Utilization of Low Rank Coal for Power Generation

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• COAL POWER PLANNING
• UPGRADING LRC
• CFBC
• COAL POWER IN THE FUTURE
• CONCLUSION
Coal Power Planning

- Demand increasing hard coal market
- Utilization of low rank coal increased
- Shale gas news temporally lowered coal price
- Coal power plant is massively being constructed
## Coal power plans of Asian countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Capacity</th>
<th>2010</th>
<th>2015</th>
<th>2020</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Korea</td>
<td>GW</td>
<td></td>
<td>26.7</td>
<td>30.0</td>
<td>35.9</td>
</tr>
<tr>
<td>Japan</td>
<td>GW</td>
<td>65</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vietnam</td>
<td>GW</td>
<td></td>
<td>48</td>
<td>51.6</td>
<td></td>
</tr>
<tr>
<td>Indonesia</td>
<td>GW</td>
<td>23.2</td>
<td>36.8</td>
<td>53.3</td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>GW</td>
<td>153</td>
<td>258</td>
<td></td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>GW</td>
<td>660</td>
<td>960</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Deposit of coal

<table>
<thead>
<tr>
<th>M/T</th>
<th>Bituminous/semit-Athracite</th>
<th>Sub-Bituminous/ Brown</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>509491</td>
<td>474720</td>
<td>984211</td>
</tr>
<tr>
<td>North America</td>
<td>116707</td>
<td>139770</td>
<td>256477</td>
</tr>
<tr>
<td>S. &amp; Cent. America</td>
<td>7839</td>
<td>13735</td>
<td>21574</td>
</tr>
<tr>
<td>Europe</td>
<td>41664</td>
<td>80368</td>
<td>122032</td>
</tr>
<tr>
<td>Former Soviet Union</td>
<td>97476</td>
<td>132707</td>
<td>230178</td>
</tr>
<tr>
<td>Africa</td>
<td>61162</td>
<td>250</td>
<td>61412</td>
</tr>
<tr>
<td>Mid. East</td>
<td>193</td>
<td>-</td>
<td>193</td>
</tr>
<tr>
<td>Australia</td>
<td>47300</td>
<td>43100</td>
<td>90400</td>
</tr>
<tr>
<td>China</td>
<td>62200</td>
<td>52300</td>
<td>114500</td>
</tr>
<tr>
<td>India</td>
<td>72733</td>
<td>2000</td>
<td>74733</td>
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<tr>
<td>Indonesia</td>
<td>770</td>
<td>4450</td>
<td>5220</td>
</tr>
</tbody>
</table>
UPGRADING LRC

• Handling problems with LRC
  – Pulverizer stick
  – Hopper stay
  – Screw feeder plugging
  – Low ash fusion temperature IDT~1055°C
  – Latent heat loss by High coal moisture
  – Self ignition in storage

• Remove moisture, ash and Mineral sulfates
Brown coal upgrading

1000 ton/day

250,000 ton/y unit X 4 units

1MTon/y facility

Dewatering

Ash separation

Briquetting

Pore treatment

• HHV 4500 kcal/kg
• Water 35~45%
• Ash 2~5%

• HHV 6500 kcal/kg
• Water 3~10%
• Ash 2~5%
Air Bed Cleaning technology

- **Dry cleaning**
  - Moisture removal
  - Ash classifying by gravity separation

- **Characteristics**
  - -3mm particles
  - <15% moisture

[Video link](http://youtu.be/9VCn2HTk1iM)
Concept of Fluidized Bed Dryer

Fluidized bed drying has the advantage of temperature control due to uniformity of bed temperature and high drying rate.

Continuous fluidized bed dryer consisting of feeder, plenums, bubbling bed, cyclones, and briquetting machine
Separation of ash by FBD

- Operating parameters for hydrodynamic classification
  - Particle size
  - Gas velocity

Adjustment of parameter

Low Midds
  Low Ash
  High Recovery

High Midds
  High Ash
  Low Recovery
A Conceptual model for future power plant

- Supercritical CFBC power plant
- Carbon Capture and gas cleaning system
- Low rank coal drying by flue gas
Case Study for Prototype FBD

Construction and Operation of Demonstration Plant in Indonesia for 30MW Coal Fired Power Plant (2013)

Expected Results

- **Moisture:** 37% → 18%
- **Calorific value:** 4,222kcal/kg → 5,428kcal/kg
- **Combustion Stability:** <800°C → 822°C
- **Coal Feed Rate:** 19.9t/h → 14.3t/h
- **Combustion Air:** 7.4% ↓
- **Flue Gas:** 11.6% ↓
- **Bottom Slag & Fly Ash:** 30% ↓
- **FD/ID Fan Power:** 7.7~11.5% ↓
- **Boiler Efficiency:** 2.9% ↑
KIER Technology Package

- **CUPO™**: Coal Upgrading by Palm Oil residue coating

Demonstration project in Indonesia
5000TPD plant
Starting from 2013

http://youtu.be/5r1k2klZxb4
CFBC

- A solution to power generation from low rank coal
Thermal power generation

Stoker boiler

Pulverized coal boiler

Fluidized bed boiler
Basics of Fluidized Bed Combustion (FBC)

- Good mixing reactor for fine chemicals
- No. 1 process for Petrochemical industry - Refinery - Polymer process
- Combustion and power generation

Diagram showing the characteristics of Fluidized Bed Combustion with different bed pressure drops and gas velocities.
Why CFBC?

- An economical way to produce quality power and steam
- Stable and easy technology that has been continuously upgraded since 1980
- Fuel flexibility from hard coal to biomass
- Versatility in size from 2MWe to 600MWe

Scale up Scenario

100MWe  150  200-300  300-400  400-600
Other fuel for industrial boiler

- Combustor
- S/H1
- S/H2
- A/H
- Econ.
- FD Fan
- ID Fan
- Stack
- Cyclone
- Sur Hopper
- Drum
- SDR
- Bag Filter
- Scrubber
- Water
- Air
- Surge Hopper
- FD Fan

Fuel types:
- COAL (Bituminous, Sub-bituminous, Anthracite, Lignite)
- Petroleum Coke
- Anthracite Culm
- Oil Shale
- Wood Waste
- Dehydrated Sewage Sludge
2. FBC boiler for Power and Steam

- 1MWe equivalent
- Industrial boiler for power and steam
FBC for Waste Fuel and Biomass

- 10MWe FBC co-generation facility for RDF
  - New concept for RDF
- Commercial scale FBC with fuel flexibility
  - Dispersed generation
  - Utilizing RDF, biomass, low rank coal

10 MWe CFBC for RDF
Prospect of FB Power Generation

Waste & Biomass
  → RDF
  → Brown coal
  → Upgrading
  → FBC Co-generation Commercial
  → FBC Power (150-300MWe)
  → SC-FBC Power Generation (500MWe)
  → FGD

For industry

Steam Boiler

Hard coal
Supercritical CFB (World)

- Large scale power generation >500MWe
- Substitutes ~ 500MWe PC
- Maximum fuel flexibility for power plant
- From low rank lignite to Anthracite
- Low emission
- High efficiency of 45% LHV

150~300MWe

Lagiza 460MWe
# Large Scale CFBC

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yeosu, Korea</td>
<td>330</td>
<td>171/30</td>
<td>541/541</td>
<td>-</td>
</tr>
<tr>
<td>Novocherkasskaya, Russia</td>
<td>330</td>
<td>248/38</td>
<td>565/565</td>
<td>41.5</td>
</tr>
<tr>
<td>Lagisza, Poland</td>
<td>460</td>
<td>275/55</td>
<td>560/580</td>
<td>43.3</td>
</tr>
<tr>
<td>Samcheok, Korea</td>
<td>550</td>
<td>257/53</td>
<td>603/603</td>
<td>42.4</td>
</tr>
<tr>
<td>Baima, China</td>
<td>600</td>
<td>254/44</td>
<td>571/569</td>
<td>43.2</td>
</tr>
<tr>
<td>Alstom</td>
<td>600</td>
<td>275</td>
<td>600</td>
<td>-</td>
</tr>
<tr>
<td>CFB 800-EU5</td>
<td>830</td>
<td>300/45</td>
<td>600/620</td>
<td>45</td>
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</tbody>
</table>

- Needs of 300MWe CFBC among Asian countries
- From SC-CFB to U-CFB is the prospect

*Technical report of Doosan Heavy, 2013
Turkish Lignite

• Candidate for CFB
  – Afsin-Elbistan (5.17Bt), Konya-Karapinar (1.83Bt), Manisa-Soma (0.86Bt), Mugla-Milas (0.75Bt)

• Upgrading Candidate
## New Project

<table>
<thead>
<tr>
<th>Capacity (Mwe)</th>
<th>Year</th>
<th>Location</th>
<th>Price (US Cents/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>600</td>
<td></td>
<td>Tufanbelyi, Adana</td>
<td>1.42</td>
</tr>
<tr>
<td>450</td>
<td></td>
<td>Manisan Soma Denis</td>
<td>2.6</td>
</tr>
<tr>
<td>&gt;270</td>
<td></td>
<td>Bursa Keles</td>
<td>3.11</td>
</tr>
<tr>
<td>?</td>
<td></td>
<td>Konya Karapinar</td>
<td>und</td>
</tr>
<tr>
<td>?</td>
<td></td>
<td>Eskisehir</td>
<td>und</td>
</tr>
<tr>
<td>?</td>
<td></td>
<td>Tekirdag Saray</td>
<td>und</td>
</tr>
</tbody>
</table>
Turkish coal mines and CFBC

CAN 2x160

Biga 5x135

Tuffanbeyli 3x150

### COAL POWER IN THE FUTURE

- **HELE (High Efficiency Low Emission) by coal**

<table>
<thead>
<tr>
<th>Plant</th>
<th>CO</th>
<th>NOx</th>
<th>SOx</th>
<th>PM</th>
<th>Max capa. Current</th>
<th>CCS penalty</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>g/kWh</td>
<td>mg/Nm3</td>
<td>MWe</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PC(USC)</td>
<td>740</td>
<td>50~100 (SCR)</td>
<td>20~100 (FGD)</td>
<td>10</td>
<td>1100</td>
<td>7~10</td>
</tr>
<tr>
<td>PC(A-USC)</td>
<td>670</td>
<td>50</td>
<td>1000</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>CFBC</td>
<td>880~900 (in situ)</td>
<td>200 (in situ)</td>
<td>50~100 (in situ)</td>
<td>10</td>
<td>460</td>
<td></td>
</tr>
<tr>
<td>IGCC</td>
<td>740</td>
<td>30</td>
<td>20</td>
<td>1</td>
<td>335</td>
<td>7</td>
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<tr>
<td>IGFC</td>
<td>550</td>
<td>30</td>
<td>20</td>
<td>1</td>
<td>500</td>
<td></td>
</tr>
</tbody>
</table>

*“High Efficiency, Low Emissions Coal Fired Power Generation”, Technology Road map IEA 2012*
USC Coal Combustion

- Efficiency (net) HHV
  - Steam Parameter
  - 25-30%
  - 33%
  - 38-40%
  - 40-45%
  - > 48%

- Modern Day Once Through Technology
- Sliding Pressure Supercritical
- Material Development
  - 1960
  - 1980
  - 2000
  - 2020

- Advanced Austenitic Materials
- Ni-based Materials

- >50% LHV
- 5400/1300/1325 (psi/°F/°F)
- 375/700/720 (bar/°C/°C)
- 4000/1150/1150 (psi/°F/°F)
- 275/600/620 (bar/°C/°C)
IEA Future Power Generation Plan

Electricity generation by fuel and region in the New Policies Scenario

Note: For each region, the largest source of electricity generation in 2008 and 2035 is denoted by its percentage share of the overall mix.
A Conceptual model of CCT Power Gen W/ CO2 capture

* Technology Roadmap, IEA 2012
• Utilization of low rank coal is a major issue in thermal power sector

• To increase efficiency coal upgrading and large scale CFBC is necessary
  – CFBC is a good solution for low rank coal
  – Market will be divided by 500MWe CFBC and 1000MWe PC
  – Both CFBC and PC will go further to HSC

• HELE will be a much debating problem in the future
Thank you for your attention!