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Clean Coal Technology Development in Hitachi

October 16, 2013

Makoto Nishimura

Engineering Division,
Thermal Power Systems Department,
Power Systems Company
Hitachi, Ltd.

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Index

1. Hitachi Power Systems Company
2. Boiler Technology
3. Steam Turbine Technology
4. Air Quality Control System Technology
5. Future Clean Coal Technology

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1. Hitachi Power Systems Company

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Hitachi Global Portfolio

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Others

Financial Services

Digital Media
& Consumer Products

Information
& Telecommunication Systems

Power Systems

Social Infrastructure
& Industrial Systems

Automotive
Systems

Electronics Systems
& Equipment

High Functional Materials
& Components

Construction Machinery

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Power Business in Hitachi

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Thermal Power Business

Coal-fired Thermal Power Plants

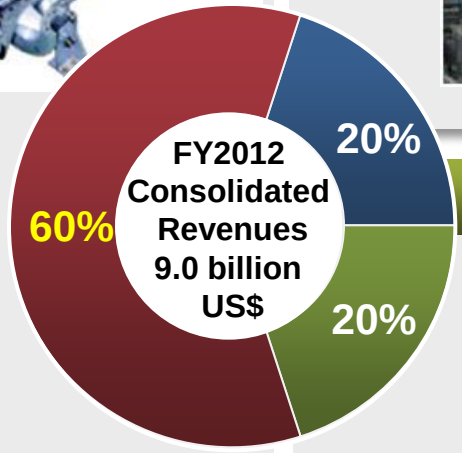
Gas Turbines

Major Equipment of Coal-fired Thermal Power Plants

Steam Turbines

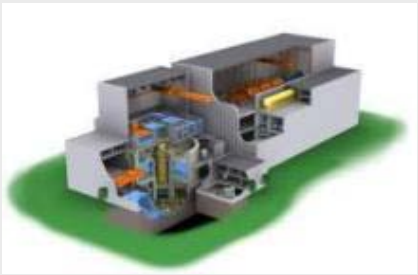
Boilers

Air Quality Control System



Nuclear Power Business

Boiling Water Reactor Nuclear Power Plants (ABWR▪ESBWR)



Preventive Maintenance, Nuclear Fuel Cycle, etc.

Transmission & Distribution, Renewable Energy and Other Businesses

Particle beam therapy systems

Wind Power Generation Systems

Transmission & Distribution (T&D) Systems

Photovoltaic Power Generation Systems

Hydroelectric Power Generation Systems, Drive Systems, Smart Grids, Power Semiconductors, etc.

ABWR: Advanced Boiling Water Reactor ESBWR: Economic and Simplified Boiling Water Reactor

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Total Power System Technology

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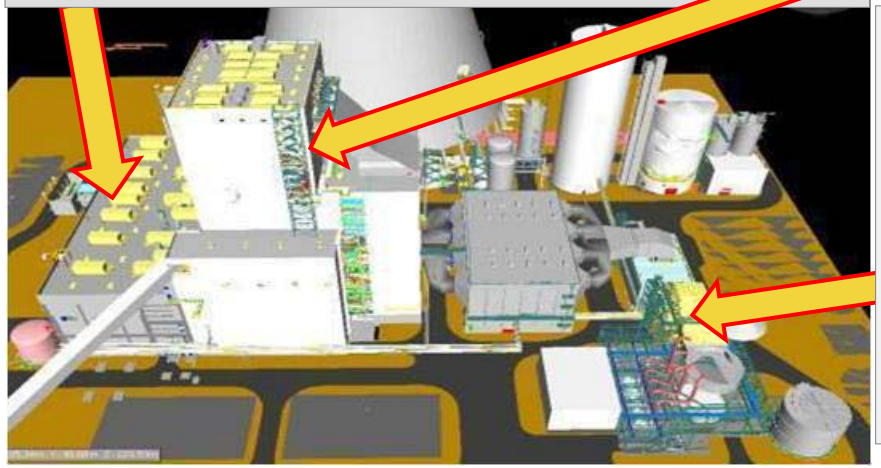
Integrated supply of BTG + AQCS ⇒ Optimize entire plants

Boilers (B)	Turbines (T)	Generators (G)	Air Quality Control System (AQCS)				
			DeNOx		Precipitators	DeSOx	CCS
			Systems	Catalysts			
○	○	○	○	○	○	○	○

■Steam Turbines and Generators (TG)

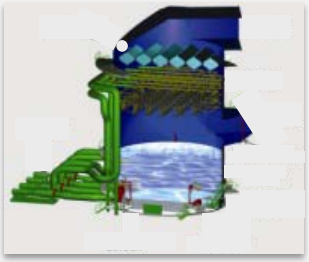
Turbines and Generators

Low-pressure Turbines

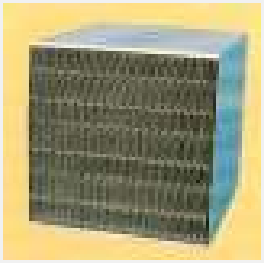


■Boilers (B)

■Air Quality Control System (AQCS)



DeSOx (Spray Type)



DeNOx Catalyst

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Accelerate Business Development

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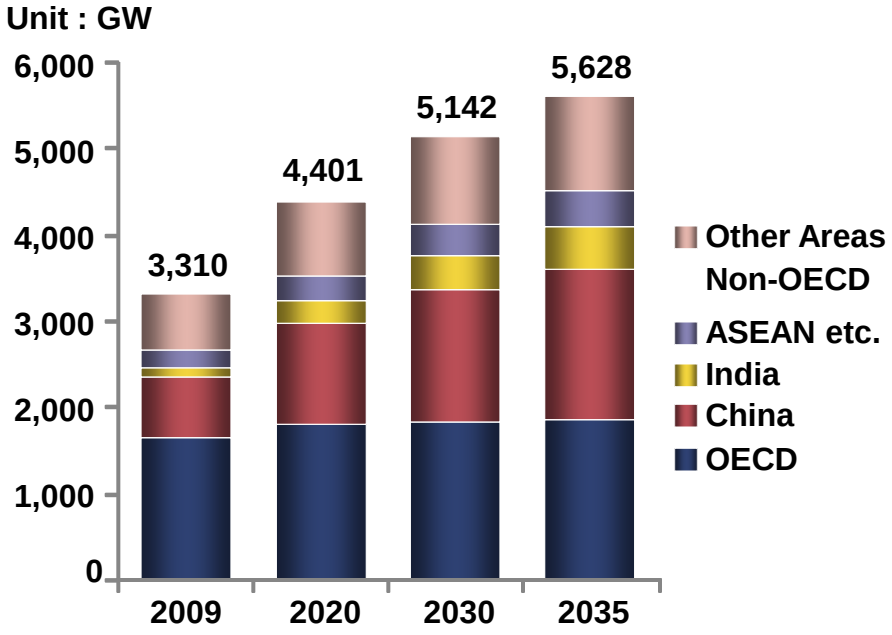
New Markets

- Expand in emerging markets, particularly in Asia
- Coal-fired systems expand in emerging markets, and gas-fired systems in all regions

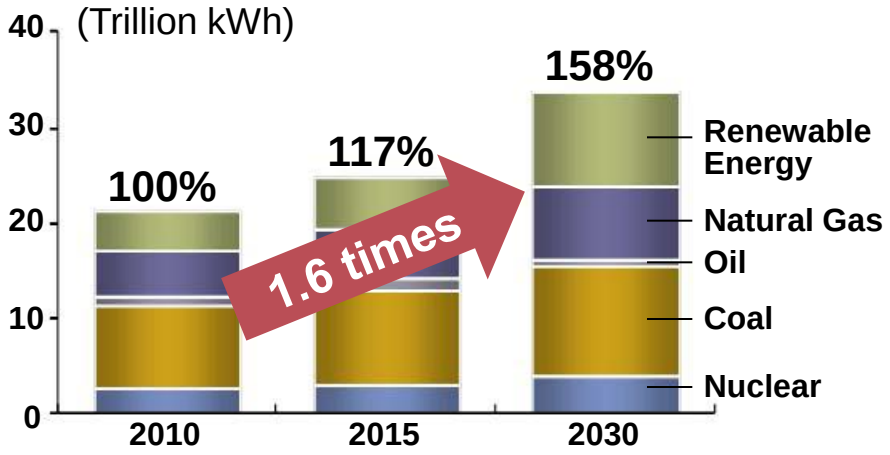
Estimation on Thermal Power Generation Capacity



Source : IEA WEO 2011

World Electricity Generation by Energy Source

- Steady growth in coal-fired thermal power plants
- Increasing demand for AQCS due to national regulation
- Accelerated adoption of renewable energy
- Expansion of power transmission and distribution market



Source: World Energy Outlook 2012

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2. Boiler Technology

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Boiler Supply Record

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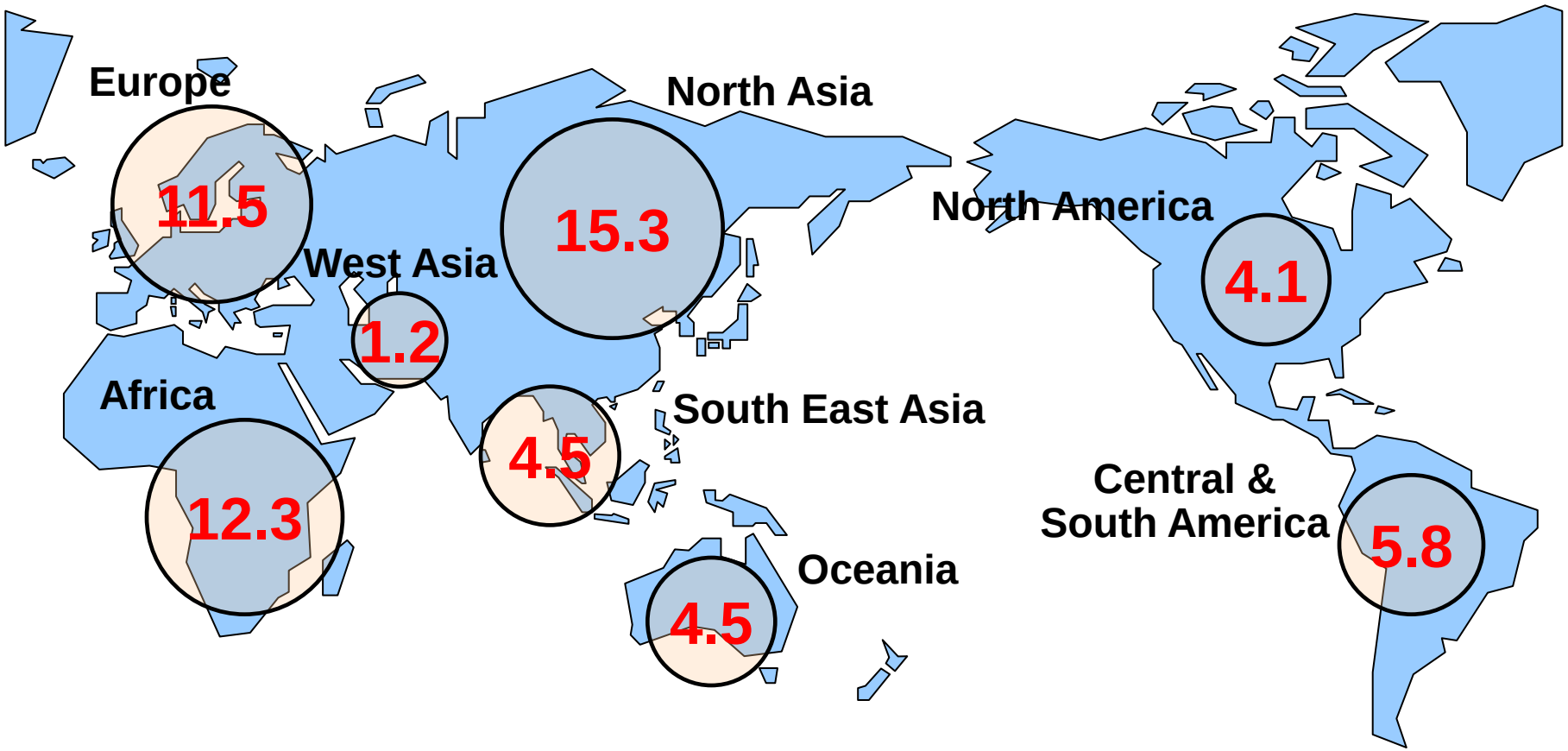
Total Installed Capacity: 107 GW (Japan: 46 GW) (As of 2012)



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Latest Boiler Supply

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Tokyo Electric Power Co., Ltd (Japan)
Hitachi Naka Unit 1 and 2

Boiler Type	:	Once-Through, Benson
Generator Output	:	1,000 MW
Main Steam Flow	:	2,870 t/h
Steam Conditions	:	25.4MPa / 604°C / 602°C
Commercial Operation	:	2003 (#1), 2013 (#2)

MidAmerican Energy Company (USA)
Walter Scott Jr. Energy Center Unit 4

Boiler Type	:	Once-Through, Benson
Generator Output	:	853 MW
Main Steam Flow	:	2,530 t/h
Steam Conditions	:	26.2MPa / 570°C / 595°C
Commercial Operation	:	2007

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4. Steam Turbine Technology

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Steam Turbine Supply Record

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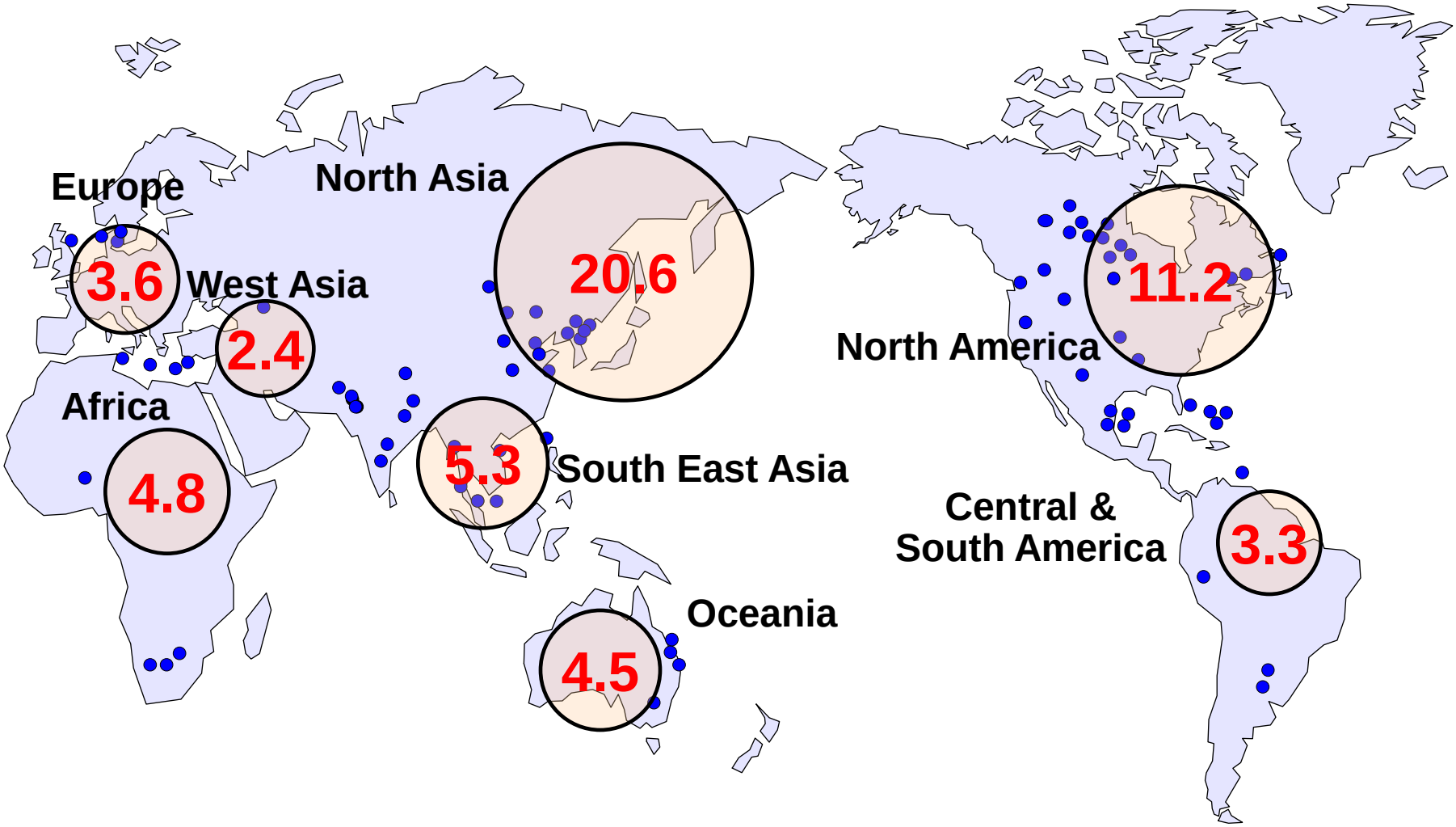
Total Installed Capacity: 110 GW (Japan: 44 GW) (As of 2012)



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Latest Steam Turbine Supply

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J-Power Co., Ltd. (Japan)
Isogo unit No.2

Turbine Type :	Tandem Compound Double Flow
Generator Output :	600 MW
Revolution:	3,000rpm
Steam Conditions :	25MPa/ 600°C / 620°C
Commercial Operation :	2009

Netherland
Rotterdam unit No.1

Turbine Type :	Tandem Compound Four Flow
Generator Output :	790 MW
Revolution:	3,000rpm
Steam Conditions :	26.3MPa/ 600°C / 620°C
Commercial Operation :	2013

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Latest Steam Turbine Supply in Philippine

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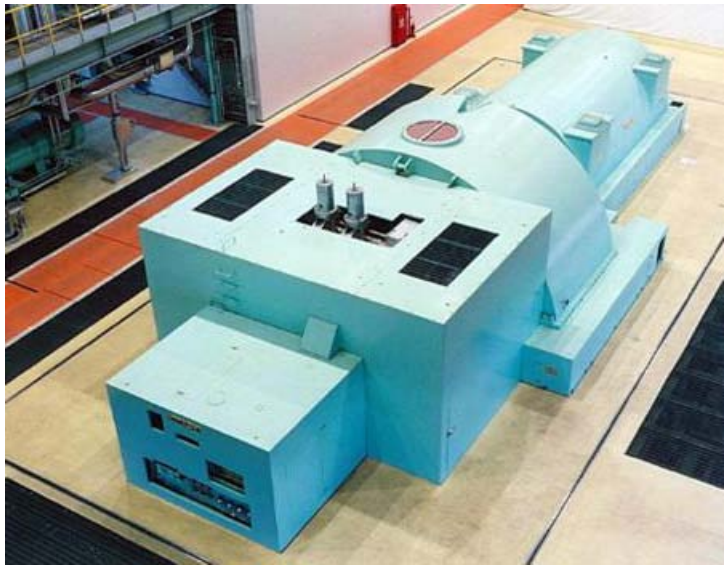
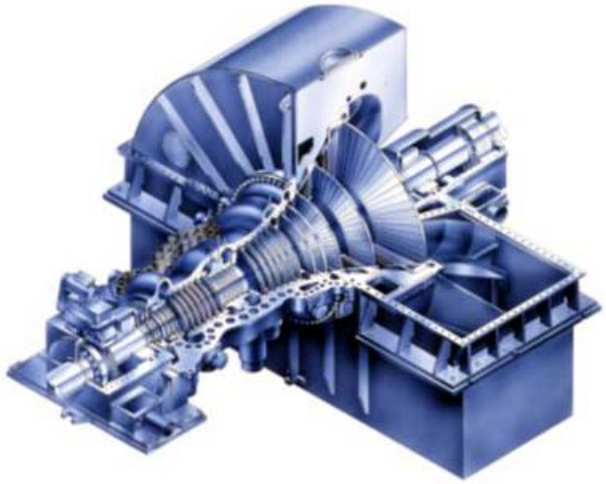
SMC Davao Power Plant Project

Owner :	San Miguel Consolidated Power Corp.
Location :	Davao in Mindanao, Philippine
Gross Output :	150MW x 2 units
Turbine Type :	Single Flow Exhaust Reheat Condensing Turbine
Steam Conditions :	12.3MPa/ 538°C / 538°C
Commercial Operation :	2015, 2016



SMC Limay Power Plant Project

Owner :	SMC Consolidated Power Corp.
Location :	Bataan in Luzon, Philippine
Gross Output :	150MW x 2 units
Turbine Type :	Single Flow Exhaust Reheat Condensing Turbine
Steam Conditions :	12.3MPa/ 538°C / 538°C
Commercial Operation :	2016



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3. Air Quality Control System Technology

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Air Quality Control System

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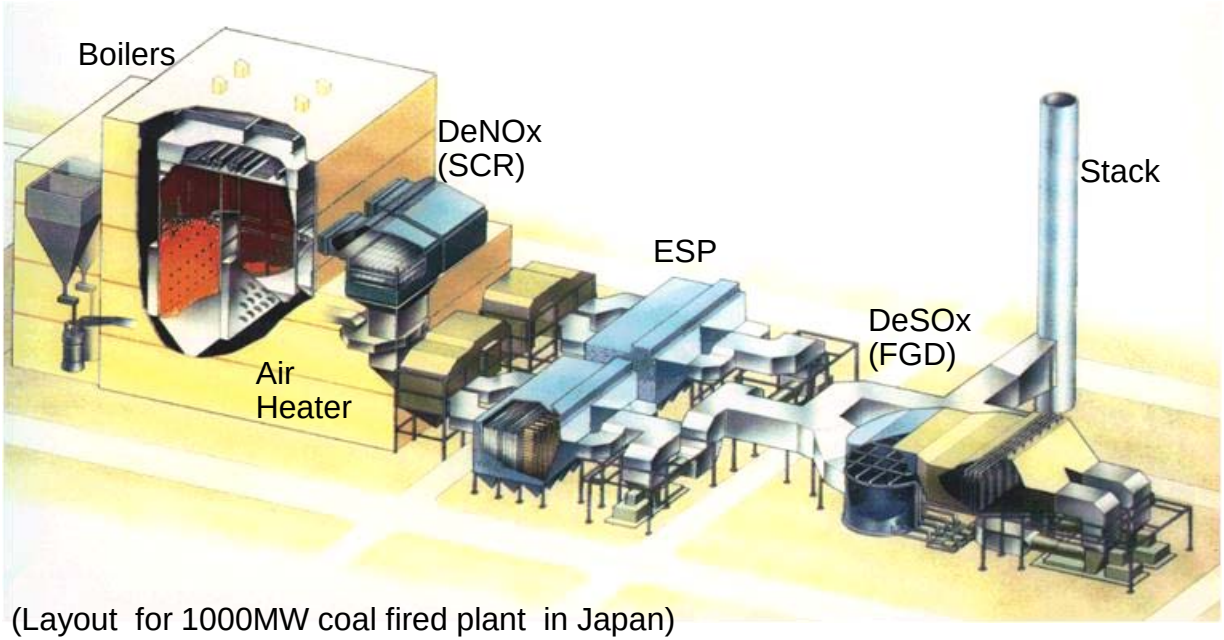

(Layout for 1000MW coal fired plant in Japan)

SCR : Selective Catalytic Reduction

ESP : Electrostatic Precipitator

FGD : Flue Gas Desulfurization

Hitachi is one of a few AQCS suppliers for total system

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5. Future Clean Coal Technology

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Roadmap of Clean Coal Technology

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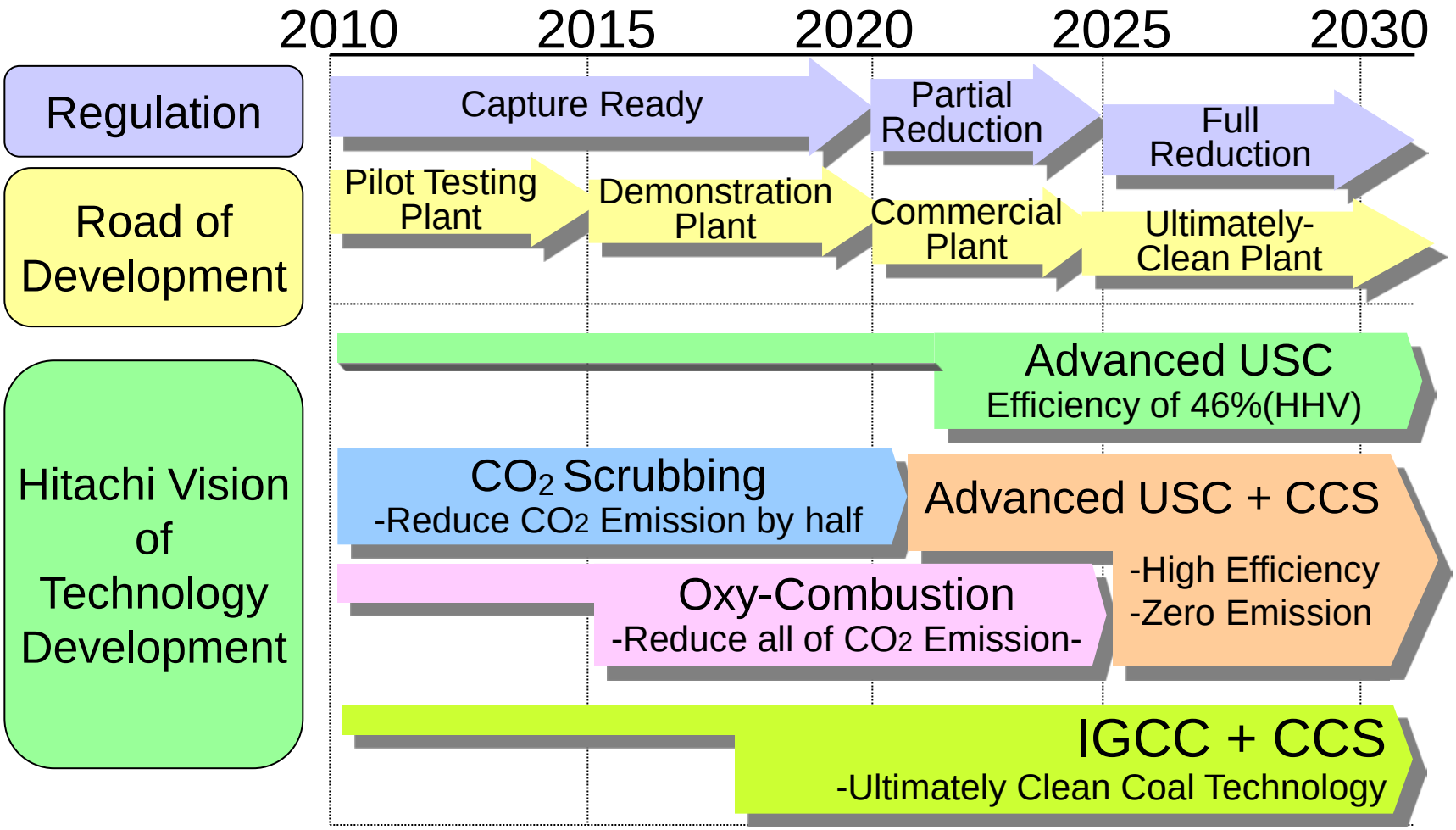
- Hitachi has been developing key technologies of clean coal system
  - Advanced USC (Ultra Super Critical)
  - CCS (CO_2 Capture and Storage)
  - IGCC (Integrated coal Gasification Combined Cycle)



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Advanced USC (Ultra Super Critical)

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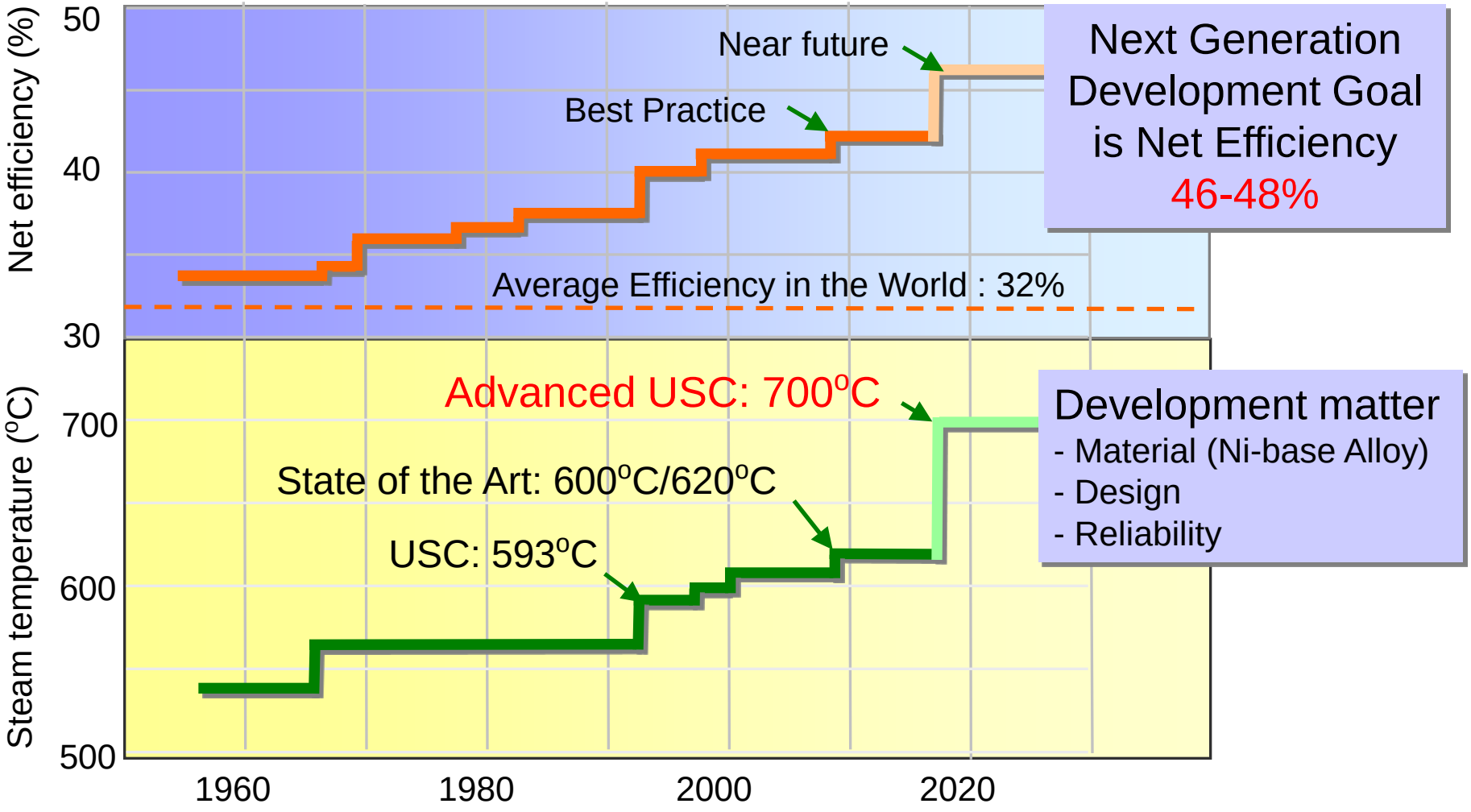
- The efficiency of the coal fired power plant has been improved by making the steam condition a high temperature.



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Development of Material for Advanced USC

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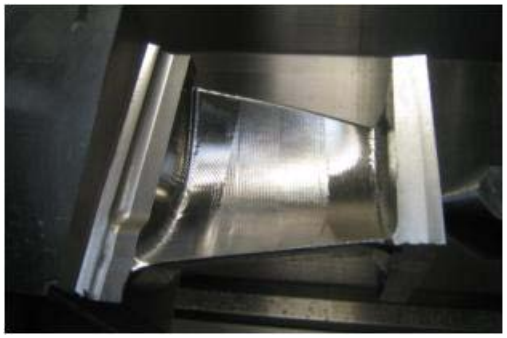
USC141: High Strength Ni-base Alloys (Upper Limit: 720°C)

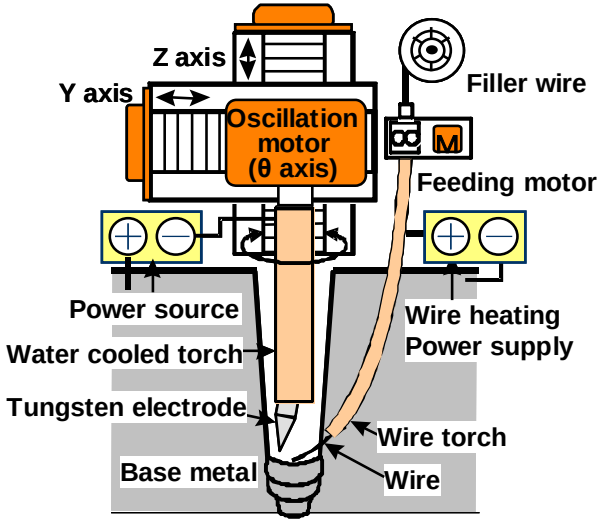


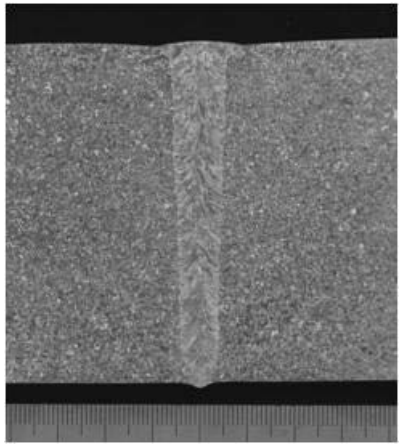
Application Use;
Turbine Moving Blade,
Bucket Bolts, Boiler Tube

FENIX700: Fe-Ni-base Alloys for Low Price, Large-scale Production (Upper Limit: 700°C)

Application Use; Turbine Rotor

Narrow Gap Hot Wire Techinology





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Reduction of CO_2 Emission

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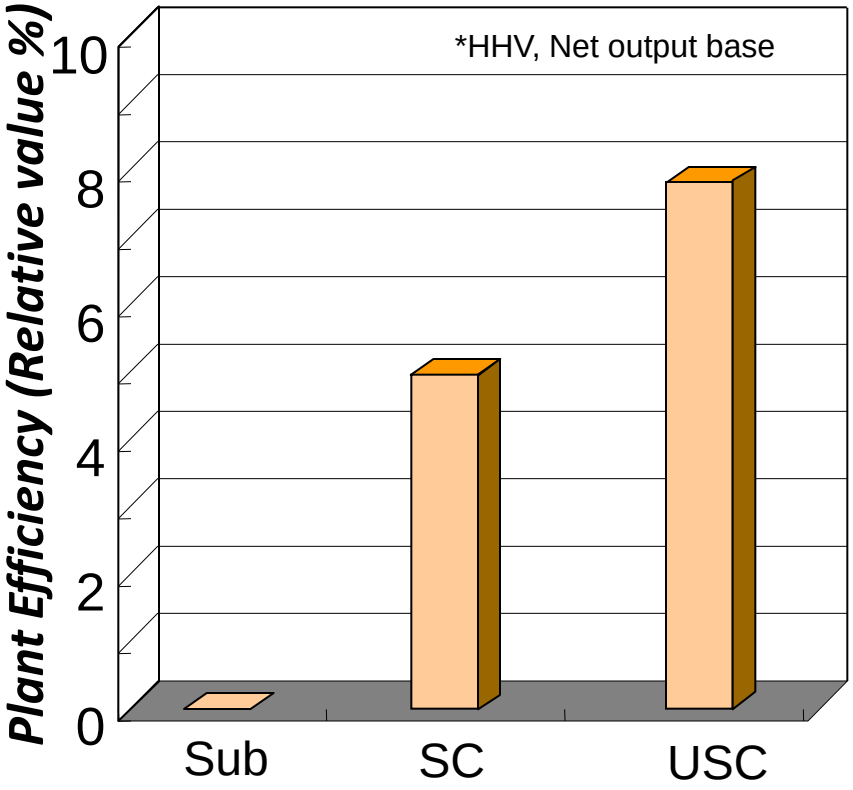
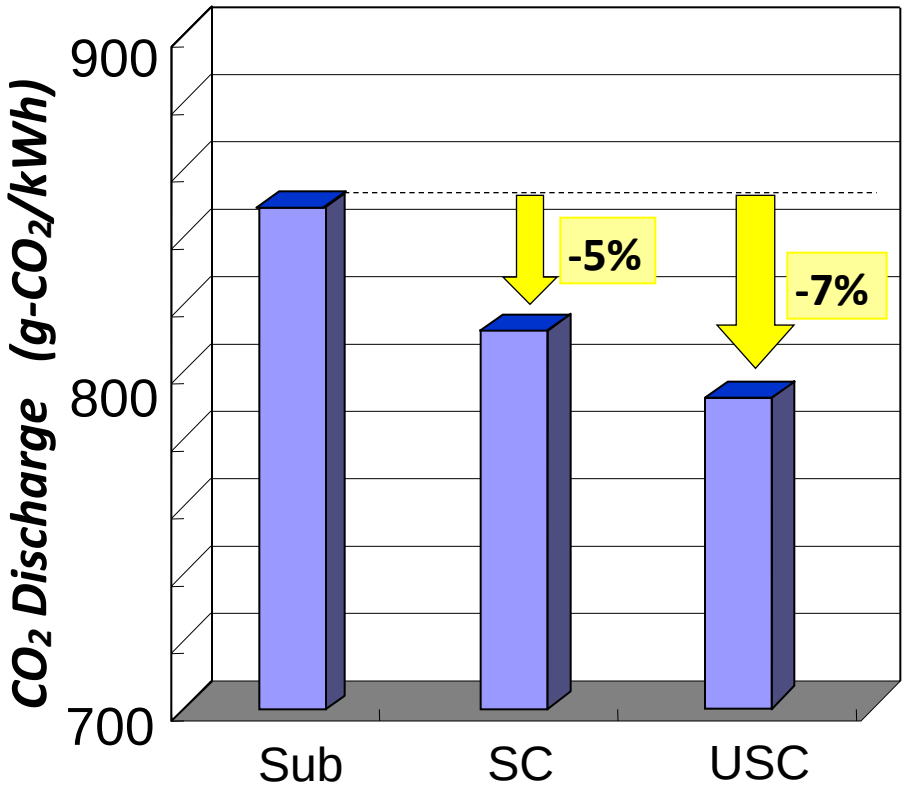
【Calculation value based on our experiences】





	Pressure (MPa)	Temperature (°C)
Sub: Sub-Critical	16.7	538/538
SC: Super Critical	24.1	566/566
USC: Ultra Super Critical	25.0	600/600

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CCS (CO_2 Capture and Storage) - Scrubbing

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Accelerate Commercialization

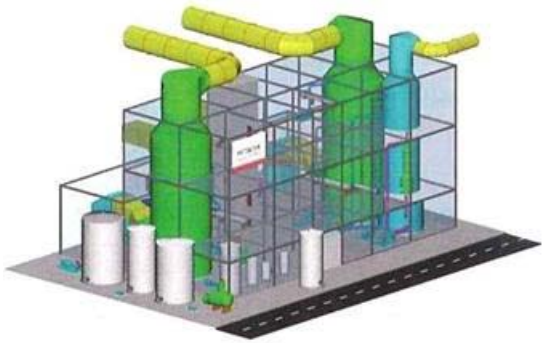
2005 — 2010 — 2015 — 2020 — 2025

Pilot Test → Demonstration Test → Commercialization

Joint Research by Power Companies (To 1995)

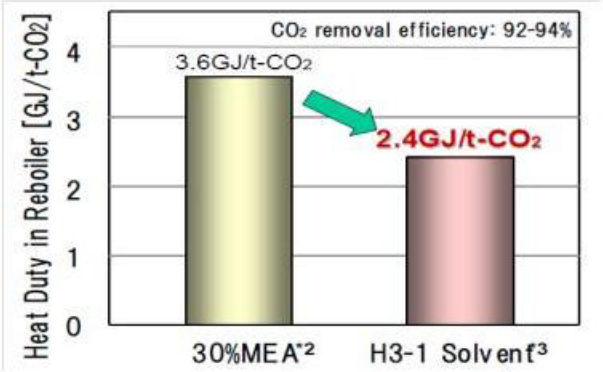
Test with Organizations Overseas (2012)

CCTF Project



Conceptual Design of CO_2 Scrubbing (800MW class)

NCCC Test Result



Hitachi has participated in SaskPower CCS Project

- Hitachi and SaskPower*4 have collaborated to design and built Carbon Capture Test Facility (CCTF, 120 t-CO_2/day) at Shand Power Station.
- Hitachi supplies the newly-designed steam turbine and generator for Boundary Dam CCS Project. (3000 t-CO_2/day)

Boundary Dam Power Station

*1 NCCC:National Carbon Capture Center *2 MEA:Standard Solvent
*3 H3-1:Hitachi Solvent *4 SaskPower : Utility company in Saskatchewan, Canada

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CCS (CO_2 Capture and Storage) - Oxy-fuel Combustion

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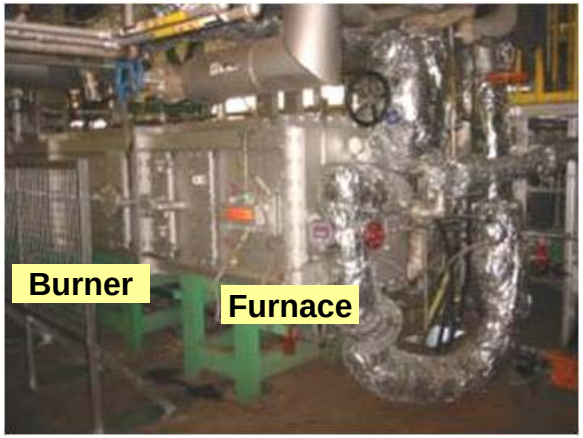
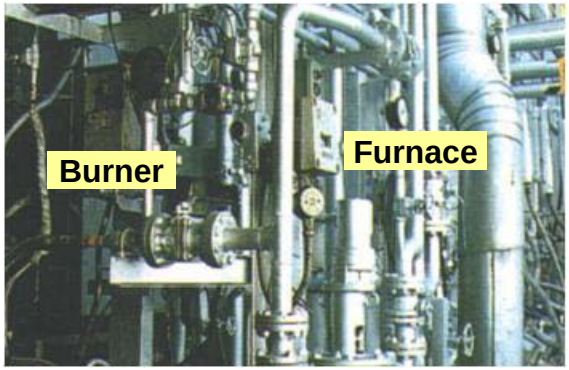
Fundamental Study
- Laboratory Test
- Basic Combustion Test (0.4MWth Test Facility)

Verification Study
- Large Scale Combustion Test (4MWth Test Facility)
- Total System Check (1.5MWth Test Facility)

Demonstration Test Feasibility Study
- Trial Design of Actual Plant (500MW class)
- Cost Evaluation



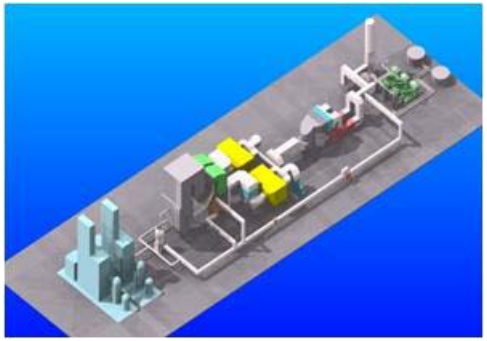
0.4MWth Test Facility



4MWth Test Facility

1.5MWth Test Facility

30MWth Test Plant *1



Conceptual Design of Oxy-combustion (500MW class)

1: Schwarze Pumpe (Vattenfall)：
Hitachi has conducted burner combustion test.

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IGCC (Integrated coal Gasification Combined Cycle)

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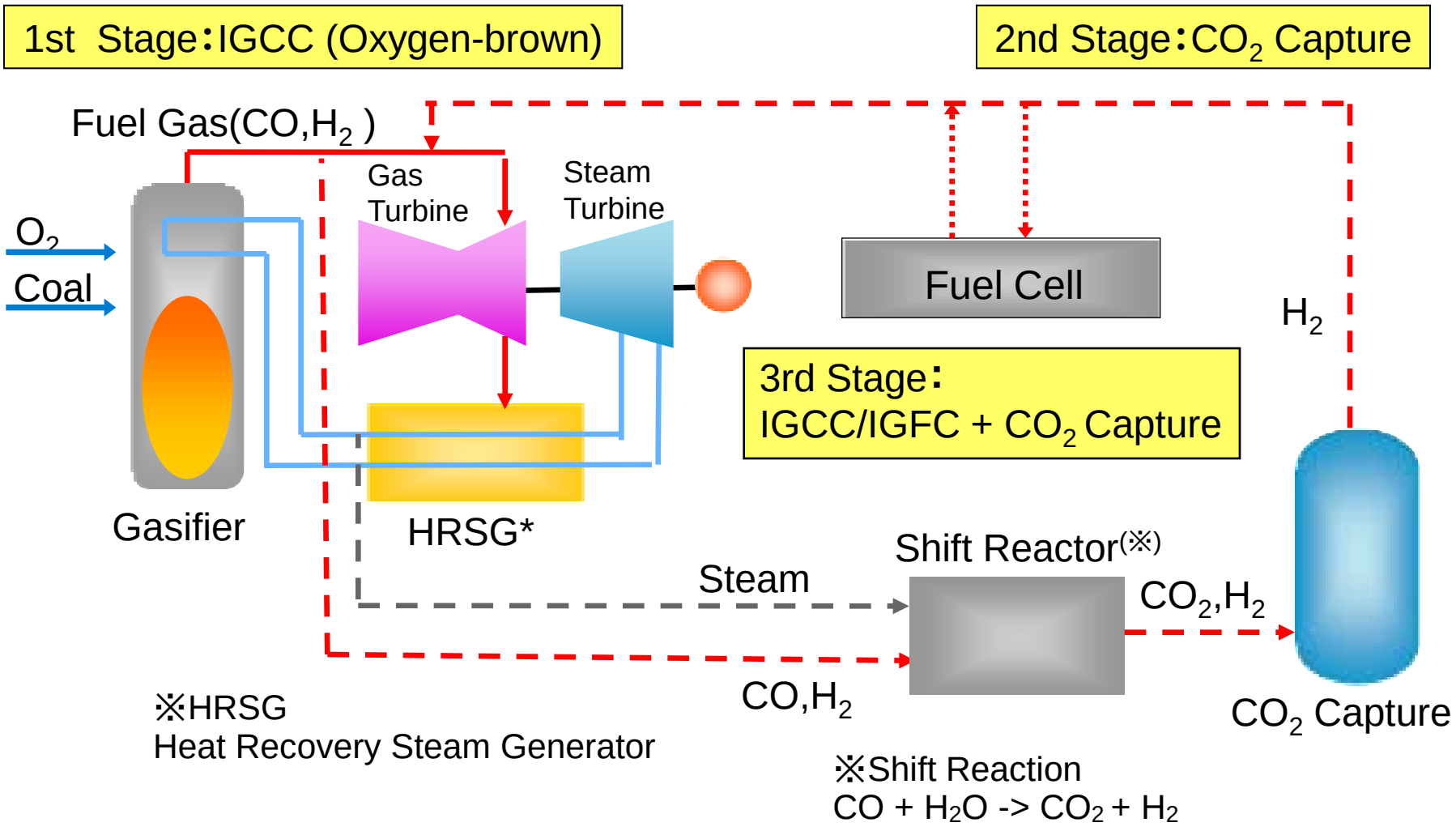

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IGCC Pilot Plant (Nakoso, Fukushima)

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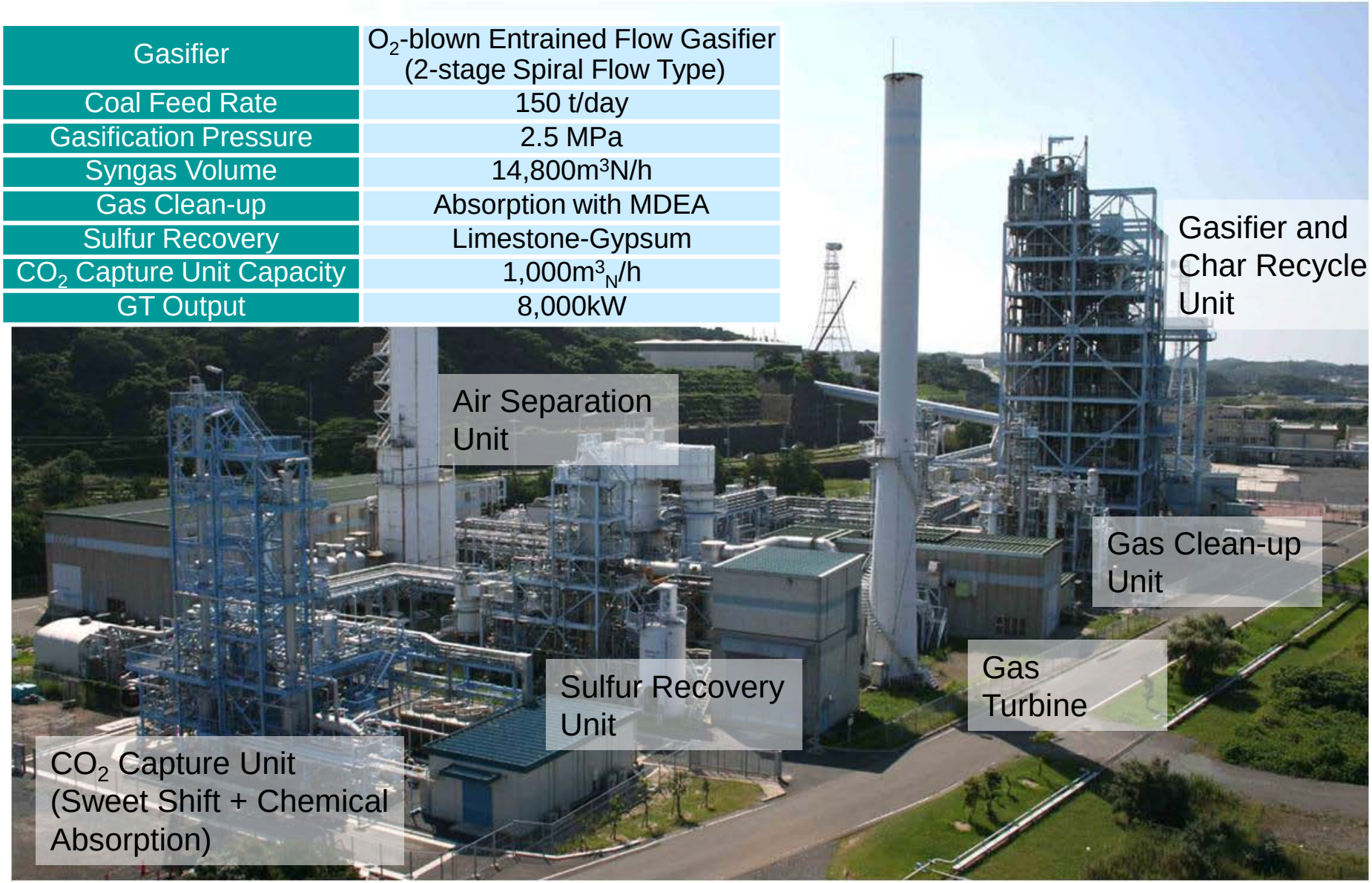
Gasifier	O_2-blown Entrained Flow Gasifier (2-stage Spiral Flow Type)
Coal Feed Rate	150 t/day
Gasification Pressure	2.5 MPa
Syngas Volume	14,800m^{3}N/h
Gas Clean-up	Absorption with MDEA
Sulfur Recovery	Limestone-Gypsum
CO_2 Capture Unit Capacity	1,000m^3_N/h
GT Output	8,000kW



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IGCC Demonstration Plant (Osaki Kami-jima, Hiroshima)

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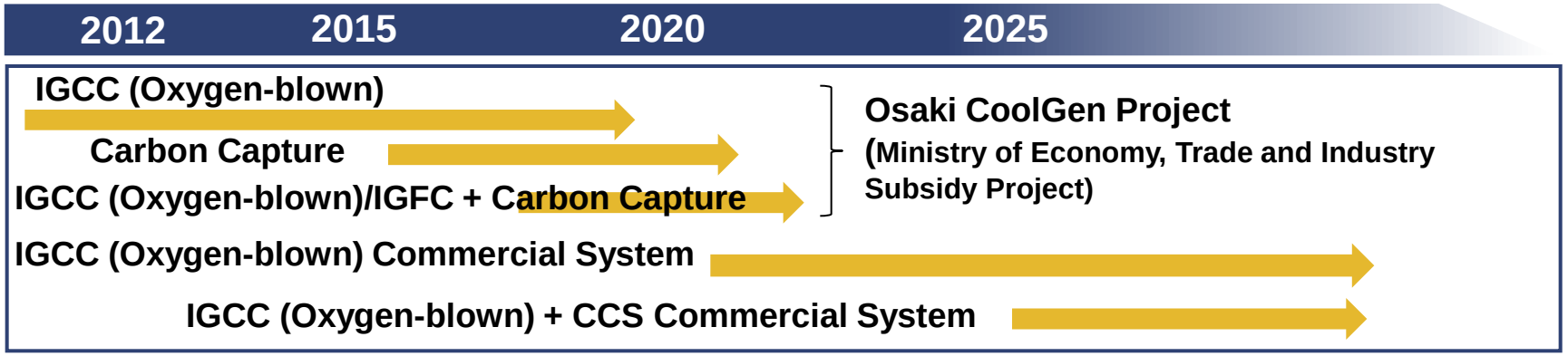
Early Commercialization with Accelerated Demonstration Test



Osaki CoolGen Project

Gasifier	1,100 tons/day
Combined cycle	170 MW class

Stared the Construction in March 2013

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Cooperation with Integrated Thermal Power Systems Company

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MH Power Systems
(Joint Stock Company with Mitsubishi Heavy Industries)

- Gas turbines
- Steam turbines & Generators
- Boilers and AQCS
- Control equipment
- Maintenance services

Cooperation

Power Systems Company
- Nuclear power systems
- Power transmission and distribution
- Electric control systems
- Renewable energy

Hitachi Power Solutions, Ltd.
- Monitoring
- Facility diagnosis

Hitachi Group

Information & Telecommunication Systems Company
- Big Data utilization
- Cloud computing

Infrastructure Systems Company
- Compressors
- Inverters
- Demand Side Management (DSM)
- Smart cities

Hitachi Capital,Ltd
- Finance
- Leasing

Hitachi Transport System,Ltd
- Logistics

T&D: Transmission & Distribution DSM: Demand Side Management

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Contact : report@tky.ieej.or.jp