Promising to contribute to global welfare with technologies of energy and environment systems
1. General Information
**Power Systems Company of HITACHI**

### Thermal Power Business

- **Coal Fired PP**
- **CO2 Capture Solution**
- **AQCS**
- **Gas Turbine**
- **Wind Power Sys.**
- **Solar Power Sys.**

#### FY2010 SALES

- **¥813.2B**

#### Major Equipment

- **RPV**
- **Nuclear Equipment**
- **Central Control Panel**
- **PBT**
- **Hydro Power Sys.**
- **Smart Grid, Transmission & Distribution System**
- **PET Service, etc.**

#### Prevention Maintenance, Fuel Cycle, etc.

**Nuclear Power Business**

**Blue : Products of BHK**
# Outline of Babcock-Hitachi K.K.

Babcock-Hitachi K.K.

Segment of **Power & Environmental** in Hitachi group

Stock holder: Hitachi Ltd. (100%)

<table>
<thead>
<tr>
<th>Babcock-Hitachi K.K.</th>
<th>Segment of <strong>Power &amp; Environmental</strong> in Hitachi group Stock holder: Hitachi Ltd. (100%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Established</td>
<td>1953</td>
</tr>
<tr>
<td>- Employees</td>
<td>3,200 (Worldwide)</td>
</tr>
<tr>
<td>- Head Office</td>
<td>Tokyo, Japan</td>
</tr>
<tr>
<td>- Works</td>
<td>Kure 1st &amp; 2nd, Noumi, Akitsu, Philippine (BHPI), China (BHDB)</td>
</tr>
<tr>
<td>- Laboratories</td>
<td>Kure, Akitsu</td>
</tr>
<tr>
<td>- Affiliated Companies</td>
<td>Domestic : 2 / Overseas :3</td>
</tr>
<tr>
<td>- Quality Certificates</td>
<td>ISO 9001, ISO 14001, ASME S, U and U2</td>
</tr>
</tbody>
</table>
### Company History

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1908</td>
<td>Hitachi Works Boiler Manufacturing Department established</td>
</tr>
<tr>
<td>1927</td>
<td>Babcock-Hitachi established</td>
</tr>
<tr>
<td>1928</td>
<td>Kure Branch Works became independent from Hitachi Works</td>
</tr>
<tr>
<td>1953</td>
<td>Corporate name changed to Toyo Babcock Ltd.</td>
</tr>
<tr>
<td>1959</td>
<td>Zenma Works Ltd. established</td>
</tr>
<tr>
<td>1961</td>
<td>Kure Branch Works became independent from Hitachi Works</td>
</tr>
<tr>
<td>1964</td>
<td>Totally independent from Hitachi Ltd.</td>
</tr>
<tr>
<td>1965</td>
<td>Merged (Capital...¥1,235 million)</td>
</tr>
<tr>
<td>1971</td>
<td>(Capital...¥1,852.5 million)</td>
</tr>
<tr>
<td>1975</td>
<td>(Capital...¥2,637.5 million)</td>
</tr>
<tr>
<td>1978</td>
<td>(Capital...¥3,000 million)</td>
</tr>
<tr>
<td>1987</td>
<td>Share Holding Ratio amounted to 100% of Hitachi, Ltd.</td>
</tr>
<tr>
<td>1995</td>
<td>(Capital...¥5,000 million)</td>
</tr>
<tr>
<td>2003</td>
<td>Babcock Borsig Power Systems (BBPS) acquired</td>
</tr>
<tr>
<td>2005</td>
<td>Hitachi Power Systems America (HPSA) established</td>
</tr>
<tr>
<td>2006</td>
<td>Hitachi Power Europe (HPE) established</td>
</tr>
<tr>
<td>2011</td>
<td></td>
</tr>
</tbody>
</table>
Main Products

Integrated & Dedicated Product Line-up for Power and Industrial Plant

Power Boilers

HRSG

Industrial Boiler

Incinerators

Industrial Plants

FGD

SCR

Nuclear Power

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Office & Works in Japan

Head office
Location: Akihabara UDX Building, Tokyo Japan

Kure First Works
Kure, Hiroshima, Japan
Design and manufacturing of boilers

Kure Second Works
Kure, Hiroshima, Japan
Manufacturing of nuclear power related products

Noumi Works
Edajima, Hiroshima, Japan
Manufacturing of heat recovery steam generators and other products

Akitsu Works
Higashihiroshima, Hiroshima, Japan
Manufacturing of catalysts
As a core company of the HITACHI/Power & Industrial group, we provide boiler and AQCS services globally.
Hitachi Power Europe GmbH (HPE)
Duisburg, Germany

Engineering, procurement, manufacturing and sales of boilers, AQCS and related equipment.

Hitachi Power Systems America, Ltd.
(HPSA)
Basking Ridge, NJ, USA

Engineering, procurement and sales of boilers and Air Quality Control System (AQCS)
FGD retrofits –HITACHI formation

Customer

EPC contract

Joint & Several Consortium

Babcock-Hitachi K.K.
Hitachi Power Europe

Local partner

Sub-Contractors
**FGD retrofits**  
- complete solution on cooperation with Knauf Gips

Customer

Off-take contract

Knauf Gips KG

Cooperation

Babcock Hitachi K.K.  
Hitachi Power Europe GmbH

Sub-Contractors

EPC contract
Knauf Reference Example

Gypsum wall board plant near the power station

- Power station
- FGD Gypsum store
- Gypsum Wall Board plant
Status of emission standards in Europe

mg/Nm³ dry

<table>
<thead>
<tr>
<th></th>
<th>SO₂ / SOₓ</th>
<th>NOₓ</th>
<th>Dust x 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>IED retrofit</td>
<td>200</td>
<td>150</td>
<td>10</td>
</tr>
<tr>
<td>IED new build</td>
<td>180</td>
<td>130</td>
<td>8</td>
</tr>
<tr>
<td>13 BmSchV</td>
<td>220</td>
<td>170</td>
<td>6</td>
</tr>
<tr>
<td>actual new build GER</td>
<td>150</td>
<td>120</td>
<td>5</td>
</tr>
</tbody>
</table>

IED = Industrial Emission Directive 2010/75/EU
Japanese regulation of flue gas treatment

Dust: 5 mg/Nm³

SO₂: 10 mg/Nm³

NOx: 25 ppm (71 mg/Nm³)

SO₂: 50 ppm (142 mg/Nm³)

NOx: 50 ppm (103 mg/Nm³)

SO₂: 70 ppm (144 mg/Nm³)

NOx: 35 ppm (71 mg/Nm³)

SO₂: 100 ppm (285 mg/Nm³)

Dust: 20 mg/Nm³

Dust: 10 mg/Nm³

Dust: 5 mg/Nm³
Air Quality Control System (AQCS)

Hitachi is one of few AQCS Supplier for total system

(Layout for 1000MW coal fired plant in Japan)
# Measures for SO₂ Reduction

<table>
<thead>
<tr>
<th>Process Type</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dry Process</strong></td>
<td>Activated carbon method</td>
</tr>
<tr>
<td></td>
<td>Fly ash method</td>
</tr>
<tr>
<td></td>
<td>Activated coke method</td>
</tr>
<tr>
<td><strong>Semi-Dry Process</strong></td>
<td>Spray Dryer Absorber (SDA)</td>
</tr>
<tr>
<td></td>
<td>Circulating Dry Scrubber (CDS)</td>
</tr>
<tr>
<td></td>
<td>Limestone Injection into Furnace and Flue Gas Humidification</td>
</tr>
<tr>
<td><strong>Wet Process</strong></td>
<td>Limestone-Gypsum method</td>
</tr>
<tr>
<td></td>
<td>Magnesium Hydroxide -Gypsum method</td>
</tr>
<tr>
<td></td>
<td>Sea water method</td>
</tr>
</tbody>
</table>
FGD Process: Wet Limestone-Gypsum Process

Technical Response to Emission regulations

- **Forced oxidation limestone gypsum process** as almost standard technology (after technological and economical comparison)

  Reasons for the wide application of Wet Limestone-Gypsum Process

  1) *Limestone* is
     - Cheapest Absorbent
     - Abundant in nature
     - Easy Handling

  2) *Gypsum* is
     - Useful for Cement Additives
     - Useful for Wallboard Materials
     - Easy Storing
     - Easy Handling

  3) *The System* is
     - Simple
     - Easy to Operate
     - High Reliability
     - High efficiency

- Performance optimisation and cost reduction results in highly standardised absorber

* also quick lime technology available (Walsum Power Plant - Branntkalk)
2. Babcock-Hitachi’s WFGD Technology
Development of Hitachi WFGD System


- Initial Stage
- Improvement of Reliability
- Meeting Middle Load Ope.
- Targeting Low Utility and Cost
- Simplification of the System
- Reduction of Utility

LIMESTONE GYPSUM FGD SYSTEM

PERFORATED TRAY TOWER

R&D / PILOT

COMMERCIAL PLANT (Total 15, - COAL 3, OIL 12)

SPRAY TOWER

COMMERCIAL PLANT (Total 9, - COAL 4, OIL 3, COM 1, PET COKE 1)

ADVANCED SPRAY TOWER

COMMERCIAL PLANT (Total 52, - COAL 41, Lignite 3 ORIMULSION 2, OIL 2, PET COKE 2, R.O. 2)

TAMASHIMA #3 – 500MW

MATSUSHIMA #2 – 500MW

MATSUURA #1 – 1,000MW

TACHIBANAWAN #2 – 1,050MW

TRAY TOWER

SPRAY TOWER

ADVANCED SPRAY TOWER
## Wide Application of BHK WFGD System

### Application of BHK FGD System

- **COAL / LIGNITE**
- **OIL**
- **RESIDUAL OIL**
- **ORIMULSION**
- **P. C.**

### BHK FGD System

- Applied many kinds of fuel
- Experience of high sulfur fuel

### FUEL Application Table

<table>
<thead>
<tr>
<th>FUEL</th>
<th>INLET SO₂ CONCENTRATION (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BHK'S EXPERIENCE</strong></td>
<td>1000</td>
</tr>
<tr>
<td>1. OIL</td>
<td>✓</td>
</tr>
<tr>
<td>2. COAL</td>
<td>✓</td>
</tr>
<tr>
<td>3. COM</td>
<td>✓</td>
</tr>
<tr>
<td>4. ORIMULSION</td>
<td></td>
</tr>
<tr>
<td>5. RESIDUE OIL</td>
<td></td>
</tr>
<tr>
<td>6. PET.COE</td>
<td></td>
</tr>
</tbody>
</table>

*BHK FGD can be applied to any kinds of fuel and various sulfur containing fuel*
**Principle and System Flow of BHK Wet FGD System**

**Chemical Principle:** SO₂ Absorption and Oxidation

$$\text{SO}_2 + 2\text{H}_2\text{O} + \text{CaCO}_3 \ (\text{LIMESTONE}) + \frac{1}{2}\text{O}_2 \rightarrow \text{CaSO}_4 \cdot 2\text{H}_2\text{O} \ (\text{GYPSUM}) + \text{CO}_2$$
**CHEMICAL PRINCIPLE: SO₂ Absorption and Oxidation**

\[
\text{SO}_2 + 2\text{H}_2\text{O} + \text{CaCO}_3 \text{ (LIMESTONE)} + \frac{1}{2}\text{O}_2 \rightarrow \text{CaSO}_4 \cdot 2\text{H}_2\text{O} \text{ (GYPSUM)} + \text{CO}_2
\]
**Principle of BHK Advanced WFGD System**

**Chemical Reaction in Absorber**

\[
\text{SO}_2 + 2\text{H}_2\text{O} + \text{CaCO}_3 + \frac{1}{2}\text{O}_2 \rightarrow \text{CaSO}_4 \cdot 2\text{H}_2\text{O} + \text{CO}_2
\]

**CHEMICAL REACTION**

<table>
<thead>
<tr>
<th><strong>SO}_2 Absorption and Oxidation</strong></th>
<th>**SO}_2 + 2\text{H}_2\text{O} + \text{CaCO}_3 (LIMESTONE) + \frac{1}{2}\text{O}_2 \rightarrow \text{CaSO}_4 \cdot 2\text{H}_2\text{O} (GYPSUM) + \text{CO}_2</th>
</tr>
</thead>
</table>
Outline of Babcock Hitachi’s Absorber

- **<Spray Header>**
- **<Spray Nozzles>**
- **<Air Dispersion>**
- **<Oxidation Agitator>**
Absorber Design

Absorption Area
SO₂ & Dust Removal

Absorber Inlet

Absorber Outlet
(horizontal or vertical)

Mist Eliminator
(2 – 3 stages, depending from allowable drop content)

Spray Levels
(number of levels depending on sulphur in fuel, if desired with space for retrofit of spare level)

Spray Nozzles
(up and/or down spray nozzles)

Absorber Sump
Oxidation
Dissolution of Limestone
Crystal growth

Absorber sump
(with agitator for mixing and oxidation air injection)
European Solution: **Rubber Lined Absorber**

Lifetime of more than 50,000 hours,
Maintenance and repair of coating by rubber lining specialist company only!
Absorber Material – Flake Lining Application

- Wear Resistant FRL or Metal lined
- Heat Resistant FRL or Metal lined
- Heat Resistant FRL
- Acid Resistant FRL

Primer
1st layer
2nd layer
Top coat

Inspection After 3 Years Operation
Spark test: Inspection of lining

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**Limestone Slurry preparation system**

**Chemical Principle:** SO₂ Absorption and Oxidation

\[
SO_2 + 2H_2O + CaCO_3 \text{ (LIMESTONE)} + \frac{1}{2}O_2 \rightarrow CaSO_4 \cdot 2H_2O \text{ (GYPSUM)} + CO_2
\]
Flow Diagram of Limestone Slurry Preparation System

Limestone

Silo

Limestone Feeder

Ball Mill

Mill Tank

Slurry Pump

H/C Classifier

Grinding / Dilution Water Supply

Distribution System

Main Process

Water

High

Low

Main Process

Water

Limestone Slurry Tank

Babcock-Hitachi K.K.

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Limestone Preparation - Wet Ball Mill

- Quarry Ground Limestone or On-Site Mill
- Horizontal Ball Mill or Tower Mill
- 95% - 325 Mesh (44 µm)
- 30% Solids

Limestone Activity Test

H₂SO₄ consumption
(= Limestone Reactivity)

Time

标准

<Before Project Start>
Evaluation of Limestone activity

Reliable Design

Photo Horizontal Ball Mill
**CHEMICAL PRINCIPLE: SO₂ Absorption and Oxidation**

\[
SO_2 + 2H_2O + CaCO_3 (LIMESTONE) + 1/2O_2 \rightarrow CaSO_4 \cdot 2H_2O (GYPSUM) + CO_2
\]
Gypsum Recovery System - Belt Filter Application

Absorber Slurry

Hydro-Cyclone

Overflow

Horizontal Belt Filter

By product Gypsum

Water for recycling

To Absorber

Filtrate Receiver

Vacuum Pump

Instrument Air

Vacuum Box

Seal Water

Belt Support Air

AIR FAN

Filtrate Pump

Vacuum Pump

CAKE WASH TANK

Seal Water Return from Vacuum Pump

Cloth/Belt Wash

Overflow

By product Gypsum

Water for recycling

To Absorber

Filtrate Receiver

Vacuum Pump

CAKE WASH TANK

Seal Water Return from Vacuum Pump

Cloth/Belt Wash

Overflow
Gypsum Recovery System - Belt Filter Application

Hydrocyclone

Slurry feed

Direction

Vacuum

Vacuum Belt Filter

Byproduct Gypsum
## Typical Requirement of Gypsum Usage

### BY-PRODUCT GYPSUM QUALITY

<table>
<thead>
<tr>
<th>ITEM</th>
<th>ACTUAL VALUE</th>
<th>GENERAL REQUIREMENT IN JAPAN</th>
<th>FOR CEMENT</th>
<th>FOR WALL BOARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>CaSO₄•2H₂O</td>
<td>98.8 %</td>
<td>&gt; 90 %</td>
<td>&gt; 95 %</td>
<td></td>
</tr>
<tr>
<td>CaSO₃•1/2H₂O</td>
<td>&lt; 0.05 %</td>
<td>—</td>
<td>&lt; 0.25 %</td>
<td></td>
</tr>
<tr>
<td>CaCO₃</td>
<td>0.32 %</td>
<td>—</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Na⁺</td>
<td>0.001 %</td>
<td>—</td>
<td>0.03 %</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>6.8</td>
<td>—</td>
<td>5~8</td>
<td></td>
</tr>
</tbody>
</table>

**PHOTO OF BYPRODUCT GYPSUM CRYSTAL**
BY-PRODUCT GYPSUM QUALITY

<table>
<thead>
<tr>
<th>ITEM</th>
<th>EURO GYPSUM Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_2O$</td>
<td>&lt; 10%</td>
</tr>
<tr>
<td>$CaSO_4 \cdot 2H_2O$</td>
<td>&gt; 95%</td>
</tr>
<tr>
<td>$MgO$</td>
<td>&lt; 0.10</td>
</tr>
<tr>
<td>$Na_2O$</td>
<td>&lt; 0.06</td>
</tr>
<tr>
<td>$Cl$</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>$CaSO_3 \cdot 1/2H_2O$</td>
<td>&lt; 0.50 %</td>
</tr>
<tr>
<td>$pH$</td>
<td>5-9</td>
</tr>
<tr>
<td>Color</td>
<td>White</td>
</tr>
<tr>
<td>Odour</td>
<td>Neutral</td>
</tr>
<tr>
<td>Toxicity</td>
<td>Non-toxic</td>
</tr>
</tbody>
</table>

VGB-M 701e: EURO GYPSUM: Quality Criteria and analysis methods
FGD Design Consideration for Lignite Coal

- Large Flue Gas Volume
- High $\text{SO}_2$ Content → High Removal Efficiency
- High Fly Ash Loading
- High Inlet Gas Temperature → High Absorber Slurry Temperature
- High Inlet Moisture →
Features of “Wet Stack on top of Absorber”

1. Small-footprint
2. Isolated from Absorber
   → Supported by Steel structure and no load to absorber shell
FGD Waste Water Treatment Flowchart
(Example in Europe)

Raw FGD Waste Water → Neutralization Tank 1 → Neutralization Tank 2 → Flocculation Tank → Lamella Clarifier → Treated Waste Water Tank

COAGULANT:
- Ca(OH)₂
- TMT-15
- FeCl₃
- Polymer

SS, Heavy Metals Removal

HCl → Cooling water → Discharge to River

Waste Product:
- Filter Press
- Sludge Storage Tank

Neutralization Tank 1
Neutralization Tank 2
Flocculation Tank
Lamella Clarifier
Treated Waste Water Tank
3. Experiences
HITACHI’s FGD Experiences in Europe

- Germany / Netherlands
  - ELECTRABEL / Wilhelmshaven, Rotterdam
    - (800MW x 2)
- Germany, Steag / Walsum 10
  - (750MW x 1)
- Germany / Netherlands
  - RWE / Westfalen, Eemshaven
    - (800MW x 4)

- UK, National Power / Drax
  - (660MW x 6) (License)

- Poland, Kozienice II
  - (800MW x 1)

- Spain, HC/Abono No.2
  - (556MW x 1)

- Spain, UF/La Robla & Narcea
  - (350MW x 2)

- Portugal, EdP/Sines No.1-4
  - (314MWx4)

- Czech Republic, Chvaltice No.1-4
  - (200MWx4)

- Czech Republic, Vresova
  - (220MW x 1)

Approx. 15 GW
equiv. in total
Reference Plant Industry Recognition

Ameren Services (USA) / Coffeen Power Plant / No. 1, 2

POWER’s 2011 Plant of the Year
- Power Magazine (Oct 2011)

Project of the Year Award
- Power Gen International 2011 in Las Vegas, USA
4. Research & Development
**R&D Facilities**

**Desulfurization Test Facility**

4 Absorbers and 1 Reaction Tank Test Facilities

- **Absorber A**
  - Gas flow: 22,000 m³N/h
  - SO₂ conc.: 500 ppm
  - Abs. dia.: 680 mm

- **Absorber B**
  - Gas flow: 250 m³N/h
  - SO₂ conc.: 20,000 ppm
  - Abs. dia.: 160 mm

**Boiler-AQCS Pilot Test Facility**

- **Combustion facility**
  - Coal Feed Rate: 100~150 kg/h
  - Gas Flow Rate: 1,000~1500 m³N/h
  - Abs. dia.: 480 mm

- **Flue gas treatment facility**
  - Coal Feed Rate: 100~150 kg/h
  - Gas Flow Rate: 1,000~1500 m³N/h
  - Abs. dia.: 480 mm

- **G/C**
- **GGH**
- **DESP**
- **WESP**
- **SCR**
- **WFGD**
- **FF**
- **CEM**
<Model Consideration>
- Spray Droplets
- Kinetic Momentum (Droplet/Gas)

Flow Model Results

Track of Spray Droplet

Gas Distribution

Confirmation of Optimized Absorber internal arrangements by Flow Model to prevent the gas short-pass.
5. Conclusions
Special Features of BHK FGD System

- Total Engineering Capability with Boiler Plant Engineering corresponding to various kinds of fuel

- Best-Mix of Japanese & European “State of the Art” Technologies

- Excellent Advanced Spray Tower Absorber Design featuring:
  a) Higher $SO_2$ Removal Efficiency & Dust Removal Efficiency
  b) Lower Gas Pressure Drop $\rightarrow$ Less Boost-Up Fan Capacity
  c) Excellent Liquid/Gas Contact $\rightarrow$ Less Recirc. Pump Capacity
  d) Higher Quality of By-Product Gypsum
     $\rightarrow$ Re-Use for Cement Additive and/or Wall Board Material

- Full Support by R&D Facility

- Proven FGD Technology and High Reliability
6. SCR Process
SCR Process

SCR ; SELECTIVE CATALYTIC REDUCTION

REACTION FORMULA

- $4\text{NO} + 4\text{NH}_3 + \text{O}_2 \rightarrow 4\text{N}_2 + 6\text{H}_2\text{O}$
- $\text{NO} + \text{NO}_2 + 2\text{NH}_3 \rightarrow 2\text{N}_2 + 3\text{H}_2\text{O}$
- $6\text{NO}_2 + 8\text{NH}_3 \rightarrow 7\text{N}_2 + 12\text{H}_2\text{O}$

CATALYST

CLEAN GAS
Scheme of SCR System

NH3 injection

SCR Reactor

Catalyst

NH3 Storage & Supply
Reactor Design
SCR Retrofit Example

SCR Retrofit to Existing boiler

SCR reactor

APH

ESP
Plate Type Catalyst

CATALYST ELEMENT

CATALYST UNIT

CATALYST BLOCK