The power of high efficiency coal

Benjamin Sporton
Chief Executive
Coal continues to grow, even as share declines.
Asia will drive new coal generation capacity

Asian share of global coal power generation capacity:

- 2000 – 38%
- 2015 – 69%
- 2040 – 77%

Will require an additional 1 billion tonnes per annum of coal
Large-scale power generation will be a critical enabler of growth in India

- Electricity demand in India is expected to average 4.4% pa over the next 25 years
- While coal generation capacity more than doubles, renewables are required to increase exponentially (non-hydro renewables over 10 times) to meet demand
- IEA indicates that maintaining an adequate electricity supply represents a significant investment challenge requiring $2 trillion (in 2013 dollars)

Source: IEA, WEO 2014
Coal will continue to play a big role in China

- China’s electricity demand growth will be around 4.8% to 2020, then decline to around 2% through to 2040
- Electricity generation from coal will be 27% higher in 2040, despite its share of generation reducing from 75% to 49%
- Non-hydro renewables are expected to increase 1200% over the same period (25% of world generation)

Source: IEA, WEO 2014
Coal will drive Southeast Asian energy

- Electricity demand almost triples over the period, to around 2,000 TWh in 2040, an increase bigger than current demand in India.
- The share of coal in power generation rises from 32% to 50%
- Renewables-based electricity generation increases three and half times from today to 2040 (481 TWh)
- IEA – requires $2.4 trillion investment over the period to 2040. This represents around 5% of the global total, or one-third of China’s investment
- Southeast Asia will move from 46% to 60% urbanised by 2040, vs OECD 85%
Higher efficiency reduces CO₂

For every 1% efficiency improvement, we get 2-3% reduction in CO₂ emissions.
HELE technologies continue to develop

CO$_2$ reduction potential of coal-fired power plants by increased efficiency

![Graph showing CO$_2$ emissions per kWh and CO$_2$ reduction over time.](image)
What is high efficiency low emissions coal?

### Which are HELE technologies?

<table>
<thead>
<tr>
<th>Description</th>
<th>Efficiency Rate</th>
<th>CO₂ Intensity</th>
<th>Coal Consumption</th>
<th>Steam Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced ultra-supercritical</td>
<td>45-50%</td>
<td>670-740g CO₂/kWh</td>
<td>290-320g/kWh</td>
<td>700°C+</td>
</tr>
<tr>
<td>Ultra-supercritical</td>
<td>Up to 45%</td>
<td>740-800g CO₂/kWh</td>
<td>320-340g/kWh</td>
<td>600°C+</td>
</tr>
<tr>
<td>Supercritical</td>
<td>Up to 42%</td>
<td>800-880g CO₂/kWh</td>
<td>340-380g/kWh</td>
<td>Approx. 550°C-600°C</td>
</tr>
<tr>
<td>Subcritical</td>
<td>Up to 38%</td>
<td>≥880g CO₂/kWh</td>
<td>≥380g/kWh</td>
<td>&lt;550°C</td>
</tr>
</tbody>
</table>

*Lower heating value

Source: Adapted from IEA, Technology Roadmaps, High-efficiency low-emissions coal-fired power generation, 2012
HELE can become the global standard for coal

- Japan and China have been the most active in building USC plants
- J-Power upgraded their 1967 sub-critical Isogo 38% efficient coal-fired power plant to an USC 43% efficiency plant with SOx, NOx, PM reduced to less than 1/3 of previous levels
- China’s Ninghai plant has a capacity of 4,400MW and China is relying on these larger, advanced units for dispatch to displace higher emission from older, less efficient power stations
- The units have integrated advanced air quality control systems, yielding non-carbon air emissions well below China’s latest more stringent standards, and also below comparable standards in North America and Europe
WCA wants to see more action on HELE
HELE is part of the Paris Agreement
Coal plant development mix of HELE and not

Source: World Coal Association analysis, 2015
China committed to HELE, others less so

Source: World Coal Association analysis, 2015
Non-OECD Asia needs to make HELE switch
HELE is cost competitive today...

Lifetime Cost of Electricity per MWh across Generation Technologies in 2015

Source: World Coal Association analysis, 2015
... and in the future (and so is coal + CCS)

Lifetime Cost of Electricity per MWh across Generation Technologies in 2035

Source: World Coal Association analysis, 2015
Per $ of investment HELE more powerful

Compared to renewables, HELE technologies can reduce more emissions for the same upfront investment.

<table>
<thead>
<tr>
<th>Investment Option</th>
<th>Generation Mix for 10,000 TWh (%)</th>
<th>Required Capacity (GW)</th>
<th>Total CAPEX (Bn $)</th>
<th>% Increase in CAPEX to Baseline</th>
<th>Annual Emission (Bn tCO₂)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coal: Renewable</td>
<td>Coal: Renewable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sub-Critical Coal Only</td>
<td>100: 0</td>
<td>1,343: 0</td>
<td>699</td>
<td>Baseline 9.5</td>
<td></td>
</tr>
<tr>
<td>Ultra Super-critical Coal Only</td>
<td>100: 0</td>
<td>1,343: 0</td>
<td>932</td>
<td>33%</td>
<td>7.0</td>
</tr>
<tr>
<td>Sub-critical Coal and Onshore Wind</td>
<td>95: 5</td>
<td>1,269: 241</td>
<td>932</td>
<td>33%</td>
<td>9.0</td>
</tr>
<tr>
<td>Sub-critical Coal and Solar PV</td>
<td>96: 4</td>
<td>1,284: 264</td>
<td>932</td>
<td>33%</td>
<td>9.1</td>
</tr>
<tr>
<td>Onshore Wind Only</td>
<td>0: 100</td>
<td>4,391: 0</td>
<td>4,944</td>
<td>607%</td>
<td>0</td>
</tr>
<tr>
<td>Solar PV Only</td>
<td>0: 100</td>
<td>6,008: 0</td>
<td>6,002</td>
<td>759%</td>
<td>0</td>
</tr>
</tbody>
</table>

Notes:
1) Based on IEAs WEO 2014 New Policy Scenarios capital cost estimates for China in 2035 with construction costs spread equally over the construction period.

Source: World Coal Association analysis, 2015
HELE in India – meeting twin objectives

Deploying cleaner coal technology promotes energy access, while managing emissions of carbon dioxide.
HELE in India – examining the impact

The environmental benefits of deploying cleaner coal technology in India

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Capacity mix</th>
<th>CO$_2$ emissions (tCO$_2$) (over 40 years)</th>
<th>CO$_2$ abated equivalent to</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>USC</td>
<td>SC</td>
<td>SubC</td>
</tr>
<tr>
<td>Mix per development pipeline</td>
<td>6</td>
<td>167</td>
<td>118</td>
</tr>
<tr>
<td>Shift to Supercritical</td>
<td>6</td>
<td>286</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>26,000</td>
<td>200 million</td>
<td></td>
</tr>
<tr>
<td>Shift to Ultra Supercritical</td>
<td>0</td>
<td>292</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>65,000</td>
<td>500 million</td>
<td></td>
</tr>
</tbody>
</table>
WCA supports coordinated international action

- International platform to help drive deployment of HELE technologies in developing and emerging economies

- Public-private partnership to overcome financial, technical, and regulatory barriers

- Currently seeking partners to help build an initial alliance
A global initiative on HELE would have impact

<table>
<thead>
<tr>
<th>Policy / Action</th>
<th>Annual emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Montreal protocol</td>
<td>5.6bn</td>
</tr>
<tr>
<td>Hydropower worldwide</td>
<td>2.8bn</td>
</tr>
<tr>
<td>Nuclear power worldwide</td>
<td>2.2bn</td>
</tr>
<tr>
<td>Increase average global efficiency of coal-fired power plants to 40%</td>
<td>2bn</td>
</tr>
<tr>
<td>Other renewables worldwide</td>
<td>600m</td>
</tr>
<tr>
<td>US vehicle emissions &amp; fuel economy standards</td>
<td>460m</td>
</tr>
<tr>
<td>Clean Development Mechanism</td>
<td>150m</td>
</tr>
<tr>
<td>Global Environment Facility</td>
<td>100m</td>
</tr>
<tr>
<td>EU energy efficiency</td>
<td>58m</td>
</tr>
<tr>
<td>EU renewables</td>
<td>29m</td>
</tr>
</tbody>
</table>

Source: Adapted from The Economist and the IEA 2014
Deploying HELE also has other benefits

**Air quality**

90-99.9% reduction of pollutants from coal combustion as a result of using cleaner coal technologies.

**CCS**

THE ROLE OF CARBON CAPTURE AND STORAGE (CCS)

CCS is an integrated suite of technologies that can capture up to 90% of the CO₂ emissions produced from the use of fossil fuels in electricity generation and industrial processes, preventing the CO₂ from entering the atmosphere. The technology is also effective in capturing other emissions.

90% Amount of CO₂ emissions that could be captured through CCS technologies.
CCS is critical to global climate objectives

- CCS is expected to deliver 12% of cumulative GHG emissions cuts through to 2050. It is therefore a key low-carbon technology.
- The world’s first large scale integrated CCS project capturing CO2 from a coal-fired power plant – SaskPower’s Boundary Dam – has just started full scale operation at the end of September 2014.
Why CCS has been slow to progress

Clean energy investment* between 2004 – 2013 (billion US$)

- CCS: $20 billion
- All clean energy: $1929 billion

* includes technology development, projects, M&A
Source: IEA
CCS is real, and happening now

- The world’s first application of CCS at large scale in the power sector became operational in October 2014, at the Boundary Dam power station in Canada (1 Mtpa CO2 capture)
- An upgrade of a 1960’s coal unit chosen by Saskpower over gas and renewables
- Two more large scale applications of CCS in power will come on line in 2016 in the US
  - Kemper County Energy Facility (3 Mtpa, Mississippi)
  - Petra Nova Carbon Capture Project (1.4 Mtpa, Texas)
- Large-scale application of CCS will become a reality in iron and steel in 2016 at the Abu Dhabi CCS Project (0.8 Mtpa)
- A further 14 projects are in advanced planning (FEED)

- Boundary Dam, Saskatchewan, Canada
- Coal-fired 110MW CCS 1Mtpa plant operational October 2014
- $1.4Bn Government and Saskatchewan Power Co partnership
In summary – the WCA view

- We must recognise that coal is an important driver of affordable, reliable energy to support economic development and competitiveness.
- Coal plays a major role in industrialising and urbanising economies.
- In any scenario coal is still going to play a major role in the world’s energy mix – especially across Asia.
- We can significantly reduce emissions from coal with commercially available technology today – we should encourage and support deployment of HELE technologies in preference of less efficient technologies.
- More public support is needed to facilitate increased commercial demonstration of CCS to drive costs down so that we can begin a transition toward near-zero emission fossil fuels.