The Case for Coal – Future Demand; Best Practice; CCS

Policy Options for Energy Security and Sustainable Development
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Coal Demand, Best Practice Today, and CCS

- IEA’s Projections for Coal
- Best Practice in Power Plant use
- Carbon Capture for Coal
World energy demand expands by 45% between now and 2030 – an average rate of increase of 1.6% per year – with coal accounting for more than a third of the overall rise
The increase in China’s energy demand to 2030 – the result of its sheer market size & stronger economic growth prospects – dwarfs that of all other countries & regions
Size of coal-fired fleet

Source: IEA Clean Coal Center and China Electricity Council
(Data 2008 unless specified otherwise)
The Reference Scenario: World electricity generation

IEA WEO 2008

The shares of coal & renewables in the power-generation fuel mix increase to 2030 – mainly at the expense of natural gas & nuclear power
Total power generation capacity today and in 2030 by scenario

In the 450 Policy Scenario, the power sector undergoes a dramatic change – with CCS, renewables and nuclear each playing a crucial role.
Global View of Coal Use Today
Recent Plant State-of-the-Art Conditions

G8 Case study plants

Max SH Steam Temperature, °C


Year

- 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
- Tachibanawan 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
Isogo New Unit 1, Japan – highlights

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
E On 50% efficient plant

... 50 plus by using new materials

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<thead>
<tr>
<th>Location</th>
<th>Wilhelmshaven</th>
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<tbody>
<tr>
<td>Efficiency</td>
<td>50%</td>
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<tr>
<td>Capacity</td>
<td>500 MW_e</td>
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<tr>
<td>Investment</td>
<td>1 billion €</td>
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<tr>
<td>Start of operation</td>
<td>2014</td>
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<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<tbody>
<tr>
<td>2007</td>
<td>Size of plant</td>
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<td></td>
<td>Search for location</td>
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<td>2007</td>
<td>Material development</td>
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<td>2010</td>
<td>Request for proposal</td>
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<td>2010</td>
<td>Construction</td>
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<td>2014</td>
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LG&E, Trimble County 2, Kentucky, USA

- 750MWₑ (net) unit
- 3938 psig / 1081 °F / 1077 °F
- BMCR steam flow 5,484,600 lbs/hr
- Sub-bituminous and high sulfur bituminous coal
- Specific attention to combustion flexibility and avoidance of furnace wall corrosion
- Boiler island scope includes pulverizers, fans, airheater, SCR, low NOₓ burners
- NOₓ 0.04 lb/mmBtu
- Designed for ease of construction
- End user E.ON - US
- Doosan Babcock Energy customer Bechtel
- Contract Awarded May 2006
- In service 2010
CO2 emission reduction by key technologies

Energy Efficiency makes big change but deep cuts of CO2 emission can be done only by Carbon Capture and Storage (CCS)
Carbon Capture
Carbon capture and storage

Three Options:
- Post-combustion
- Pre-combustion
- Oxyfuel

Two Options:
- Pipelines
- Ships

Three Options:
- Coal seams, 40 Gt CO₂
- Oil and gas fields, 1,000 Gt CO₂
- Deep saline aquifers – up to 10,000 Gt CO₂
Vattenfall’s 30 MWth oxy fuel carbon capture unit
China’s 1st Post Combustion CO2 Capture Pilot Plant

The design parameters are:

- Flue gas flow to unit 2000-3000 Nm³/h
- Steam consumption 3GJ/tonne CO2
- Solvent consumption < 1.35 kg/tonne CO2
- Owners: Huaneng
- CSIRO assisted
2015-2017: 500 MWe 700°C PCC demo in Europe should be supplemented with other demos. Sidestream CO₂ capture needed

2017-2020: 700°C plants should be offered commercially, supported by continuing materials dev/testing

Full-flow CO₂ scrubbing demo should be designed on a 700°C plant for this period and oxy-coal material tests should be conducted at these steam temperatures

Demonstration of 700°C technology with oxy-firing would follow in 2020-2025, commercialisation later
RWE Power will develop a zero-CO$_2$ lignite-fired IGCC in Germany

Plant will be commissioned with CO$_2$ transport and storage if market and regulatory conditions are appropriate

- Capacity: $450$ MW$_{\text{gross}}$, $360$ MW$_{\text{net}}$
- Net efficiency (target): $40\%$
- CO2 storage: 2.6 million tonnes per year in depleted Gas reservoir or saline aquifer
- Commissioning: 2014
Near Tiajin, southeast of Beijing. The first phase of GreenGen is expected on line in 2011, generating 250MWe, expanding to 650 megawatts in later phases.
THE END

Thank you for Listening

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SOME EXTRA SLIDES
Lagisza Supercritical CFBC – new design

- The world’s first CFBC unit with supercritical steam conditions
- Largest CFBC; 460 MWe
- Start-up in 2009
- Emissions of SOx, NOx and particulates lower than required by latest EU LCPD limits.
- Located to NE of Katowice, Poland
Geological Storage Options

Unminable Coal Seams
30 Gt CO₂
Able to store <2 Years of 2030 Emissions

Depleted Oil & Gas Fields
930 Gt CO₂
Able to Store 50 Years of 2030 Emissions

Deep Saline Aquifers
400-10 000 Gt CO₂
Able to store 20 - 530 Years of 2030 Emissions

Note: CO₂ Storage capacity at cost of 20 US $ per tonne of CO₂
Largest CO₂ Storage Projects

- Sleipner: capturing and injecting 1 Mt/y CO₂ since 1996
- Weyburn: capturing and injecting 1.6 Mt/y CO₂ since 2000
- Rangeley: injecting 0.8 Mt/y CO₂ since 1980's
- Snohvit: capturing and injecting 0.7 Mt/y CO₂ since 2008
- In-Salah: capturing and injecting 0.8 Mt/y CO₂ since 2004

Total Anthropogenic CO₂ captured and injected currently 5 Mt/y
Sleipner CO$_2$ injection

CO$_2$ plume in map view

Time-lapse seismic data

1994

2001

2008


2008-1994
How Does the CO2 Stay Underground?

- **Structural Trapping**
  - CO2 moves upwards and is physically trapped under the seals

- **Residual storage**
  - CO2 becomes stuck between the pore spaces of the rock as it moves through the reservoir

- **Dissolution**
  - CO2 dissolves in the formation water

- **Mineralisation**
  - The CO2 can react with minerals in the rock forming new minerals