METI
Ministry of Economy, Trade and Industry

The Role of Clean Coal Technology in the Long Term

December 14th 2016

Masana Ezawa

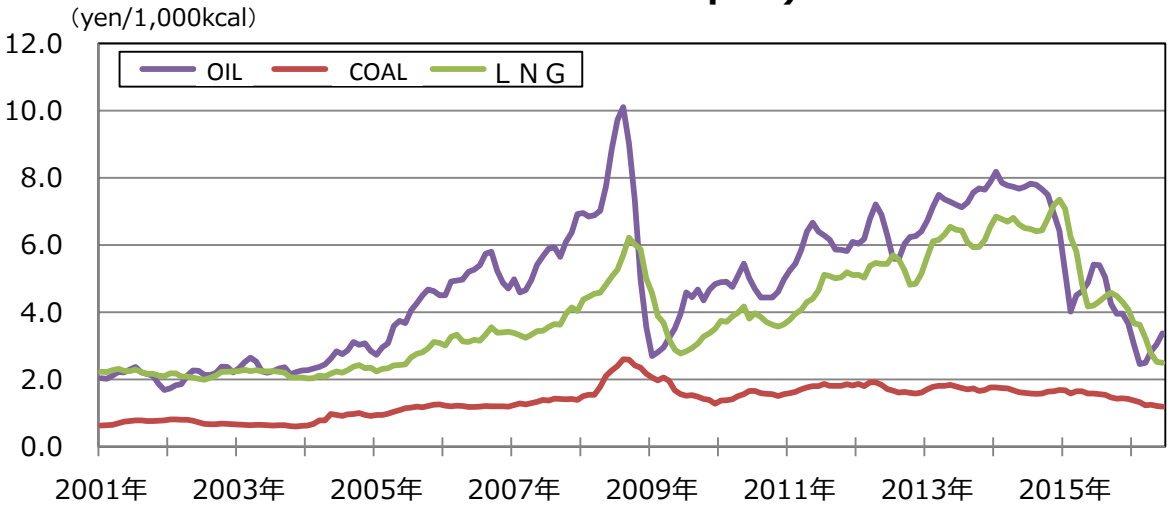
Director, Clean Coal Division
Agency for Natural Resources and Energy
Ministry of Economy, Trade and Industry

※This presentation reflects personal views and this is not reflecting the official position of the Japanese government.

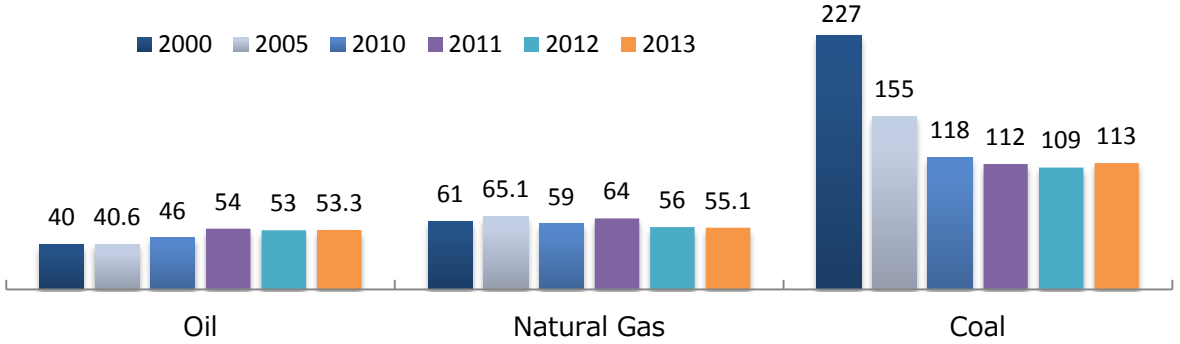
Advantages of Coal

- Coal is not only the most abundant fossil fuel, it also exists worldwide.
- In many parts of the world, coal is the low-cost and stable energy resource.

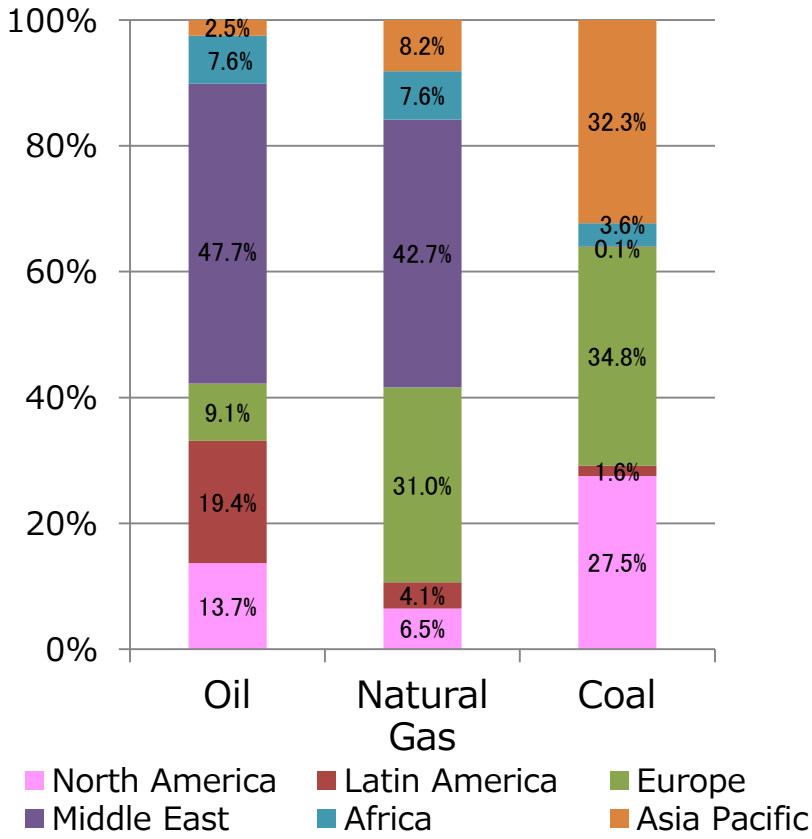
Fuel Cost (CIF in Japan)



Recoverable reserves (year)



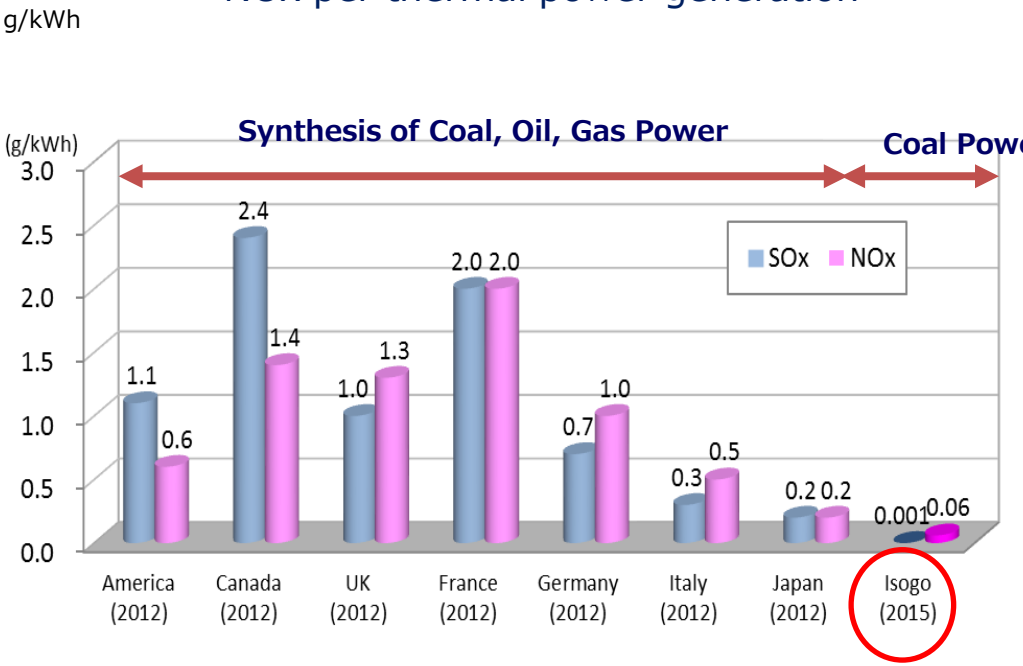
Fuel reserve locations



Disadvantages of Coal

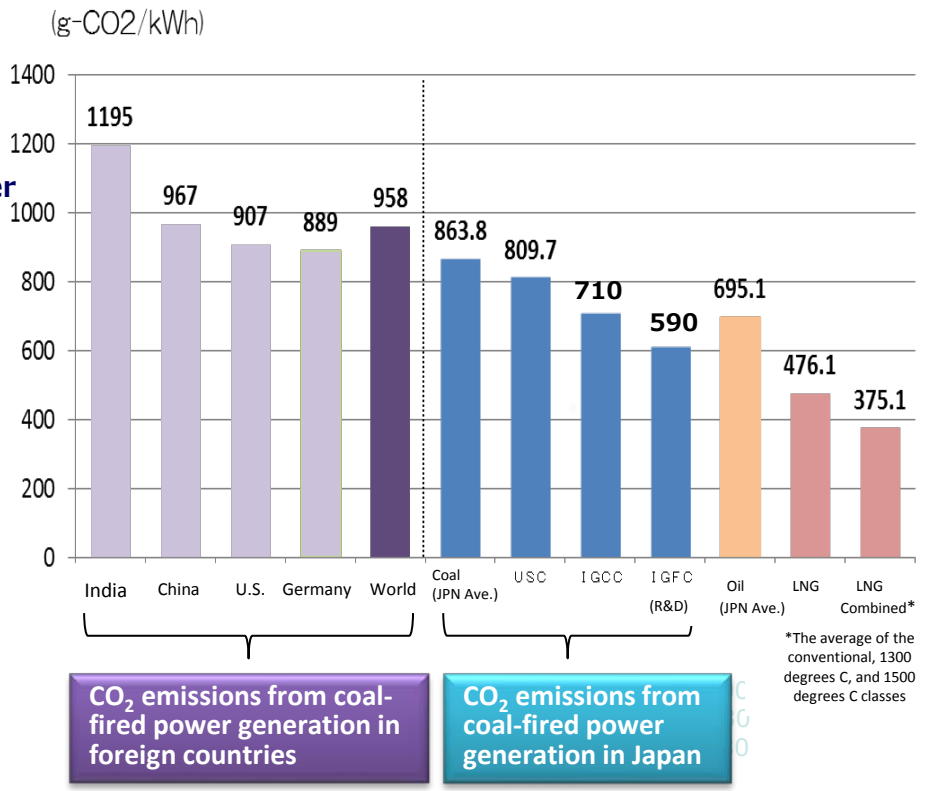
- As coal power plants emit more CO2 and air pollutants (SOx, NOx, PM) compared to other energy sources, it is essential to utilize the coal power plants in cleaner way.

International comparison of the amount of SOx, NOx per thermal power generation



Source:
overseas: emission／OECD Stat Extract Complete database available via OECD's iLibrary
electricity generation／IEA ENERGY BALANCES OF COUNTRIES 2012 EDITION
Japan: Federation of Electric Power Companies investigation J-POWER・Isogo: actual data at 2012

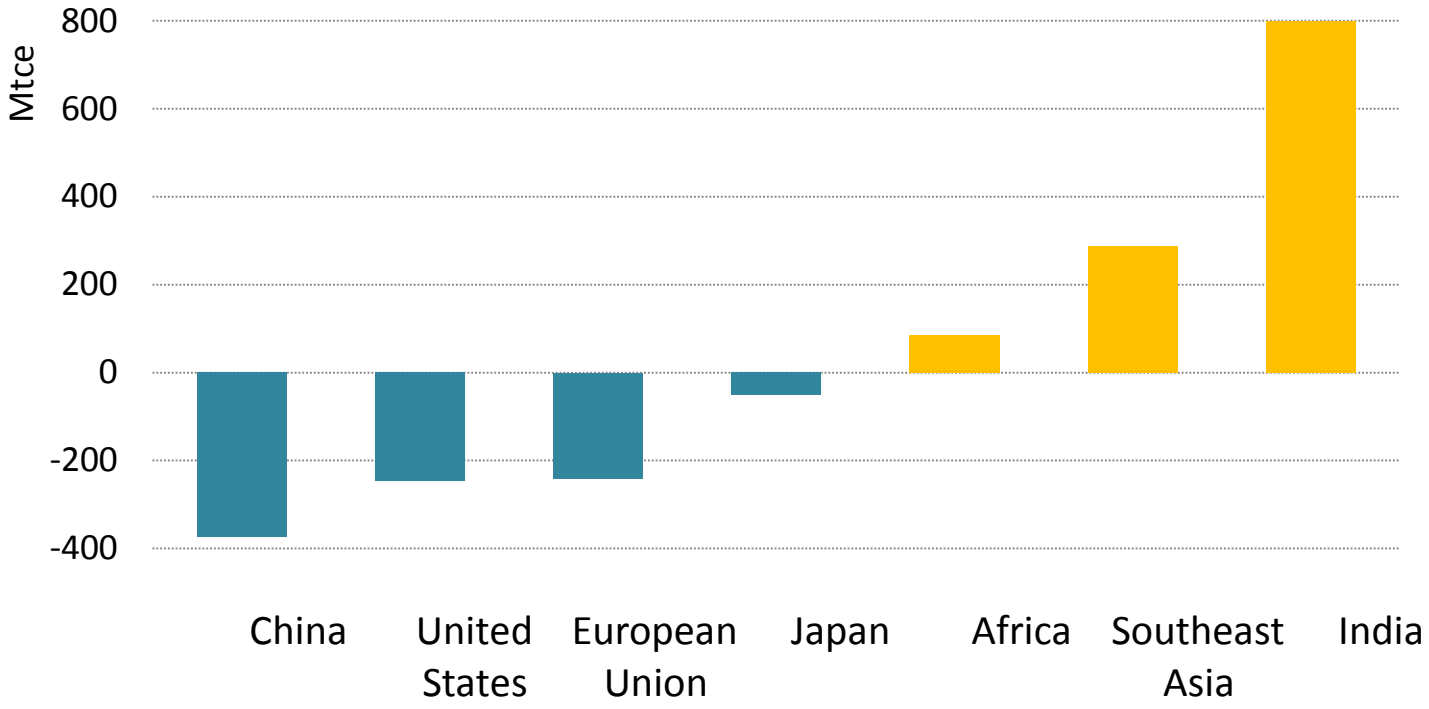
CO2 Emissions/kWh by Fuels for Power Generation



Source: Figures in Japan were estimated based on the report by the Central Research Institute of Electric Power Industry (2009) and development goals of each research project. Figures in foreign countries were taken from "**CO_2 Emissions from Fuel Combustion 2012**".

Regional trends in coal demand

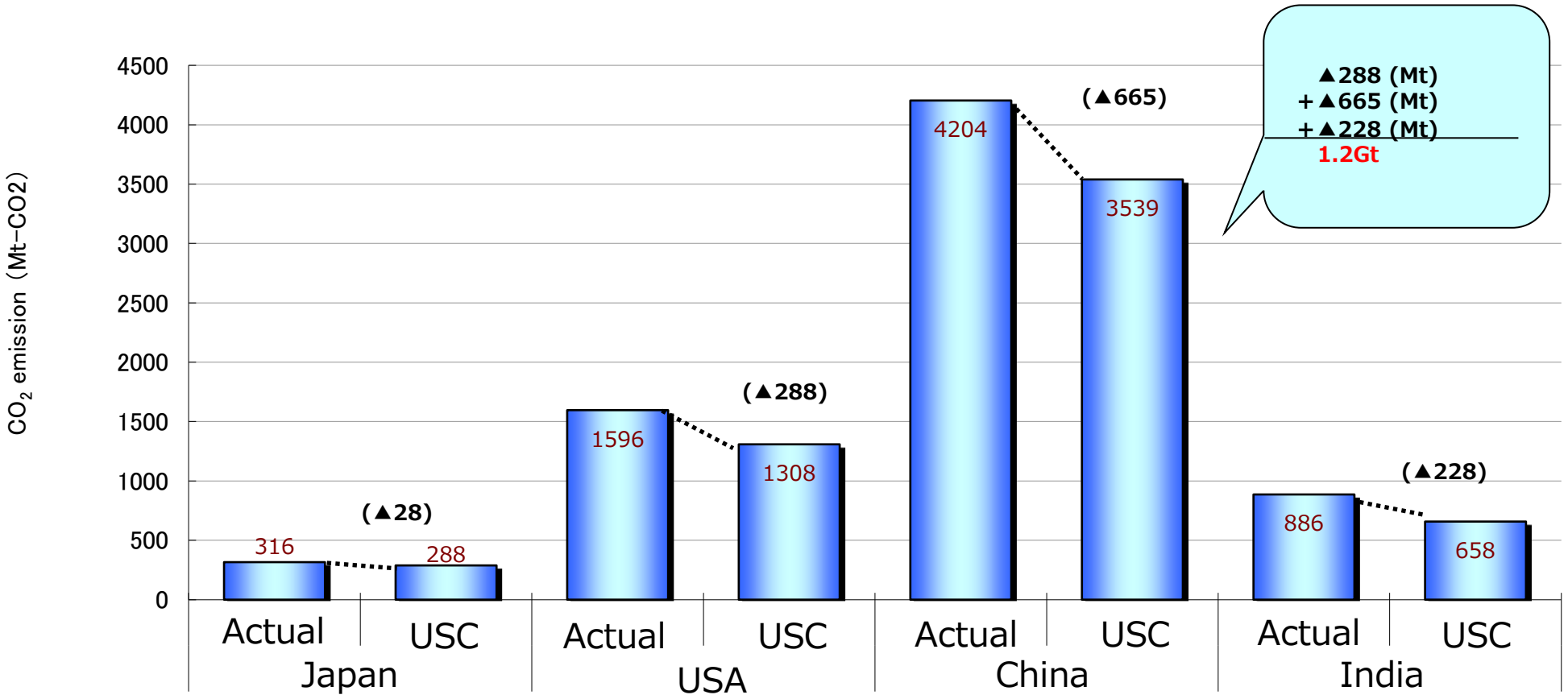
- As the electricity demand is expected to increase steadily over a few decades, coal remains the major source for electricity generation especially in India and Southeast Asia countries under the WEO's New Policies Scenario.



Source: WEO2016

CO_2 Reduction Potential by Efficient Coal-fired Power Plant

- The CO_2 reduction potential applying the efficient USC power plant to existing coal-fired power plants in the USA, China and India is 1.2Gt in total.(Based on the 2013 data.)



Source: IEA World Energy Outlook 2015

Agreement on OECD's Support for Coal-Fired Power Plants (Agreed in Nov, 2015)

Maximum repayment terms

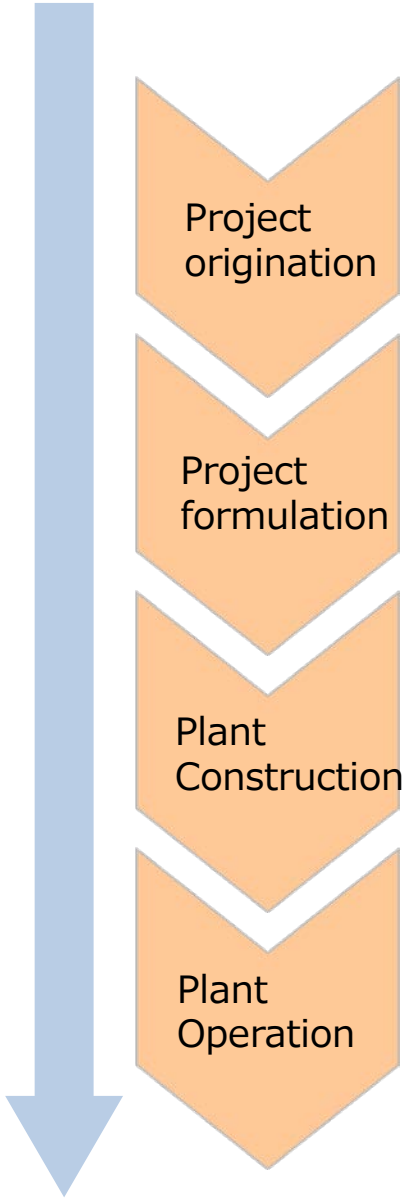
PLANT UNIT SIZE (gross installed capacity)	**Unit > 500 MW**	**Unit ≥300 to 500 MW**	**Unit < 300 MW**
Ultra-supercritical (*i.e.*, with a steam pressure >240 bar and ≥593°C steam temperature), OR Emissions < 750 g CO_2/kWh	12 years[1]	12 years[1]	12 years[1]
Supercritical (*i.e.*, with a steam pressure >221 bar and >550°C steam temperature), OR Emissions between 750 and 850 g CO_2/kWh	Ineligible	10 years, and only in IDA-eligible countries[1,2,3]	10 years, and only in IDA-eligible countries[1,2,3]
Subcritical (*i.e.*, with a steam pressure < 221 bar), OR Emissions > 850 g CO_2/kWh	Ineligible	Ineligible	10 years, and only in IDA-eligible countries[1,3]

1 Where eligible for official support, an additional two years repayment term is allowed for project finance transactions consistent with paragraph d) below, subject to the maximum repayment terms in Article 2 of Annex VII.

2 To help address energy poverty, ten year export credit support may be provided in all countries where the National Electrification Rate (as per the most current IEA World Energy Outlook Electricity Access database) is reported as 90% or below at the time the relevant completed application for export credit is received.

3 Export credit support may be provided in non-IDA-eligible countries for geographically isolated locations, where, (1) the alternatives analysis referred to in Article 4b)1) of this Sector Understanding deems that less carbon-intensive alternatives are not viable and (2) the physical/geographic and existing grid features (including inability to connect to a larger grid) justify the proposed project's efficiency category as the best available technology. In cases where the project is not located on a physical island, the interested Participant shall seek the consent of all Participants through the use of a Common Line procedure in accordance with Articles 58 to 63 of the Arrangement.

Support for CCT project in developing countries



HR development

- Invite people from government/power companies to Japan to understand cutting edge CCT.
- Send Japanese coal expert to hold a seminar or to diagnosis old coal power plants.

F/S support

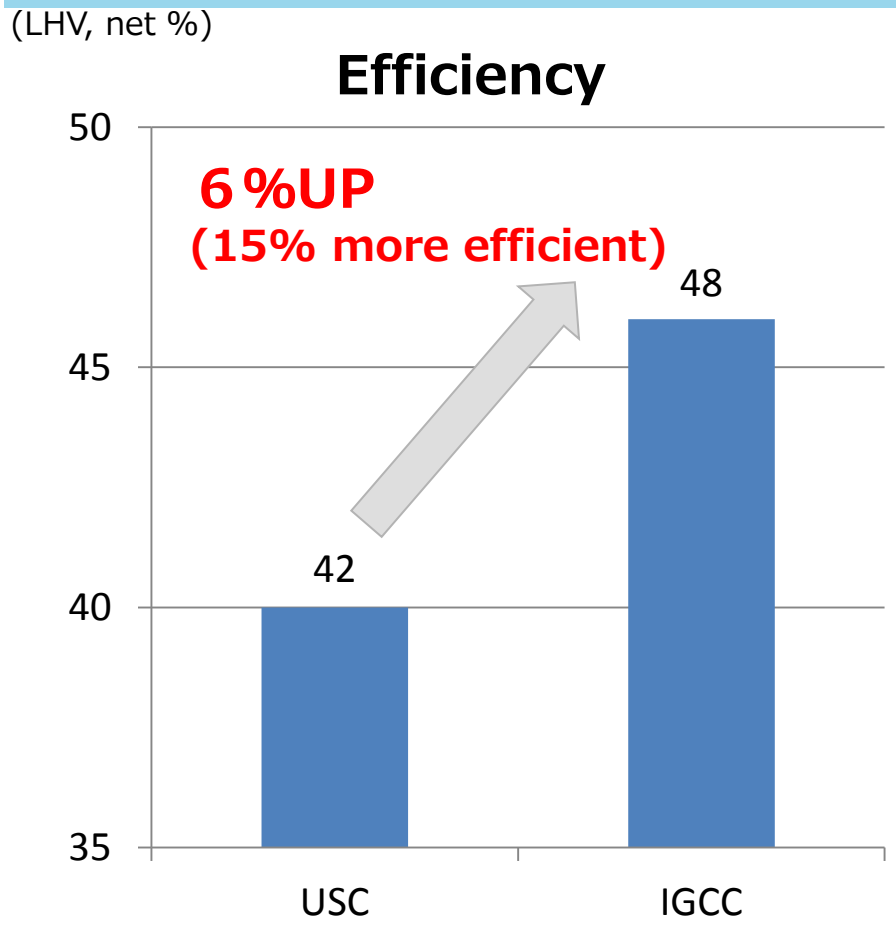
Financial support

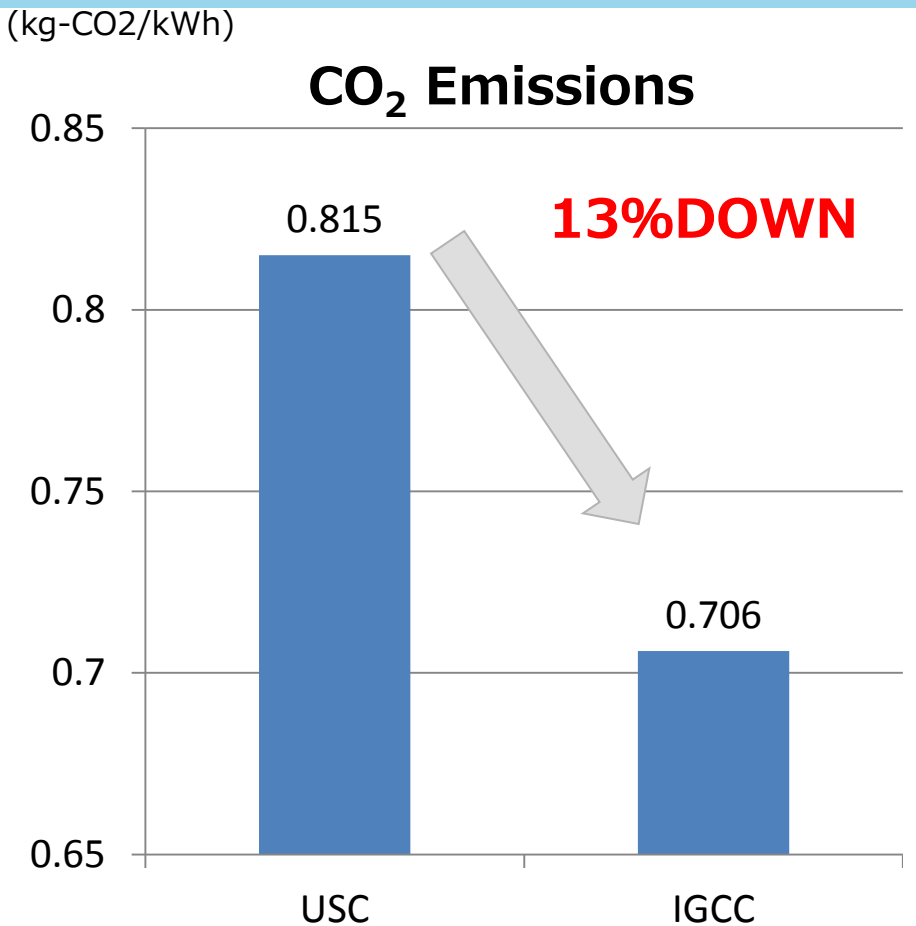
O&M skill training

- Provide O&M training program for engineers, through inviting them to Japan.

IGCC (Integrated coal Gasification Combined Cycle) −Thermal efficiency and CO_2 reduction of IGCC

- IGCC is the latest technology for coal-fired power plant.
- IGCC's thermal efficiency will be 48% up from 42% of USC, which will also lead to reduce CO_2 emission by 13% compared with USC.





IGFC Demonstration Project (Osaki CoolGen)

Overview

○ Osaki CoolGen Project aims to realize innovative low-carbon coal-fired power generation that combines CO_2 separation and capture with IGFC, which is the ultimate high-efficiency coal-fired power generation technology. Demonstration operation started on August 16, 2016.

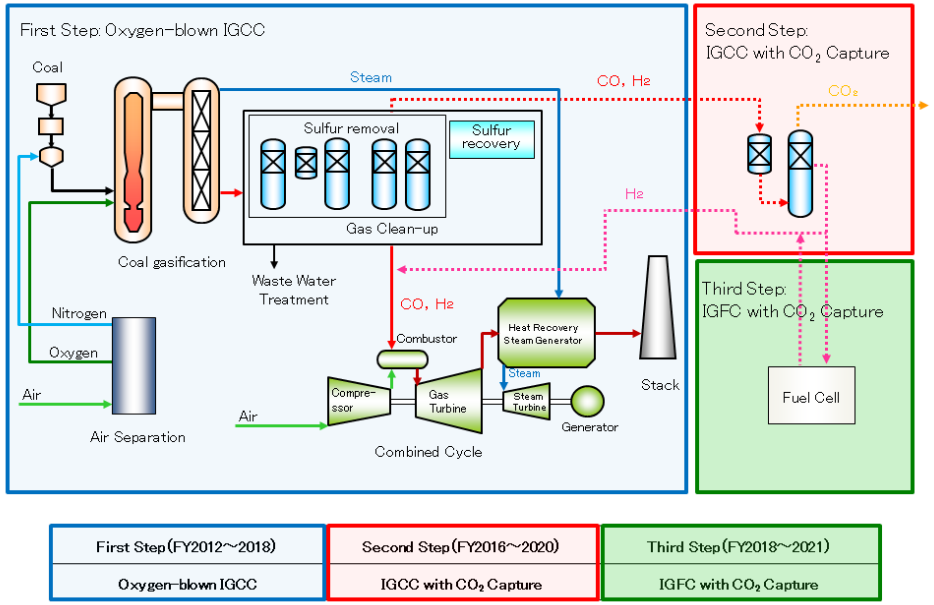
(1) Technical feature

- Thermal Efficiency Target: 55% (up from 40% of USC)
  ※net, HHV
- CO2 capture & storage through Oxygen-blown IGCC

(2)Project entity: Osaki CoolGen Corporation
(Joint Venture of J-POWER and Chugoku Electric Power)

(3)Project Schedule: FY2012 to FY2021

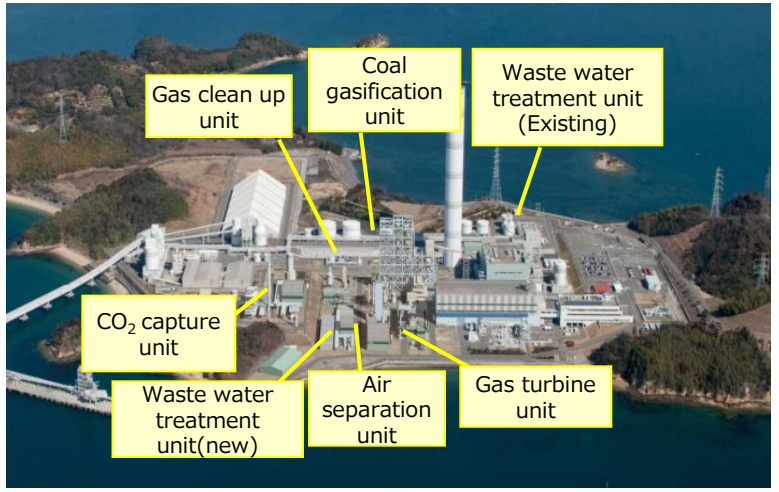
Project Outline



Project Schedule

FY	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
<1st stage> Oxygen blown IGCC Demonstration	Oxygen blown IGCC Design, Manufacturing and Construction						Demonstration test			
<2nd stage> CO2 Capture with IGCC Demonstration			Feasibility study		CO2 Capture Design, Manufacturing and Construction			Demonstration test		
<3rd stage> CO2 Capture with IGFC Demonstration					Feasibility study		CO2 Capture with IGFC Design, Manufacturing and Construction		Demonstration test	

Plant image



Project Site: Osakikamijima cho, Toyota gun, Hiroshima

The prospect of highly efficient and low-carbon next-generation thermal power generation technology

Power generation efficiency

65%

60%

55%

50%

45%

40%

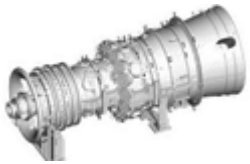
GTFC
(Gas Turbine Fuel Cell Combined Cycle)

63%, 280g-CO_2/kWh

LNG thermal power

Coal-fired power

Ultrahigh Temperature GTCC



57%, 310g-CO_2/kWh

GTFC

20% CO2 reduction

1700 deg. C-class GTCC

10% CO2 reduction

30% CO2 reduction

IGFC

GTCC (Gas Turbine Combined Cycle)

52%, 340g-CO_2/kWh

IGFC (Integrated Coal Gasification Fuel Cell Combined Cycle)

55%, 590g-CO_2/kWh

20% CO2 reduction

AHAT (Advanced Humid Air Gas Turbine)

51%, 350g-CO_2/kWh

1700 deg. C-class IGCC

A-USC

IGCC
(Integrated coal Gasification Combined Cycle)

46 to 50%,
650g-CO_2/kWh

IGCC
(Verification by blowing air)

A-USC
(Advanced Ultra Super Critical)

46%, 710g-CO_2/kWh

Ultra Super Critical (USC)
40%, 820g-CO_2/kWh

Photos by Mitsubishi Heavy Industries, Ltd., Joban Joint Power Co., Ltd., Mitsubishi Hitachi Power Systems, Ltd., and Osaki CoolGen Corporation

Present **Around 2020** **2030**

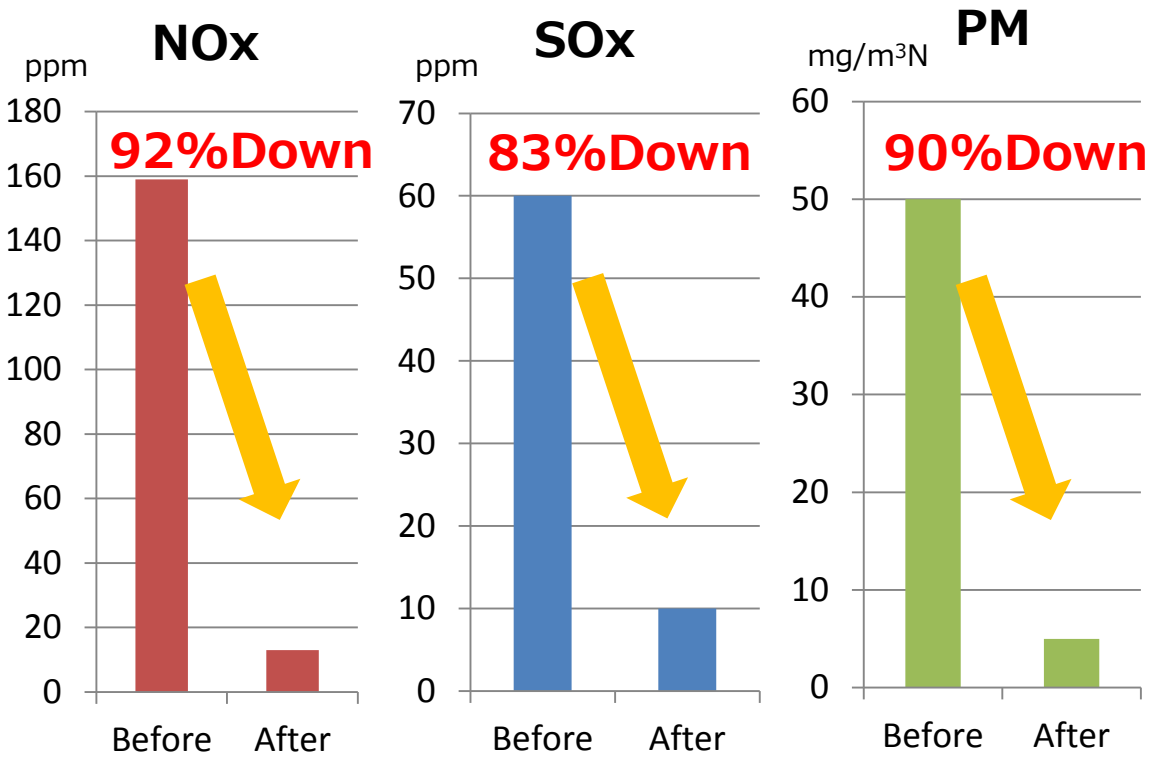
Air Pollutant Reduction Technology
—Isogo Coal power plant, Yokohama City

- Isogo coal power plant is located near residential areas in Yokohama City-Air pollutants are reduced drastically by using CCT.

Before (Capacity 256MW×２) 1967～2001

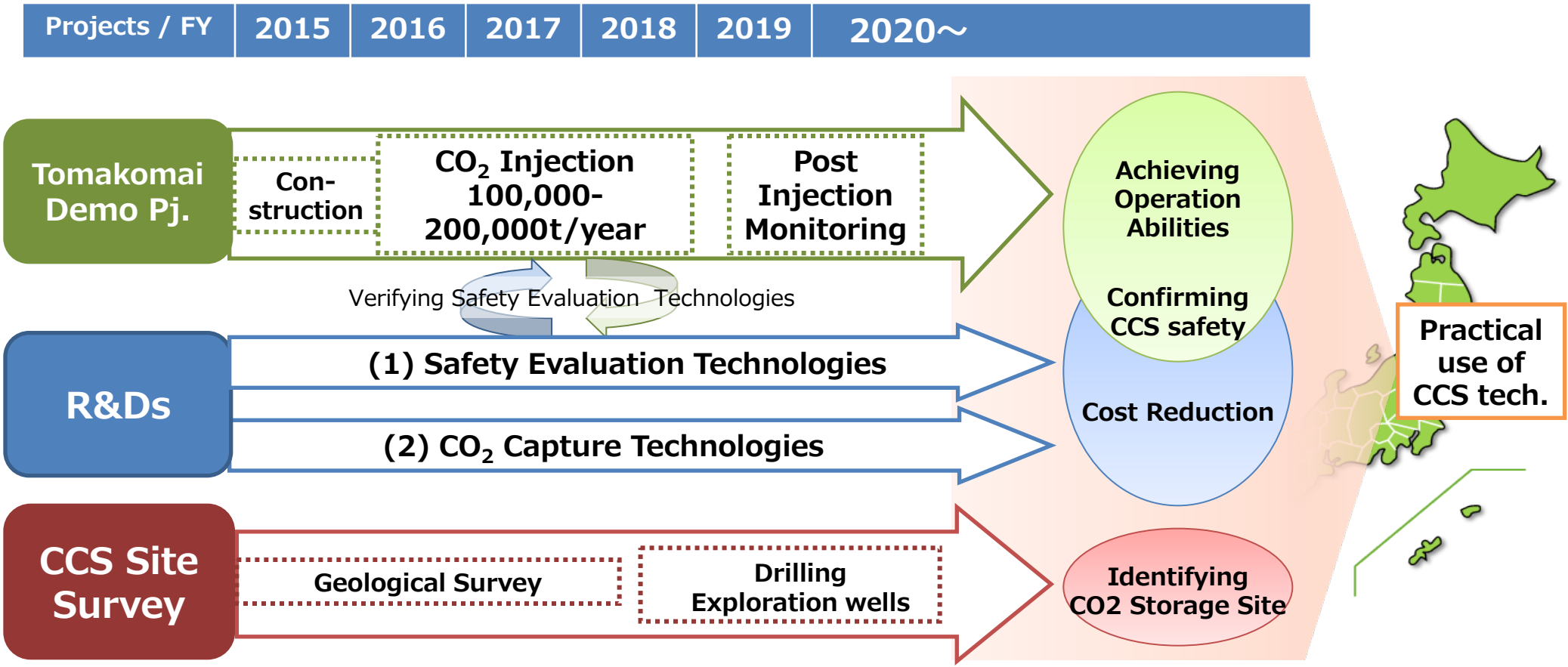
2002～

After (Capacity 600MW×2)



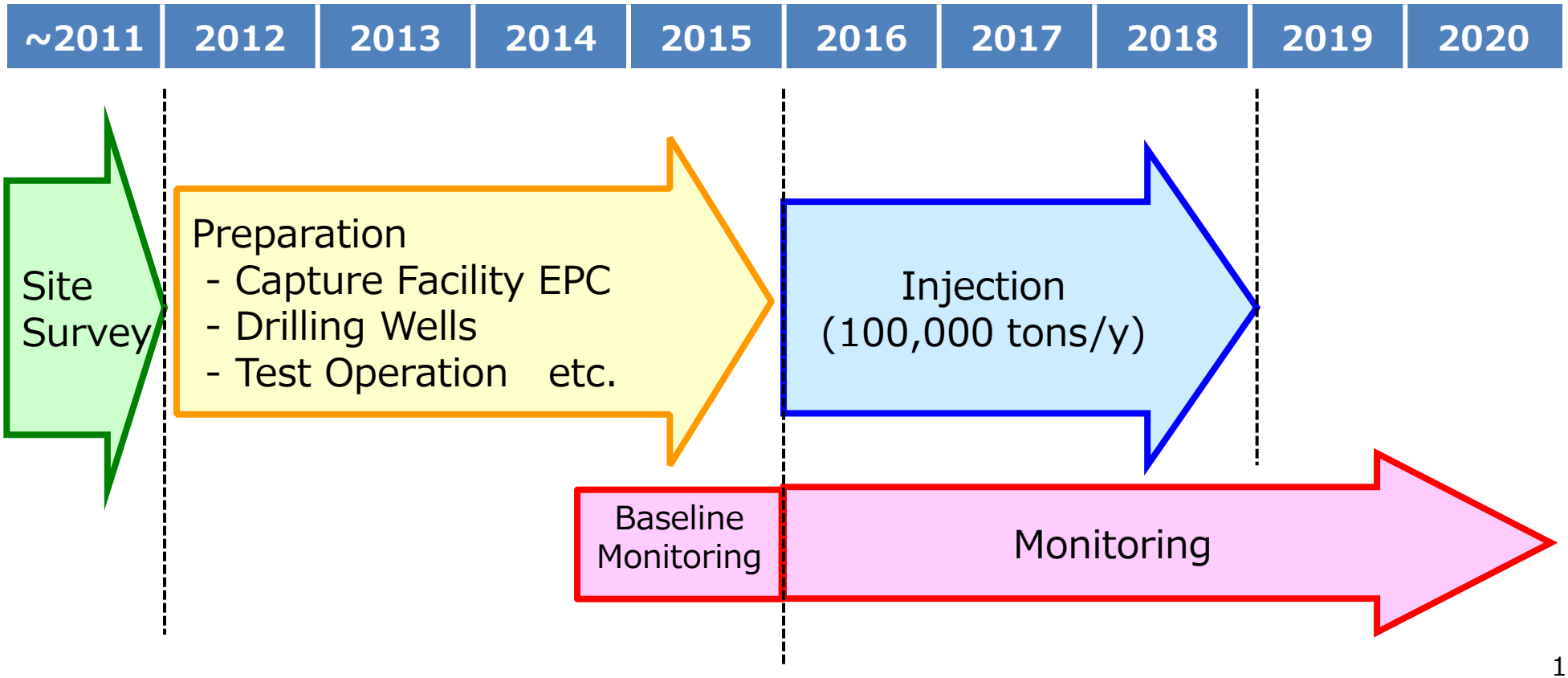
Japan's CCS Policy

- To aim the practical use of CCS technology around 2020, METI conducts Tomakomai Demonstration Project, R&D projects of elemental technologies for CCS, and survey for potential CO_2 storage site.



Tomakomai Demonstration Project - Schedule

- The first large scale CCS demonstration project in Japan has started from April, 2016 in Tomakomai, Hokkaido
- Approx. 100,000 tons of captured CO_2 from gas emissions at an oil refinery will be injected annually, and demonstration will be conducted on such technologies as stored CO_2 monitoring technologies.

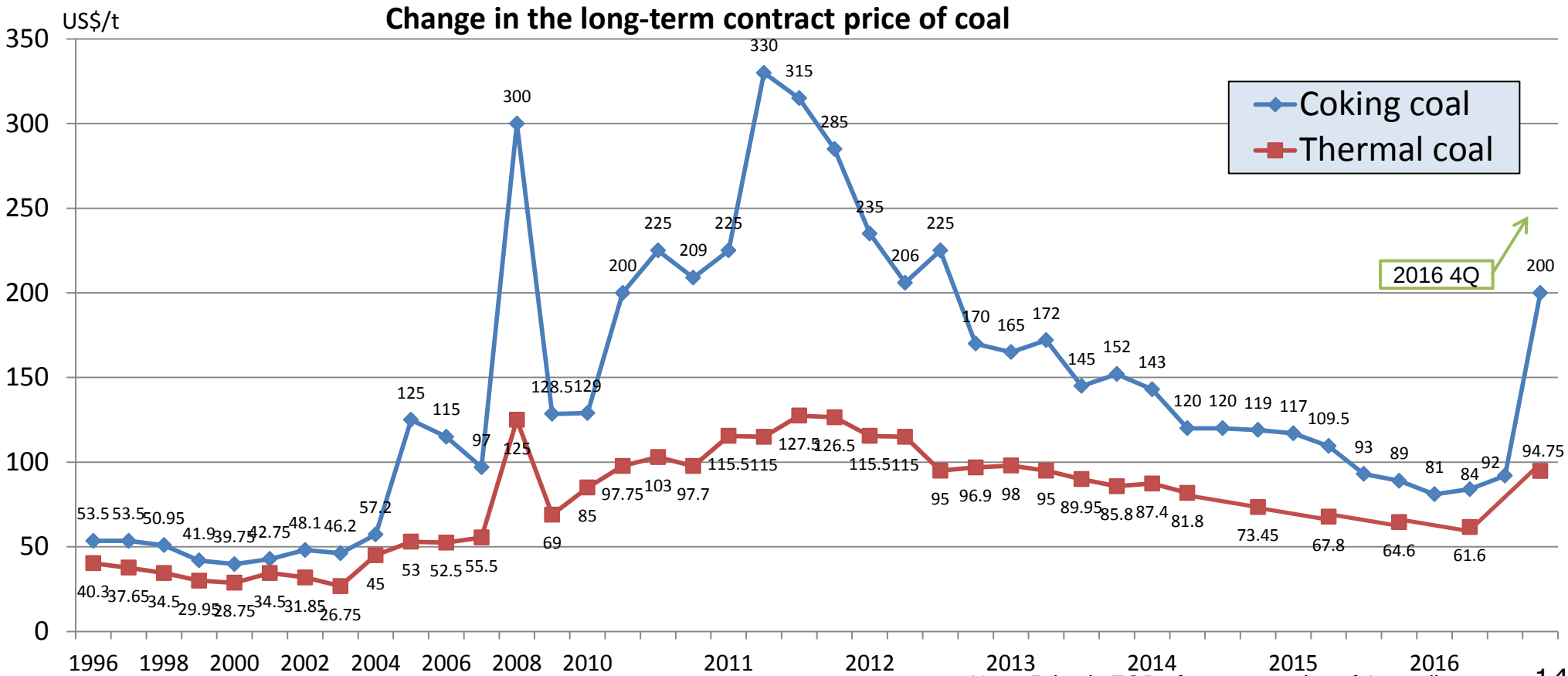


Summary (message)

- As electricity demand increases steadily over a few decades, coal remains the major source for electricity generation especially in India and Southeast Asia countries under the WEO's New Policies Scenario.
- As coal power plants emit more CO_2 and air pollutants (SOx, NOx, PM) compared to other energy sources, it is essential to utilize the coal power plants in cleaner way.
- In this context, continuous R&D spending on coal power plant is indispensable to improve the thermal efficiency as well as to commercialize the CCS technology. This allows us to balance the stable energy supply and environmental issues, paving the way to long-term deeper decarbonization.
- Japan will contribute to world electricity supply and climate change issues by Clean Coal Technologies and efficient gas-fired power generation.

Change of coal price

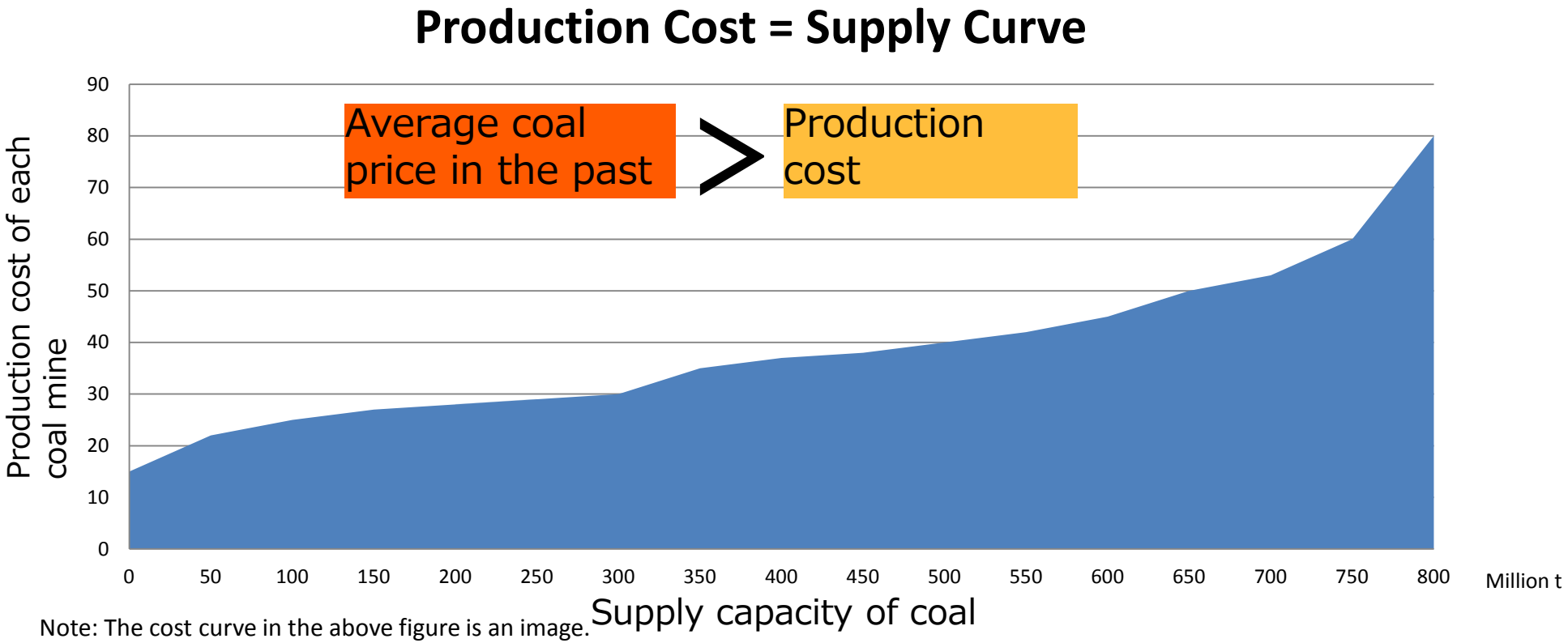
- The long-term contract price of coal has trended downwards since mid 2011, owing to market oversupply and a global economic slowdown, especially in China.
- However, the spot price of coking coal reached 300 US$/t this November due to the restriction of coal production in China and weather conditions such as heavy rain
- Also, the long-term contract price of coking coal reached 200 US$/t in 2016 4Q.



Note: Price is FOB of representative of Australian

Supply curve (Production cost of coal)

- The supply curve reflects production costs, which is affected by the following factors:(a)production technology, (b)operating costs, such as personnel expenses, (c)transportation costs, and (d) in the short term, weather conditions, such as heavy rain, and breakdowns in infrastructure
- The current supply cost is formed on the basis of past coal prices. Since the average coal price in the past would be equivalent to the “sales” for each coal mine, the production cost must be lower than the average coal price in order to earn profits.
- Furthermore, coal prices significantly vary according to the quality and the transaction place.



Note: The cost curve in the above figure is an image.