Social Implementation of Synthetic Methane
to Achieve Carbon Neutrality

2022/3/25

Tokyo Gas Co,. Ltd.
Tokyo Gas's Steps Toward Achieving Carbon Neutrality by 2050

Tokyo Gas will contribute to the carbon neutrality by 2050 through the following three perspectives and measures:

1. Decarbonization/green transformation (GX)
2. Improving resilience of energy supply
3. Effective utilization of existing infrastructure

Digital technologies are actively and effectively used in all measures.

From the perspective of minimizing additional social costs, synthetic methane is an effective solution for the mid to long-term active decarbonization measure of gas energy.
Group Management Vision and Initiatives for Carbon Neutrality

- Further accelerate actions in order to achieve "net zero CO₂ emissions.
- As part of our challenge decarbonizing gas, we have set a new target of 1% synthetic methane of our city gas supply by 2030.

### Milestone in 2030

- **Contribution to CO₂ reduction**: 17 Mt
- **Synthetic methane**: 1% of city gas
- **Hydrogen cost**: Lower than 3 $/kg
- **Renewable energy**: 6 GW

### Use natural gas as low-carbon solutions

- **Sophisticated use**

### Decarbonize gas & electricity

- **Creation of new strengths**

### Contribute to CO₂ reduction at customers

- **Use natural gas as low-carbon solutions**
- **Sophisticated use**
- **Decarbonize gas & electricity**
- **Creation of new strengths**

### Reduce in-house CO₂ emissions

- **Thorough elimination**

### Transition toward decarbonization

- **2030**
  - **Reduction contribution**: 17 million tons
  - **Accelerate carbon neutrality**

- **2040**
  - Deployment of decarbonized energy in society (Methanation pilot projects, offshore wind farm operation)
  - Phase for achieving decarbonized society (Commercial scale methanation; expand use of renewables)

- **2050**
  - Expand deployment of carbon-neutral methane

### Carbon-neutral methane: Transition to large-scale & high-efficiency methanation and commercial use

- **Launch small-scale pilot projects**
- **Implement medium-/large-scale pilot projects**
- **Expand commercial use**

### Gas

- **Switch from coal, oil, etc. to natural gas as fuel, introduce cogeneration systems, develop smart cities, strengthen resilience in Japan and global markets**
- **Increase provision of carbon-neutral LNG (CNL)¹ / Expand use for balancing renewable power**
- **Develop & expand CCU²**
- **Expand commercial use of CCUS**

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### Hydrogen: Establish practical, affordable hydrogen production technologies

- **Develop technologies for low-cost hydrogen production**
- **Practical use of the technology**

### Expand renewable energy installation

- ** Increase solar, wind & biomass power generation**
- **Develop low-cost technologies for constructing floating offshore wind power**
- **Realize practical deployment & scaling up**
- **Active employment of hydrogen (including procurement)**
- **Introduction at a timing of replacement**

### Achieve zero emissions in our own thermal power plant

- **Active employment of hydrogen (including procurement)**

### Achieve net-zero CO₂ in city gas production

- **Implementation at our facilities: Ultra-high efficiency fuel cell, solar power generation (self-consumption), CCU, CNL, etc.**

### Switch company vehicles to HEV, FCV & EV³

- **Net-zero of in-house emissions**

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¹: A type of LNG that is deemed carbon neutral as greenhouse gas emissions generated by the processes from natural gas exploration to combustion are offset with carbon credits received on forest conservation projects, etc.
²: Carbon capture & utilization
³: Hybrid electric vehicles, fuel cell vehicles & electric vehicles

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Promotion of hydrogen supply chain (production, supply, and utilization)

- Promoting overall hydrogen supply chain development in Japan and overseas to expand the hydrogen business.
- Considering on-site hydrogen production and utilization in Japan, and transportation of hydrogen from overseas to Japan by energy carriers like synthetic methane, NH₃, liquefied H₂, chemical hydride.
- Hoping to work with partners to enter the green hydrogen market in Japan and overseas, which is expected to grow in the future.

**Production**

- Development of low cost water electrolyzer
  - Low-cost water electrolysis technology required for green hydrogen production is under development.
  - Considering the use of this technology for methanation and new hydrogen businesses.

- Onsite H₂ production
  - Small to large hydrogen production equipment has been developed to meet a wide range of hydrogen demand for industrial users.

**Transportation**

- Local hydrogen network
  - Construction and operation of pipelines dedicated to hydrogen in HARUMI FLAG*

- **H₂ pipelines in Tokyo bay areas**
  - Dehydrogenate from energy carriers and supply of H₂ to power generation applications and industrial applications via pure H₂ pipelines.

**Utilization**

- Energy supply using H₂ local network
  - In Harumi area, heat and power will be supplied using fuel cells.

- **H₂ refueling station (4 stations)**
  - Toyosu Station supplies carbon-neutral hydrogen* and has the highest annual hydrogen refilling volume and frequency in Japan.

- **Utilization of synthetic methane and H₂**
  - Supply chain of synthetic methane

*Plan to redevelop the former site of the Tokyo 2020 Olympic and Paralympic Village

*Hydrogen produced using CNL as raw material (electricity used is 100% renewable energy)
Heat demand and the importance of its decarbonization

- Heat demand accounts for 60% of Japan's energy consumption in the commercial and industrial sectors. It is difficult to meet the high-temperature heat demand of the industrial sector by only electrification.
- To achieve carbon neutrality by 2050, decarbonization of the heat demand sector is important, and decarbonization of gas, which supplies heat energy to the demand side, will play a major role.

### Energy Consumption by Use in the Commercial and Industrial Sectors

- **Power demand**: 28.5%
  - Energy consumption in the consumer and industrial sectors (9,700 PJ)
- **Process demand**: 62%

### Heat demand in the industrial sector by temperature range

- Machinery Manufacturing
- Steel industry
- Cement industry
- Polymer industry
- Chemical industry
- Textile industry
- Food industry

*presented by METI at Basic Policy Subsection Meeting*
CO₂ recycling through the use of synthetic methane

- Synthetic methane is produced by reacting hydrogen with CO₂ recovered from factories or thermal power plants.
- The utilization of synthetic methane does not increase CO₂ in air overall.
- The advantage of synthetic methane is that existing infrastructure (LNG facilities, gas pipelines, gas equipment, etc.) can be used without any modification and additional costs.

Renewable energy

Green H₂

4H₂+CO₂ → CH₄+2H₂O

Domestic model

Synthesis

CH₄

Distribution

CO₂ recycle

Power plant etc.

Capture

Utilization

Emission

CO₂

Global supply chain of synthetic methane
Roadmap for social implementation of synthetic methane (1% adoption by 2030)

- Utilizing existing methanation technology, conduct a small-scale demonstration (Step I, ~50,000 m³/y) from the end of FY 2021 and a middle-scale demonstration (Step II, approximately ~ 1.6 million m³/y or equivalent) in the late 2020s.
- We will also promote the development of innovative methanation technologies for future cost reduction and realize the introduction of 1% synthetic methane (approx. 80 Mm³/y) in 2030 through a large-scale overseas demonstration (Step III).

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### Establishment of technology

- **R&D of innovative technology**
- **Prototype of innovative technology**
- **Innovative technologies: hybrid sabatier, PEMCO₂ reduction, bioreactors, etc.**
- **In-house demonstration**
- **Apply to e-fuel**

### scale-up

- **STEP I**
  - Domestic small-scale demonstration
  - Plant scale: 12.5 Nm³/h
  - 1.6 Mm³/y

### social implementation

- **STEP II**
  - Domestic middle-scale demonstration
  - Plant scale: ~400 Nm³/h

- **STEP III**
  - Large-scale overseas demonstration and supply chain establishment
  - Plant scale: ~20,000 Nm³/h

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Social Implementation Initiatives of Synthetic Methane

- **Small-scale demonstration**: We have started a small-scale demonstration experiments of technology and collaboration for regional carbon-neutrality, and will acquire the skill and know-how for scaling up to mid-scale.

- **Mid-scale demonstration**: We will promote social implementation through conduit injection of the produced synthetic methane, on-site utilization, and regional cooperation toward large-scale production overseas.

### Small

**Demonstration at Tokyo Gas’s facilities (12.5 Nm³/h) and regional collaboration**

- **Period**: Since March 2022 small-scale demonstration in Yokohama has started.
  - Regional collaboration with Yokohama City facilities, etc. is undergoing

- **Feature**:
  - Electricity: Optimization of renewable energy and grid power
  - CO₂: Receive and utilize CO₂ from neighboring facilities.
  - Others: Linkage of recycled water, biogas (digestion gas), CO₂, etc. with surrounding facilities of Yokohama city.

- **R&D**: Existing technologies (Sabatier) will be tested and innovative technologies will be also developed.

### Middle

**Domestic regional cooperation and on-site use (100 Nm³/h scale)**

- **Period**: Middle-scale demonstration + regional collaboration and on-site use demonstration planned from mid-20s.
- **Feature**: Production and utilization, and pipeline injection are planned for optimal utilization of resources in industrial areas, large consumers and specific regions in Japan.
- **Examples**: Employment of synthetic methane in cement, chemical and steel plants.

**On-site utilization model**

- Renewable energy
- CO₂
- Electrolyzer
- Methanation plant
- Hydrogen storage tank
- Gas appliances
- Control unit
- Exhibition room
- CO₂ storage tank
- Methanation plant
- Electrolyzer
- Solar panel
- Regional Cooperation Model

(Cement. chemical ad steel industry)

(municipalities, industrial parks, etc.)
Key points to implement synthetic methane in society in 2030

- We will introduce synthetic methane equivalent to 1% of city gas by 2030.
- Key points are 🛠 R&D (large scale of synthetic methane) 🛠 Partnership 🛠 Institutional design and Public support.

Commitment of Tokyo Gas

- Aiming to introduce 1% by 2030 has been set as one of the main measures to achieve the corporate vision to reach carbon neutrality by 2050 as soon as possible.
- Multiple actions across the company groups to achieve the goals.

Focusing points

🛠 R&D (scale-up)
- Cost reduction by various technology options
- Development of innovative technologies for methanation and hydrogen production
  ✓ Also in related technologies synthetic methane: CCUS, DAC
- Technological verification through demonstration and with scale-up of plants

🛠 Partnership
- Extensive partnerships with leading domestic and international players
  ✓ Collaboration and portfolio management across city gas industry
  ✓ Supply chain development (trading companies, NOCs, IOCs and other LNG companies, customers, local governments)
  ✓ Engineering collaboration and open innovation (manufacturers, research institutions, start-ups, etc.)

🛠 Institutional design and Public support
- Ongoing support for technology development according to phase, including elemental technology development, demonstration testing, and social implementation
- Institutional Design for Establishing the Environmental Value of Synthetic Methane
- Public support for social implementation, design of incentives for customers to use synthetic methane, etc.
• The cost of synthetic methane in 2030 is estimated still much higher than the target price (equivalent to LNG price), even assuming lower the cost of electrolyzer and the securing of inexpensive renewable power from overseas.
• To expand the introduction of synthetic methane, it is necessary to reduce costs through innovation and to bridge the price gap between synthetic methane and LNG through multiple measures.

Cost Image of Synthetic Methane

**Issues**

- Technologies that contribute to improve energy conversion efficiency and lower equipment costs.
- Technologies to produce hydrogen from green electricity at higher efficiency and lower cost.
- Procurement of inexpensive renewable electricity for green hydrogen production.
- Public support to bridge the gap between synthetic methane and current LNG price.
- Return of the environmental value of the produced synthetic methane to user.

**Measure**

1. **Innovative R&D**
   - Low-cost hydrogen production technology
   - Innovative methanation technology
   - Other technologies related to synthetic methane value chain

2. **Partnership**
   - Collaboration across and beyond the gas industry
   - Collaboration with research institutions and start-ups
   - Customers, trading companies, engine manufacturers, different industries, local governments, etc.

3. **Institutional design and support**
   - Institutional Design for Establishing the Environmental Value of Synthetic Methane
   - Public support for social implementation
We are currently working with local energy companies and trading companies on feasibility studies in Malaysia, North America, Australia, and other regions.

In addition, we are exchanging information on synthetic methane, hydrogen carriers, biogas, and other initiatives with a wide range of overseas energy companies to accelerate partnership actions toward the decarbonization of gaseous energy and its implementation in society.

The LNG market in Southeast Asia is expected to a further growth. We are looking for an opportunity to support the introduction of synthetic methane in those Asian market through cooperation among respective parties (operators etc.).
In order to carry through responsible transitions toward a carbon neutral society, we will continue to implement the most appropriate ways and hydrogen carriers, considering the time frame and technology maturity, while advancing the smart use of natural gas and the introduction of carbon-neutral LNG in the immediate future.

In the future, we will contribute to local and global carbon neutralization as a decarbonizing energy player in the thermal demand sector and create new decarbonization model originating from Japan. With such, we can play a role in the construction and social implementation of a synthetic methane/hydrogen value chain from Japan to other Asian countries with the cooperation of all concerned parties and stakeholders.

Furthermore, our decarbonization challenge in the thermal demand sector is not only with synthetic methane(methanation) but through innovation and collaboration with other industries to seek for other wider fields such as synthetic fuels(e-fuels, etc.) with which we have high technological affinity.