Case studies on adoption of advanced coal-fired power technology in emerging economies

“Cleaner and more efficient coal technologies in Russia”
Expert meeting
10 December 2012, World Trade Center, Moscow

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The IEA recommends High-Efficiency, Low-Emissions (HELE) technologies

Efficiency improvement reduces specific fuel consumption and also reduces specific pollutant emissions.

Source: IEA, Workshop on Advanced-USC Coal-fired Power Plants
Vienna, Austria, 19-20 September 2012
Hitachi covers all High-Efficiency, Low-Emissions coal-fired power technologies

Integrated supply of BTG + AQCS ⇒ Optimize entire plants

<table>
<thead>
<tr>
<th>Boilers (B)</th>
<th>Turbines (T)</th>
<th>Generators (G)</th>
<th>DeNOx Systems</th>
<th>Catalysts</th>
<th>Precipitators</th>
<th>Desulfurizers</th>
<th>CCS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

Steam turbines and power generators (TG)
Highly efficient and reliable
Achieved world's highest level efficiency with the new No. 2 unit of Isogo Thermal Power Plant for Electric Power Development Co., Ltd.

Source: McCoy Reports 2010 (Excluding China and India)

Boilers (B)
Highly efficient combustion:
Low Nox/CO₂ emissions, high economical efficiency
Compatible with various coal types:
Applicable to low grade coals

AQCS
Integrated system (DeNOx reactor, precipitator, desulfurizer)
High-performance DeNOx catalyst: In-house development and production system

DeNOx Catalyst Share

Top share
Hitachi 26%
Hitachi built global business structure for growing power markets

Provide solutions to target markets by expanding and enhancing global bases

- Expand and enhance sales functions of overseas bases
  (India, South Africa, Dubai, etc.)
- Make integrated proposals from power generation to transmission & distribution
- Expand and enhance overseas procurement,
  overseas production and overseas engineering

Source: Hitachi IR Day 2012
Hitachi has experiences of building coal-fired power plants in many regions.

Expand business through three core bases (Japan, Europe and the Americas) and India.

- **Europe, South Africa**
  - Neurath (Under commissioning) B [1100MW × 2]
  - Moorbeg (Under construction) B [820MW × 2]
  - Wilhelmshaven (Under construction) BTG [790MW]
  - Medupi-1～6 (Under construction) B [800MW × 6]
  - Kusile-1～6 (Under construction) B [800MW × 6]

- **Asia**
  - TEPCO/Hitachinaka No.2 unit (Under construction) BTG [1,000MW]
  - South Korea/Yonghung Thermal Power Plant No.5 and No.6 unit (Under construction) TG [870MW × 2]
  - South Korea/Dangjin Thermal Power Plant No.9 and No.10 unit (Preparing for construction) B [1,000MW × 2]

- **Americas**
  - Duke Energy (Under commissioning) B [900MW]
  - U.S./KCP&L AQCS × 2
  - South Korea/Tagen Thermal Power Plant, Units No.9 and No.10 units [1,050MW × 2] BTG
  - India/NTPC [660MW × 6] B
  - India/NTPC [800MW × 4] (First refusal right) TG

**Recent orders**
- <H-25 gas turbines> 6 orders from China, India, etc.
- <H-25 gas turbines> 4 orders from Canada, etc.

Source: Hitachi IR Day 2012
Development of process parameters
Recent high efficient steam generators

Actual running power plants projects in Germany and western Europe
marking the worldwide most modern state of the art

**Japan since 1995**

**Poland**

**India**

**South Africa**

**Germany, lignite**

**Germany/Western Europe, bituminous**

<table>
<thead>
<tr>
<th>Location</th>
<th>SH Outlet Pressure</th>
<th>SH Outlet Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tachibana</td>
<td>300</td>
<td>560</td>
</tr>
<tr>
<td>Hitachi-Naka #1</td>
<td>320</td>
<td>580</td>
</tr>
<tr>
<td>Haramachi #2</td>
<td>340</td>
<td>600</td>
</tr>
<tr>
<td>Matsuura #2</td>
<td>360</td>
<td>620</td>
</tr>
<tr>
<td>Nanao-Ohta #1</td>
<td>380</td>
<td>640</td>
</tr>
<tr>
<td>Shinchi #1</td>
<td>400</td>
<td>660</td>
</tr>
<tr>
<td>Noshiro #1</td>
<td>420</td>
<td>680</td>
</tr>
<tr>
<td>Hekinan #2</td>
<td>440</td>
<td>700</td>
</tr>
<tr>
<td>Medupi / Kusile</td>
<td>300</td>
<td>560</td>
</tr>
<tr>
<td>Raghunathpur</td>
<td>320</td>
<td>580</td>
</tr>
<tr>
<td>Altbach 2</td>
<td>340</td>
<td>600</td>
</tr>
<tr>
<td>Staudinger 5</td>
<td>360</td>
<td>620</td>
</tr>
<tr>
<td>Rostock</td>
<td>380</td>
<td>640</td>
</tr>
<tr>
<td>Moorburg</td>
<td>400</td>
<td>660</td>
</tr>
<tr>
<td>Neurath F/G</td>
<td>420</td>
<td>680</td>
</tr>
<tr>
<td>Boxberg R</td>
<td>440</td>
<td>700</td>
</tr>
<tr>
<td>RKW NRW</td>
<td>300</td>
<td>560</td>
</tr>
<tr>
<td>Maasvlakte</td>
<td>320</td>
<td>580</td>
</tr>
<tr>
<td>Niederaußen K</td>
<td>340</td>
<td>600</td>
</tr>
<tr>
<td>Lippendorf</td>
<td>360</td>
<td>620</td>
</tr>
<tr>
<td>Boxborg R</td>
<td>380</td>
<td>640</td>
</tr>
<tr>
<td>NOSI</td>
<td>400</td>
<td>660</td>
</tr>
<tr>
<td>Solarpur/ Meja/ Raghunathpur</td>
<td>420</td>
<td>680</td>
</tr>
<tr>
<td>Medupi / Kusile</td>
<td>440</td>
<td>700</td>
</tr>
</tbody>
</table>

Δη ≈ 3 %

Δη ≈ 4 %

Δη ≈ 4 %
Measures for Increasing the Efficiency of the Water / Steam - Cycle

### Increase of Steam Parameters

<table>
<thead>
<tr>
<th>Pressure (bar)</th>
<th>Steam Temperature (°C)</th>
<th>Net efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>167</td>
<td>538/538</td>
<td>1.5</td>
</tr>
<tr>
<td>221</td>
<td>540/560</td>
<td>0.7</td>
</tr>
<tr>
<td>250</td>
<td>600/600</td>
<td>0.6</td>
</tr>
<tr>
<td>270</td>
<td>620/620</td>
<td>1.3</td>
</tr>
<tr>
<td>285</td>
<td>625/640</td>
<td>0.7</td>
</tr>
<tr>
<td>300</td>
<td>700/720</td>
<td>1.6</td>
</tr>
<tr>
<td>300</td>
<td>720/720</td>
<td></td>
</tr>
</tbody>
</table>

### Development of Processes and Components

- **0.4**: Double reheat
- **0.6**: Waste heat utilization in steam generator
- **1.6**: Steam turbine efficiency
- **0.8**: Auxiliary power requirements
- **0.6**: Boiler efficiency
- **0.4**: Pressure losses (vertical tubing)
- **0.6**: Water/steam cycle

**Fuel**: bituminous coal / **Condenser pressure**: 0.04 bar
Coal Consumption vs. Efficiency of Power Production

Source: Wege zum emissionsfreien fossilen Kraftwerk (COORETEC)
CO₂ Emissions of Power Plants Fired with Different Fuels

- **hard coal**
- **lignite (rhinish)**
- **100% biomass**
- **natural gas**

![Chart showing CO₂ emissions vs. net efficiency for different fuels.](chart-image)
HPE know-how for a world wide range of coal qualities
P.S. Rotterdam (790 MW)
Supercritical Steam Parameters

- 1 x 790 MWel / 1 x 2143 t/h
- Start Commissioning 2013
- Bituminous Coal
  - \( H_u = 24.9 \text{ MJ/kg} \)
  - \( A = 14.7 \% \)
  - \( W = 8.1 \% \)
- Design parameters:
  - \( \text{SH: } 603 \, ^\circ\text{C} / 290 \text{ bar a} \)
  - \( \text{RH: } 621 \, ^\circ\text{C} / 75 \text{ bar a} \)
P.S. Maasvlakte (1100 MW)
Supercritical Steam Parameters

- 1 x 1100 MWel / 1 x 2939 t/h
- Start Commissioning 2013
- Bituminous Coal
  \[ Hu = 24,9 \text{ MJ/kg} \]
  \[ A = 14,3 \% \]
  \[ W = 8,2 \% \]

MPS® 265 (Capacity 114 t/h)
The Largest Thermal Power Generation Equipment in terms of Power Generation Capacity in South Korea

Two boilers and two steam turbines and generators for use in the No. 9 and No. 10 units of the Taean Thermal Power Plant. The boilers are 1,050MW-class for ultra-supercritical (USC) coal-fired thermal power generation and the steam turbines and generators are to be developed independently by Hitachi.

<table>
<thead>
<tr>
<th>Boiler</th>
<th>Type: Once-Through Benson</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Steam Flow:</td>
<td>3145 t/h</td>
</tr>
<tr>
<td>Steam Conditions:</td>
<td>25.9MPa, 603°C/613°C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Steam Turbine</th>
<th>Type: Tandem Compound Four Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Last Stage Blade:</td>
<td>50” Ti</td>
</tr>
<tr>
<td>Steam Conditions:</td>
<td>25MPa, 600°C/610°C</td>
</tr>
<tr>
<td>Output:</td>
<td>1050MW</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Generator</th>
<th>Type: Hydrogen cooled, cylindrical rotor type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity:</td>
<td>1254 MVA</td>
</tr>
<tr>
<td>Terminal Voltage:</td>
<td>27kV</td>
</tr>
<tr>
<td>Power Factor:</td>
<td>0.90 (lagging), 0.95 (leading)</td>
</tr>
</tbody>
</table>
Case studies on adoption of advanced coal-fired power technology

- Construction of Super Critical boilers in South Africa (800MW x 12 unit (B))
- Construction of Boilers and Turbines by partnering with local manufactures in India (660MW x 6 unit (B),
- EPC project for a Super Critical coal-fired power plant in Poland (1000MW x 1 unit (B,T,G & AQCS))
P.S. Medupi
Supercritical steam parameters

- 6 x 794 MWel / 2290 t/h
- Start Commissioning 1st Unit 2013
- Bituminous Coal
  \( \text{Hu} = 17,8 \text{ MJ/kg} \)
  \( \text{A} = 32,3 \% \)
  \( \text{W} = 10,6 \% \)
- Design parameters:
  - SH: 564 °C / 258 bar
  - RH: 572 °C / 53.2 bar
Indien NTPC
Supercritical steam parameters

- 6 x 660 MWel / 6 x 2120 t/h
- Start Commissioning 2016
- Bituminous Coal
  Hu =12.7 MJ/kg
  A  = 41.4 %
  W= 14.0 %
- Design parameters
  SH 568 C / 251 bar,
  RH 596 C / 52 bar
Kozienice
Supercritical steam parameters

- 1 x 1000 MWel / 1 x 2016 t/h
- Start Commissioning 2016
- Bituminous Coal
  Hu = 21.5 MJ/kg
  A = 22.0 %
  W = 11.3 %
- Design parameters
  SH 603 C / 267 bar,
  RH 621 C / 65.7 bar

DS® Burner
**DS® Burner Development**

- **Vortex Burner before 1976**
- **Vortex Burner developed in 1978**
- **DS® Burner today**

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**Graph: NOx, mg/m³**

- **Vortex-Burner**
- **WS-Burner**
- **DS-Burner**

**Burner air ratio**

- NOx values:
  - 0 to 1400 mg/m³
  - 0.7 to 1.4

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**Key Components:**
- Core Air
- Pulverized Coal
- Secondary Air
- Oil Gun
- Swirl Blades
- Tertiary Air
- Adjustable Swirl Blades
- Fuel Nozzle

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**Legend:**
- Oil Gun
- Core Air
- Pulverized Coal
- Secondary Air
- Tertiary Air
- Swirl Blades
- Adjustable Swirl Blades
- Fuel Nozzle
Advanced Coal-Fired Power Technology
Supercritical Tower Type Steam Generator
Advanced Coal-Fired Power Technology
Supercritical Tower Type Steam Generator
Advanced Coal-Fired Power Technology
Supercritical Tower Type Steam Generator
Technology of steam turbine in Poland

800-1300MW Class Steam Turbine for Polish Power Plant

- 2-LP Casings (4 Flow) with various size of last stage blade
- IP Turbine (Double Flow)
- HP Turbine (Single or Double Flow)
- Advanced Vortex Nozzle to improve the stage efficiency
- Continuous Covered Blade to improve the seal performance
Technology of steam turbine in India and Poland

Super Critical Pressure Steam Turbine Technology

Japan / Isogo No.2 / 600MW
600°C / 620°C  25MPa
(Commercial Operation since 2009)

Poland/Kozienice No. 11 / 1075MW
600°C / 620°C  25MPa

Europe

Japan

USA

China
Hitachi can provide all technologies for advanced coal-fired power generation.

Hitachi has experiences of making an optimum design for coal-fired power plants considering local conditions.

Hitachi is open for technical collaboration with competent local companies.

Hitachi would like to contribute to implementing cleaner and more efficient coal technologies in Russia.
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