Coal Demand and Supply prospects world-wide & the development of cleaner technologies

Dr John Topper, Managing Director
Porto Alegre, Brazil
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A source of unbiased information on sustainable use of coal world-wide

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Addressing the environmental challenges of generating electricity from coal

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Welcome to the IEA Clean Coal Centre (CCC). We are the world’s foremost provider of information on the clean and efficient use of coal worldwide, particularly clean coal technologies, in a balanced and objective way, without political or commercial bias. Our products include in-depth topical reports and online databases of coal information. We also provide advice, facilitate R&D networks and organise workshops. We are funded by member countries and industrial sponsors so our analysis stays impartial.

Coal Online
Coal Online is a major database that provides comprehensive information.

Next Workshop
The Eighth International Workshop on Mercury Emissions from Coal will be held on 18-20 May.
GLOBAL COAL SUPPLY AND DEMAND TO 2035
Recent policy commitments, if implemented, would make a difference.

Source: IEA World Energy Outlook 2010

World primary energy demand by region in the New Policies Scenario

Global energy use grows by 36%, with non-OECD countries – led by China, where demand surges by 75% – accounting for almost all of the increase.
Emerging economies dominate the growth in demand for all fuels

Incremental primary energy demand in the New Policies Scenario, 2008-2035

Demand for all types of energy increases in non-OECD countries, while demand for coal & oil declines in the OECD
Coal remains the backbone of global electricity generation

Source: IEA WEO 2010

Coal-fired electricity generation by region in the New Policies Scenario

A drop in coal-fired generation in the OECD is offset by big increases elsewhere, especially China, where 600 GW of new capacity exceeds the current capacity of the US, EU & Japan.
Coal Fired Power Stations Today
Torrevaldaliga Nord

USC, boilers supplied by Babcock Hitachi, using bituminous coal

3 units at 660MWe = 1980MWe station

Very low conventional emissions (NOx <100 mg/m³, sulphur oxides <100 mg/m³, particulates 15 mg/m³, at 6% O₂, dry); full waste utilisation

Highest steam conditions: 604°C/612°C at turbine: 25 MPa

Operating net efficiency >44.7% LHV

Wet scrubber based limestone/gypsum FGD

NOx abatement SCR

Particulates removal Bag filters

New sea port for coal delivery

Solids handling all enclosed
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 Combustion measures
Particulates removal ESP
Desulphurisation Wet FGD
Isogo New Unit 1, Japan

USC, tower boiler, opposed wall firing, intent 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
Status of USC boilers ordered by end of May 2008: China now leads the world in Supercritical Boiler installations

<table>
<thead>
<tr>
<th>Supplier</th>
<th>1000 MWe</th>
<th>660 MWe</th>
<th>600 MWe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>Capacity, GWe</td>
<td>No</td>
</tr>
<tr>
<td>Harbin</td>
<td>16</td>
<td>16.0</td>
<td>18</td>
</tr>
<tr>
<td>Shanghai</td>
<td>36</td>
<td>36.0</td>
<td>16</td>
</tr>
<tr>
<td>Dongfang</td>
<td>28</td>
<td>28.0</td>
<td>10</td>
</tr>
<tr>
<td>Beijing B&amp;W</td>
<td>4</td>
<td>4.0</td>
<td>2</td>
</tr>
<tr>
<td>Sub-total</td>
<td>84</td>
<td>84.0</td>
<td>46</td>
</tr>
<tr>
<td>Project</td>
<td>Implementing agency</td>
<td>State</td>
<td>Capacity (MW)</td>
</tr>
<tr>
<td>------------------------</td>
<td>---------------------</td>
<td>------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Sipat Stage I</td>
<td>NTPC</td>
<td>Chhattisgarh</td>
<td>3×660</td>
</tr>
<tr>
<td>Barh Stage I</td>
<td>NTPC</td>
<td>Bihar</td>
<td>3×660</td>
</tr>
<tr>
<td>Barh Stage II</td>
<td>NTPC</td>
<td>Bihar</td>
<td>2×660</td>
</tr>
<tr>
<td>North Karanpura</td>
<td>NTPC</td>
<td>Jharkhand</td>
<td>3×660</td>
</tr>
<tr>
<td>Lara</td>
<td>NTPC</td>
<td>Chhattisgarh</td>
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<tr>
<td>Darlipalli</td>
<td>NTPC</td>
<td>Orissa</td>
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<tr>
<td>Mundra UMPP</td>
<td>Tata Power Company</td>
<td>Gujarat</td>
<td>4,000</td>
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<tr>
<td>Sasau UMPP</td>
<td>Reliance Power</td>
<td>Madhya Pradesh</td>
<td>4,000</td>
</tr>
<tr>
<td>Krishnapatnam UMPP</td>
<td>Reliance Power</td>
<td>Andhra Pradesh</td>
<td>4,000</td>
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<td>SPV</td>
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<td>SPV</td>
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<td>Girye UMPP</td>
<td>SPV</td>
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<td>Cheyyur UMPP</td>
<td>SPV</td>
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<td>Udangudi</td>
<td>TNEB-BHEL JV</td>
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<td>Meja</td>
<td>UPRVUNL-NTPC JV</td>
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</tbody>
</table>

Note: The list is not exhaustive
High Efficiency, Low Emissions Coal Technology Status Today (1)

Pulverised coal combustion

- Hundreds of GWe installed, units to ~1000 MWe
- Efficiency to upper 40s% (LHV) in best locations
- Conventional emissions control well established
- How will it be in 10 or 20 years?
- Still the most deployed coal technology
- Advanced emissions control, including dry systems
- Incremental efficiency improvements
- Further efficiency gains from novel lignite drying and from jump to 35 MPa/700°C steam
- CCS as integrated technology using flue gas scrubbing or oxygen firing
50% efficient plant

... 50 plus by using new nickel alloy superheater tubing at 700C

<table>
<thead>
<tr>
<th>Location</th>
<th>Wilhelmshaven</th>
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</thead>
<tbody>
<tr>
<td>Efficiency</td>
<td>50 %</td>
</tr>
<tr>
<td>Capacity</td>
<td>500 MW_e</td>
</tr>
</tbody>
</table>

Postponed/Cancelled in 2010

Will this ever be reinstated?
What are the prospects for solving welding and heat treatment issues?
Does it look just too expensive for the efficiency gain?
Circulating fluidised bed combustion

- Hundreds of units, experience to 460MWe
- Suited to low quality coals and other fuels
- Emissions control systems well established
- How will it be in 10 or 20 years?
- Still important, probably burning even more biomass and wastes
- Further incremental efficiency improvements
- Higher steam conditions (460 MWe S/C unit now operating in Poland – full load achieved Mar 2009)
- CCS using flue gas scrubbing, oxygen firing or, in new designs, chemical looping
Lagisza Supercritical CFBC – new design

The world’s first CFBC unit with supercritical steam conditions

Largest CFBC; 460 MWe

First electricity in February 2009

Emissions of SOx, NOx and particulates lower than required by latest EU LCPD limits.

Located to NE of Katowice, Poland
Commercial demonstrations in USA and Europe and Japan. Shortly in China, another in USA. Others at FEED stage.

Cost and availability concerns have held back orders in past.

Efficiency ~43-45% LHV.

Very low emissions, mercury capture simple.

How will it be in 10 or 20 years?

More widely deployed.

Advancing performance and perhaps reducing cost differential with PCC.

Above from more advanced gas turbines and new gasifier designs, dry gas cleaning.

Polygeneration.

CCS using pre-combustion capture.
PSE-CO$_2$ project: CO$_2$ Capture Pilot Plant

Puertollano IGCC power plant and pilot plant location

Pilot plant general view

Courtesy of Elcogas

IGCC power plant general view

PREFLO Gasifier
Coal preparation
ASU
New CO$_2$ capture pilot plant
Sulphur Recovery
Combined Cycle

Courtesy of Elcogas
Coal Conversion to Liquids or Gas
Direct Coal Conversion to Liquid Fuels

Make-up H₂ → Recycled H₂ → Gas Recovery Treatment → H₂S, NH₃, COₓ → Methane & Ethane → LPG

Coal + Catalyst → Coal conversion → H-Donor → Hydro-treating Unit → Refining → Gasoline → Diesel Fuel

H₂ Donor → Slurry → Fractionation → Heavy Vacuum Gas Oil → Deashed Oil → Gasifier → Ash Reject

Solvent Deashing → Unconverted Coal → Coal conversion
Indirect Coal Conversion

Coal, Petcoke, Biomass etc → Oxygen/Steam → Gasification & Gas Cleaning → H₂ + CO → Syngas → Catalyst → Fischer-Tropsch Synthesis → CₓHᵧ Liquids & Wax → FT Product Separation & Upgrading → Water & Oxygenates → Ultra-Clean Liquid Fuels & Chemical Feedstocks

Sulfur, CO₂ and Ash → Steam → Electric Power Generation → Steam → Electricity
This recently published report on UCG covers:

- What UCG involves
- The technologies applicable
- UCG potential
- Trials and prospective developments
- Geological and environmental issues
- Syngas use
- Conclusions
UCG at Bloodwood Creek, Australia (Carbon Energy)

UCG surface facility
~100 m x 50 m

30 m spacing
600 m panel length

ignition well

natural surface

200 m depth of cover

30 m x 30 m x 10 m
block consumed
in the demonstration trial

production well
(product) H₂, CO, CH₄, CO₂

injection well
(oxygen and steam)

oxygen and steam supply line

boiler and
steam generator

control room
gas collector

gas flare

water holding dam

 Courtesy of Carbon Energy
Eskom’s Majuba UCG, South Africa
Eskom UCG Development Plan

2002
- Scoping Study

2003
- Pre-feasibility Study

2005
- Site Characterisation

- Commissioned 5000 Nm3/h pilot plant on Majuba coalfield

- Commissioned 15000 Nm3/h co-firing into Majuba power station

Provisional Future Dates

Apr 2009
- Design
- Construction
- Commission

2100MW 1st Proof-of-Concept Plant

Dec 2011

Mar 2015
- Design
- Construction
- Commission

Sep 2015

Mar 2020
- U1 Comm
- U2 Comm
- U3 Comm
- U4 Comm
- U5 Comm
- U6 Comm

Sep 2022
Carbon Capture and Storage

Three Options;
- Post Combustion
- Pre Combustion
- Oxy fuel

Three Options;
- Coal seams, 40 Gt CO₂
- Oil and gas fields, 1,000 Gt CO₂
- Deep saline aquifers – up to 10,000 Gt CO₂

Two Options;
- Pipelines
- Ships

Capture
- CO₂ capture & separation plant
- CO₂ source (eg. power plant)

Transport
- CO₂ compression unit
- Reservoir Engineering & Geoscience Input
- CO₂ transport
- CO₂ injection

Storage
- CO₂ storage
There is an ambitious growth path for CCS from 2010 to 2050.
Expanded collaboration on CCS R&D and technology transfer will be critical.
IEA CCS Roadmap is not just about Coal for Power

Coal power only makes up around 40% of stored emissions in 2050.
Status of CCS – LSIPs Large Scale Integrated Projects

- Annex C tables LSIP project criteria & details
- 67 LSIPs active
- Over half with EOR or gas/oil field storage
- About half related to coal fired power
- All the coal projects are in development
- About 40% of all projects in USA
- Over 20 cancelled LSIPs listed
Vattenfall’s 30MWth oxy fuel pilot plant at Schwarze Pumpe

Operating almost 3 years

Collected good data on boiler, CO2 clean up etc
2nd International Oxyfuel Combustion Conference
12th – 16th September 2011
Capricorn Resort, Yeppoon, Australia

Includes visit to Callide 30MWe oxy fuel retrofit

Stanley.santos@ieaghg.org
Huaneng Group: leaders in post combustion capture in China

3000 CO2 tonnes/year industrial pilot in Beijing, 2008

120,000 CO2 tonnes/year capture unit in Shanghai, 2010
Boundary Dam, SaskPower post combustion test facility
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.
## FINALLY – ARE WE MAKING PROGRESS?

<table>
<thead>
<tr>
<th></th>
<th>2007</th>
<th>2009</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grandchildren to have electricity from coal through their lifetime</td>
<td>Grandchildren to have electricity from coal through their lifetime</td>
<td>Grandchildren to have electricity from coal through their lifetime</td>
<td></td>
</tr>
<tr>
<td>Coal can be part of the portfolio of solutions to climate protection</td>
<td>Coal with CCS is indispensable in next decades</td>
<td>Coal with CCS is indispensable in next decades</td>
<td></td>
</tr>
<tr>
<td>No single winning clean coal technology, but R &amp; D worldwide is based on a core set of technologies</td>
<td>Still no single winning clean coal technology. Research on 2nd generation technologies underway</td>
<td>Still no single winning clean coal technology. Research on 2nd generation technologies advancing</td>
<td></td>
</tr>
<tr>
<td>Different policies in different regions = different technology pathways</td>
<td>Different policies in different regions = different technology pathways</td>
<td>No clear picture now about technology preferences in different regions</td>
<td></td>
</tr>
<tr>
<td>Many CCS demos announced (but none for post combustion capture)</td>
<td>CCS Demo intentions hardened, inc post combustion but action delayed by regulation and finance</td>
<td>More projects underway but also some stopped. Still no large full CCS chain coal based project in operation</td>
<td></td>
</tr>
<tr>
<td>Financial and regulation under development but a long way to go</td>
<td>Regulation now becoming set in some major OECD countries. Finance still woefully inadequate</td>
<td>Regulation still not widespread, finance remains poor. Public acceptance problems</td>
<td></td>
</tr>
</tbody>
</table>
THE END
THANK YOU ALL FOR LISTENING

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