

# System developing from GTCC to GYCCs

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## Abstract

This study shows all about Japanese history of electric power generation. In the 1960's, Japan experienced air polluting problems in rapid economic growth. In 2011, after Fukushima nuclear disaster, Japanese government decided national energy policy.

For the future world 2050, energy policy should be resilient and sustainable. Society with renewable plants and GTCCs plants that produce high energy with less air polluting, high efficiency and flexible location selecting.

Presentation PDF in IAIA16 is attached.

## 1. Preface

Through high economic growth in 1960s and 1970s, Japan became to be called "Japan as Number One" in 1980s. But after 90s, Japan has been in economic recession more than 20 years. And Global warming problem occurred worldwide issue since 90s. In 2011 Japan encountered Fukushima nuclear plant accident by the huge earthquake. Japanese government decided it's basic energy policy, but we cannot see pragmatic way yet.

When thinking about future 2050, there seems to be one or another solution, renewable energy and the next GTCCs by Natural Gas. Applying these technologies world-widely, we could hand over the sustainable society to the future generation.

## 2. History of Power plant in Japan

Industrial revolution in Japan begun around 1870 adopting western technologies and constitutions.

Before and after World War II till around 1950s, electric power as infrastructure was mainly generated by coal thermal plant.

After the war, Japanese government changed electricity policy to liberalization, and 9 power companies were established. During ten years in high economic growth in 1960s, power consumption increased to former 3 times. Japanese government accepted local monopoly of power companies and made constitutions for construction fund under Electric Utility Industry Law. Japanese Government had the national policy for the stable power supply at that time.

In 1950s, hydraulic plant was the main power. For more demand, 3 large hydraulic power plants (more than 300,000kW) were constructed under government funding and technologies of J-Power. For increasing demand, trend of the power plant shifted to petroleum.

During 1970s, some trend shifts happened.

- (1) LNG supply started for electricity and as city gas in metropolitan area.
- (2) Air pollution problems occurred with urbanization from 1960s.
- (3) The price of oil went up by more than 10 times through two oil crisis.
- (4) Constructions of nuclear power plan progressed while petroleum stations had difficulties of plant location in urban area.

Planning of nuclear power station launched in late 50s. After 1970, all of 9 power companies in Japan started nuclear plant construction under government institutional support.

In the early 80s, new constructions of petroleum plants were prohibited internationally on the trend of de-oil and energy conservation.

Three major metropolitan areas in Japan consume two-thirds electricity in Japan. Power

companies in those area shifted oil-fuel to LNG because they could procure at low cost in long-term contract. Other 6 power companies shifted oil-fuel to coal.

In 1990s, Global warming became one of the world wide issues. It is said greenhouse gas (CO<sub>2</sub>) discharged by fossil-fuel consumption, is the reason of the global warming. Common world target becomes to reduce 50% of CO<sub>2</sub> emission by 2050.

### 3. Construction of power plant and Environmental Impact Assessment(EIA)

EIA system in Japan is basically for public facilities such as road, railway, airport and garbage incineration site.

Power plant is in private sector. If this EIA system was instituted in developing era, it could be quite difficult to proceed a plant planning even in high demanding time.

In 1960s, Japan was in high economic growth, there were a lot of severe pollution problems and many respiratory patients in cities, and moreover many pollution suits continued until late 90s. People were against fossil-fuel power plants.

So, Law of EIA was launched quite late in Japan. That was 1999. This law focuses on only large scale facilities that have huge impact on environment, so then, simple assessment system that US and Chinese administration do for small scale of facility planning doesn't grow in Japan.

After 1980 some GTCC (gas turbine combined cycle by LNG) are getting installed. They are less air polluting than fossil-fuel plant. But especially in cosmopolitan area, people are reluctant to accept new technology, then administration should regulate new planning based on law of EIA. There are some records of replacement from thermal power generation to GTCC, but no new GTCC in city area. New GTCC could be planned not in urban but suburb area like coal thermal plant. This is quite nonsense and not innovative, because GTCC generate only 10% air-polluting gas and half CO<sub>2</sub>, compared to coal power plant.

#### 3-1 Superiority of LNG and GTCC

Resources of GTCC are clean LNG, which does not include SO<sub>x</sub>, soot and SPM. The air-polluting exhaust gas is only NO<sub>x</sub>.

Gas turbine is the same structure of jet engine which has been used since 1970s. It's compact, reliable to be used for long term through periodic inspection maintenance. Generating efficiency is quite high. When inlet temperature is 1,600°C, the efficiency is 60% (LHV). It is approximately 1.5 times of a latest coal thermal plant (43-44%).

New electric law has launched in 1995 in Japan, which includes further liberalization. Three major electric power companies raised the purchase of independent power producer (IPP).

Past GTCC project (150,000kw) in Osaka, cleared local government EIA regulation with NO<sub>x</sub> 4ppm (O<sub>2</sub>:16%) and chimney stack height 45meter.


This plant is being operated high efficiently and economically. This case has been the de facto standard on denitrification measures for more than 20 years.

After this case, few GTCC projects were completed in metropolitan area in Japan.

Last year 2015, one GTCC plan on Tokyo bay was submitted to Ministry of Economy, Trade and Industry

**Torishima Energy Center(New establishment)**

GTCC:150MW

<p><b>Environmental impact assessment</b></p> <p>1996~1998 33 months</p> <p>Construction: 22 months</p> <p>Starting operation: 2002.3</p> <p>● <b>NO<sub>x</sub>: 4ppm</b></p> <p style="color: blue; text-decoration: underline;">Stack height: 45m</p> <p>✕ Evaluation by workshop of Well-informed persons</p> <p>(Reader: Professor Michio Nakano)</p>	
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**Prototype of GTCCs**

NO<sub>x</sub> 4ppm became de-facto-standard of Japan

(METI). METI requests to reduce more NO<sub>x</sub> and CO<sub>2</sub>. Finally, it's time to shift to GTCC in cosmopolitan area!

#### **4. Imagine 2050 after Severe disaster at Fukushima nuclear plant**

On March 2011, serious nuclear disaster occurred. After the accident, all nuclear stations in Japan are not operating, even though occupied 30% of all electricity.

During this period, there are no major power-cuts throughout the country. Energy saving is progressed, so power supply is basically secured even under difficult circumstances.

Japanese government showed three energy themes.

- (1) De-nuclear power generation dependence
- (2) Enlargement of renewable energy
- (3) Reinforcement of GTCC by LNG

Recently government released the new energy basic policies in 2030. If “thermal power generation instead of nuclear power generation” will prospect of the realization, energy basic policies shall be reviewed and updated.

#### **4-1 From GTCC to GTCCs**

Thermal power generation plant will be operated during 30years or more, so if installed in 2020 it will be operated until 2050. Power station will be planned from the point of view of “Best Available Technology”, and will be installed from the point of view of “Merit Order which means power plant priority ranking”.

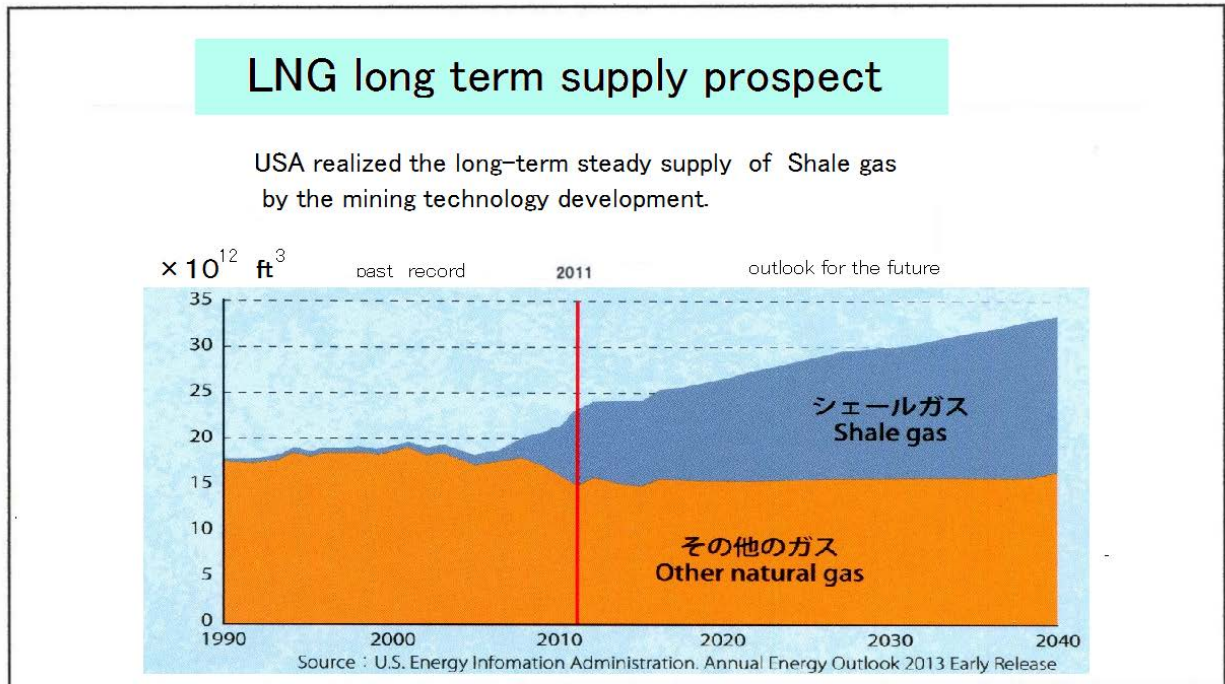
LNG excels in safety, environmental integrity and economic efficiency. Especially, it's a big point that stable use expansion of USA shale gas will be expected until 2050. Natural gas exists whole world, therefore natural gas will be superior to oil. By procurement of shale gas from U.S.A., Japan-US trade balance improvement will be anticipated.

In 2050, electricity generation system will become to the conclusion of the use of renewable energy (include hydraulic power) and GTCCs. Solar photovoltaic generation and wind power generation will occupy the main-stream of renewable energy, but these power will fluctuate by weather condition. The combination of renewable energy and GTCCs will eventually make sure of the stable power supply.

Advanced GTCCs (improved model of GTCC) has characteristics;

- (1) 99% of NO<sub>x</sub> will be removed by catalyst, and air pollutant will become substantially zero. So, chimney stack will become needless, economic efficiency and townscape will be improved.
- (2) Recover latent heat from water vapor in the exhaust gas, improve thermal efficiency.
- (3) Recycled water is effectively utilized as boiler make-up water etc.  
Stable operation will be possible by keep-watching of exhaust gas and recycled water.
- (4) Catalytic denitrification device and latent heat recovery mechanism will install separately from conventional GTCC, therefore 30years quality security system will be easily built.
- (5) Improvement of Existing GTCC, performance improvement, ESCO business can be planned, and these contribute economic efficiency and discharge reduction of CO<sub>2</sub>.
- (6) “Film separation technology” which practical application is approaching by recently development advances, can be planned to built-in.
  - 1) Further recovery of H<sub>2</sub>O, and effective utilization.
  - 2) If CH<sub>4</sub> manufacturing technology (CO<sub>2</sub> from exhaust gas reacted with H<sub>2</sub>) will advance, CH<sub>4</sub> become fuel on site, and CO<sub>2</sub> free plant will come true in the future.
- (7) Within 2 years, enforcement design specifications decision will step up. For this purpose, necessary information will be obtained for proof examination. In other words, catalytic denitrification device and latent heat recovery mechanism are,
  - 1) Heat exchange examination is being conducted by reduction model (1/10,000 - 1/15,000), and data will be collected. Also numerical simulation will apply to accurate design factors.
  - 2) Proof examination can be planned by using reduction model of actual machine (1/100 - 1/1,000).

Each technology components are application of already established technologies. And usage conditions is good, as temperature is about 350°C for the former device(catalytic denitrification device) and less than 100°C for latter(heat recovery mechanism). There is no anxiety factor of 30years quality security system. Therefore it's possible to set and operate actual machine from 2020, and we can see the figure of 2050. These systems are applicable to whole world, and these technologies will be able to contribute world-wide from Japan technology in 2050.



#### 4-2 Prospect of other fuel in 2050

##### (1) Nuclear power generation

Nuclear plant generates highly-concentrated radioactive emission, and difficulty of waste disposal. This system has a fatal defect, namely last disposal place to shut away radioactivity for 100 thousand years equal to the human history is not foreseen.

Therefore nuclear power generation is called connector of 20<sup>th</sup> century and 21<sup>st</sup> century, and newly construction is extremely difficult. Existing plant life-time is max 60years, so there is no plant exists in 2050. This situation is the same in the world.

##### (2) petroleum-fired power

Petroleum-fired power generation will be finished in 2050. Liquid fuel is conveniently used for moving body such as car, ship, air plane.

##### (3) Coal-fired power

Coal-fired power plant raised the generating efficiency by heightening of steam temperature about 600°C. Further research and development are promoting, but these are close-to-capacity.

There are many problems compared to GTCC.

1) Low generating efficiency.

2) Significant carbon(C) in the fuel.

CO<sub>2</sub> discharge volume ( 1)+ 2)) is twice of GTCC.

3) Construction cost is 2 times of GTCC, and maintenance also costly.

4) Air pollution material volume is numerous, and it's difficult to get inhabitants agreement.

Film separation technology that future GTCCs can use is not applicable.

5) These plant will be operating up to 2050.

On the other hand, merits are written below.

- 1) Richness of coal resources.
- 2) Cheapness of cost.
- 3) Location restriction is smaller than LNG.
- 4) In Japan, bank fund financing is easy.

But, foreign countries there will be troubles like as atmosphere pollution, uneasiness and objection of inhabitants etc.

#### (4) Sustainable society promotion plan

In Japan, for the purpose of promotion plan of renewable energy such as solar photovoltaic generation, wind power generation, biomass etc, Feed-in Tariff (FIT) was started on Jul 2012.

Although nuclear plant accident accelerated the law establishment, the spread of sustainable society promotion plan was taken. But there is only about 3% of total generated energy in 2014.

Long term of view, renewable energy spread promotion is very important.

### **5. Sustainable Electrical Power composition in 2050**

“Sustainability and resilience” are important concept up to 2050.

Even if energy saving technique and smart meter will be promoted, figure of 2050 will be concluded as the combination of renewable energy and GTCCs.

Unstable renewable energy by means of natural weather condition will be reinforced by GTCCs. Therefore aggressive installation of GTCCs, and reduction of CO<sub>2</sub> have big significance, up to 2050.

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