Clean Coal Day in Japan 2017

Toshiba's high-efficiency and low emission technology in thermal power

September 6, 2017
Shinya Fujitsuka
Technology Executive
Energy Systems & Solutions Company
Toshiba Corporation
TOPICS

01 Toshiba’s Profiles
02 Advanced Ultra Super Critical
03 High Efficiency Combined Cycle
04 Carbon dioxide Capture Technology
05 Super Critical CO₂ Cycle Generation
TOPICS

01 Toshiba’s Profiles

02 Advanced Ultra Super Critical

03 High Efficiency Combined Cycle

04 Carbon dioxide Capture Technology

05 Super Critical CO$_2$ Cycle Generation
Toshiba’s Profiles

Board of Directors

President & CEO
Satoshi Tsunakawa

Energy Business Domain

Energy Systems & Solutions Company
Nuclear energy Systems & Solutions Division

Social Infrastructure Business Domain
Toshiba Infrastructure Systems & Solutions Corporation
Toshiba Tec Corporation

Electrical Devices Business Domain
Toshiba Electronic Devices & Storage Corporation
Toshiba Memory Corporation

Digital Solutions Business Domain
Toshiba Digital Solutions Corporation

Basic Corporate Data (Financial and Stock Data, as of March 31, 2017)

- Founded: July 1875
- Location: 1-1, Shibaura 1-chome, Minato-ku, Tokyo, Japan
- Common Stock: ¥200,000 million
- Net Sales: ¥4,870.8 billion (As of June 23, 2017)
- Number of Employees: approximately 153,000

As of July 1, 2017
Toshiba Field for Energy Business

**Power Generation systems**
- Thermal Power
- Transmission and Distribution / Energy Storage
  - T&D
  - Battery-based Energy Storage Systems

**Renewable Energy**
- Hydro Power
- Geothermal Power
- Photovoltaic

Providing the world with technologies and services for making, transmitting and storing clean energy

**Realizing a low-carbon economy**
Top Market Share Products of Energy Business

Thermal Power

Coal fired ultra super-critical turbines

No.1 share* 44% in Japan
*Number of unit basis

Geothermal Power

Geothermal turbines

World's No.1 share* 23%
*Operating plant capacity basis

Thermal Power

*World's most efficient class C/C system 64%
*LHV(Low Heating Values) basis

Hydro Power

Adjustable-speed pumped storage systems

World's No.1 share* 55%
*Number of plant basis

We supply various No.1 products all over the world
Toshiba Turbine Generator Experience

Total: 1,975 Units / 198,838 MW (Delivery record)
The first Shipment 1927

As of June, 2017

Note: manufactured by Toshiba Keihin Product Operations and TJPS(Toshiba JSW Power Systems Pvt. Ltd.)
Advancing CO₂ Emission Reductions at Thermal Power Plants

We have supplied products to reduce CO₂ emissions.
TOPICS

01  Toshiba’s Profiles

02  Advanced Ultra Super Critical

03  High Efficiency Combined Cycle

04  Carbon dioxide Capture Technology

05  Super Critical CO₂ Cycle Generation
Advanced Ultra Super Critical (A-USC)

Further efficiency improvements with steam in excess of 700 degC

Coal-fired thermal power
USC maximum efficiency: **about 42%** (transmission end HHV)
Main steam pressure: 25Mpa
Main steam temperature / reheat steam temperature: 600/600℃

A-USC efficiency: a further **10% improvement**
Main steam pressure: 35Mpa
Main steam temperature / reheat steam temperature: 700/720/720℃
We developed a Ni base material that can withstand high temperature steam, and manufactured rotor, casing and turbine blade.
A-USC Turbine & Material verification

Boiler test

- Boiler of Mikawa power plant
- Boiler test
- Casing test

Rotation test

- Rotation test equipment
- Rotor after test

We are verifying the developed materials by boiler test and rotation test.
TOPICS

01 Toshiba’s Profiles
02 Advanced Ultra Super Critical
03 High Efficiency Combined Cycle
04 Carbon dioxide Capture Technology
05 Super Critical CO\textsubscript{2} Cycle Generation
High Efficiency Combined Cycle

Realize world-class efficiency through a combination of gas and steam cycles (combined cycle)

Gas-fired thermal power
Maximum efficiency: **about 64%** (generation end LHV)

Image of combined cycle power plant

High efficiency gas turbine + latest steam turbine cycle
High Efficiency Steam Turbine Technology

High performance blade profile

Advanced seal

LSB series / Exhaust hood

Toshiba will realize high efficiency of the power plant.
High Efficiency Turbine Generator Technology

Optimization of stator core end structure

Increased heat transfer by HTC insulation

Trends in generator cooling methods and power generation capacity ranges

Toshiba will realize high efficiency of the power plant.
TOPICS

01 Toshiba’s Profiles

02 Advanced Ultra Super Critical

03 High Efficiency Combined Cycle

04 Carbon dioxide Capture Technology

05 Super Critical CO₂ Cycle Generation
Advancing Post-Combustion CO₂ Capture

Capturing CO₂ from all emission sources

Technology Features

- Capture CO₂ at high purity
- Flexible design (Amount of CO₂ Capture, Can be integrated into operating plants)
- Track record in coal-fired power plants (10,264 operating hours)

Technology Applications

(as of October 10, 2016)

Mikawa※1 pilot plant
Commissioned: September 2009
Captures 10t / day from Mikawa thermal power flue gas

Saga CCU plant
Commissioned: September 2016
Captures and utilizes 10t / day from Saga waste incineration plant flue gas

Mikawa Ministry of the Environment PJ demo plant
Commission: 2020 (scheduled)
Capture more than 500t /day from Mikawa thermal power plant flue gas
A-USC & CCS

R&D for Zero Emission solutions:

- A-USC: 700C/720C/720C, efficiency 46% (HHV)
- CCS capture performance: < 2.0 GJ/ton-CO₂

90% CO₂ reduction by combination of A-USC & CCS

A-USC Thermal Plant with CCS

CCS Pilot Plant in Japan

- CO₂ capture capacity: 10 t-CO₂/day
- Cumulative 10,264 hours of operation
  (as of Oct. 2016)
TOPICS

01 Toshiba’s Profiles

02 Advanced Ultra Super Critical

03 High Efficiency Combined Cycle

04 Carbon dioxide Capture Technology

05 Super Critical CO$_2$ Cycle Generation
Super Critical CO₂ Cycle Generation

CO₂ capture without separation and recovery system

Super Critical CO₂ Cycle

Efficiency comparison

Size Comparison

100% CO₂ Capture

High Pressure CO₂
Technology Validation

◆ NET Power * is developing demonstration plant in Texas
  * 8 Rivers, Exelon and CB&I

Already started construction of 50MWt natural gas demo-plant
  • Scaled down from 250MW class commercial plant design

◆ Toshiba is to provide **turbine and combustor** to this demo-plant

  • Started R&D in 2012
  • 1/5 Scale Combustor test finished in 2015 in LA
  • Turbine Site delivery in Nov. 2016
  • 1/1 Scale Combustion test expected before turbine operation
50MWth Turbine for Demo-plant

General
- Scaled down model of future commercial unit
- Combination of gas turbine technology and steam turbine technology

We shipped turbine for demo-plant in Nov. 2016
Combustor Development

First Ignition:
- January 14th, 2013
First 30MPa Combustion:
- July 27th, 2013
Completion:
- November 3rd, 2015

We are manufacturing combustors for demo-plant