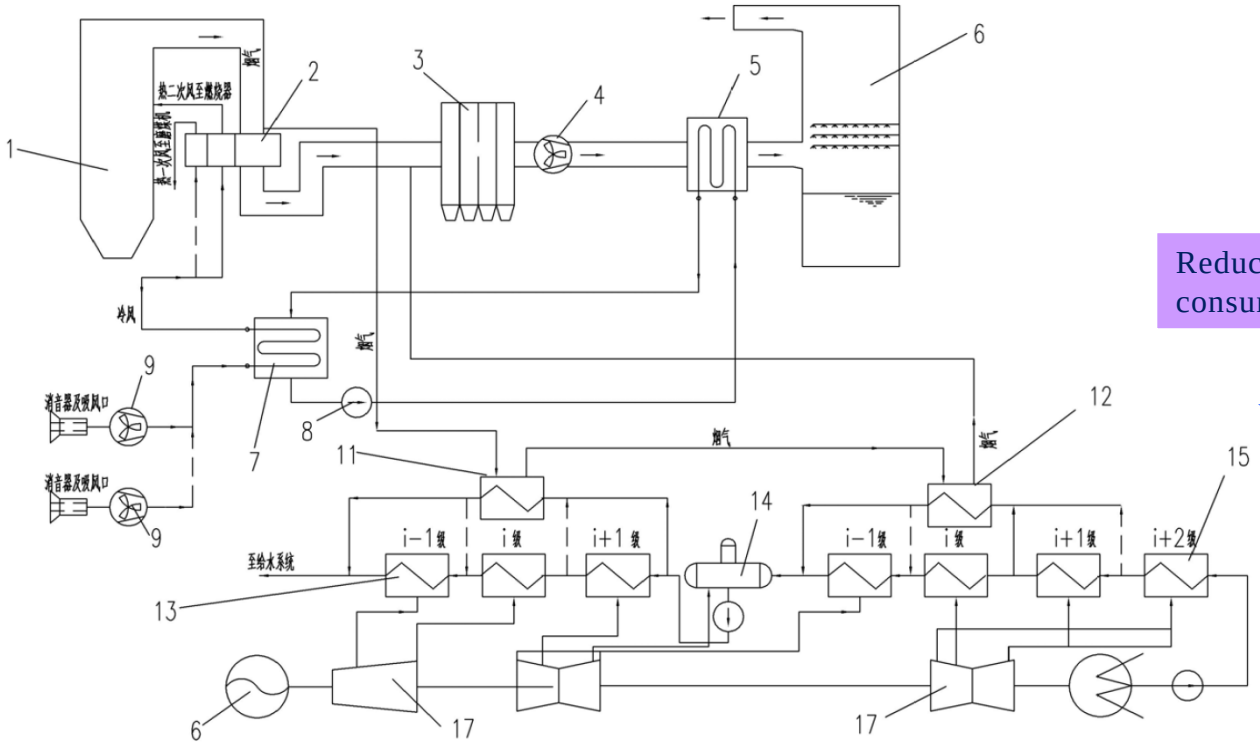
Efficiency Improvement Tools

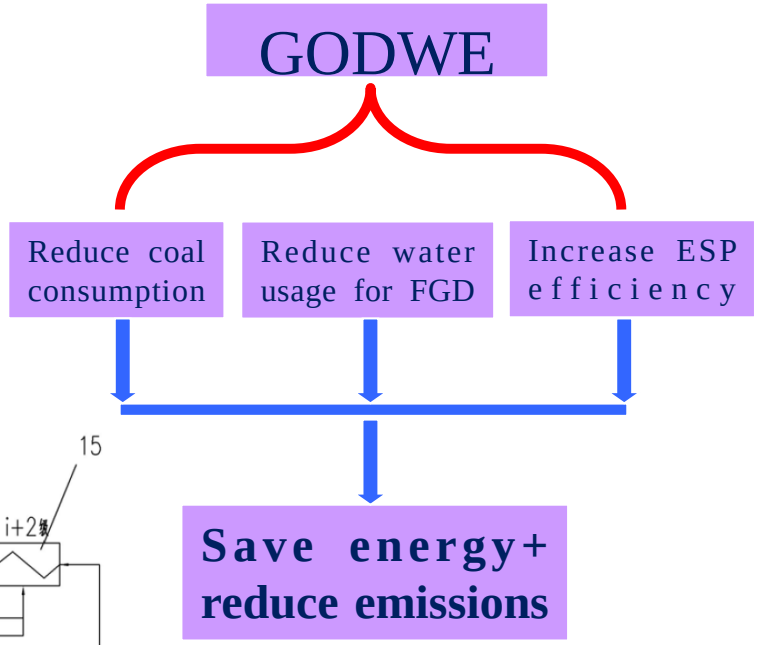


ECEPDI Patent: Back-pressure Extraction Steam Turbine

Efficiency Improvement Tools

Flue Gas Heat Recovery





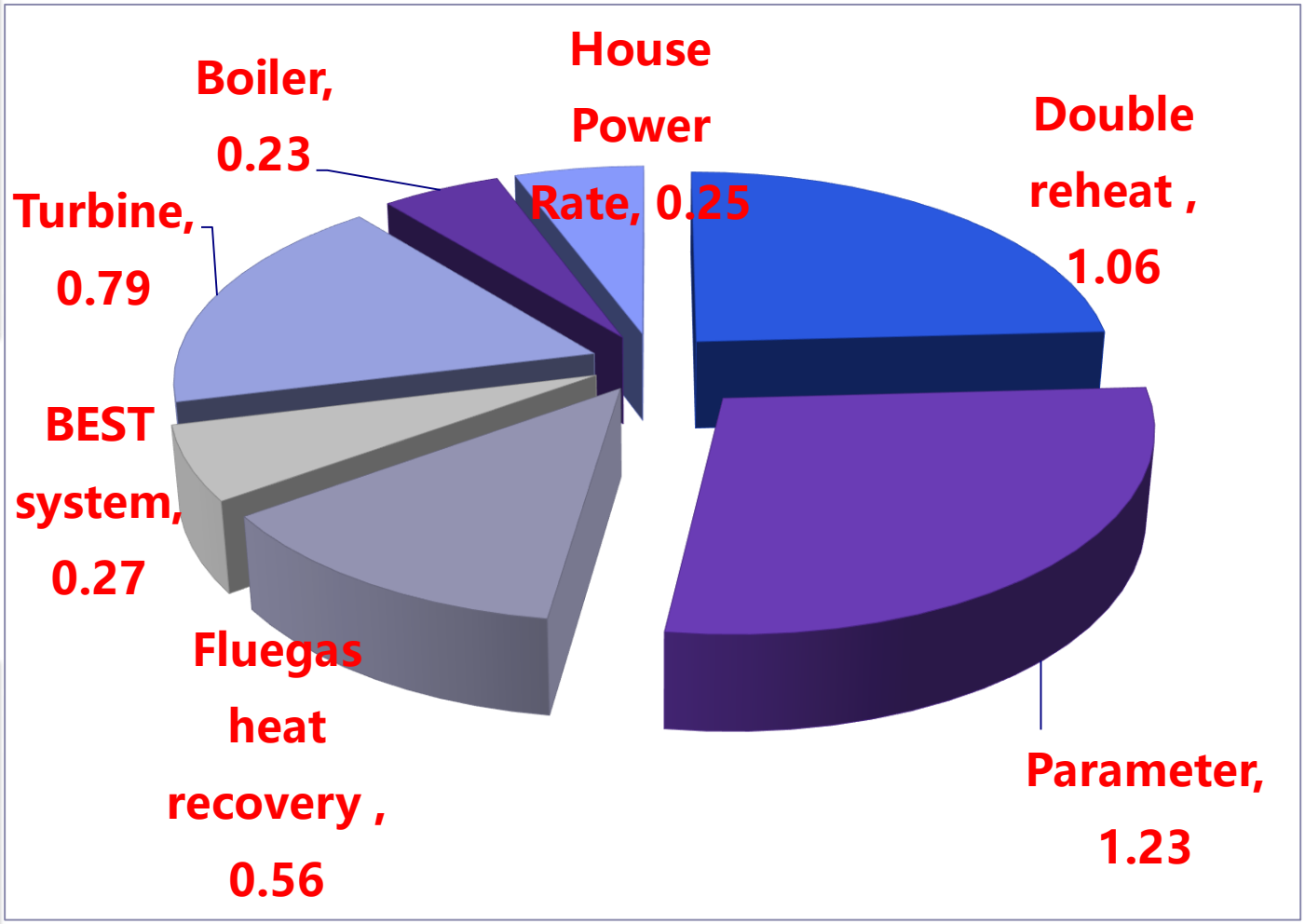
ECEPDI Patent: GODWE System

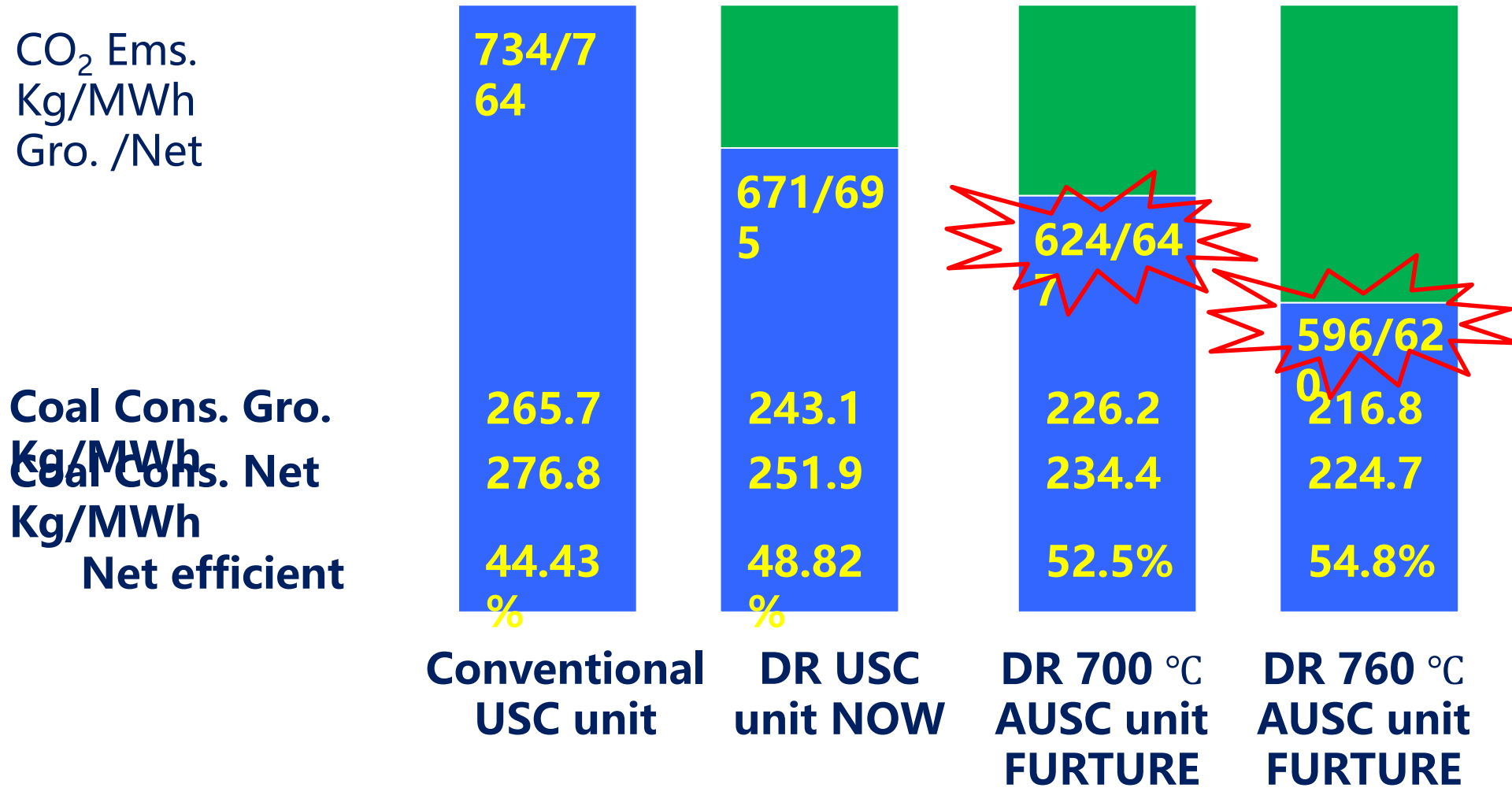
Efficiency Improvement Tools

Net Efficiency breakdown

STATE OF ART USC DR (35MPA/615 ℃/630 ℃ /630 ℃) NET EFF. UP TO 48.82%

CONVENTION USC SR (27MPA/600 ℃/600 ℃ /) NET EFF. 44.43%




CO_2 Ems. Kg/MWh Gro. /Net
734/764
671/695
624/647
596/620
Coal Cons. Gro. Kg/MWh
265.7
243.1
226.2
216.8
Coal Cons. Net Kg/MWh
276.8
251.9
234.4
224.7
Net efficient
44.43%
48.82%
52.5%
54.8%
Conventional USC unit
DR USC unit NOW
DR 700 ℃ AUSC unit FURTURE
DR 760 ℃ AUSC unit FURTURE

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CHP Unit

- Recover the cool-end heat loss of turbine with steam extracted for heating
- Civil heating and industrial heating
- Heating radius up to 50km~100km

Heating-electricity Ratio

Ratio of heat to electricity generated by the unit (converted into Joule)

Heating-electricity Ratio of industries

- Metallurgy, chemistry, pharmaceutics 8:2
- Electronic, Mechanic 2:8
- Civil and commercial complex 3:7

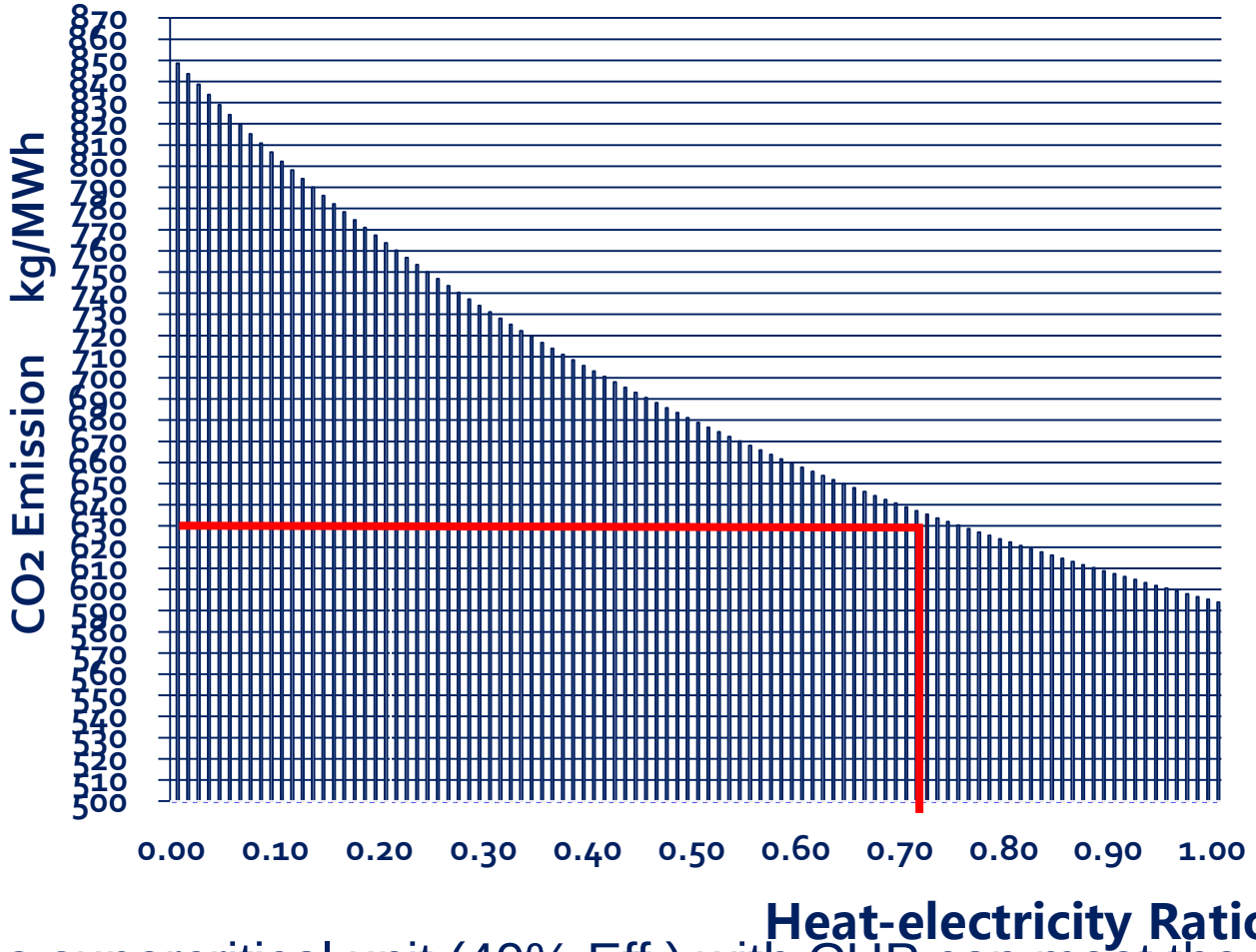
CCHP Unit

- Expanded from CCPP to coal-fired power plant
- Especially for small city/residential complex utilities
- With pollutants emission as clean as CCPP

- The comprehensive efficiency of CHP/CCHP unit can be as high as 80%~90%.
- The CO_2 emission cutting down is considerable of CHP/CCHP technology.
- CHP/CCHP technology is proven, largely applied and cheap.
- CHP/CCHP can be employed in different situations.

USC with CHP/CCHP

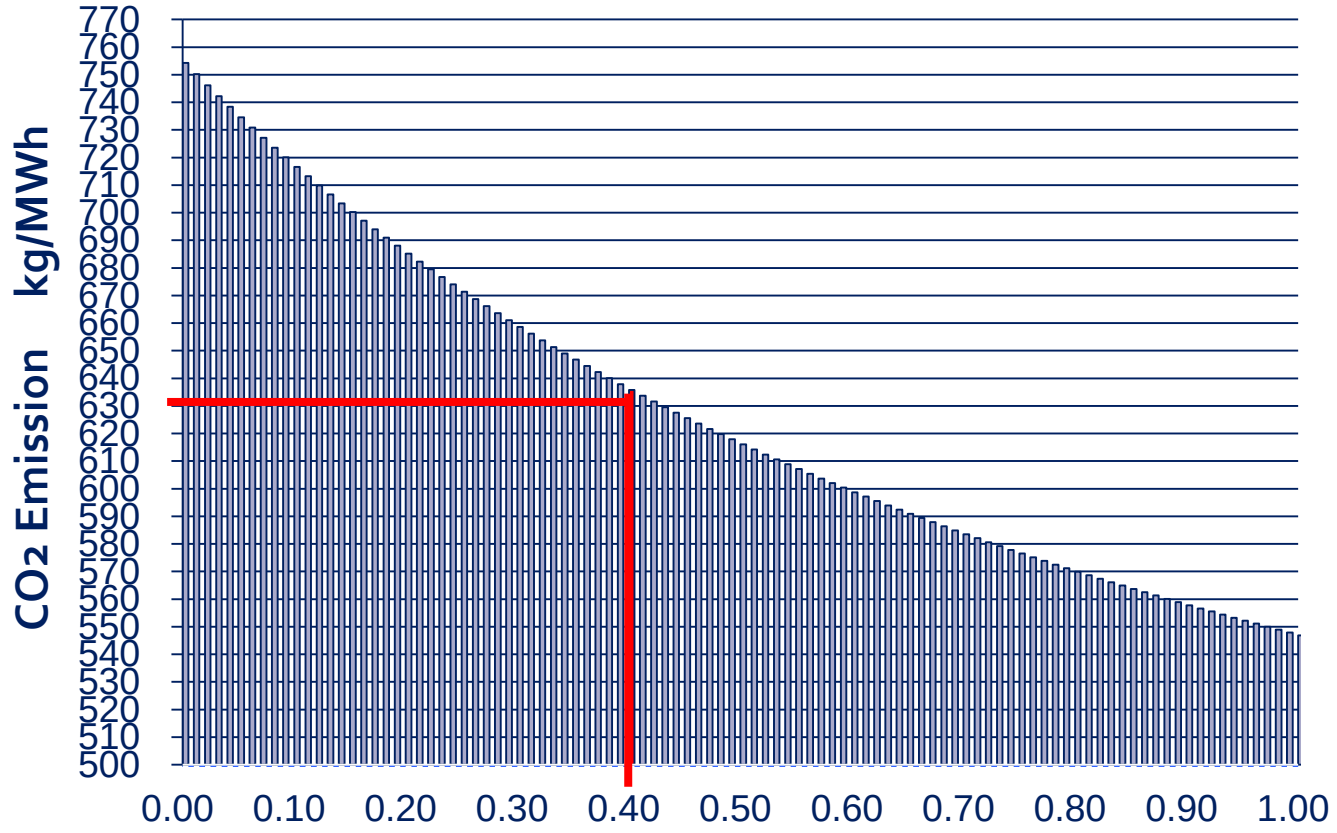
635kg/MWh for SC-CHP-unit



The supercritical unit (40% Eff.) with CHP can meet the CO_2 635kg/MWh emission with heat-electricity-ratio of approx. 0.7.

USC with CHP/CCHP

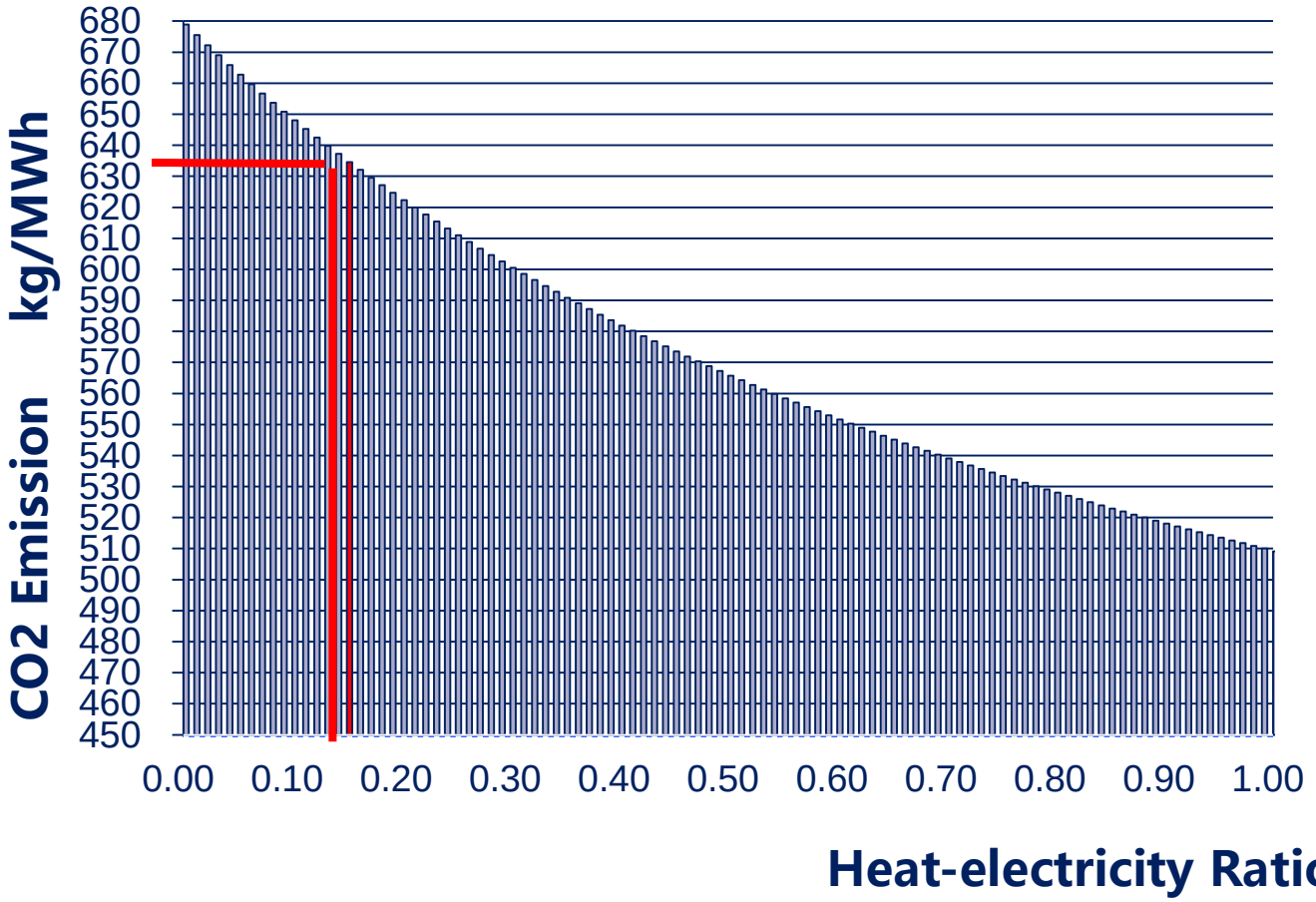
635kg/MWh for USC-CHP-unit



The Ultra-supercritical (45% Eff.) with CHP unit can meet the CO_2 635kg/MWh emission with heat-electricity-ratio of approx. 0.4.

USC with CHP/CCHP

635kg/MWh for DR-USC-CHP-unit



The DR Ultra-supercritical (50% Eff.) with CHP unit can meet the CO_2 635kg/MWh emission with heat-electricity-ratio of approx. 0.15.

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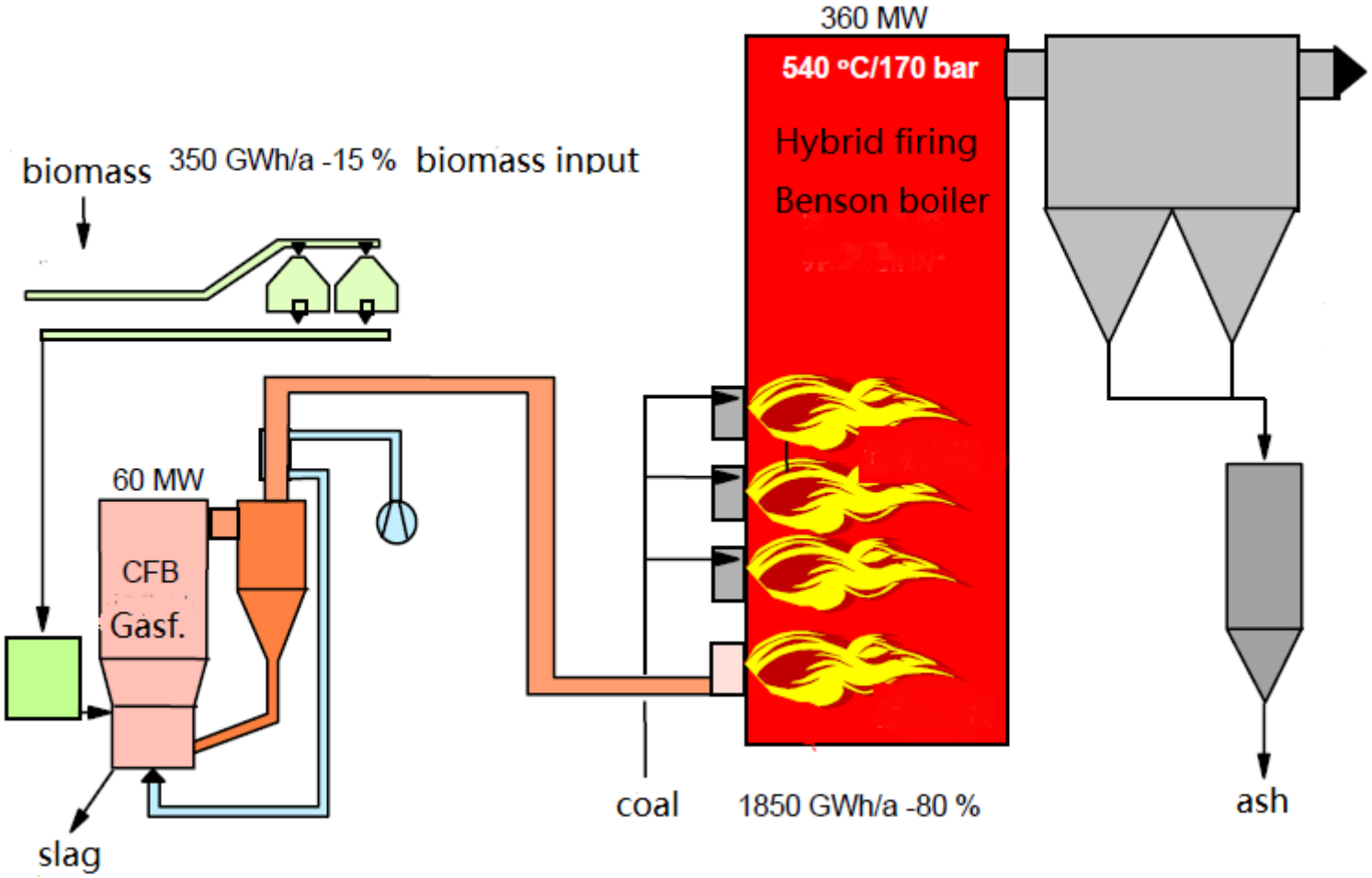
Hybrid-firing with Biomass

Biomass fuel is a kind of renewable resource, regarded as CO_2 neutralizing fuel.

Biomass fuel is a kind of commercial fuel with low NOx and Sox emission.

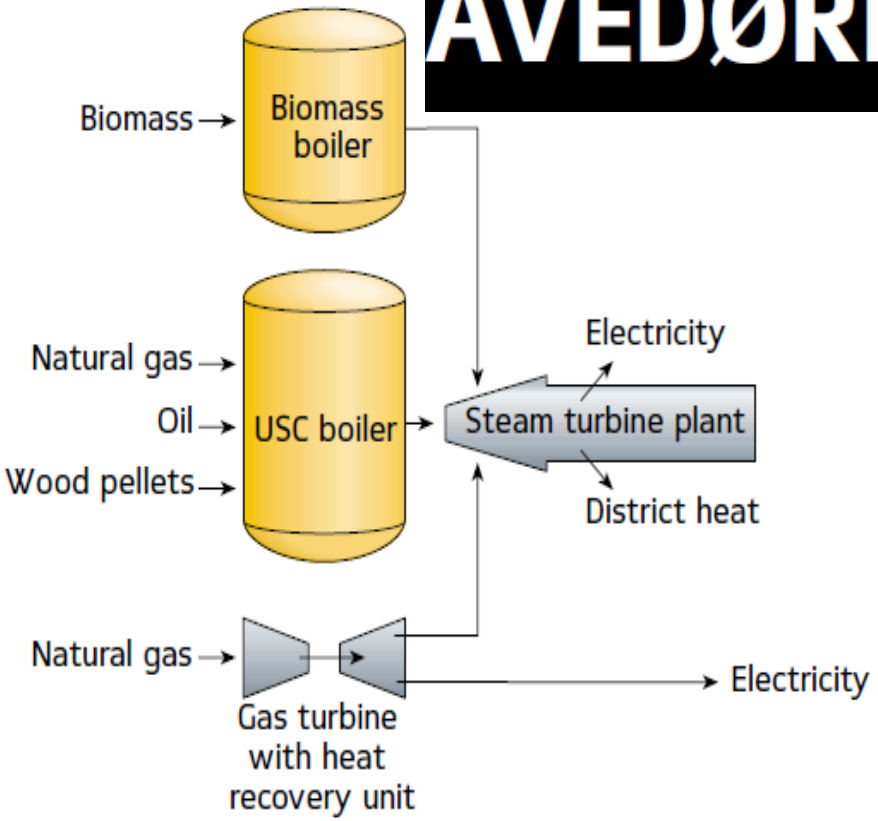
The potential biomass fuel is in equivalent heat about 4 billion tons standard coal in China.

Hybrid-firing with Biomass



Hybrid-firing with Biomass

AVEDØRE POWER STATION



Three aspects related with furnace hybrid-firing

1. Boiler efficiency

Boiler efficiency is related with biomass proportion .

$$\eta_{blend}/\eta_{coal} = 1 + AY_b$$

η_{blend} : boiler efficient with hybrid firing, %

η_{coal}: boiler efficient with coal firing, %

Y_b : biomass fuel proportion in weight, %

A: Coefficient . In a case in China, A is −0.03474

2. Burn-out rate

Burnout rate is related with type of biomass fuel, water content and size of biomass fuel, and biomass proportion

3. Combustion stability

Combustion stability is related with biomass burner type and burner location in the furnace.

Reasonable biomass fuel proportion in weigh:

- No individual Biomass Burner. The biomass fuel shall be not larger than 10%, which will be almost no effected to boiler efficiency.
- Individual Biomass Burner. The individual biomass fuel burner equipped with biomass bin, conveying system and pulverizing system is helpful to increase the proportion up to 35%.

BIOMASS GASIFICATION FIRING

BIOMASS-COAL PARALLEL FIRING

FURNACE HYBRID-FIRING

The conventional USC unit with 45% efficiency can meet the CO_2 emission CAP of 636kg/MWh if the 15% biomass hybrid-firing is available.

CONCLUSION

Hybrid-firing with biomass is an economical, technical-reasonable, easily-established means to reduce CO_2 emission for coal-fired unit, comparing with CCS, AUSC and CHP.

谢谢！

Thank You