Gas quality variation impact on gas appliances in Japan: a status report

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Date: June 7th, 2012

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IGU
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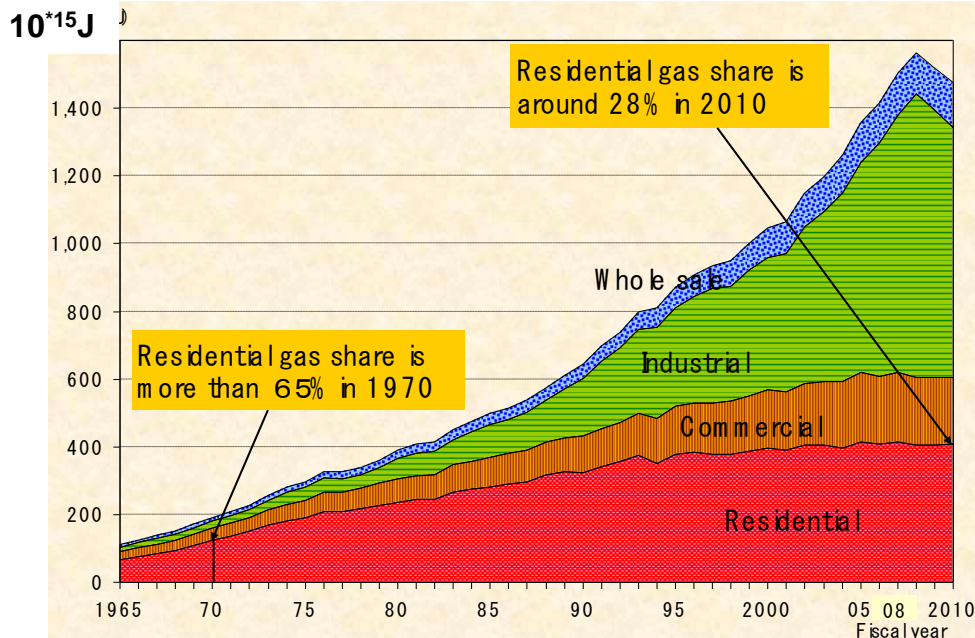
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Summary

- Japanese gas market is expanding continuously and along with this natural gas demand is increasing.
- Almost all natural gas supply in Japan depends on imported LNG.
- Japanese gas quality has been very stable compared to that of foreign countries .
- According to the increase of gas demand in Japan, LNG supplying countries have been diversified and unconventional gas such as shale gas and coal bed methane will be imported in near future.
- Third party access and biogas injection has started in Japan.
- Compared to foreign countries, various types of gas appliances such as Fuel cell, GHP, m-CHP etc have been widely introduced to the market in Japan.
- In case of disaster such as the Tohoku earth quake, temporal natural gas supply using LPG +air etc. is effective.
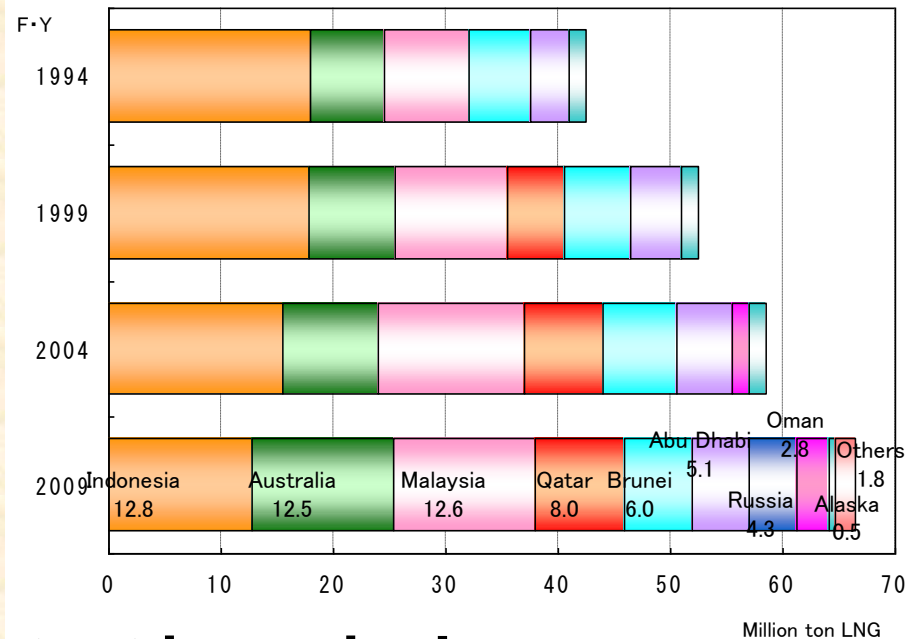- The impact of gas quality variation on gas appliances will become a keen issue to the gas industry.

Background

➢ **Natural gas ,especially LNG was relatively stable in quality.**

➢ **Various kinds of gas appliances and high efficiency furnaces have been developed and introduced to the market in Japan.**

   : High performance CHP, Glass processing machine , atmospheric metal treatment furnace, GHP, m-CHP, Fuel cell etc.

➢ **Source of natural gas have been diversified and also biogas injection to the grid has began.**

Natural gas sales in Japan

$10^{*15}J$

Residential gas share is around 28% in 2010

Whole sale

Industrial

Residential gas share is more than 65% in 1970

Commercial

Residential

1,400
1,200
1,000
800
600
400
200
0

1965 70 75 80 85 90 95 2000 05 08 2010
Fiscal year

LNG import volume：Mil（t）

F・Y

1994

1999

2004

2009

| Indonesia 12.8 | Australia 12.5 | Malaysia 12.6 | Qatar 8.0 | Brunei 6.0 | Abu Dhabi 5.1 | Oman 2.8 | Russia 4.3 | Alaska 0.5 | Others 1.8 |

0 10 20 30 40 50 60 70

Million ton LNG

➢**Gas quality becomes important issue in Japan.**

Japanese Gas Interchangeability

1. Natural gas in Japan is classified in 2 Categories. : 13A and 12A
2. Almost all natural gas in Japan are LNG based.   : 13A   98%
3. Interchangeability of 13A is very wide.
4. All gas appliances for residential use must burn well in this interchangeability .
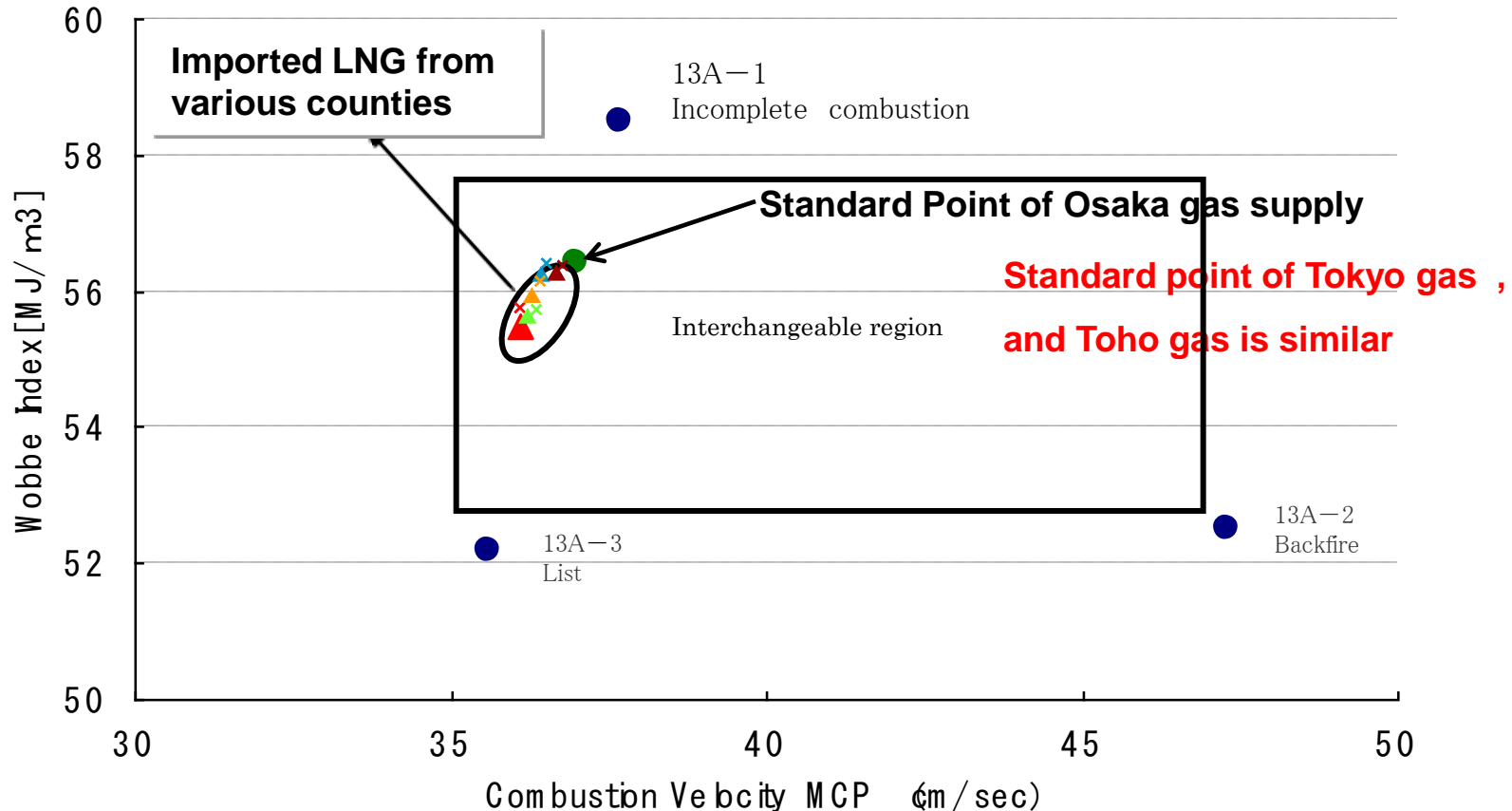
Interchangeability of Japan :13A
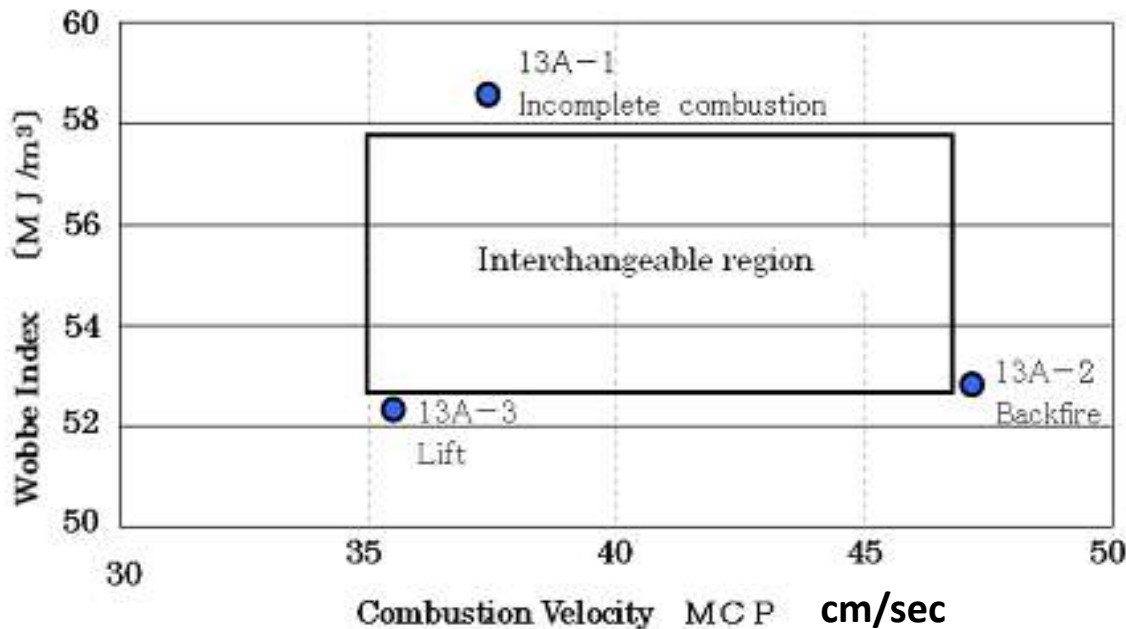
Actually Gas companies control their gas quality very strictly ,for their industrial customers.
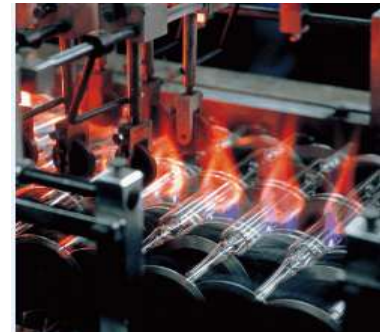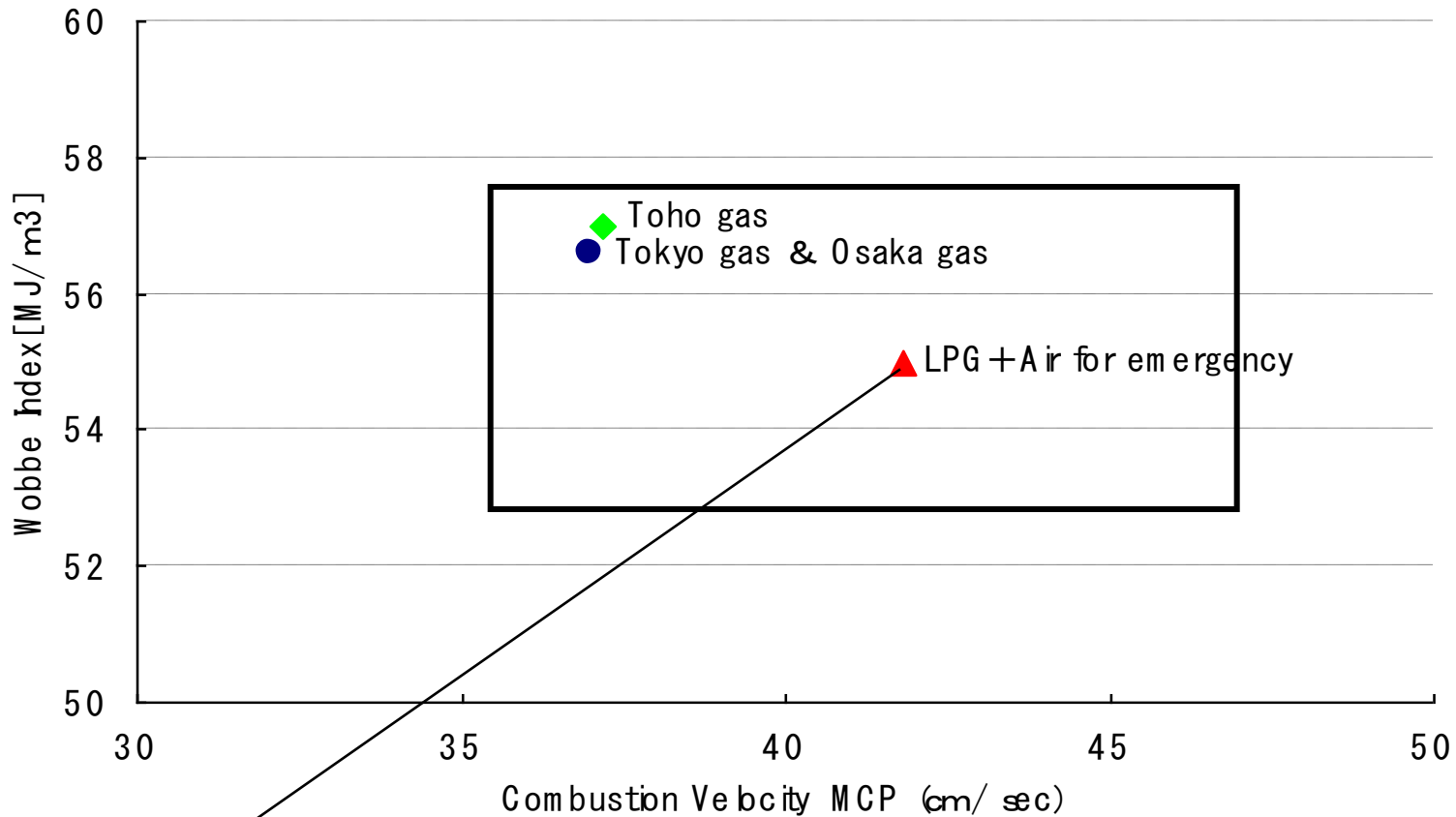
Regulated by the Gas Business Act :1970 enacted

Japanese Gas Interchangeability

- **Originally natural gas in Japan is mainly LNG based, so gas quality is very stable.**
- **Almost all gas companies is adjusting their heat value with LPG for their customers.**

Every gas company keeps the value close to this standard point by adjusting heating Value with LPG.
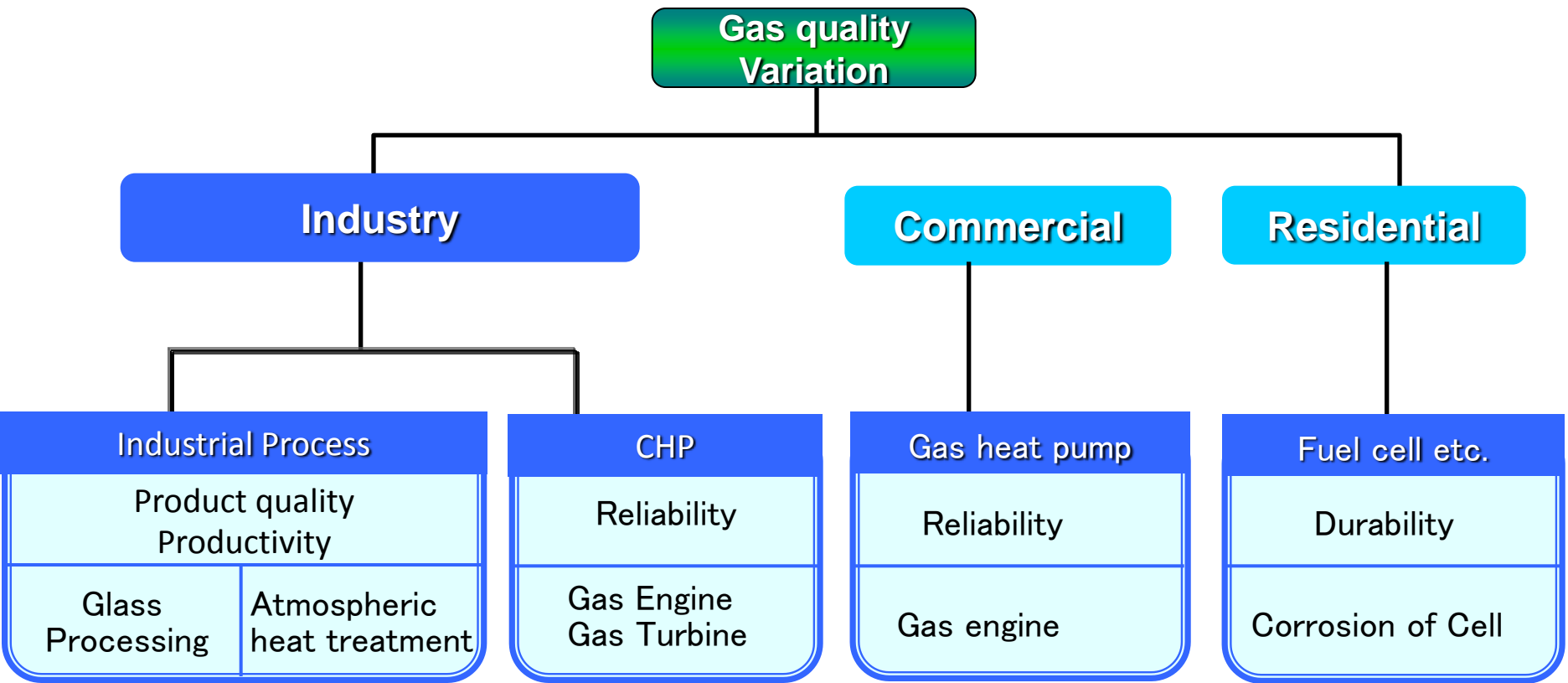
In emergency, temporary natural gas supply by LPG +Air Unit

Gas quality impact on gas appliances in Japan

1. **Industry especially glass procesing and heat treatment customers are affected severely**
2. **Commercial customers : especially GHP and m-CHP affected**
3. **Residential customers : Fuel cell and m-CHP affected.**

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                        Gas quality
                         Variation
    ┌──────────────────────────┼──────────────────────────┐
 Industry                  Commercial              Residential
 ┌─────────┬─────────┐
Industrial Process    CHP    Gas heat pump        Fuel cell etc.
```

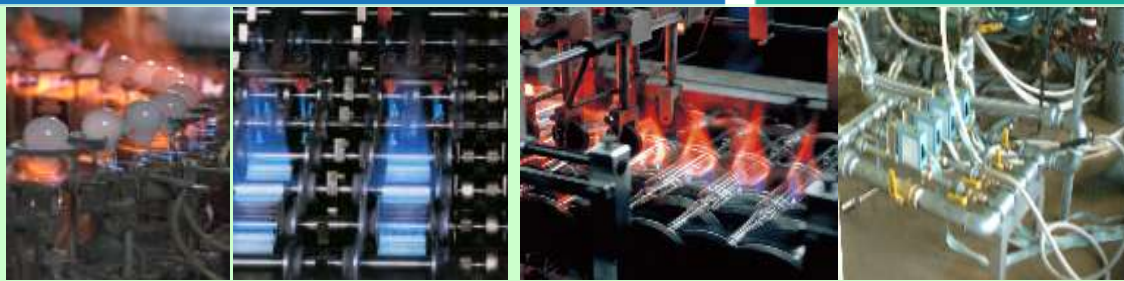| Industrial Process		CHP	Gas heat pump	Fuel cell etc.
Product quality Productivity		Reliability	Reliability	Durability
Glass Processing	Atmospheric heat treatment	Gas Engine Gas Turbine	Gas engine	Corrosion of Cell

Gas quality impact on industrial users

Industry

Industrial Process

Glass Processing

If Wobbe Index fluctuate
Δ1% Flame temp Δ5-10℃ → **Productivity, product quality** **Heavily damaged** → **Wobbe controller,** **Mass flow controller**

Metal atmospheric heat treatment

If Wobbe Index fluctuate Δ2%
Carbon potential Δ0.2-0.3% Down → **Product quality,** **Heavily damaged** → **Mass flow controller**

CHP

Gas engine

Gas engine: Knocking occur and Unstable operation , Power down

Gas turbine: Performance decline due to lack of compression → **Keep constant of Knocking Index and Wobbe Index**
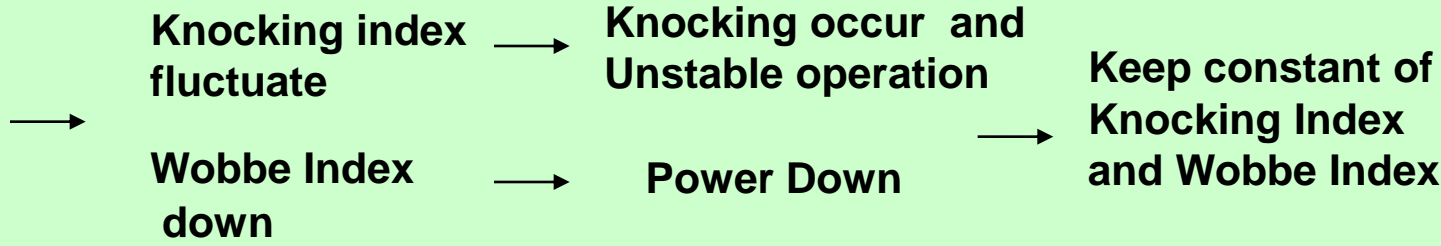
Gas quality impact on commercial and residential users

## Commercial

GHP and m-CHP

Gas Heat Pump

M-CHP → **Knocking index fluctuate** → **Knocking occur and Unstable operation**

Wobbe Index down → **Power Down**

→ **Keep constant of Knocking Index and Wobbe Index**

Residential

Fuel cell and m-CHP

ENE·FARM

Fuel cell →
- **Sulphur content Moisture** → **Corrosion , Life of Cell** → **Install Pre-treatment unit**
- **Wobbe Index down** → **Power Down**

Gas engine →
- **Knocking index fluctuate** → **Knocking occur and Unstable operation** → **Keep constant of Knocking Index and Wobbe Index**
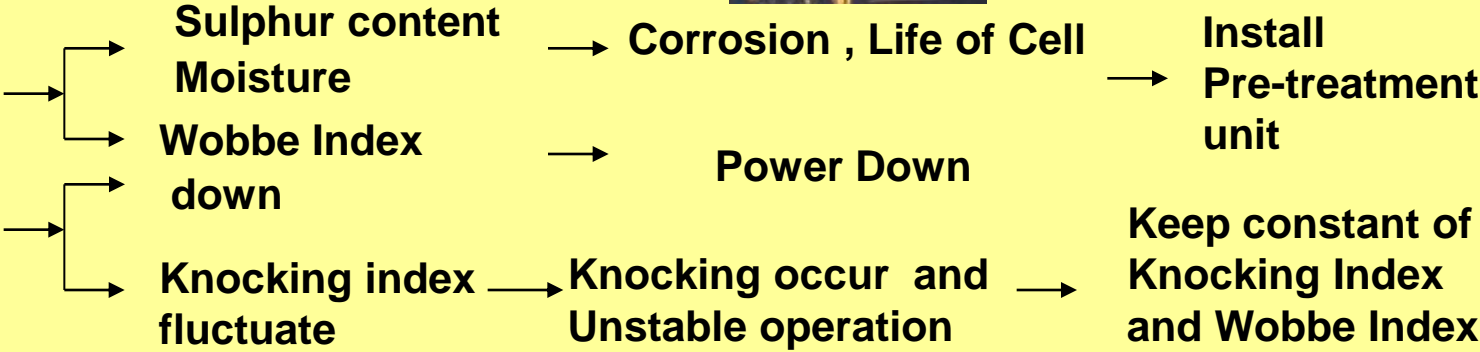
Standards of Gas Quality of Osaka gas

Items	Standard	Note
Standard calorific value	45MJ/m³N	To follow the definition of the standard calorific value of the gas business law.
Range of calorific value	44.2〜46.0MJ/m³N	The height and the lowest difference of 24 hours must be 1MJ/m3N or less.
Wobbe Index	52.7〜57.8	To calculate from the content ratio of the gas elements.
Combustion Velocity	35〜47	To calculate by the method described in the gas business law
Specific Gravity	Less than 1.0	The specific gravity of air is defined as 1.0
H_2S	1.0mg/m³N or less	
Total S	Less than 5.0mg/m³N	To exclude the sulfur content included in the odorizer
Ammonia	Not detected	
Conc. Odor	12〜16mg/m³N	To use the same odorizer as Osaka Gas Co.,Ltd uses.
Conc. H_2	4vol%or less	
Conc. CO	0.05vol%or less	
Conc. O_2	0.01vol%or less	
Conc. N_2	1.0vol%or less	
Conc. CO_2	0.5vol%or less	
Temperature	0℃〜40℃	
Others	separate consultation	Dew point of hydrocarbons Moisture Knocking Index Oil and trace element Olefin Benzene etc
Pressure	Below the highest pressure of the injection point of the grid	To secure pressure necessary for handing over the amount of the biogas purchase contract from upper point of the equipment that controls gas quantity or pressure .

Osaka gas itself control calorific value, Wobbe Index ,Combustion velocity, more severely.

Accepting standards are very wide according to gas business law.

Biogas injection and third party common carriage

Conclusion

- In the Japanese gas industry, the quality of gas is closely monitored and adjusted with the gas supply rules and provisions set by gas utilities.

  This is especially essential for industrial customers to run the state-of-the-art gas appliances requiring fine gas quality control to maintain high quality products.

  But originally gas quality of LNG is very stale ,so gas quality control is easy at the moment.

- In recent years, the hurdle to achieve the target has become higher due to the new developments in the gas industry including the introduction of third party access and biogas injection into pipeline.

- In the near future, the gas utilities may have to deal with new types of unconventional gases such as shale gas and coal bed methane as their supply gas.

  In case they cannot modify the calorific value of such gases to the current level, they must introduce a solution to the problem, such as installing Wobbe controllers to the gas appliances at the industrial customers' sites.

- Emergency temporally supply of natural gas , gas quality change largely.

  Especially gas engine is needed adjustment for the gas.

Thank you for your attention!

▪ Under these circumstances, the Japanese gas companies have established their own provisions for gas supply and has set the terms and conditions for quality of gas to be received from outside to maintain the quality of supply gas on the standard level for the gas appliances at their customers. This report explains the current status of gas quality issues in Japan and measures taken by gas utilities to secure the quality standard.

	Standard 13A	13A-1	13A-2	13A-3
CH4	88.9	85.0	55.0	98.0
C2H6	6.8	0	0	0
C3H8	3.1	15.0	15.0	0
C4H10	1.2	0	0	0
Others	0	0	H2 : 30.0	N2 : 2.0
Heat Value (MJ)	45.00	49.15	37.05	39.1
Heat Value (kcal/m3)	10,750	11,741	8,851	9,840
Specific Gravity	0.638	0.705	0.494	0.563
Combustion Velocity (cm/s)	37.00	37.70	47.30	36.00
Wobbe Index	56.40	58.50	52.70	53.10

Knocking Index : NGKI

- NGKI: Natural Gas Knocking Index < 15
- NGKI=λX0.125 × [H2]+0.20 × [C2H6]+0.38 × [C3H8]+1.00 × [n-C4H10]+0.85 × [i-C4H10]
- λ: =Excess Air Ratio 空気過剰率
- [ ] Concentration of Component　各成分の容積百分率御
- Suitable Air ratio 1.0 - 2.4　燃料ガスの理論空気量
- Ref.　Typical Air ratio
- 理論混合比ガスエンジン=1.0
- 単室式希薄燃焼ガスエンジン= 1.5 〜1.7
- 副室式希薄燃焼ガスエンジン= 1.8 ~2.4
- 水素 [H2]=0 〜 15%
- エタン [C2H6]=0 〜10%
- プロパン　[C3H8]=0 〜 15%
- nブタン　[n-C4H10]=0 〜10%
- I ブタン　[i-C4H10]=0〜5%