Coal for Power Generation to 2050

Dr John Topper
IEA Clean Coal Centre

Energy Studies Institute &
Institute of South East Asian Studies Seminar
Singapore 4 November 2010
IEA CCC MEMBERS

- Austria
- Australia
- Canada
- Germany
- Italy
- Japan
- Poland
- Rep. of Korea
- S Africa
- Spain
- UK
- USA
- CEC
- GCCSI
- Beijing Research Inst Coal Chemistry
- Banpu
- Coal Assoc NZ
- Danish Power Group
- Eletrobras
- Schlumberger
- Anglo Coal
- Netherlands Group
- BHEL
- Suez
- Vattenfall*
- Suek

* To be decided

© IEA Clean Coal Centre

www.iea-coal.org.uk
Contents

- Coal Demand to 2030

- State of the Art in coal fired power plant

- Up grading and replacing old coal fired power plant

- The long term CCS roadmap for sustainable use of fossil fuels

- Current status of carbon capture
World primary energy demand in the Reference Scenario: WEO 2009
World primary energy demand under the 450 Scenario, Mtoe (WEO, 2009)
"World Coal Consumption was essentially flat in 2009, the weakest year since 1999. For the first time since 2002 coal was not the fastest growing fuel in the world. The OECD and Former Soviet Union experienced the steepest declines on record, while growth elsewhere was nearly average, largely due to the above average growth in China which accounted for 46.9% of global consumption."

Source: BP Statistical Review of World Energy, June 2010
People without access to electricity in IEA WEO Reference Scenario (millions)

World population without access to electricity
2008: 1.5 billion people
2030: 1.3 billion people

$35 billion per year more investment than in the Reference Scenario would be needed to 2030 – equivalent to just 5% of global power-sector investment – to ensure universal access
Coal Fired Power Plant – State of the Art
Recent Plant State-of-the-Art Conditions

G8 Case study plants

- Studstrup (DK) 540/540
- Maatsura 1 (J) 538/566
- Esbjerg (DK) 560/560
- Schwarze Pumpe (D) 547/565
- Maatsura 2 (J) 593/593
- Haramachi 2 (J) 600/600
- Nordjylland (DK) 580/580/580
- Boxberg (D) 545/581
- Tachibanaawan 1 (J) 600/610
- Avedore (DK) 580/600
- Niederaussem (D) 580/600
- Hekinan (J) 568/593
- Isogo (J) 600/610
- Yunghung 566/576
- Genesee 3 580/570
- Hitachinaka (J) 600/600
- Torrevaldaliga (I) 600/610
- Huyan (China)
Nordjylland 3, Denmark – highlights

USC, tower boiler, tangential corner firing, int. bituminous coals, cold sea water

- Most efficient coal-fired plant
- Operating net efficiency 47% LHV, power only mode/44.9% HHV (not annual)
- High steam conditions 29 MPa/582°C/580°C/580°C at boiler by early use of new materials (P91)
- Large number of feedwater heating stages
- Double reheat has prevented LP blade erosion
- Very low emissions and full waste utilisation
- NOx abatement Combustion measures and SCR
- Particulates removal ESP
- Desulphurisation Wet FGD

© IEA Clean Coal Centre www.iea-coal.org.uk
Niederaussem K, Germany

USC, tower boiler, tangential wall firing, lignite of 50-60% moisture, inland

- Most efficient lignite-fired plant
- Operating net efficiency 43.2% LHV/37% HHV
- High steam conditions 27.5 MPa/580°C/600°C at turbine; initial difficulties solved using 27% Cr materials in critical areas
- Unique heat recovery arrangements with heat extraction to low temperatures – complex feedwater circuit
- Low backpressure: 200 m cooling tower, 14.7°C condenser inlet
- Lignite drying demonstration plant being installed to process 25% of fuel feed to enable even higher efficiency
- NOx abatement
- Particulates removal
- Desulphurisation

www.iea-coal.org.uk
Isogo New Unit 1, Japan

USC, tower boiler, opposed wall firing, int bitum and Japanese coals, warm sea water

- Near zero conventional emissions (NOx 20 mg/m³, sulphur oxides 6 mg/m³, particulates 1 mg/m³, at 6% O₂, dry); full waste utilisation
- Highest steam conditions: 25.0 MPa/600°C/610°C at turbine: ASME CC 2328 steels in S/H; P122 for main steam pipework
- Operating net efficiency >42% LHV/40.6% HHV
- Efficiency tempered slightly by 21°C CW, fewer FW heating stages
- Dry regenerable activated coke FGD (ReACT)
- NOx abatement Combustion measures and SCR
- Particulates removal ESP
- Isogo New Unit 2 will use ReACT specifically for multi-pollutant control, including mercury
Huaneng Yuhuan 4x 1000MWe USC coal fired power plant
## Status of USC boilers ordered in China by end of May 2008

<table>
<thead>
<tr>
<th>Supplier</th>
<th>1000 MWe</th>
<th></th>
<th>660 MWe</th>
<th></th>
<th>600 MWe</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>Capacity, GWe</td>
<td>No</td>
<td>Capacity, GWe</td>
<td>No</td>
<td>Capacity, GWe</td>
</tr>
<tr>
<td>Harbin</td>
<td>16</td>
<td>16.0</td>
<td>18</td>
<td>11.9</td>
<td>10</td>
<td>6.0</td>
</tr>
<tr>
<td>Shanghai</td>
<td>36</td>
<td>36.0</td>
<td>16</td>
<td>10.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dongfang</td>
<td>28</td>
<td>28.0</td>
<td>10</td>
<td>6.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beijing B&amp;W</td>
<td>4</td>
<td>4.0</td>
<td>2</td>
<td>1.3</td>
<td>4</td>
<td>2.4</td>
</tr>
<tr>
<td><strong>Sub-total</strong></td>
<td><strong>84</strong></td>
<td><strong>84.0</strong></td>
<td><strong>46</strong></td>
<td><strong>30.4</strong></td>
<td><strong>14</strong></td>
<td><strong>8.4</strong></td>
</tr>
</tbody>
</table>
CO2 emission reduction pathways

Energy Efficiency makes big change but deep cuts of CO2 emission can be done only by Carbon Capture and Storage (CCS)
Potential for CO2 emissions reductions by adopting state of the art

- Coal-fired power and CHP plants worldwide account for ~25% of total CO₂ production

- Replacement potential - ~300 GW

- Upgrade potential - up to 200 GW

- Replacement or upgrade of some units under progress or already planned

- Globally 1.35 - 1.7 billion ton/annum of CO₂ reduction possible by moving to current state of the art pc-plants – about 5% of global anthropogenic emissions

© OECD/IEA 2008
China - Latest old plant closure announcements

China to reduce emissions, save coal by closing old power stations

BEIJING, May 21, 2010 -- Xinhua

China's energy watchdog, the National Energy Administration, signed agreements with 26 provincial governments Friday to close at least 10 million kilowatts of outdated coal-fuelled power capacity before October this year. The agreement means China will close 70 million kilowatts of small-scale, outdated thermal power station capacity in the Eleventh Five-Year Plan period from 2006 to 2010. If achieved on time, the plan will save 81 million tonnes of coal annually, or 2.6 percent of the coal used in 2005; eliminate 1.4 million tonnes of sulfur dioxide emissions, or 5.5 percent of 2005 levels; and cut carbon dioxide emissions by 164 million tonnes, about 3.2 percent of 2005 levels.
TOP DOWN CCS ROADMAP
The ETP BLUE Map Scenario
There is an ambitious growth path for CCS from 2010 to 2050.
A Global Challenge

CCS will be required in all regions of the world in power, industry and upstream.
An ambitious growth pathway

OECD regions must lead in demonstrating CCS, but the technology must quickly spread to the rest of the world.
CCS is not just a “clean coal”

Coal power only makes up around 40% of stored emissions in 2050.

- Coal power: 39.6%
- Biomass power: 4.8%
- Biomass synfuel: 20.2%
- Natural gas synfuel: 4%
- Gas processing: 4.3%
- Iron and Steel: 10%
- Pulp and paper: 0.2%
- Chemicals: 3.3%
- Cement: 5.3%
- Gas power: 8.4%
Demonstration to Commercial

Expanded collaboration on CCS R&D and technology transfer will be critical

2010 – 2025
Majority of early Large-scale projects located in OECD countries

2010 – 2030
Collaborative R&D efforts between OECD and Non-OECD countries to develop and deploy Pilot & Demo projects

2030+
Non-OECD countries take the lead in commercialising CCS plants

2035+
Declining need for Pilot & Demo projects

New build projects

Pilot & Demo (OECD)

Pilot & Demo (non-OECD)
Status of CCS
At Chongqing Hechuan Shuanghuai 2x300MWe Power Plant. First operated in January 2010. Annual CO2 capture capacity is 100000 tonnes. This unit is part of a range of test units assessing various environmental control systems, including SO2, mercury and NOx.
Vattenfall Oxy Fuel Technology
(Courtesy Vatenfall)

The size of the plant is about 30 MWth
Operational since late 2008
Located at Schwarze Pumpe in Germany
Trials with lignite and hard coals
250MWe IGCC under construction at Tianjin
(Phase 1 of the Greengen project)
Barriers and Hurdles are primarily non-technical

- Real Political will – global agreement lacking
- Regulation
- Finance
- Social acceptability of Transport Routes and Storage
CONCLUSIONS

- Even if ambitious targets for achieving 450ppmCO2 are achieved, the world will still be using very substantial amounts of coal.

- Coal use will be increasingly in developing countries where pressures to maintain economic growth and increase living standards could take precedence.

- Decarbonising power and industrial use requires thousands of projects, will cost around several trillion $ and will encompass, coal and gas fired power, large industrial use of fossil fuels and after 2030 be very dependent on actions in non-OECD countries.

- Immediate action is required for sustainability and much of it to address non-technical issues.
THE END

Thank you for Listening

John.topper@iea-coal.org
+44 20 8780 2111
www.iea-coal.org.uk