Efficiency upgrades for existing coal-fired power plants

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Clean and efficient power generation from coal
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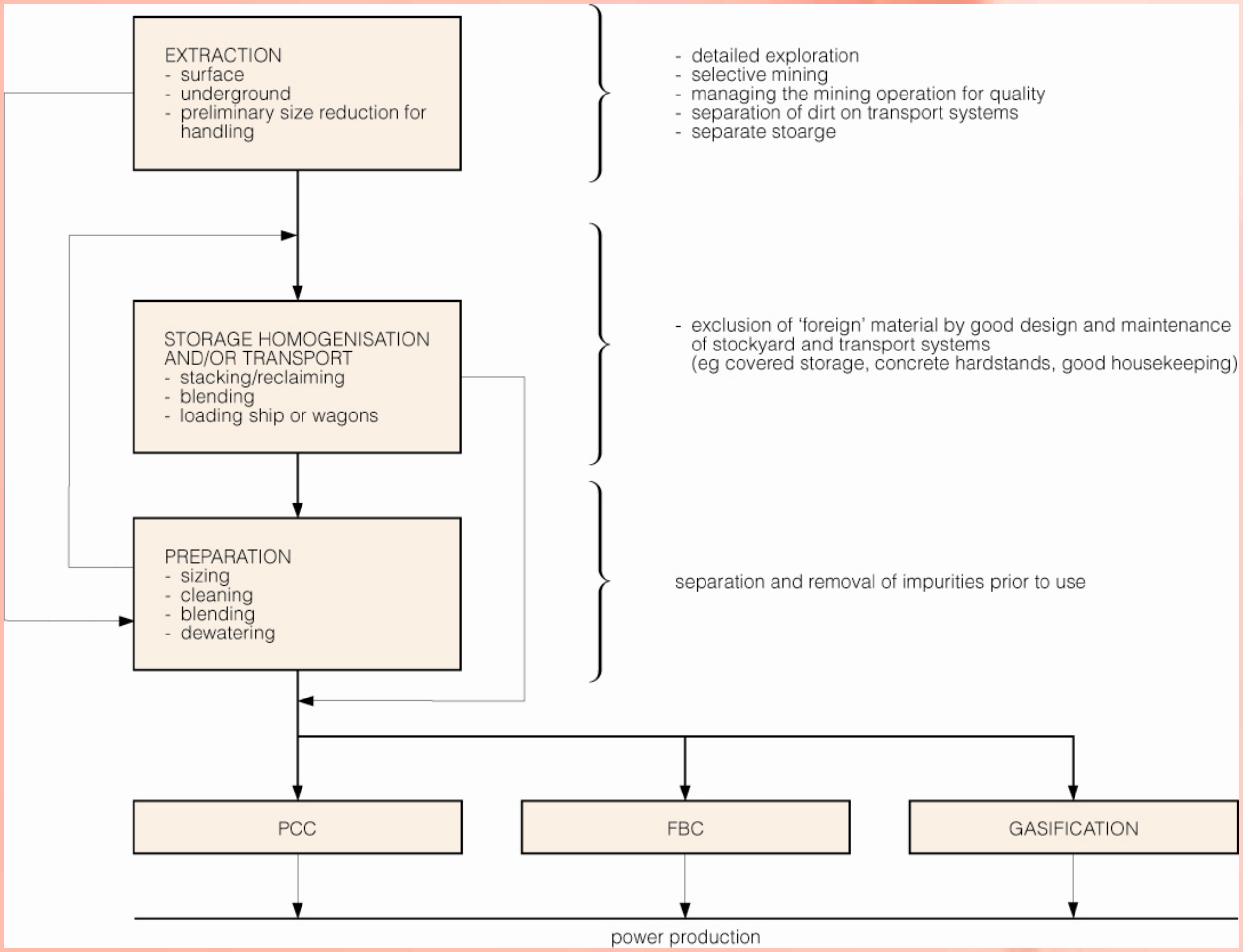
Coal upgrading

Coal properties that influence efficiency include

- Amount of ash in the coal
- The moisture content of the coal
- The reactivity of the coal

Coal upgrading aims to improve quality and consistency, and reduce moisture content.

Stages in the coal-to-user chain (Couch, 2002)



Benefits of coal upgrading

Lower ash and/or moisture content

Greater heating value

Reduced volumes for transport = lower costs

Often reduced sulphur content

Reduction in amounts of various trace elements

More consistent coal quality

Second order effects

Could increase thermal efficiency by 2-3 percentage points and reduce CO_2 emissions by 0.3-0.5 Gt/y

Efficiency measures

Maintenance strategy

Instrumentation and control

Boiler cleaning

Turbine re-blading

Turbine back pressure reduction

Boiler back-end temperature reduction

Upgrading the economiser

Housekeeping

Low cost options that save small amounts of CO_2

Efficiency measures

Auxiliary power reduction

Heat recovery systems

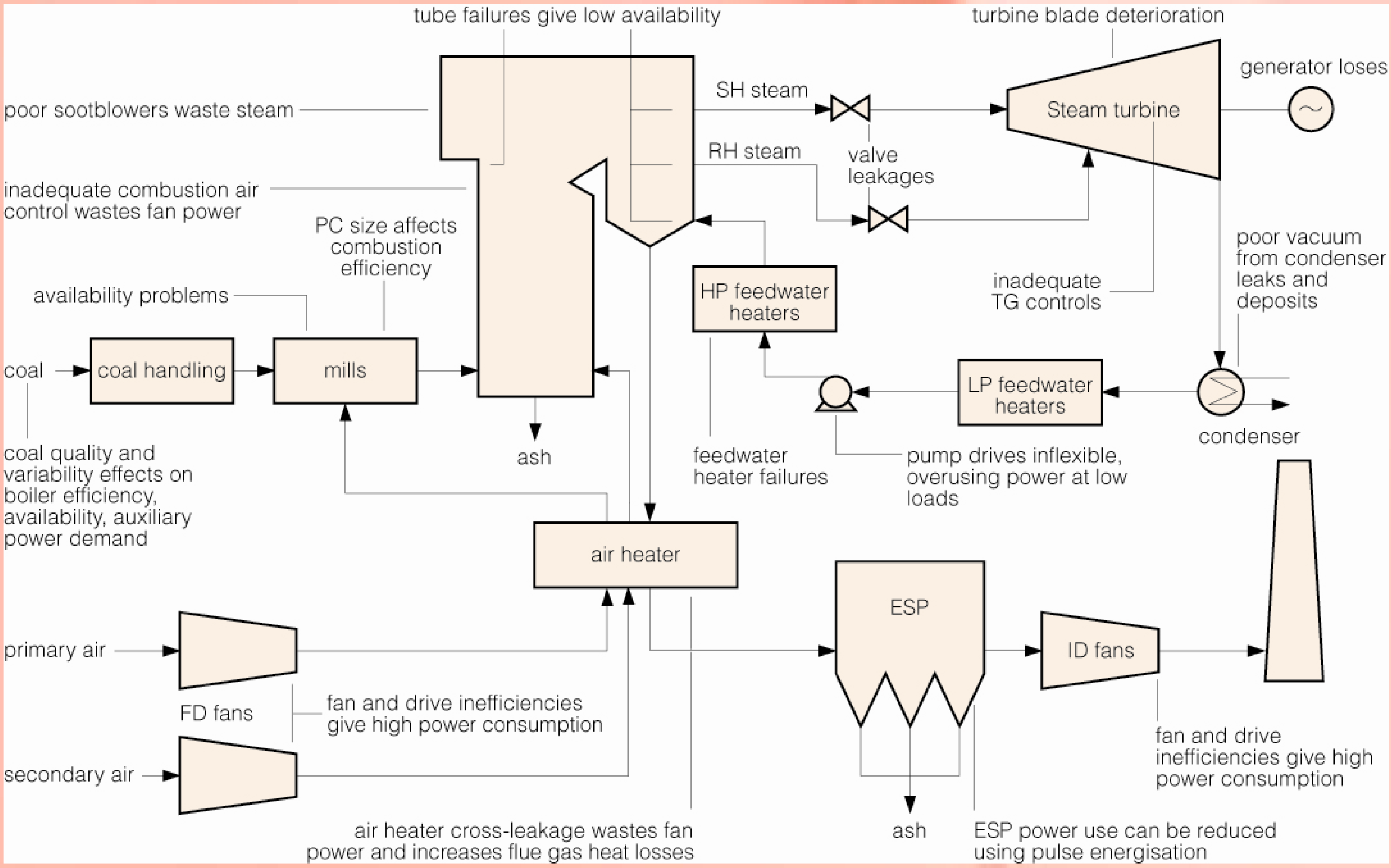
Cooling tower improvements

Monitoring and controlling excess air levels

Maintaining operating conditions closer to set points

Possible improvements of 4-5 percentage points

Main sources of efficiency losses on a PC boiler turbine unit (Henderson, 2003)



Plant upgrades

1/3 of global generation capacity is over 30 y old.

Retrofit to state-of-the-art supercritical steam conditions and abatement technology can extend plant life by 20+y.

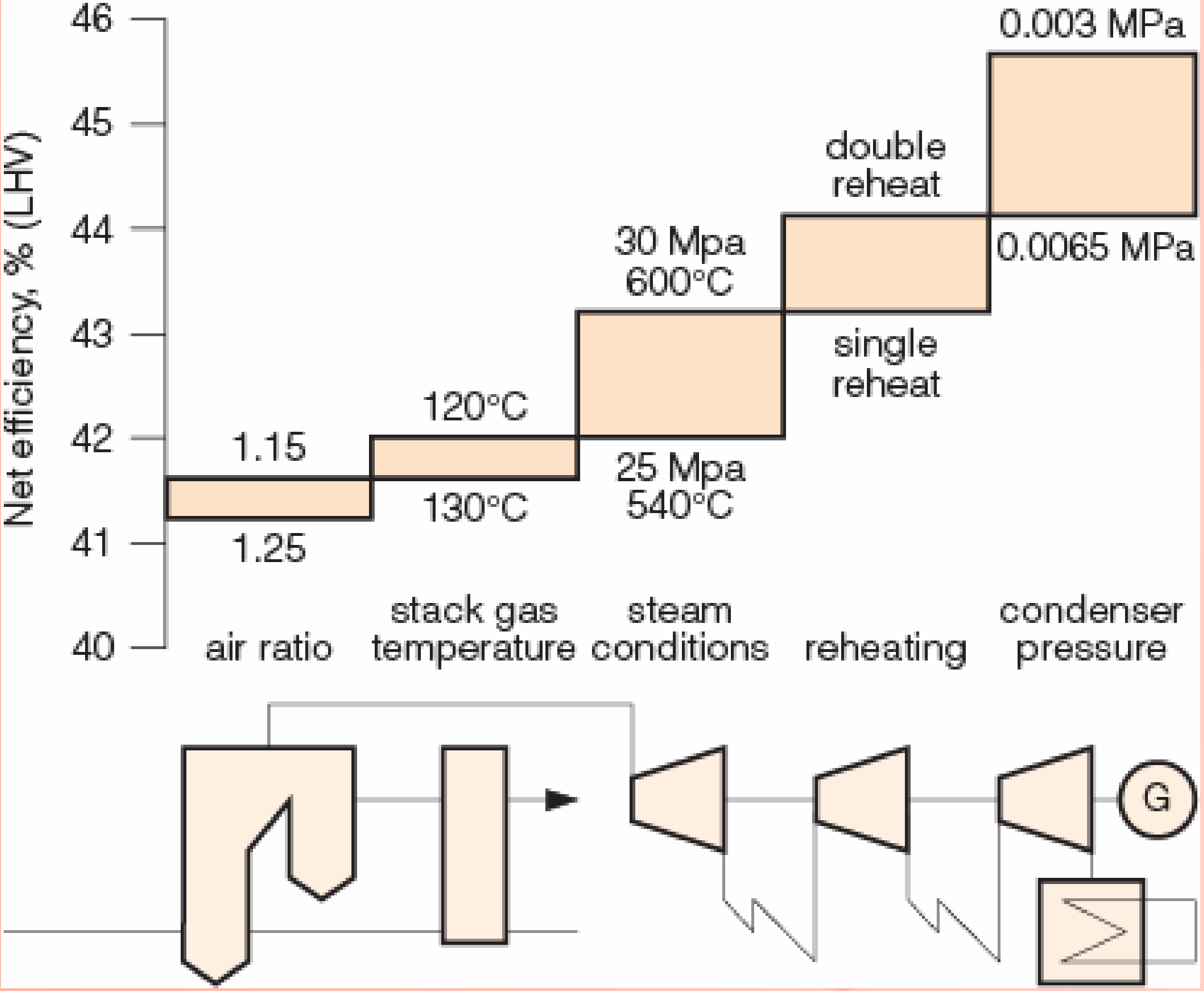
Subcritical: 40% efficiency, CO_2 emitted 380 t/h

Supercritical: 42% efficiency, CO_2 emitted 364 t/h

IGCC: 44% efficiency, CO_2 emitted 320 t/h.

An advanced USC plant (efficiency 46-48% LHV) emits about 18-22% less CO_2/MWh than an equivalent sized subcritical PC unit.

Effect of various measures for improving the efficiency of PC-fired power plant (Beer, 2007)



Supercritical and ultra supercritical

Major barriers to advances in SC and USC steam cycle are metallurgical and control problems. Developments in new and high-alloy steels will increase the number of SC plants installed.

A subcritical PC plant with 36% LHV efficiency produces about 0.9 tCO_2/MWh of electricity.

The best supercritical with 46% LHV efficiency, produces just over 0.7 t

= reduction of CO_2 of over 20%

Coal fired generating capacity of 1000 GW

Almost 2/3 are over 20 y old, and have efficiency of 29%

Emit 3.9 billion tCO_2/y

If replaced at 40 y with USC, emissions reduced by 1.4 billion tCO_2/y

= 36%

Biomass cofiring

Substitution of 20% of the heat input from coal with biomass in a USC coal-fired plant can reduce CO_2 emissions from 700 g/kWh to 560 g/kWh.

In general, co-firing ratios are less than 10% on a heat input basis, and have modest impacts on the boiler performance.

Advantages of cofiring:

- Lower investment costs
- Higher efficiency due to scale effects
- Large demand helps to establish fuel supply chains.

Conclusions

- More widespread use of coal upgrading could reduce emissions of CO2 by 0.3-0.5 Gt/y.
- Most existing coal-fired power plants are subcritical with efficiencies of 32-38% LHV, with CO_2 emissions around 900-1000g/kWh+. Retrofit of the turbine and boiler could reduce emissions of CO_2 by about 20%.
- Biomass co-firing could replace up to about 14% of fossil fuels currently used for electricity production.
- Adoption of all the measures described could reduce emissions by about 50%. CCS will be more effective if added to efficient plant.

Efficiency upgrades and partial carbon capture for coal-fired power plants.

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