



# Gas Field Development - Challenges and Current Best Practices to Maximise Value

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# Introduction of a Field Development Project for Gas Dissolved in Water in Japan

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# ENEOS Group's BUSINESS & Company ACTIVITIES in JAPAN

 <p>Energy Business <b>ENEOS</b></p>	 <p>Oil and Natural Gas Exploration and Production Business <b>JX Nippon Oil &amp; Gas Exploration</b></p>	 <p>Metals Business <b>JX Metals</b></p>
 <p>High Performance Materials Business <b>ENEOS Materials</b></p>	 <p>Electricity and City Gas Business <b>ENEOS Power</b></p>	 <p>Renewable Energy Business <b>ENEOS Renewable Energy</b></p>

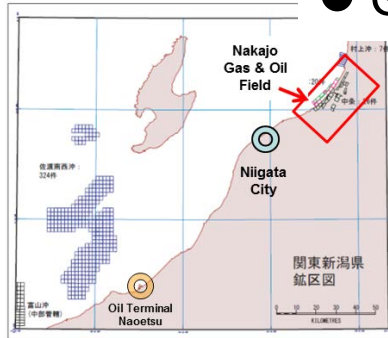
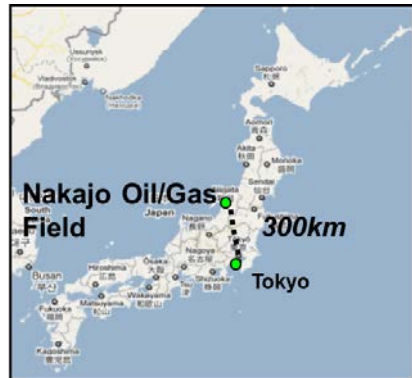
We believe the mission of Japanese energy companies is to secure energy sources in Japan.  
We aim to secure a stable energy supply by continuing to explore promising areas of Japan.



- JX Nippon Oil & Gas Exploration is the group company of ENEOS
- JX Nippon Oil & Gas Exploration has several exploration blocks, while Nakajo Oil & Gas Field is only the production area in Japan

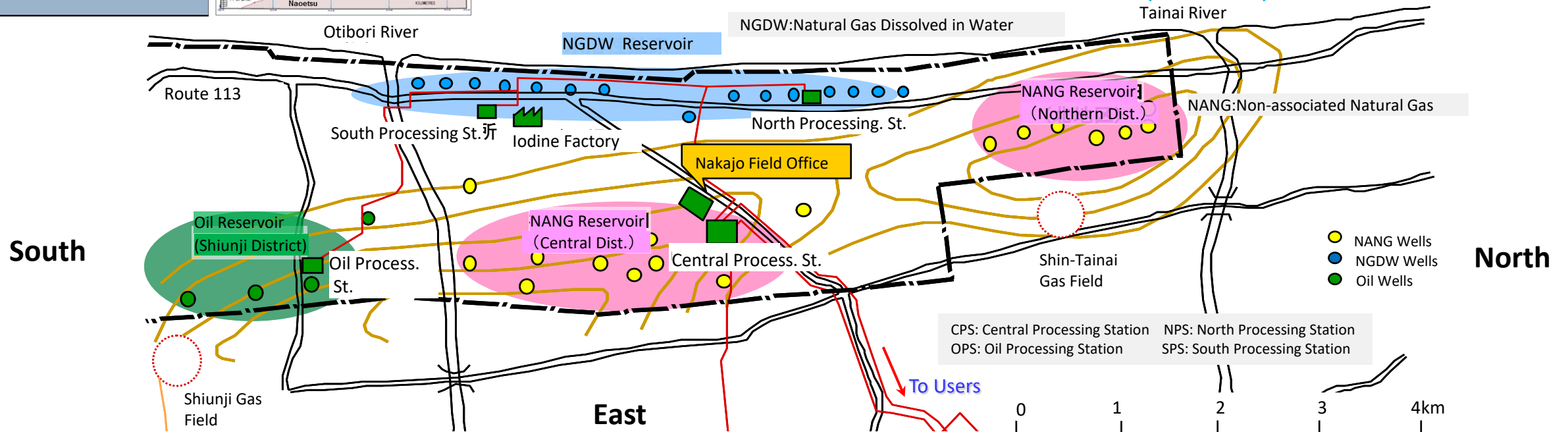
# Nakajo Oil & Gas Field Location Map

- Location: about 300 km North of Tokyo / about 40 km North-East of Niigata City.
- Gas/Oil Concession Area: 12 km North to South and 2 km West to East.



Nakajo Fields have several reservoirs;

- Non-Associated Natural Gas Reservoir (NANG)
- Oil Reservoir
- Natural Gas Dissolved in Water Reservoir (NGDW)



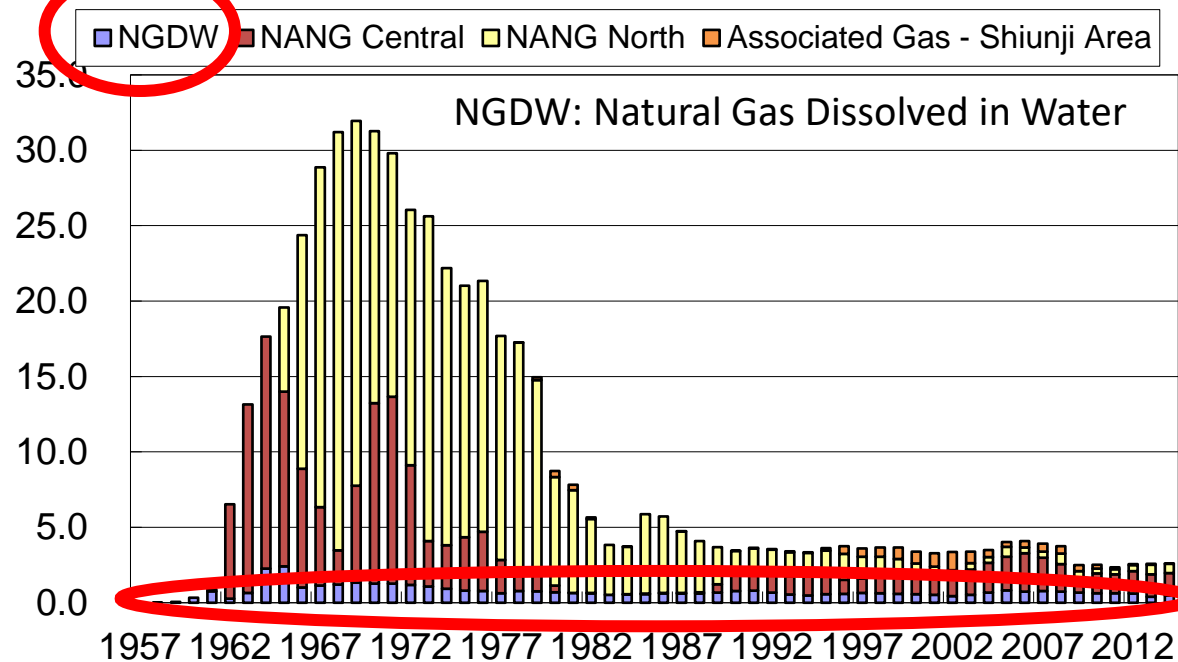
# Production History of Nakajo Oil & Gas Field

## Average Production Rate (2023)

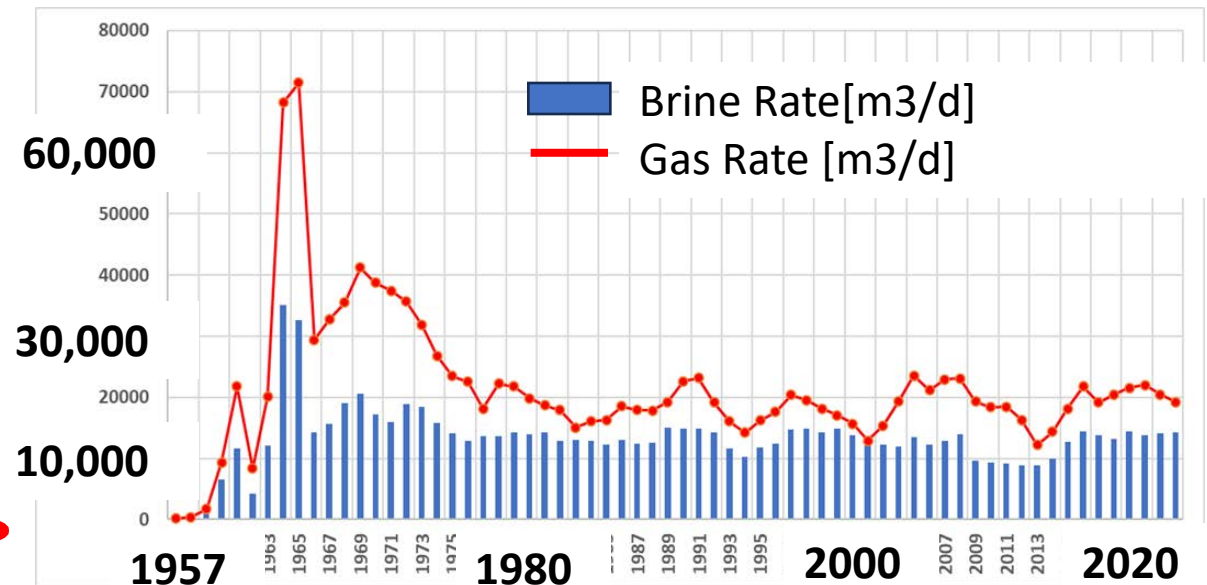
- Gas 2-3MMscf/d
- Oil 10-20 stb/d
- **Iodine 200-300t/year**
- Hot spring Water 60-70 t/d

- Non associated gas used to be dominant in the past, but it declined in 1980's.
- Gas from Brine is small portion, but Iodine extracted from Brine is the most profitable products in these days.

## Production History of Gas [MMscf/d]



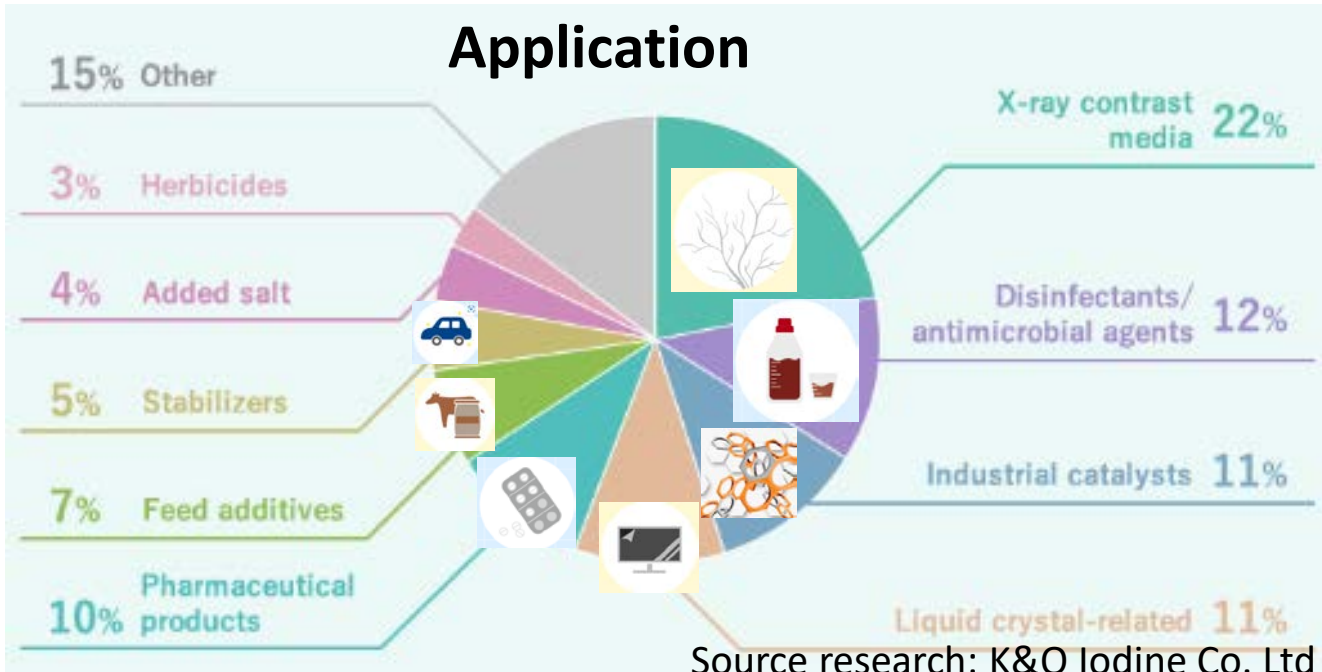
## Production History of Brine [m3/d]



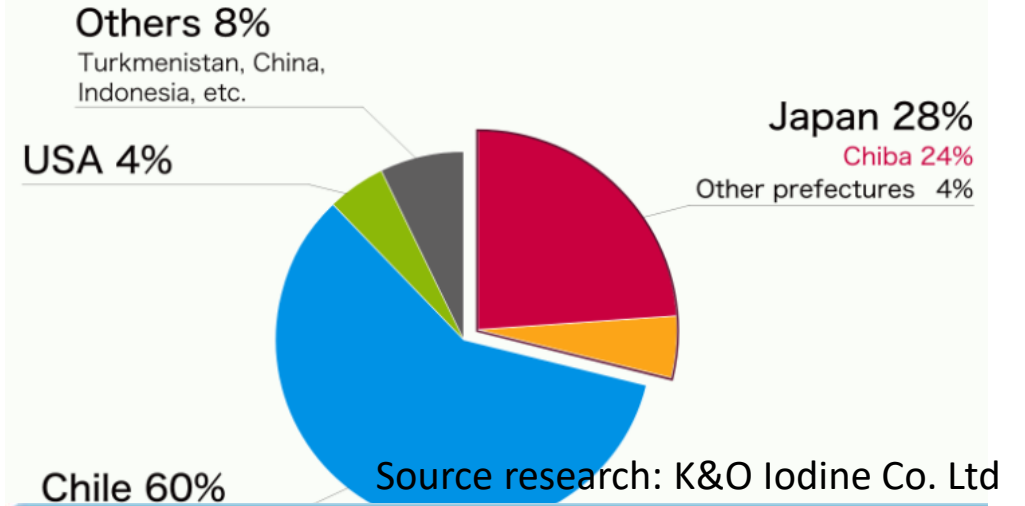
# About Iodine...

- Iodine is produced by only limited countries
- Iodine is used for many purposes
- Global iodine market is expanding gradually

## Application

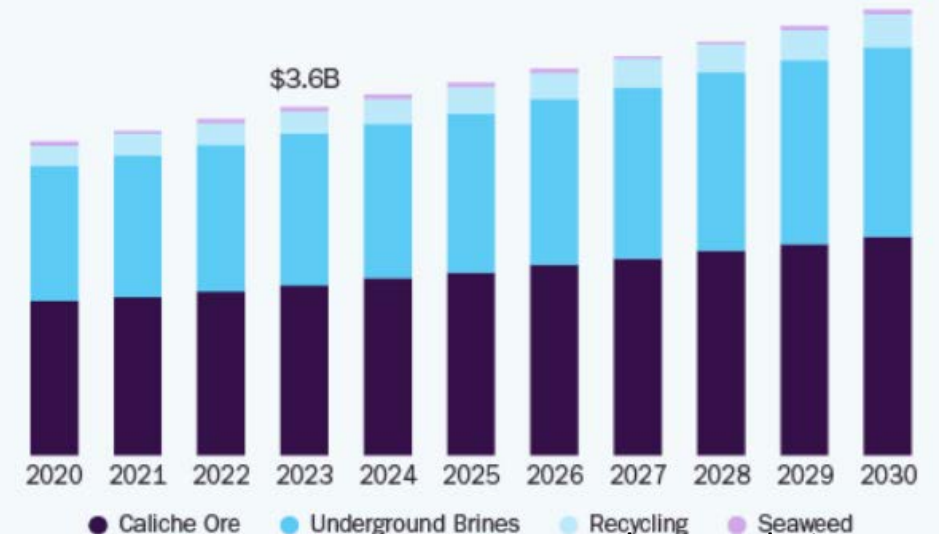


## Production Share by Country



## Global Iodine Market

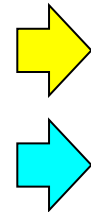
Size, by Source, 2020 - 2030 (USD Billion)



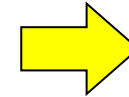
# Flow Diagram of Natural Gas Dissolved in Water Wells



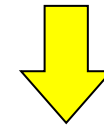
**No naturally flowing wells  
(Low reservoir pressure)**



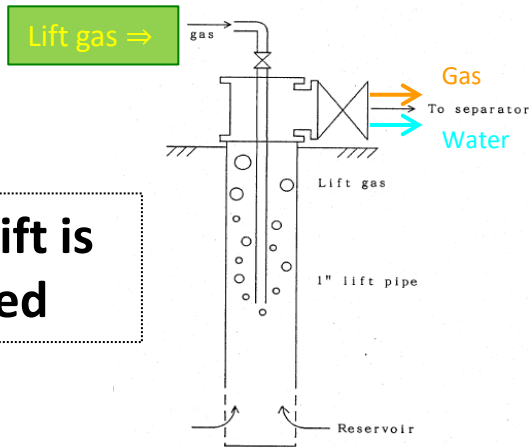
Natural gas to North or South processing station



**Central Process Facility**



**Natural Gas is exported to  
Local Consumption**



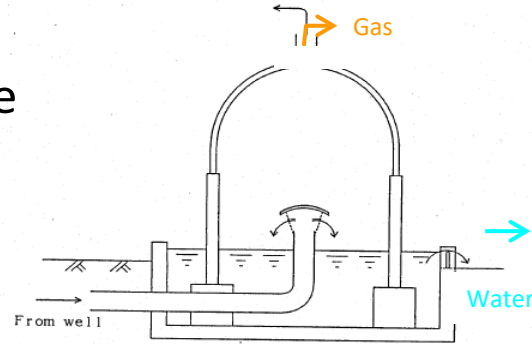
**Gas Lift is applied**

**Injecting Lift Gas**



**Hot SPRING**

Brine



Brine



**Iodine  
Factory**

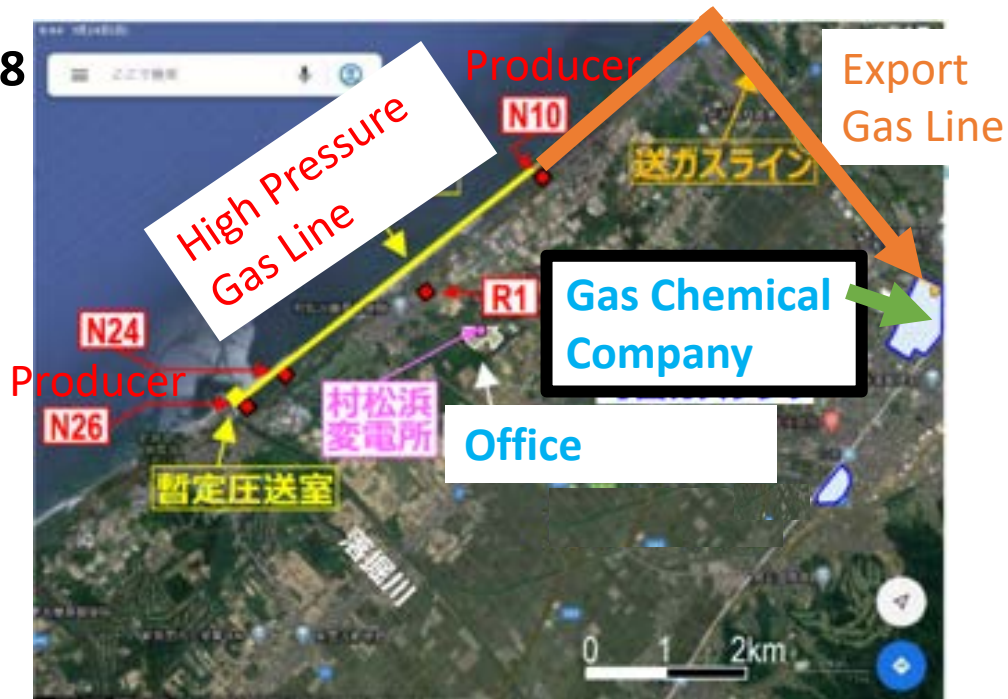
**Iodine is exported to  
overseas market mainly**



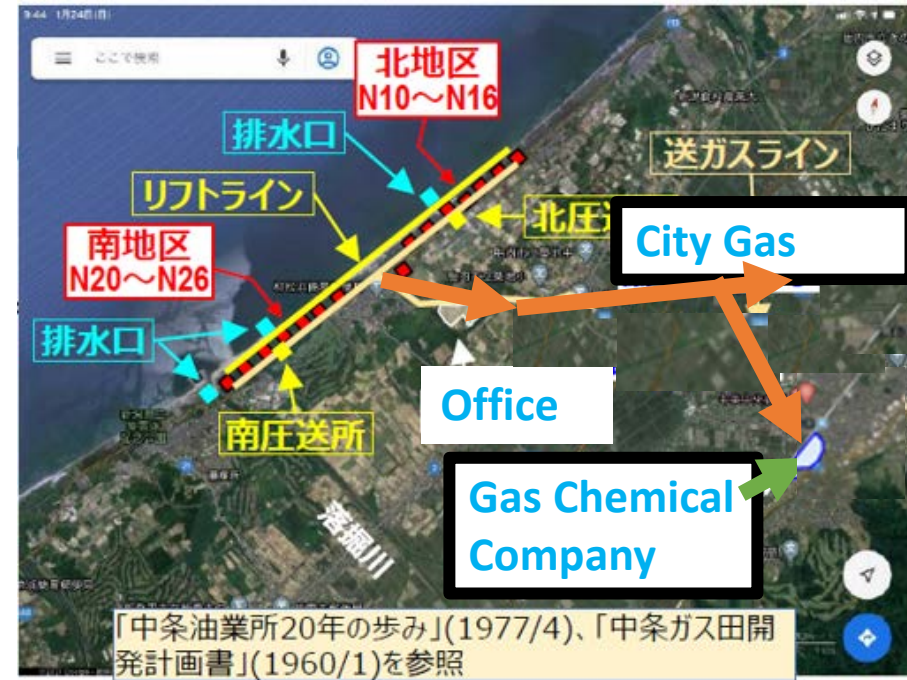
# Challenges: Establish the Local Gas Consumption System

- There was no sales market for the produced natural gas at the time of gas discovery
- ⇒ To utilize this gas resource, a local gas chemical company was established in cooperation with other companies in 1958
- ⇒ Gas market is expanded locally and currently gas is exported for city gas, chemical company and so on.

In 1958



Current





## Challenges: Estimation of Permeability

- Subsurface evaluation required to optimize field development and production
- However, no available core is taken due to unconsolidated sandstone reservoir in the past
- Only has the image of high productivity from production performance without no measurement of permeability
- The well is producing over  $1,000\text{m}^3/\text{d}$  (more than  $6,000\text{bbl}/\text{d}$ ) with small drawdown.

How to estimate the permeability...??



# Challenges: Estimation of Permeability

- Well permeability through back calculation using Darcy's law from the productivity index

$$P.I = \frac{Q_w}{(SIBHP-FBHP)}$$

$$P.I = \frac{7.08 \times 10^{-3} kh}{\mu B_o \left( \ln \frac{r_e}{r_w} - \frac{3}{4} + s \right)}$$

- There is no pressure gauge in the well
- Water level is measured during annual regular maintenance, which is converting static reservoir pressure
- Water level during the flow period can be measured from some particular wells (ESP packer less Completion)
- Well permeability is estimated from back calculation using Darcy' law under the assumption of Skin and vertical net thickness

## Measurement of water level



## Summary

- The Nakajo gas field is one of the largest gas fields in Japan and JX has been operating for more than 60 years.
- The field is so unique that several reservoirs are existed in the area such as Oil reservoir, Non-Associated Gas reservoirs and Natural Gas Dissolved in Water reservoirs.
- The products from Natural Gas Dissolved in Water reservoirs is also unique. Iodine demand is rapidly expanding in the world, while providing area is so limited.
- JX has established the local gas sales market cooperating with some other companies at the timing of gas discovery
- Technically wise, permeability is estimated through back calculation using Darcy's law from the productivity index as best practice.