Operating experience of circulating fluidised bed combustion (CFBC) when using low grade fuels

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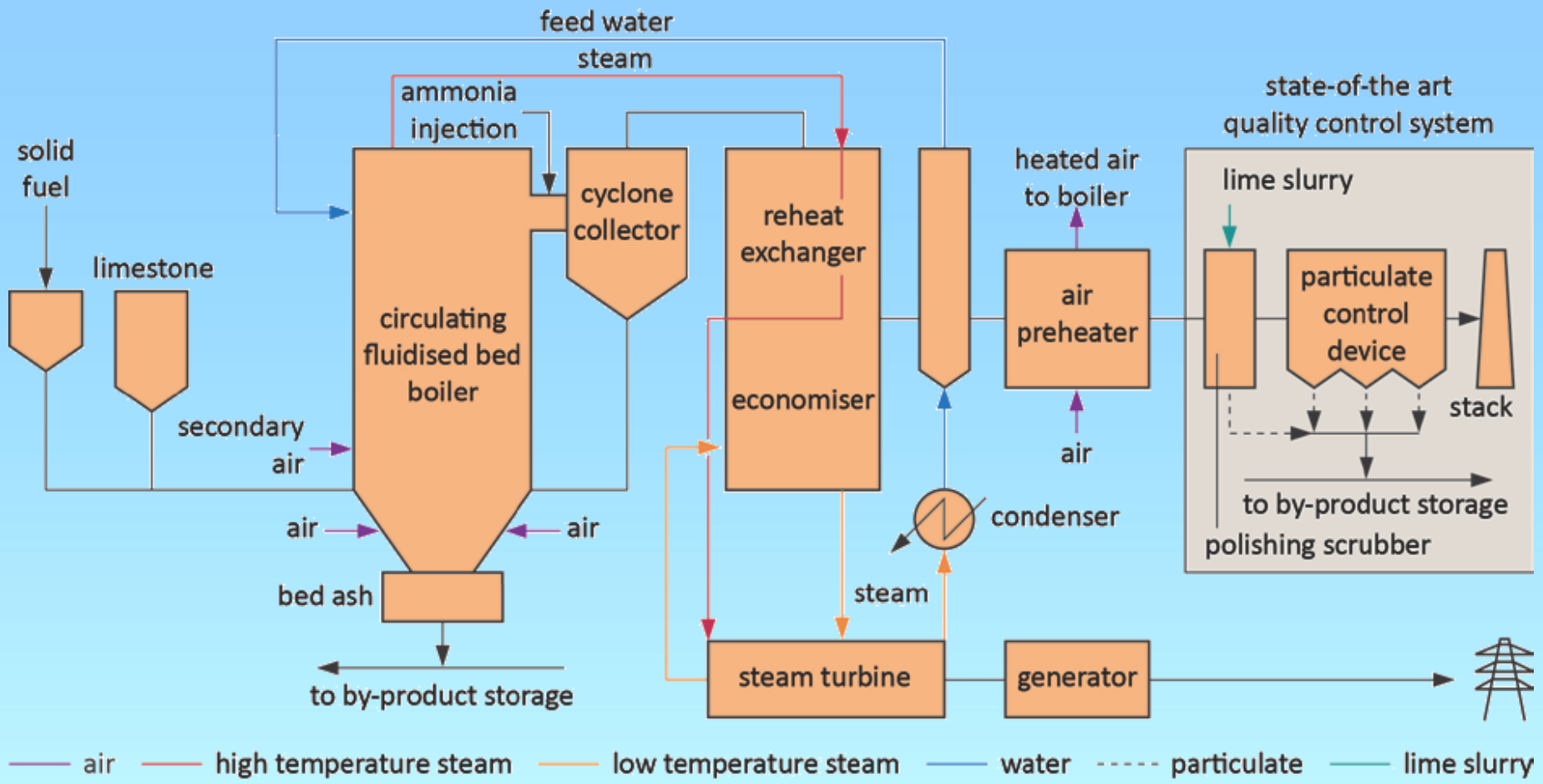
Scope of presentation

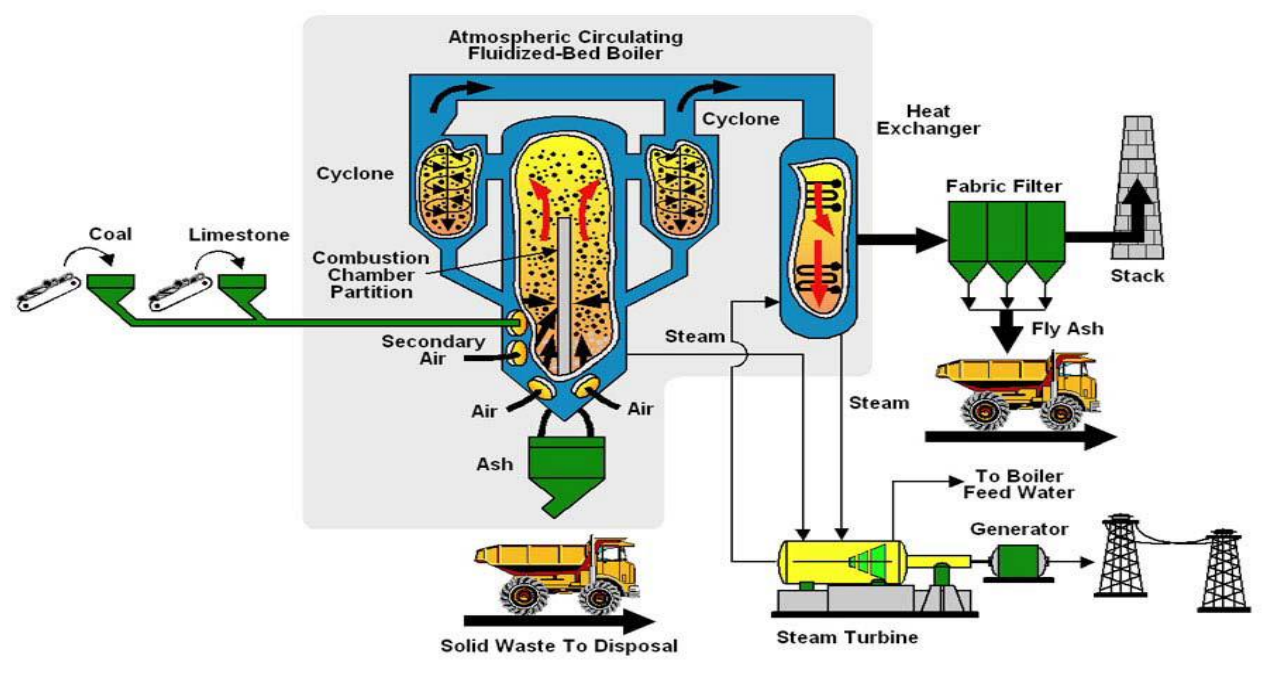
- **Rationale for CFBC**
- **Development route to date**
  - Retrofit applications
  - Economies of scale
  - Supercritical steam conditions
  - Fuel flexibility capability
- **Fuel options, especially low grade fuels**
- **Future development pathways**

CFBC schematic



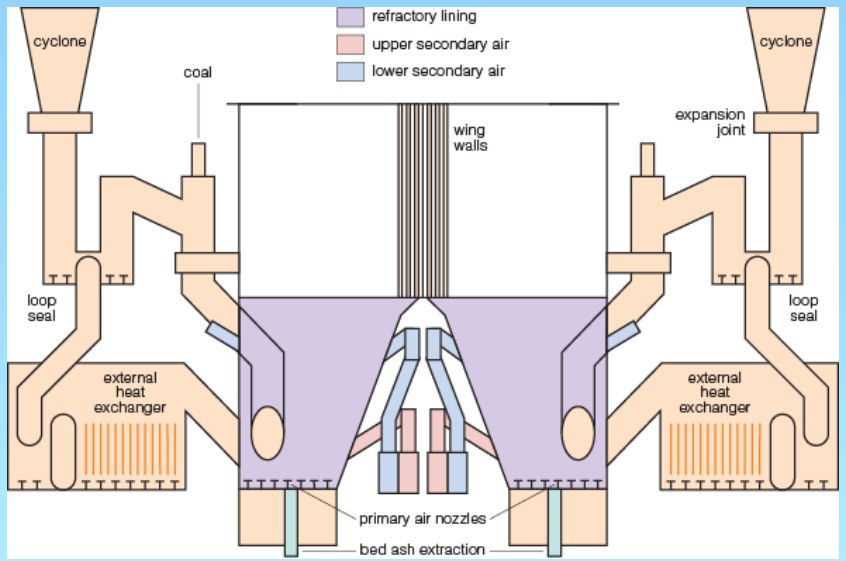
Advantages of CFBC

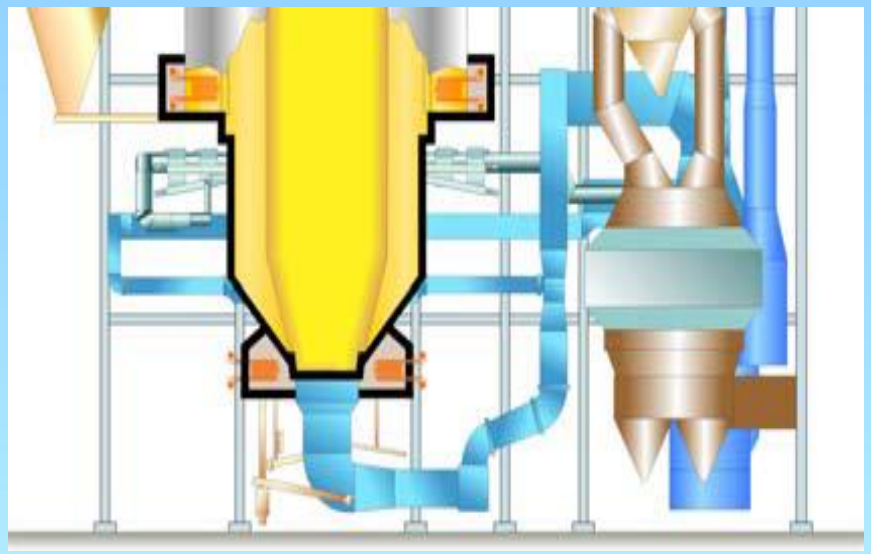
- Fuel flexibility
- Low emissions
- Stable operating conditions and good turndown and load following capability



CFBC developments

Furnace design



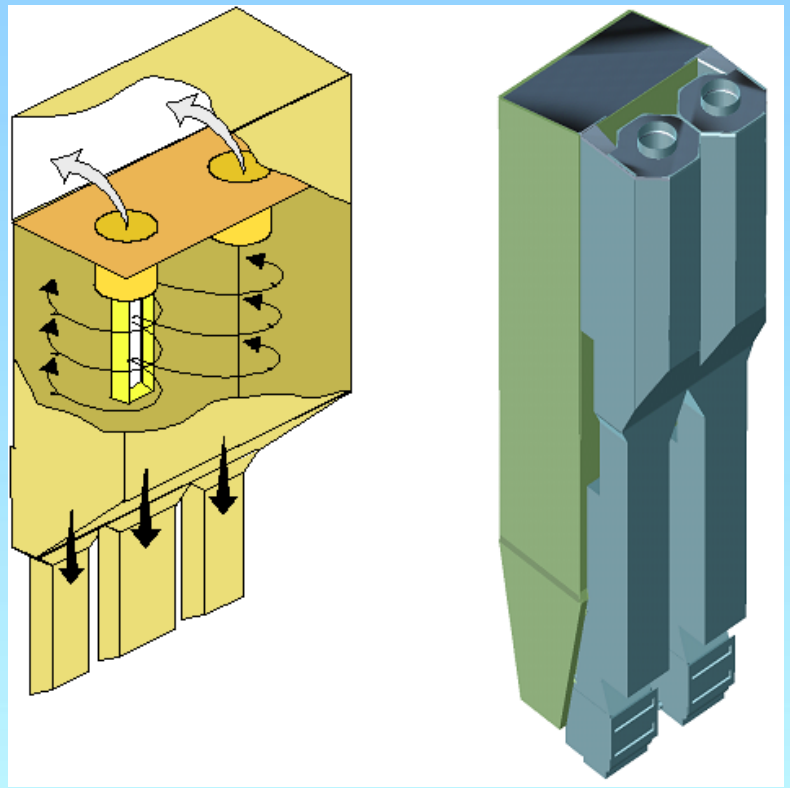


Alstom's pant-leg design

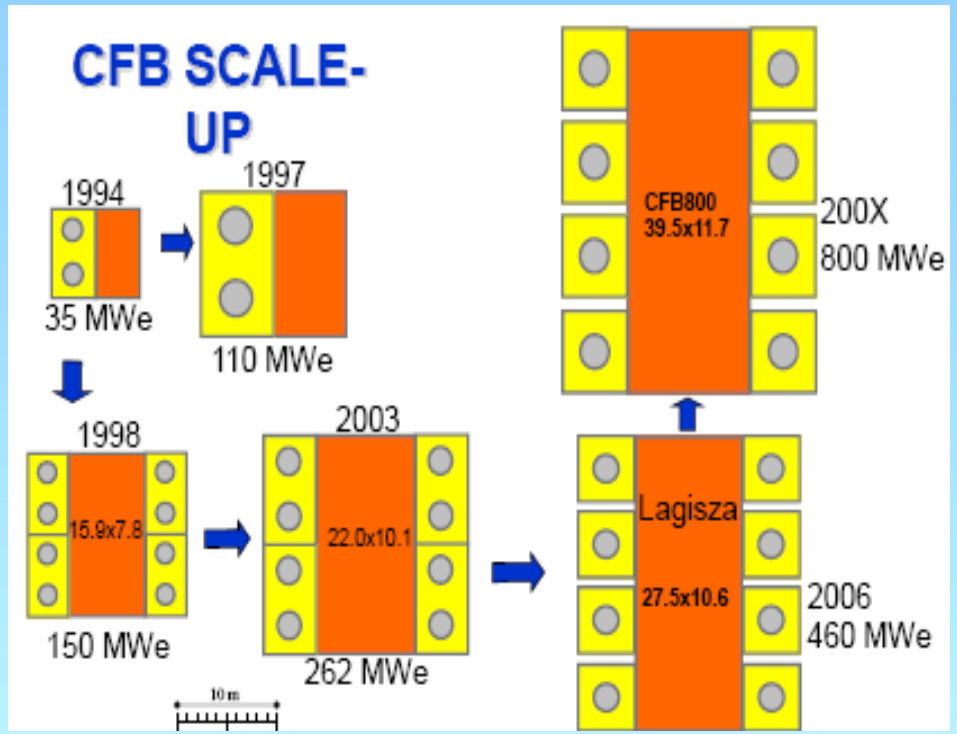
FW's single grid CFBC design

CFBC developments

Solid separation systems



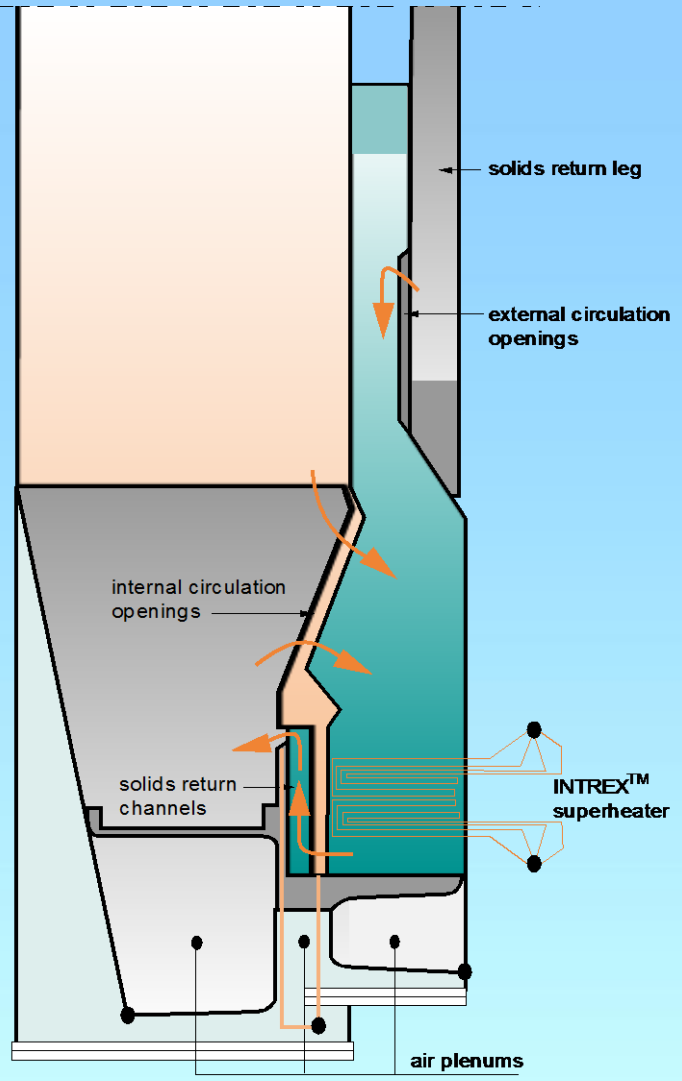
Compact Separator



Scale-up principle for cyclones arrangement

CFBC developments

External heat exchanger (EHE)

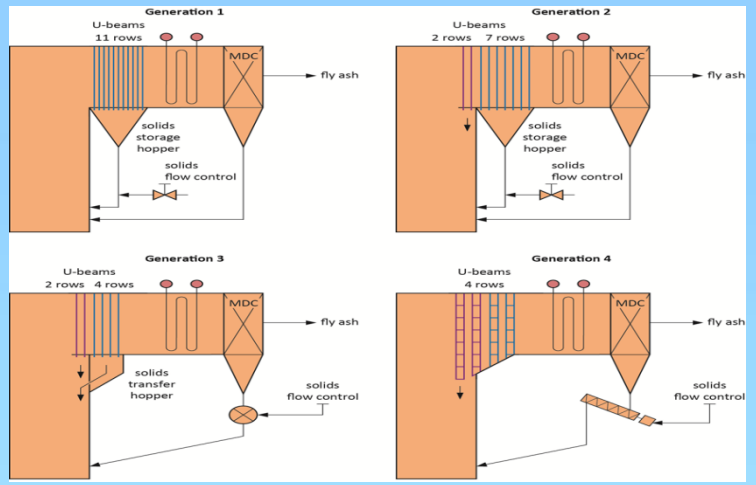


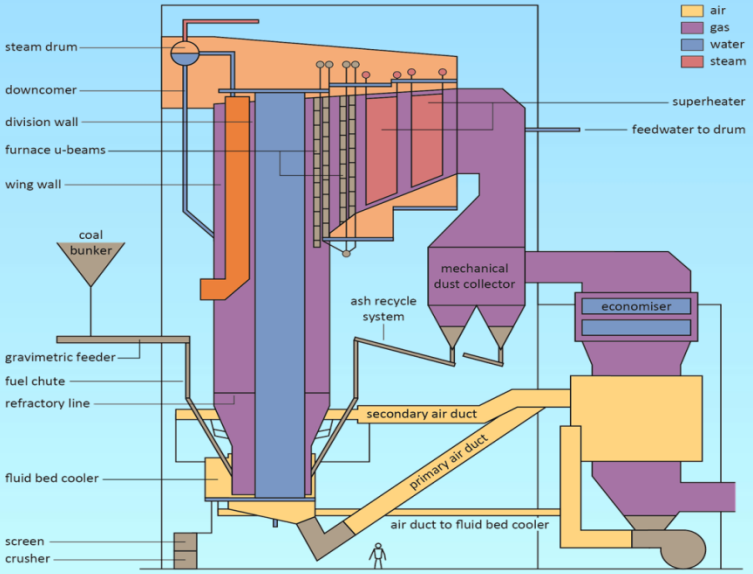
Internal recirculation CFBC boiler

IR-CFB boilers feature a two-stage solids separator:

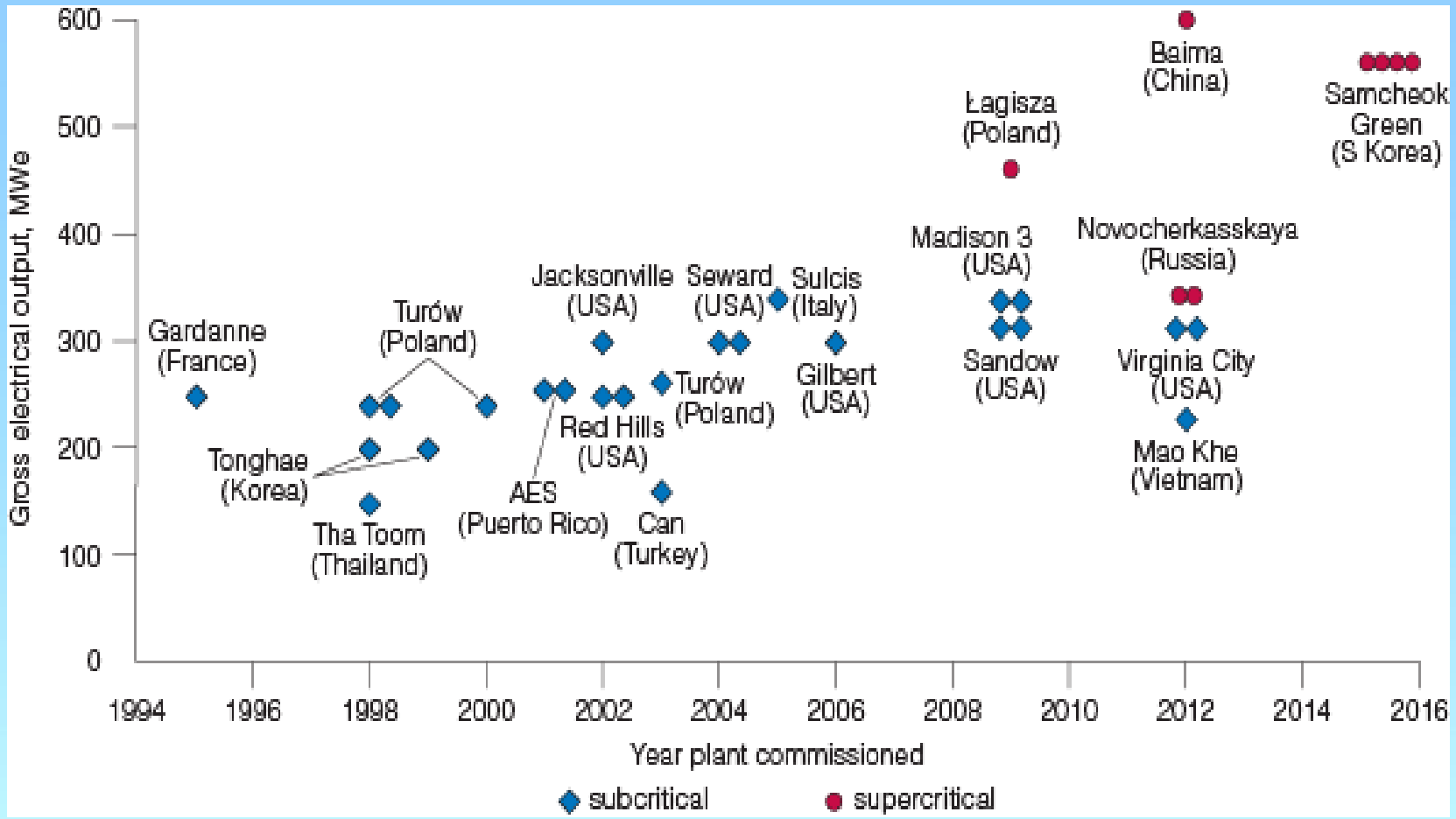
- **Primary stage impact solids separator (“U beams”) located at the furnace exit collecting the bulk of the solids (95% to 97%) that are then returned to the furnace by gravity.**
- **Secondary separation stage, typically a multi-cyclone dust collector (MDC), is located in the lower gas temperature region of the boiler convection pass, i.e., 250° C to 510° C.**

The U-beam separator design has evolved through several designs





CFBC developments: scale- steadily increasing unit size



CFBC: once-through boiler technology with supercritical steam conditions

Lagisza 460 MWe

SC Unit

(27.5 MPa/560ºC/580ºC) Poland

Baima 600MWe

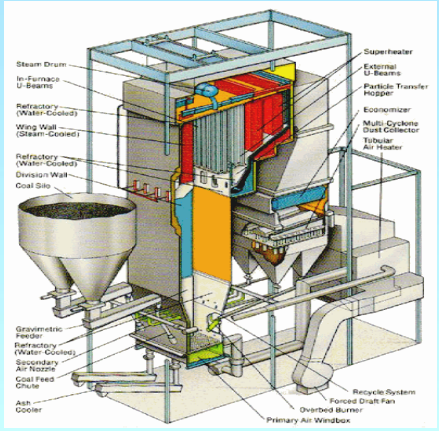
SC unit

(24.5 MPa/565ºC/565ºC)

China

CFBC: fuel flexibility

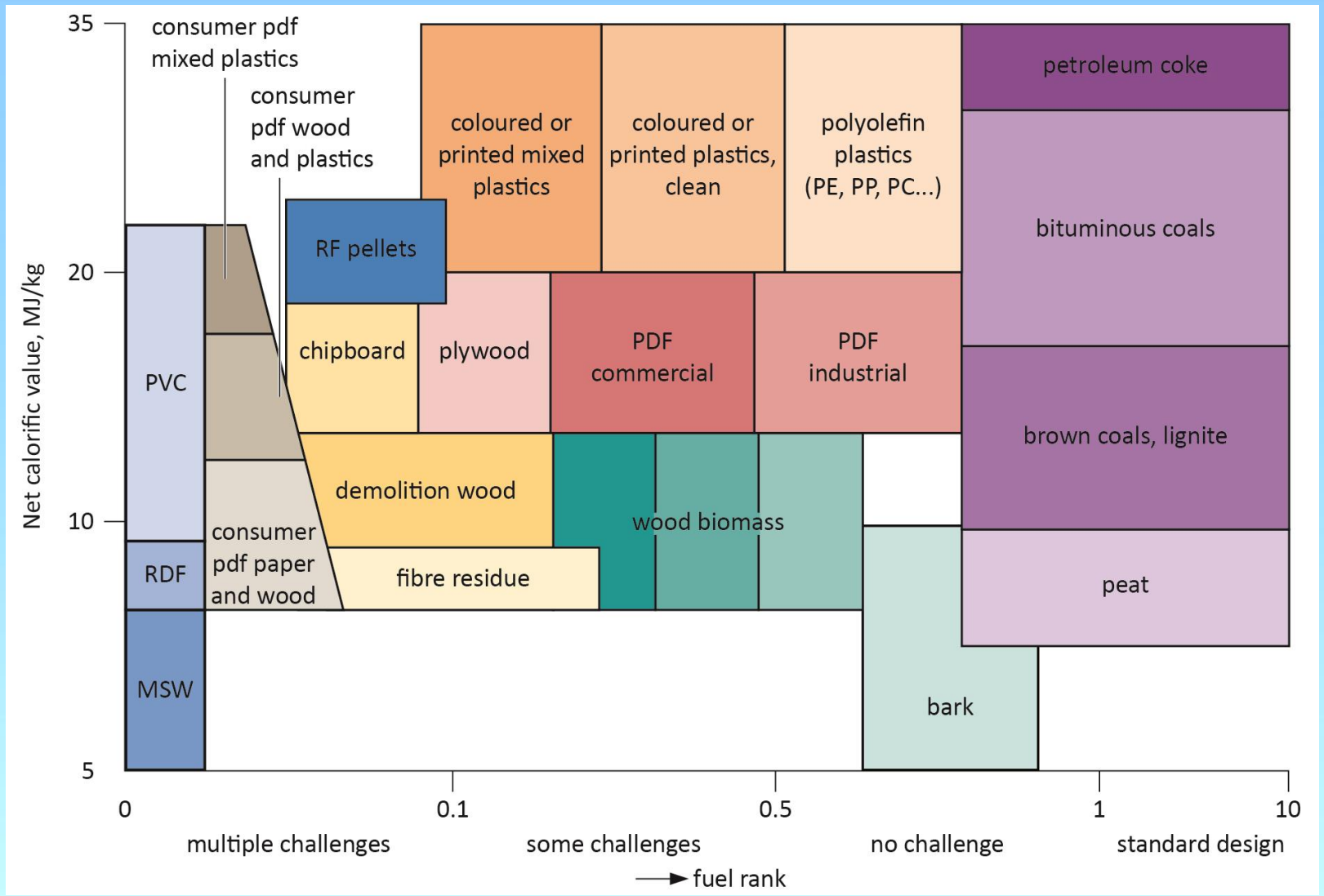
- Units originally designed for coal
- Large inert bed accommodates a wide range of fuel properties
- Possible to change fuels online with minimum process disruption
- Lower combustion temperatures reduce fouling and slagging risks
- Low temperatures and long residence times facilitate emissions control



CFBC retrofit advantages

	Turow 6 x 200 MWe Lignite	Narva 2 x 200 MWe Oilshale
•	Improved plant efficiency 31% to 40%	30 % to 39 %
•	Additional capacity/unit 200 MWe to 262 MWe	200 MWe to 215 MWe
•	Improved emissions	
	SO_2 92 % reduction	90 % reduction
	NO_x 50 % reduction	30 % reduction
	CO_2 24 % reduction	24 % reduction

Challenges for CFBC boiler design of a range of fuels (Koornneef and others, 2007)



What are low grade fuels?

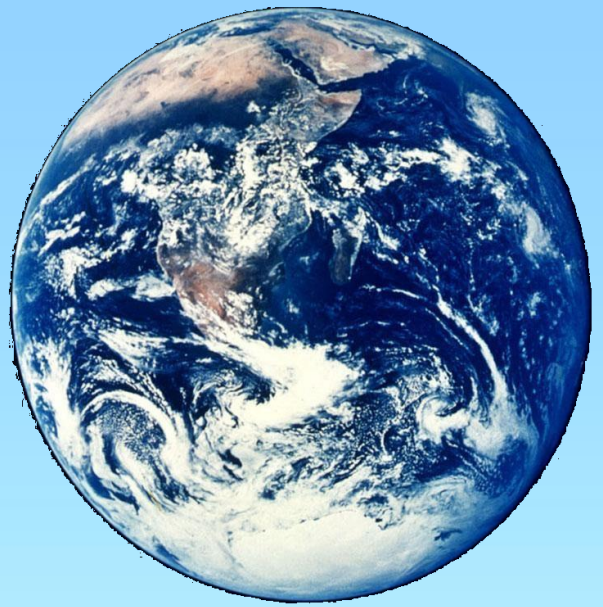
Characterised by:

- **An energy content lower than the range expressed in normal fossil fuels (oil, gas and coal)**
- **High in “inerts” (mineral matter and/or moisture)**
- **May have high concentrations of pollutant precursors**

Pelletised industrial waste

Global low grade fuel resources

- Biomass
- Peat
- Oil shale
- Lignite and brown coals
- Oil sands
- Coal mill rejects
- Coal washery rejects
- Petroleum coke
- Wood and fibre residue
- Refuse-derived fuel
- Plastics
- Sewage sludge
- High chlorine and high sulphur coals



What are the attractions of low grade fuels?

- Financial – a low cost resource
- May reduce emissions when co-fired with coal (esp. biomass)
- May otherwise be considered as waste materials that have a relatively high disposal cost and this cost can be offset or eliminated by using that waste for energy generation.
- May assist in “clean up” activities e.g. old coal workings

Challenges posed by low grade fuels – heating value

- The heating value of the fuel can vary widely and quite often correlates to the moisture content of the fuel.
- Biomass, with moisture content 60%, has an energy content around 6.5 MJ/kg (LHV) as-fired, with the highest energy content in petroleum coke at 32 MJ/kg (LHV).
- Some waste coals or coal washing residues have an energy content as low as 4.5 MJ/kg. For these materials, the moisture content is low and the reason for the low heating value is an extremely high ash content.

Refuse derived fuel (RDF)

Challenges posed by low grade fuels – sulphur and chlorine

Sulphur content is very low in wood-based biomass, only 0.01-0.05 %. The other extreme is petcoke which contains normally 6-8 % of sulphur.

Chlorine content is a challenge in recycled fuels because of possible problems of corrosion, and the formation of chlorine-containing pollutants. In refuse derived fuel (RDF) the chlorine content can be greater than 1%.

RDF processing

Key messages

- CFBC plants represent close to 10% of the global power plant capacity
- For power generation applications, they can be offered with commercial guarantees up to 800MWe and with supercritical steam conditions when fired on coal
- Globally, there is a significant resource comprising low grade fuels, and these materials can be exploited successfully in combination with coal, or separately for both power and non-power applications

Thank you for listening!

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