

**UNECE Best Practice in Production of
Electricity from Coal**



**Clean Coal Technology
for the Future Power Generation**

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October 29, 2015**

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Japan Coal Energy Center

JCOAL



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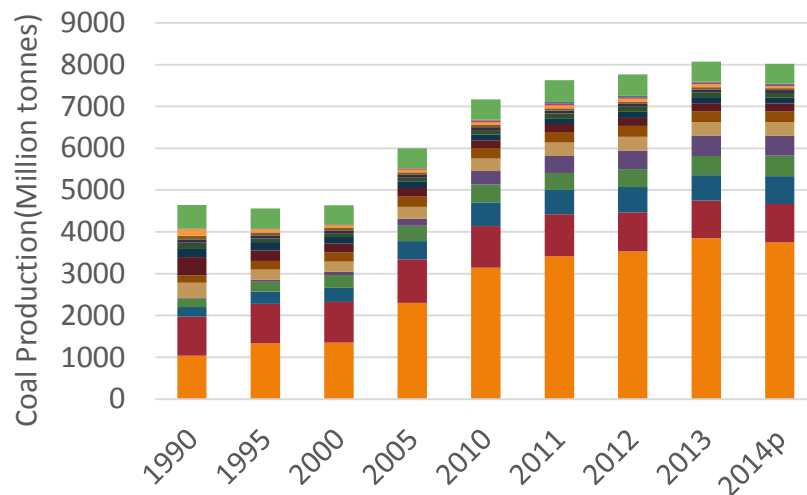
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1. Coal Now

World Coal Production and Consumption

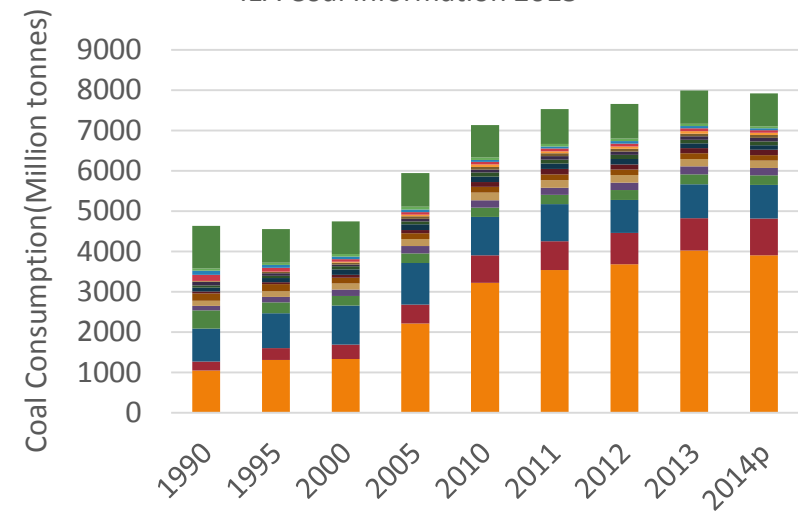
World Coal Production

IEA Coal Information 2015



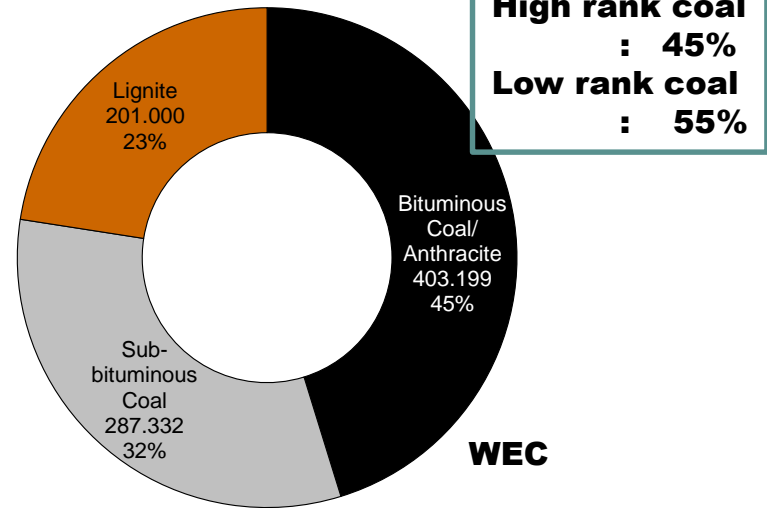
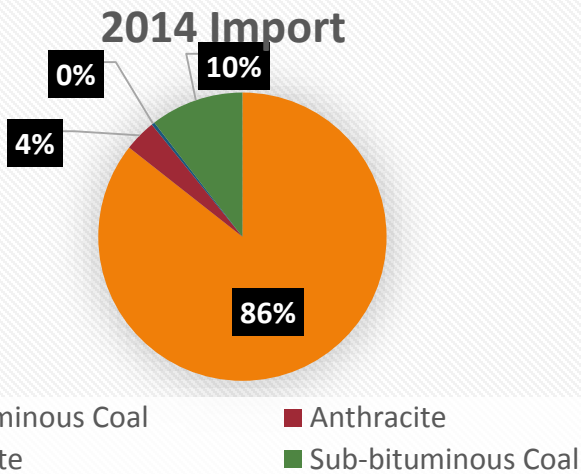
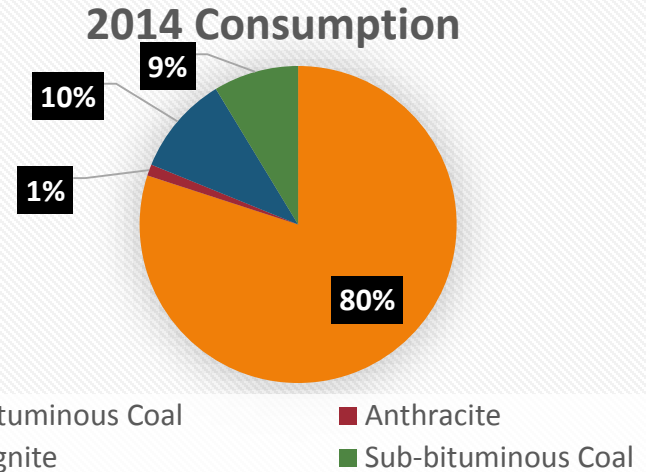
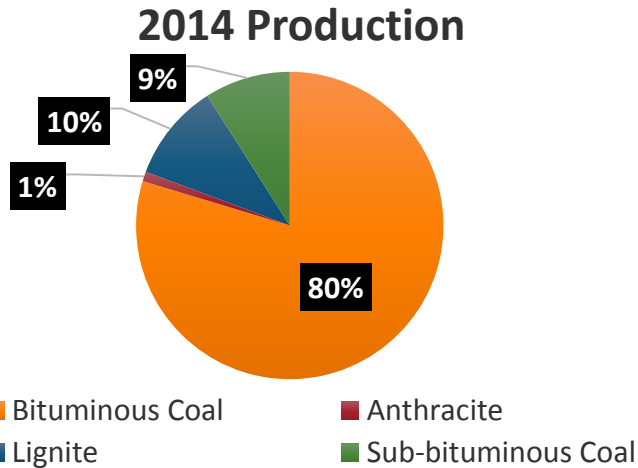
World Coal Consumption

IEA Coal Information 2015

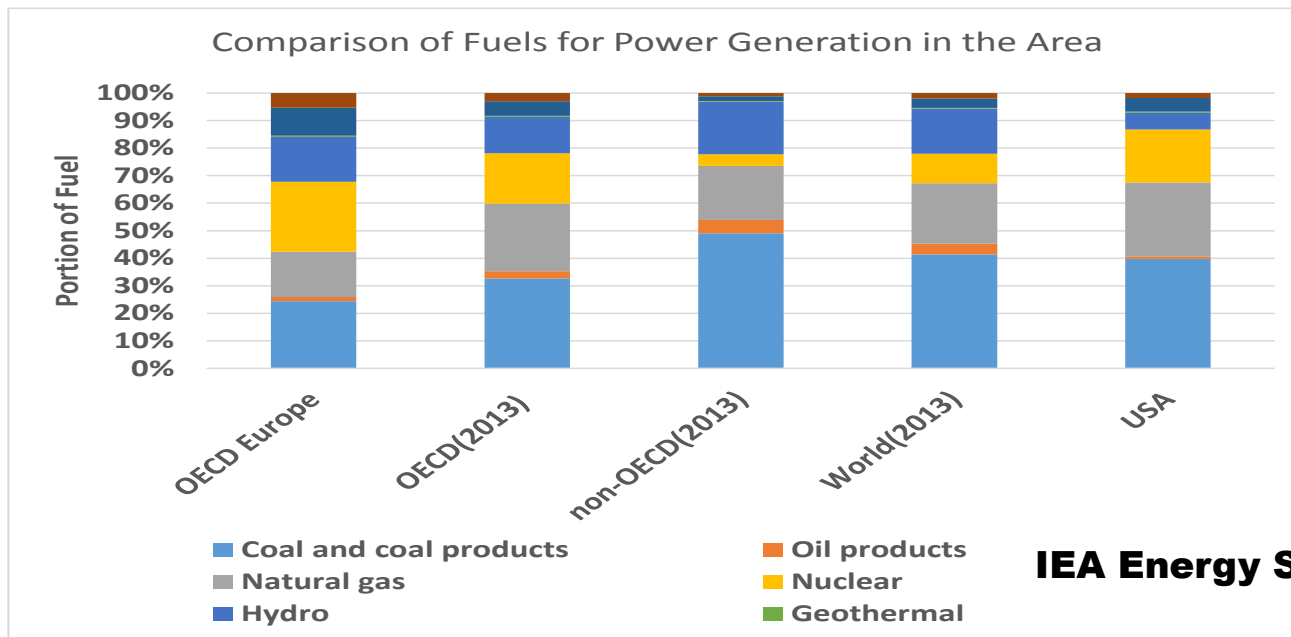
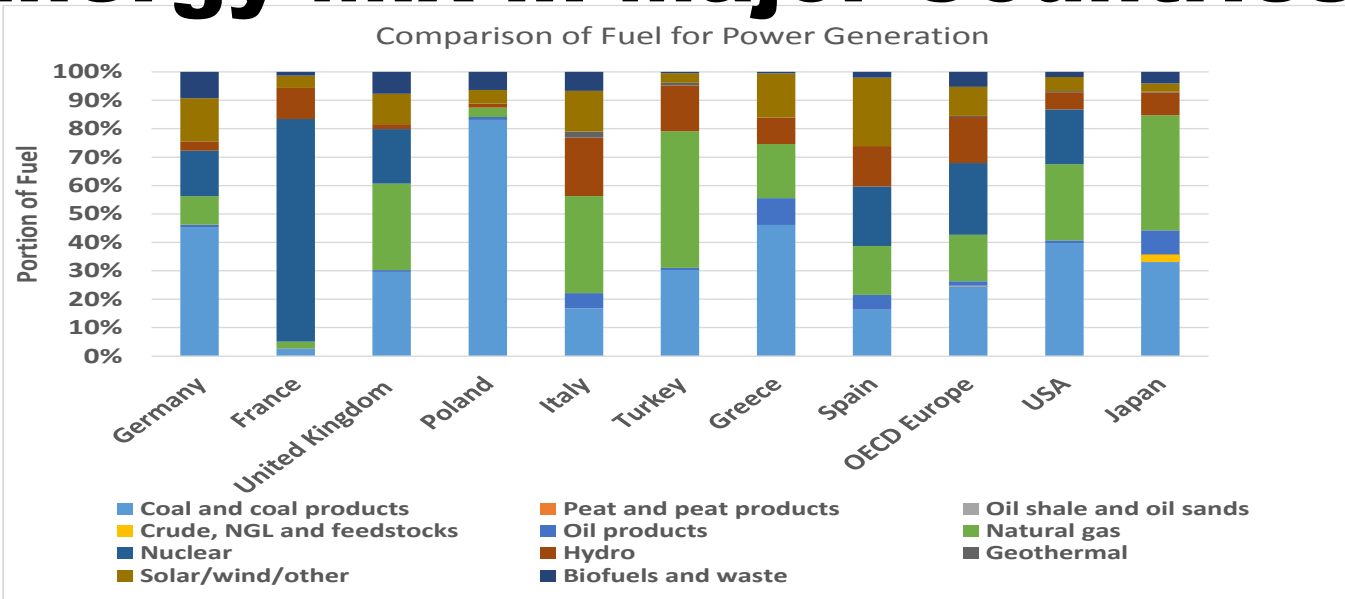


Coal Information 2015

World Coal Status



Energy Mix in Major Countries

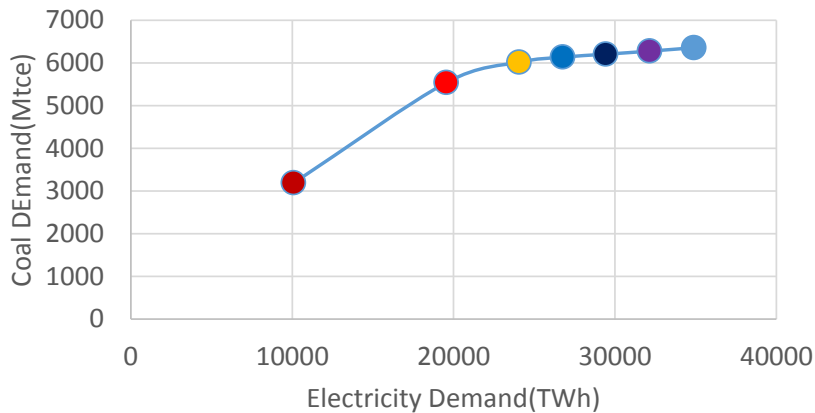


Coal and Electricity Demand

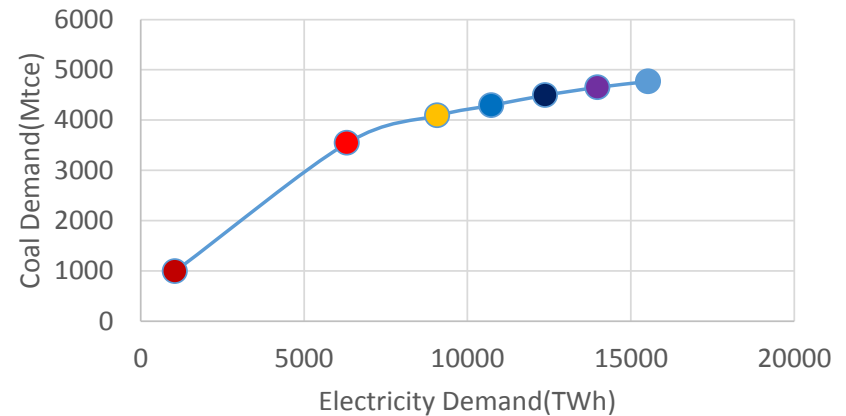
From 1990 to 2040



World Electricity and Coal Demand

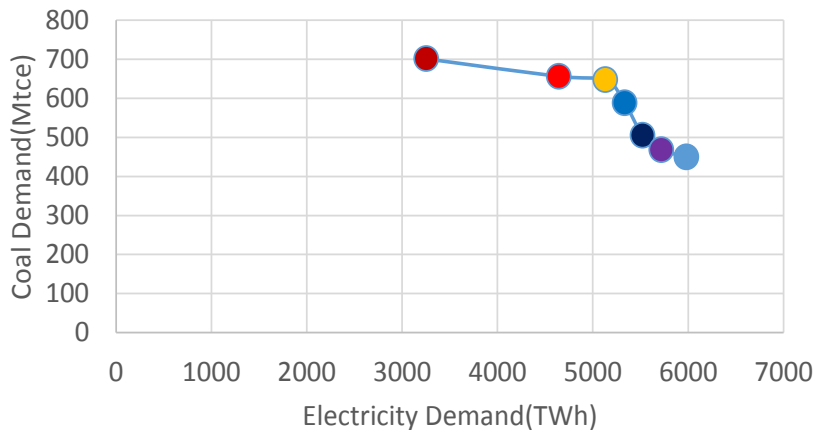


Asia Electricity and Coal Demand

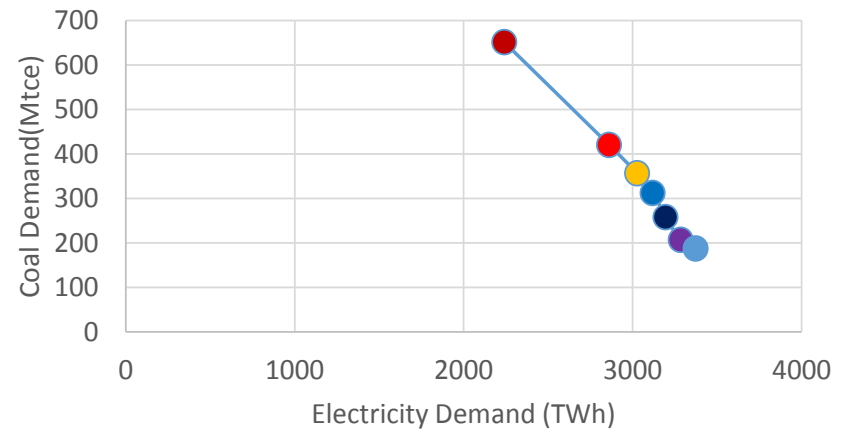


Data: 1990, 2012, 2020, 2025, 2030, 2035, 2040

America Electricity and Coal Demand



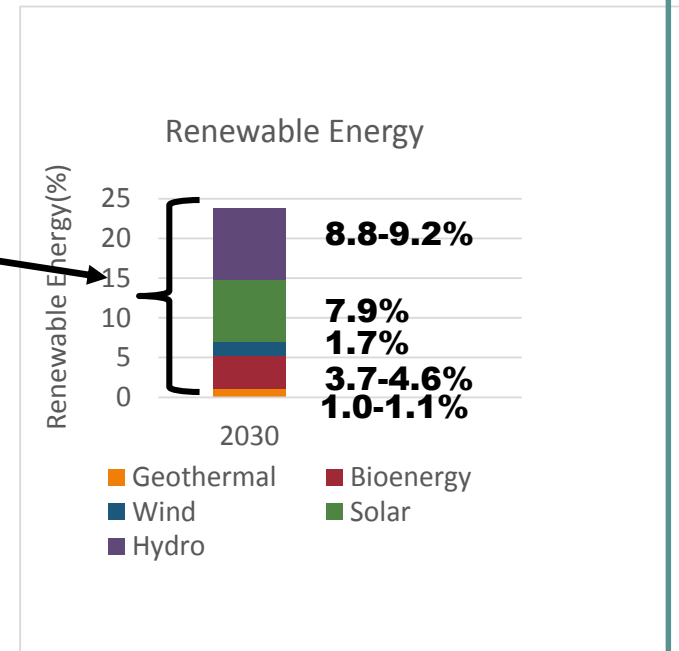
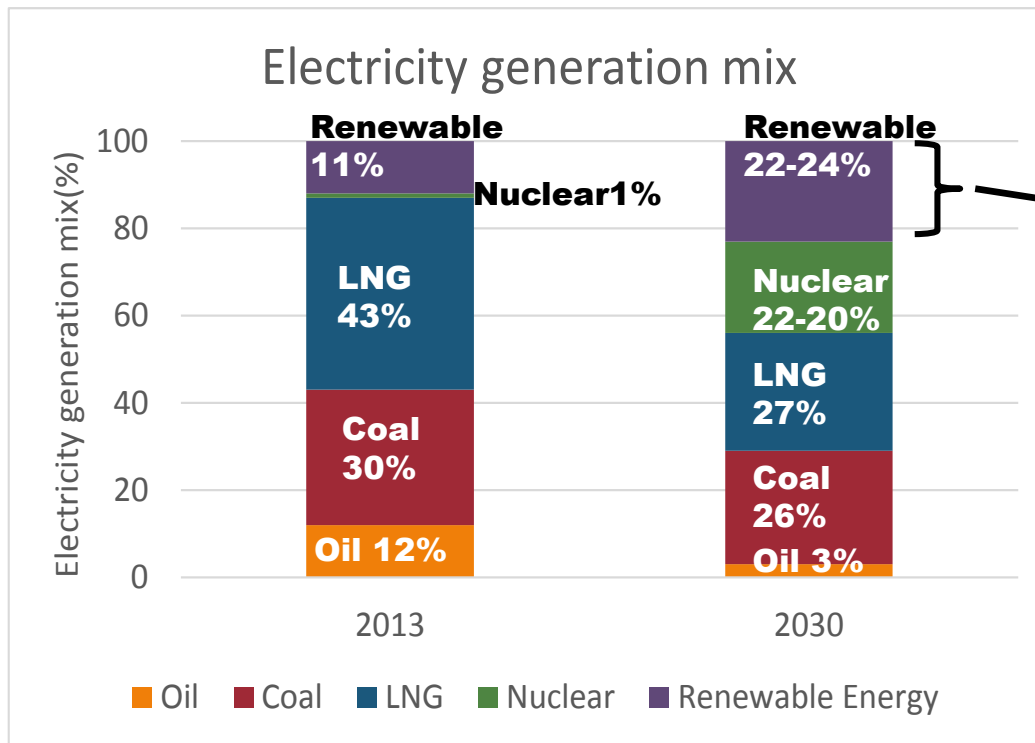
Europe Union Electricity and Coal Demand



Source: IEA World Energy Outlook 2014 8

Electricity Generation Mix of Japan

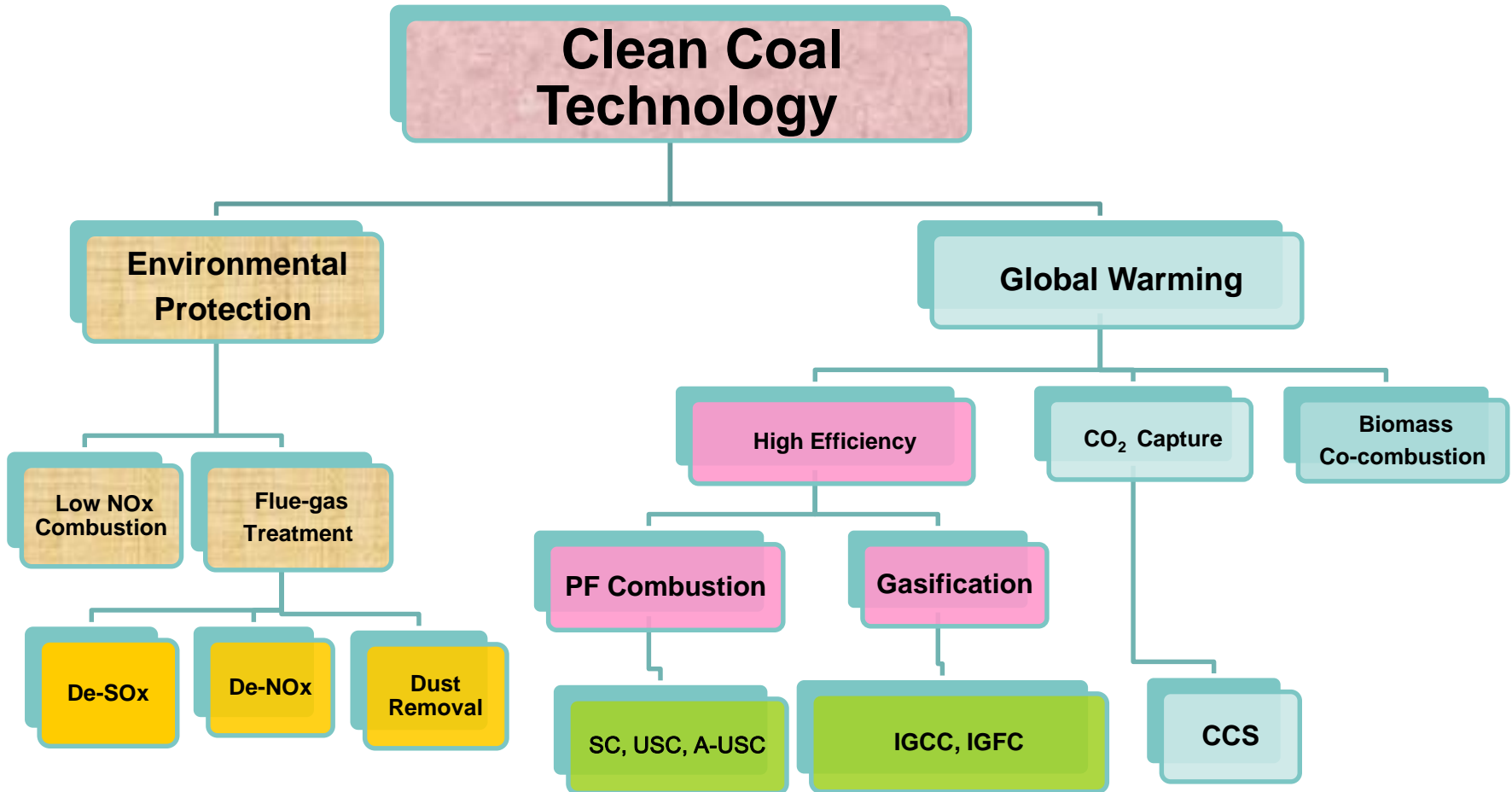
- July 2015, Japan's New Energy Mix towards 2030 was decided.
- The basic policy of "Energy Mix" is to realize a balanced power source composition, while achieving 3E+S(Safety, Energy Security, Economic efficiency and Environment).
- Coal is positioned as the important energy source to be used while the environmental burden.



METI Website

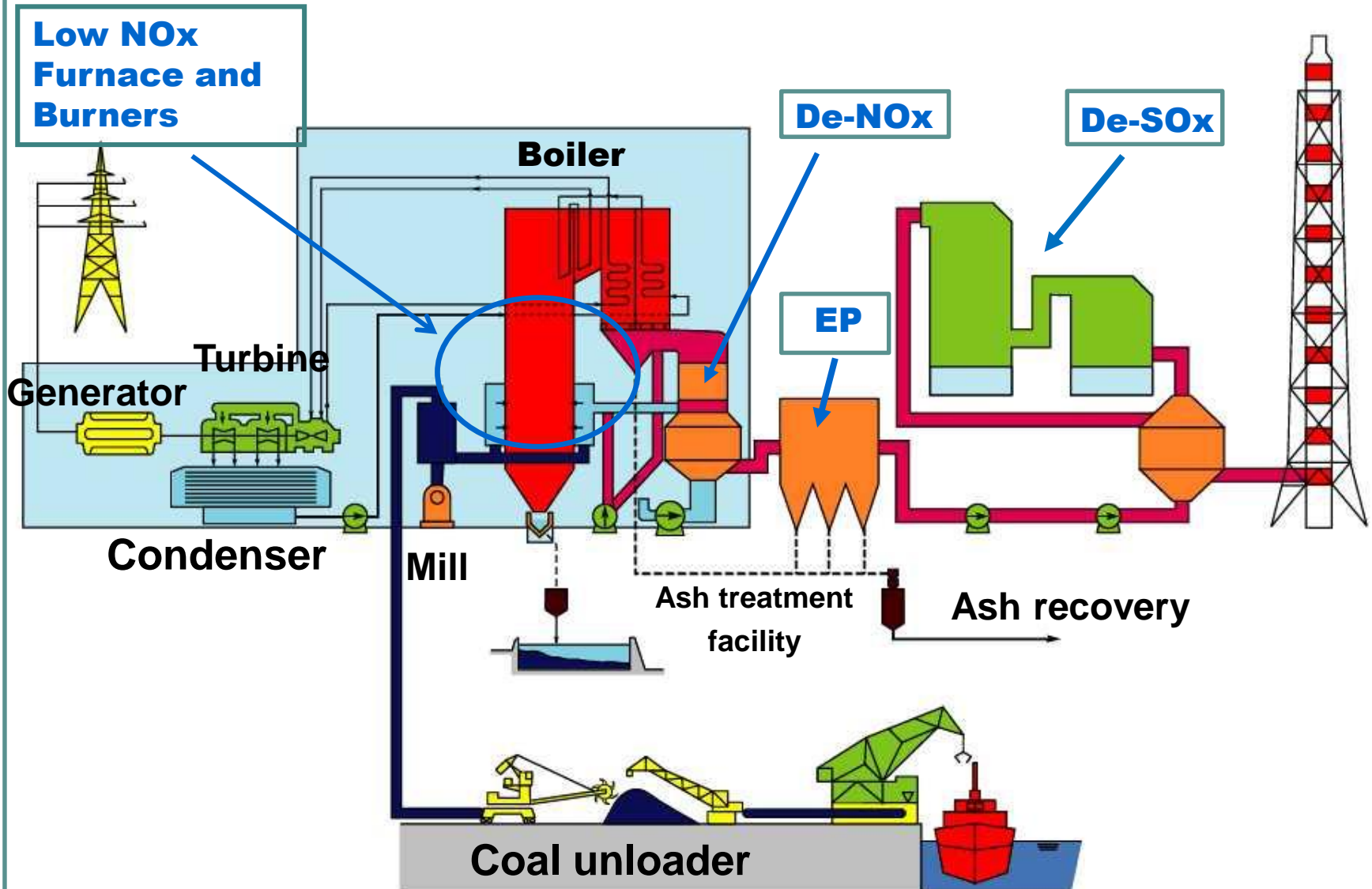
2. What is Clean Coal Technology ?

Clean Coal Technology



3. Environmental Protection

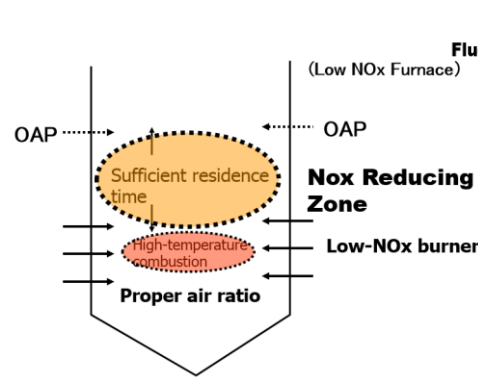
Environmental Protection of Coal Fired Power Station



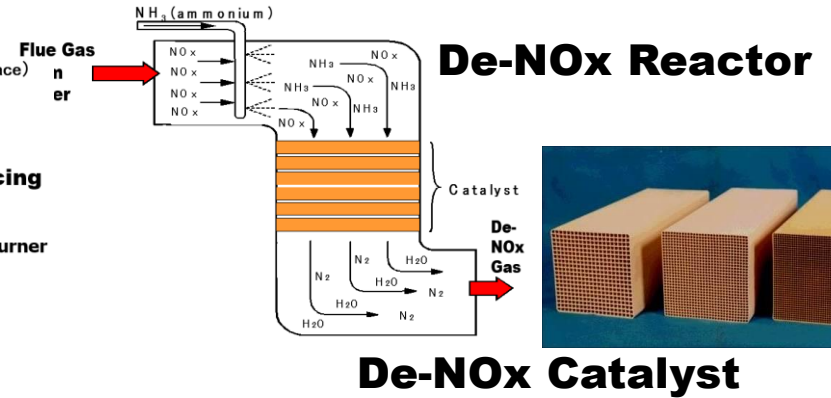
Facilities of Environmental Protection



Low NOx Burner



Low NOx Furnace



De-NOx Catalyst



De-Sulphur Facility



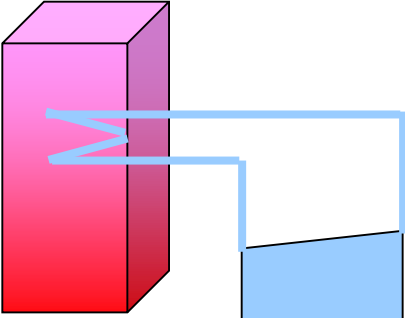
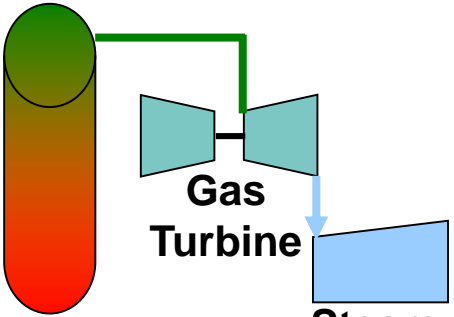
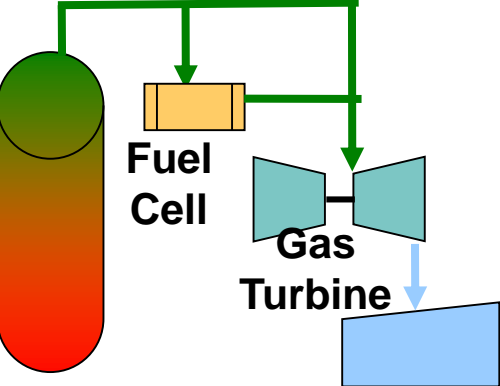
Electrostatic Precipitator

4. Global Warming

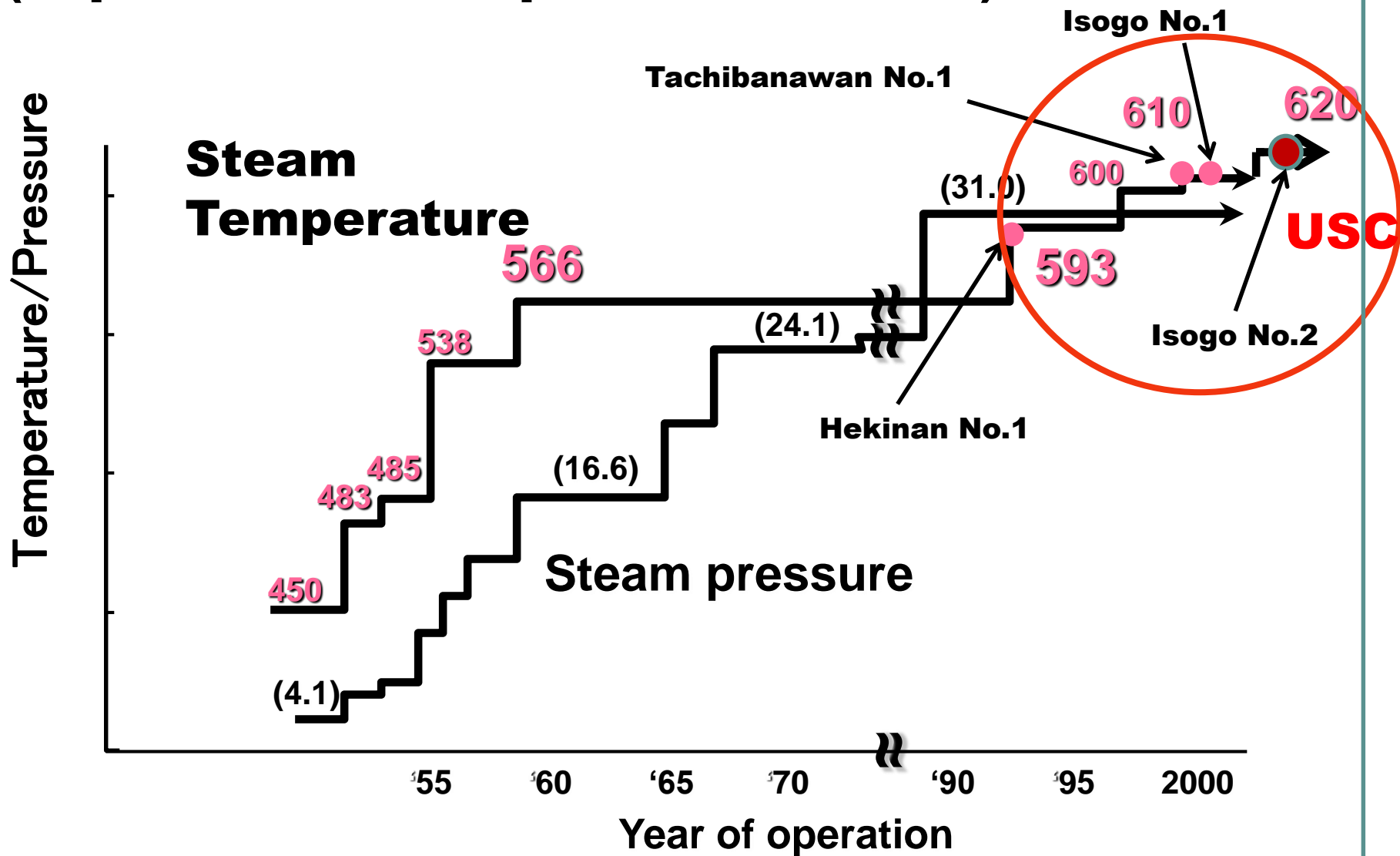
4.1 High Efficiency

High-Efficient Coal Fired Power Generation

Efficiency: HHV Basis

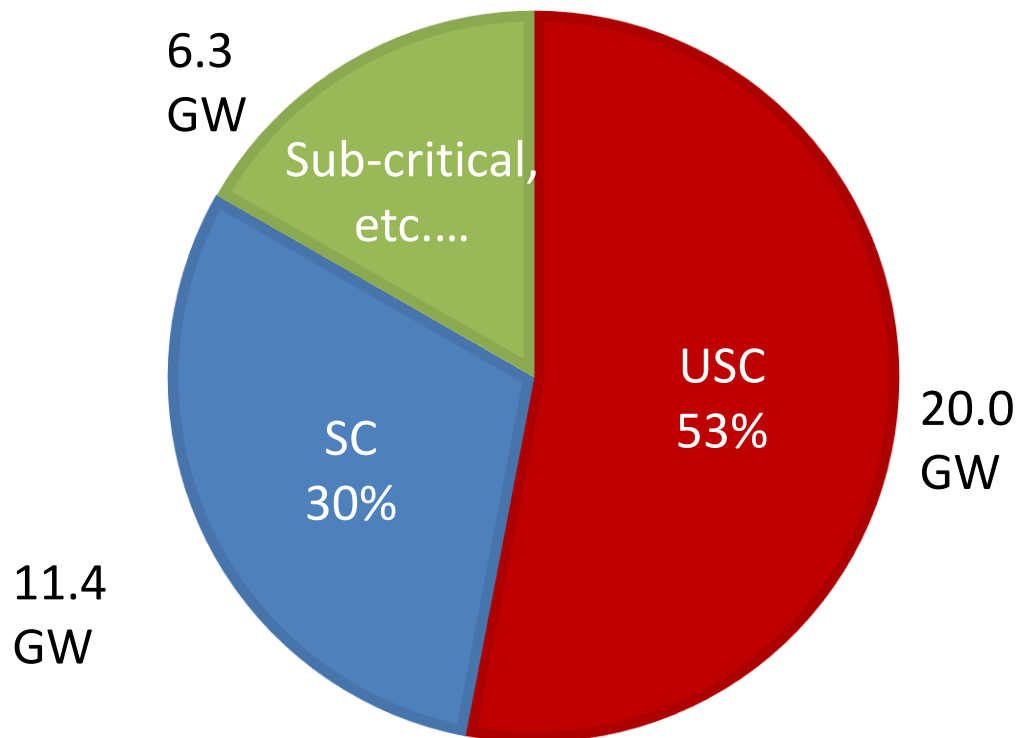
| Pulverized Coal (USC) | IGCC (1500C Class Gas Turbine) | IGFC |
|--|---|--|
| <p>High Steam Temp: 620C</p>  <p>Boiler Steam Turbine</p> |  <p>Gasifier Gas Turbine Steam Turbine</p> |  <p>Gasifier Fuel Cell Gas Turbine Steam Turbine</p> |
| <p>Gross Efficiency :44%</p> <p>Net Efficiency :41%</p> <p>Commercialized</p> | <p>Gross Efficiency :49%</p> <p>Net Efficiency :46%</p> <p>Commercialized</p> | <p>Gross Efficiency :60%</p> <p>Net Efficiency :54%</p> <p>Under Development</p> |

Steam Temperature Increase of Boiler (Japanese Ultra Super Critical Units)



Coal-fired Power Generation Capacity in Japan (2013)

Total 37.7 GW
(excl. off-grid plants)



Note:

Sub-critical ... steam pressure < 22.1 MPa

SC: Super Critical ... steam pressure ≥ 22.1 MPa, steam temperature $\leq 566^\circ\text{C}$

USC: Ultra Super Critical ... steam pressure ≥ 22.1 MPa, steam temperature $\geq 593^\circ\text{C}$

※ None adapting steam temperature between $566^\circ\text{C} <$ and $< 593^\circ\text{C}$

Courtesy JPOWER

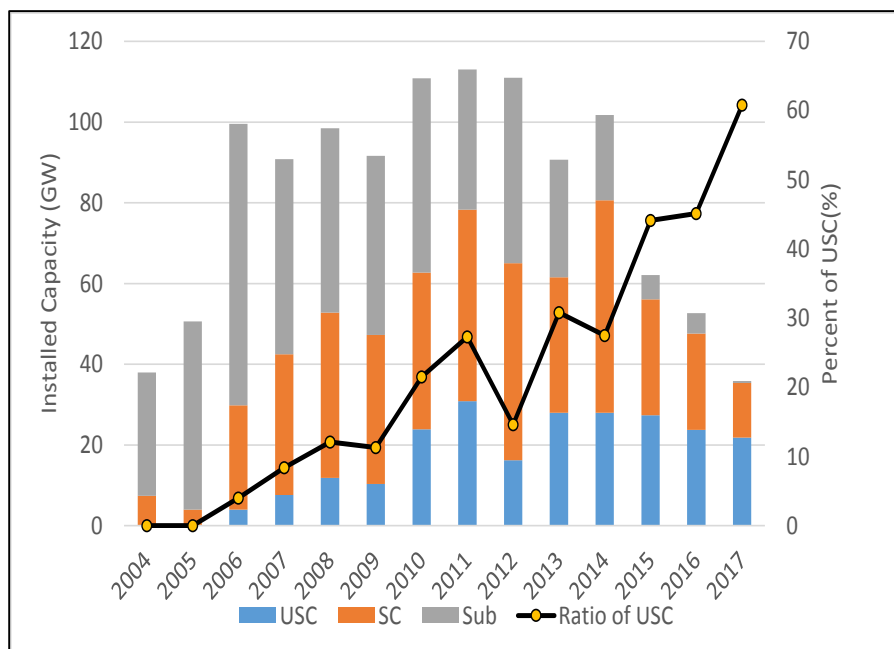
World Highest Efficient Coal fired Power Station

---Isogo No.2 600MW 600/620C USC (Japan)---

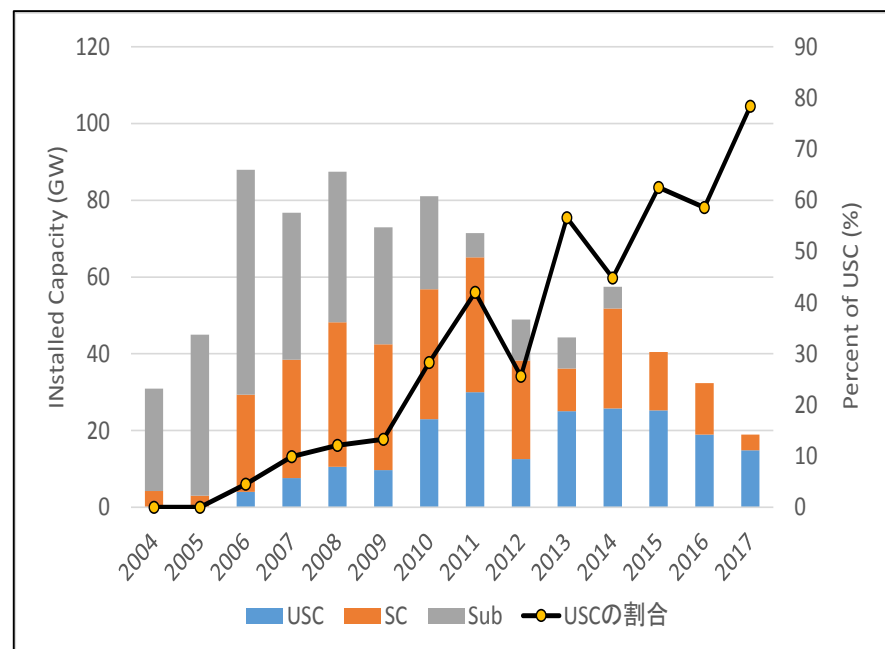


Installation of USC in the World

- Installed capacity of coal fired power generation is 100–110GW/year by 2014.
- First Ultra Super Critical Unit (USC) was installed in Japan in 1993.
Since then, USC is increasing. But super critical and Sub critical units are decreasing.
- 60% of recent installation is USC in the world. SC is less than 10%.
- Recent installation is almost USC in China.



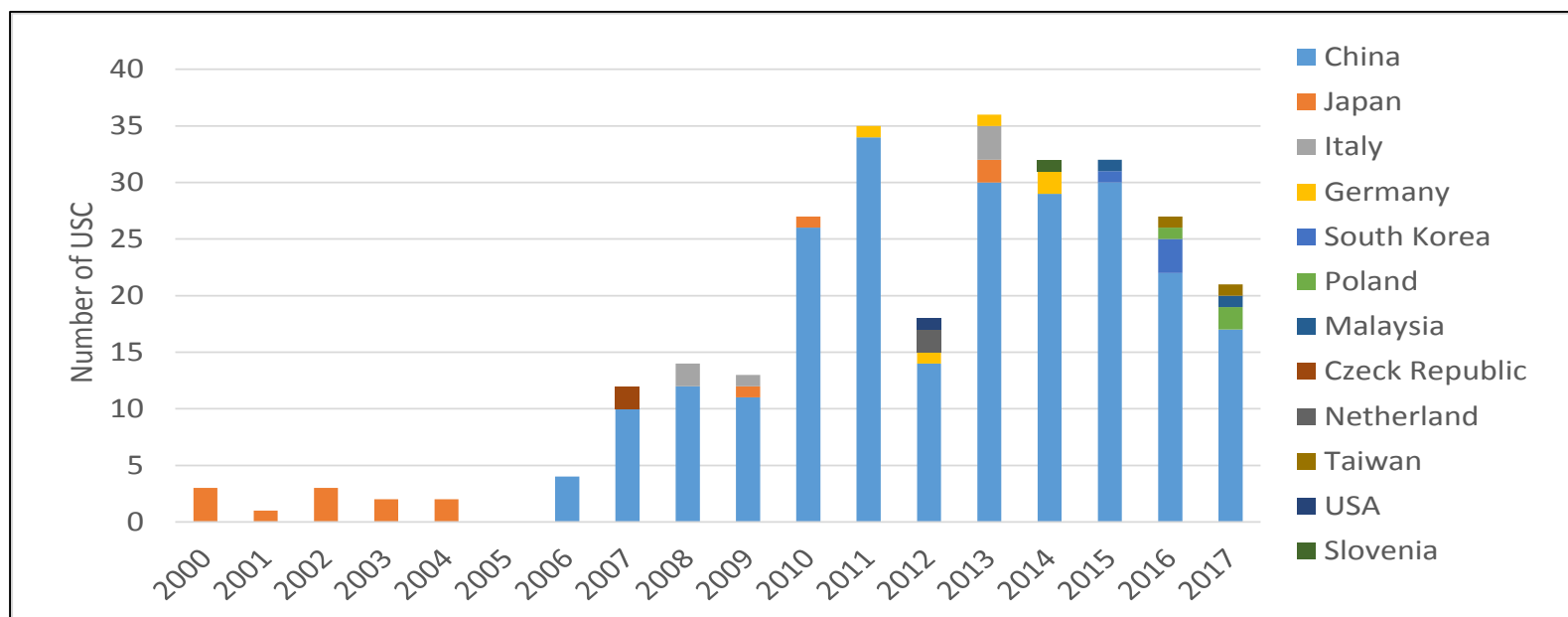
World installation



Chinese installation

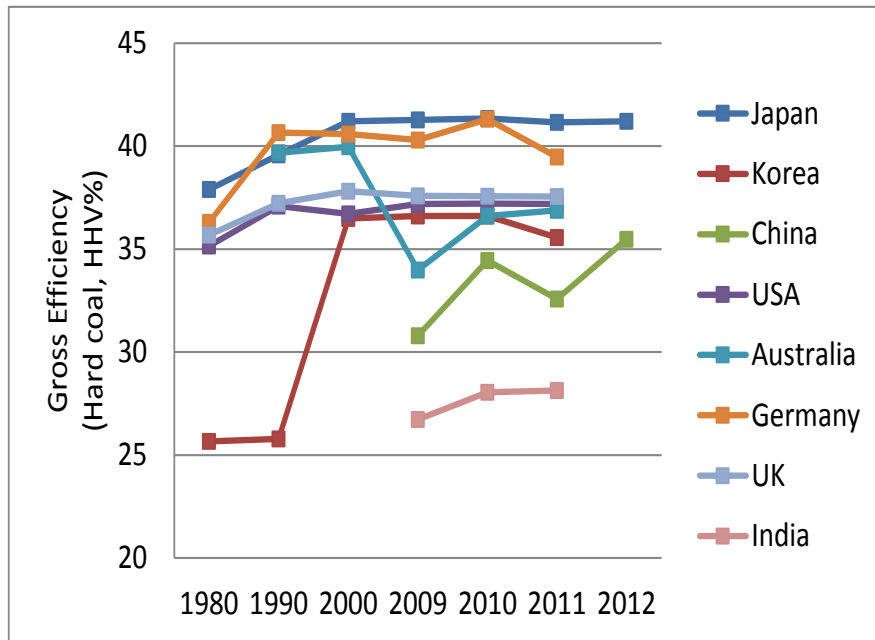
Number of USC installed in the World

- Japan installed first USC unit in 1993. Since then, units for utility use are all USC.
- In 2006, first USC unit was put into operation in China. Since then, 30–35 units have been installed in China every year. Now total number of Chinese USC is largest in the world.
- USC units were operated in more than ten countries at present.
Recent USC units are Malaysia in 2015 and Taiwan in 2016.

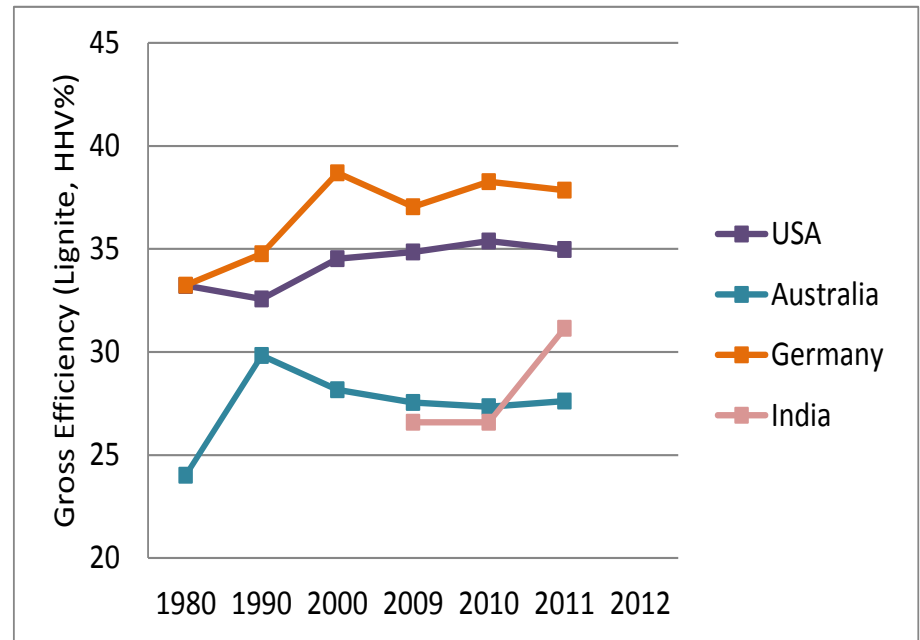


| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|------------------------|------|--------|-----------------|------------------------------------|---------------------------|----------------------------|------------------------------------|---------------------------|--|-------------------------------------|--------------------------------------|------------------|---------------------------|
| Installed USC in China | 0 | 1000*4 | 600*6 1000*4 | 600*2 660*2 1000*7 1036*1 | 660*4 1000*5 1036*2 | 660*9 1000*16 1036*1 | 600*4 640*2 660*5 1000*23 | 600*2 660*2 1000*10 | 600*4 630*1 660*9 1000*14 1050*2 | 660*7 700*4 1000*15 1100*3 | 600*1 660*13 1000*15 1100*1 | 660*9 1000*13 | 660*7 1000*8 1100*2 |

Efficiency of Coal Power Generation of Various Countries (HHV, Gross)



Hard Coal

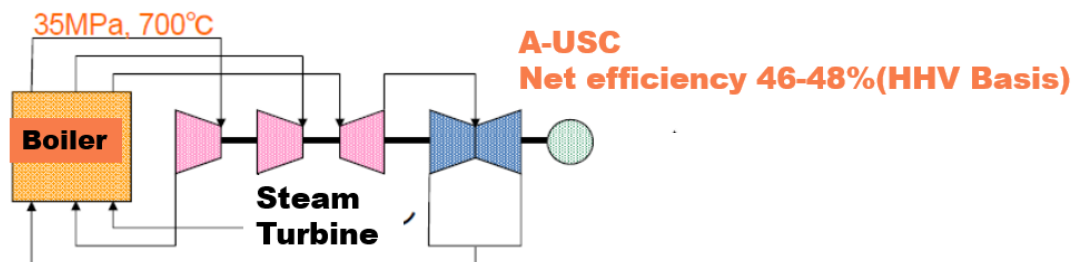


Lignite

**IEA Electricity Information 2013 :
Calculated by JCOAL**

Advanced USC (A-USC)

- **Japan**



- **EU**

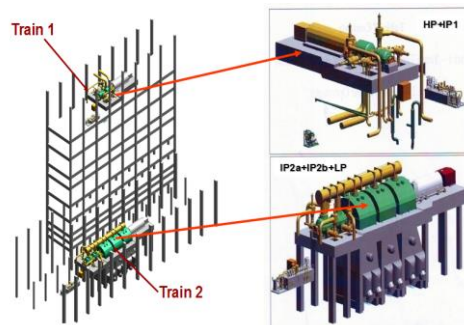
700 degree C, 540MW

- **USA**

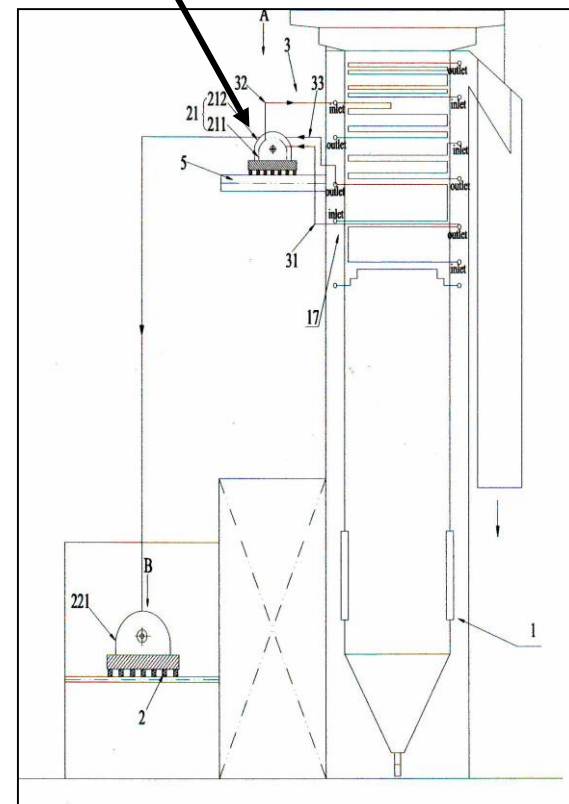
760 degree C 35MPa Developed by NETL

- **China**

700 degree C, Double Reheat



High P. Turbine



Development of IGCC

Japanese IGCC

- **Nakoso NO.10 : 250MW**
Commercial Operation : April 2013
- **Osaki CoolGen : 170MW**
Operation: 2017

New IGCC plan(Website of Nakoso and Hirono)

- **Nakoso About 540MW : Start of construction 2016(Planned)**
Start of operation Early 2020(Planned)
- **Hirono About 540MW : Start of construction 2016(Planned)**
Start of operation Early 2020(Planned)

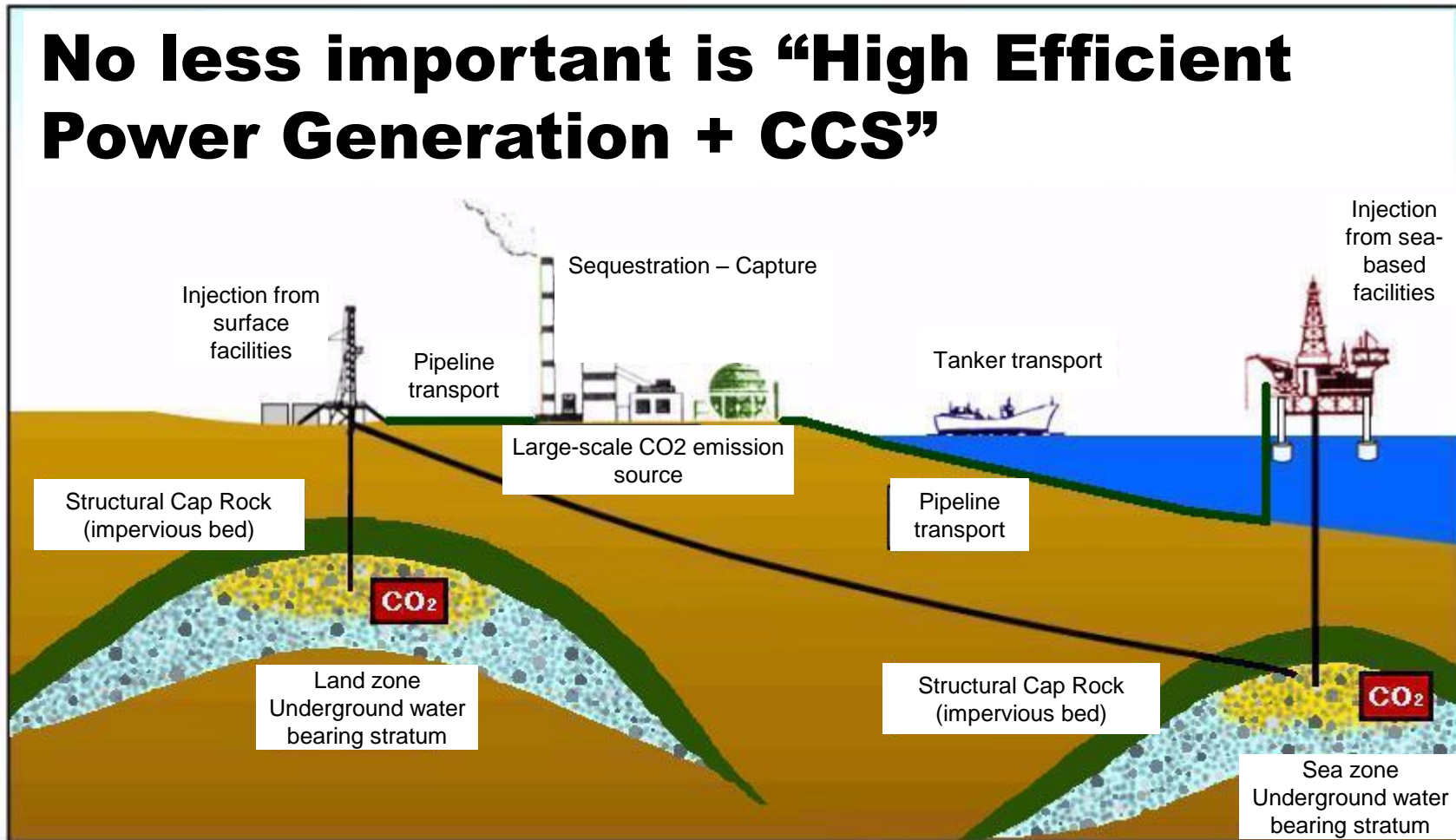
Existing Commercial IGCC:

**Puertollano(335MW), Wabash River(296MW), Tampa(322MW),
Nakoso(250MW), Edwardsport(630MW), Tianjing(250MW)**

4.2 Carbon Capture and Storage

METI CCS 2020

No less important is “High Efficient Power Generation + CCS”



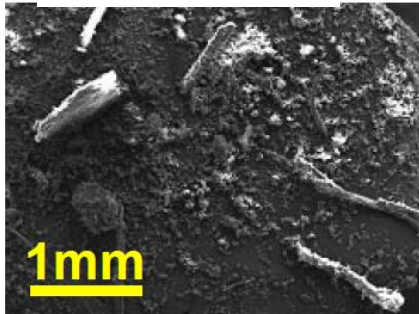
4.3 Biomass Co-combustion

SEM



Pulverization coal/biomass

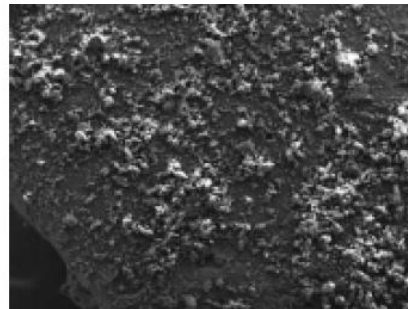
Cedar bark



Pine tree bark



Newlands coal

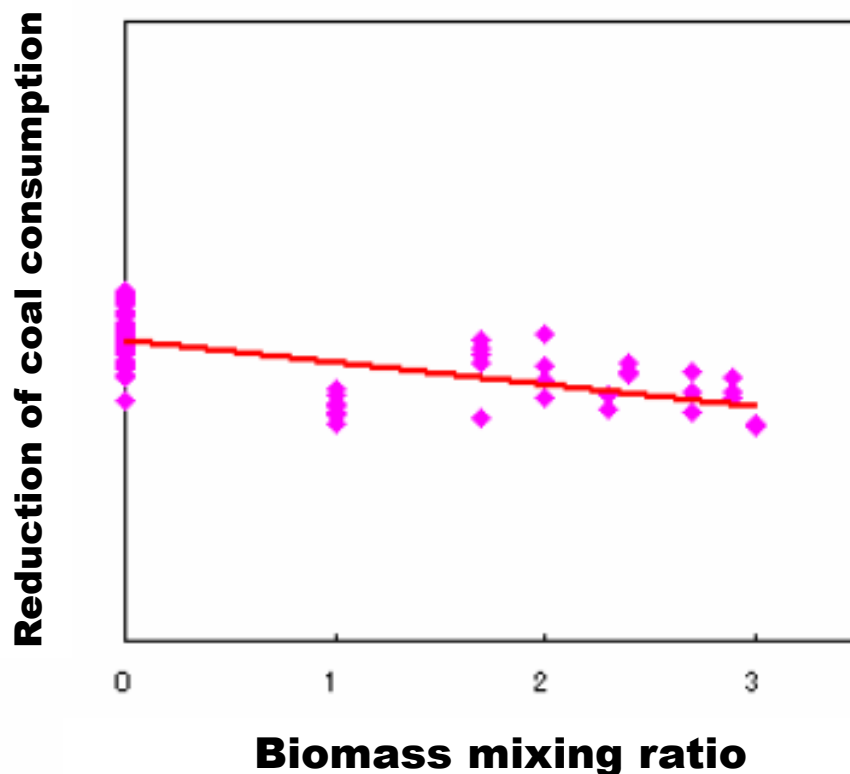


Cedar chip



Saw dust of pine tree

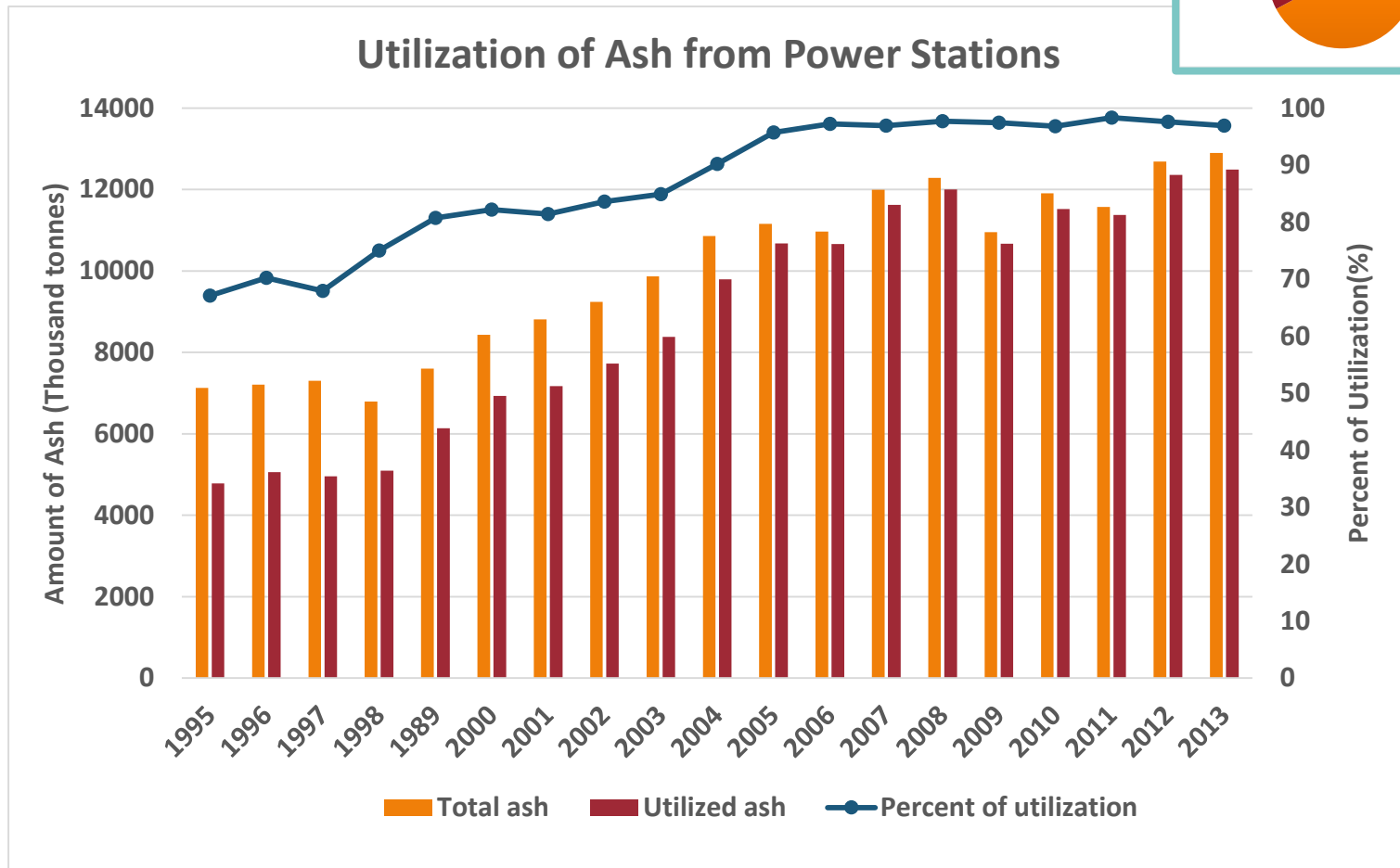
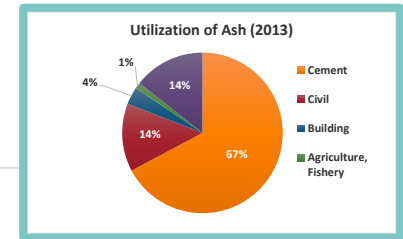
Reduction of Coal Consumption with Biomass mixing



Coal technology conference(Shikoku Power)

5. Coal Ash Utilization

Amount and Utilization of Ash from Boiler in Japan



6. Japanese Roadmap of Clean Coal Technology

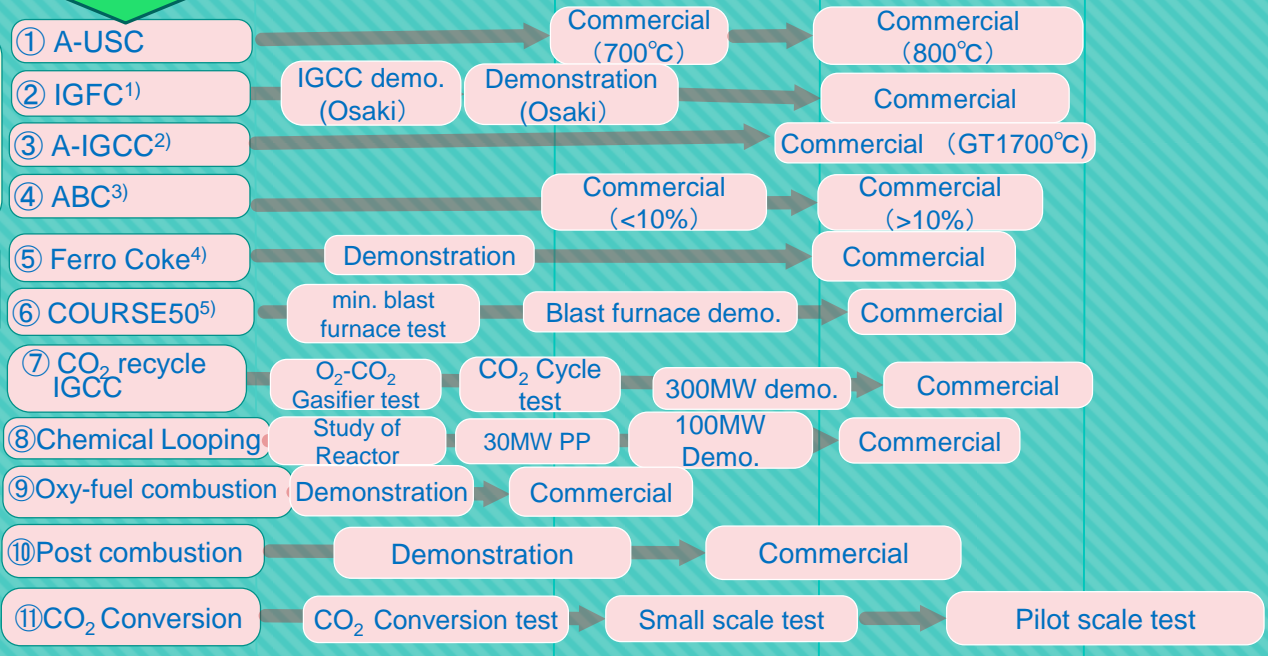


High efficiency and low carbon

Power generation

Steel Industry

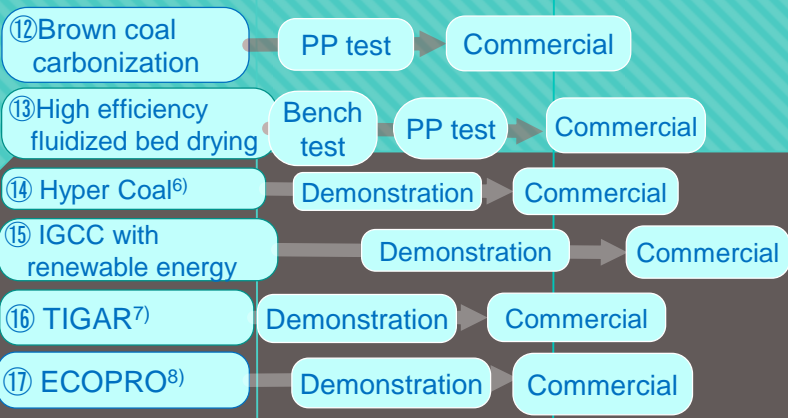
CO2 capture



Low rank coal utilization

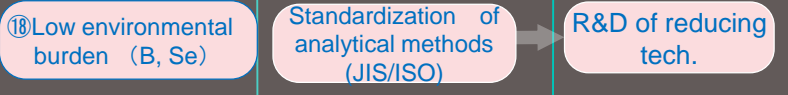
Upgrading

Industrial use



Environmental protection

Low environmental burden



7. Lastly-----

- **Coal should be used as a main fuel in the future. Non-OECD countries will use much more coal than OECD countries in the future.**
- **However, consideration should be paid to reduce air pollution and GHG emission in order to continue using coals.**
- **Now, Clean Coal Technology is essential.**

**Thank you
for your attention.**