Energy and Green House Gas Mitigation Technologies

Japan Society for the Promotion of Science-Imperial College London-University of Tokyo Symposium on Climate Change

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Imperial College London, South Kensington Campus, London SW7 2AZ

Current State of Japanese Researches on Geological CO_2 Storage

JSPS London Symposium on "Energy and Greenhouse Gas Mitigation Technology"

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Outline of Presentation

- Introduction
- Geological CO_2 Storage in Aquifer
- Geological CO_2 Storage in Coal Seam
- Methane Hydrate Production by CO_2 Injection
- Estimate of Geological Storage Capacity
- Conclusion

Introduction

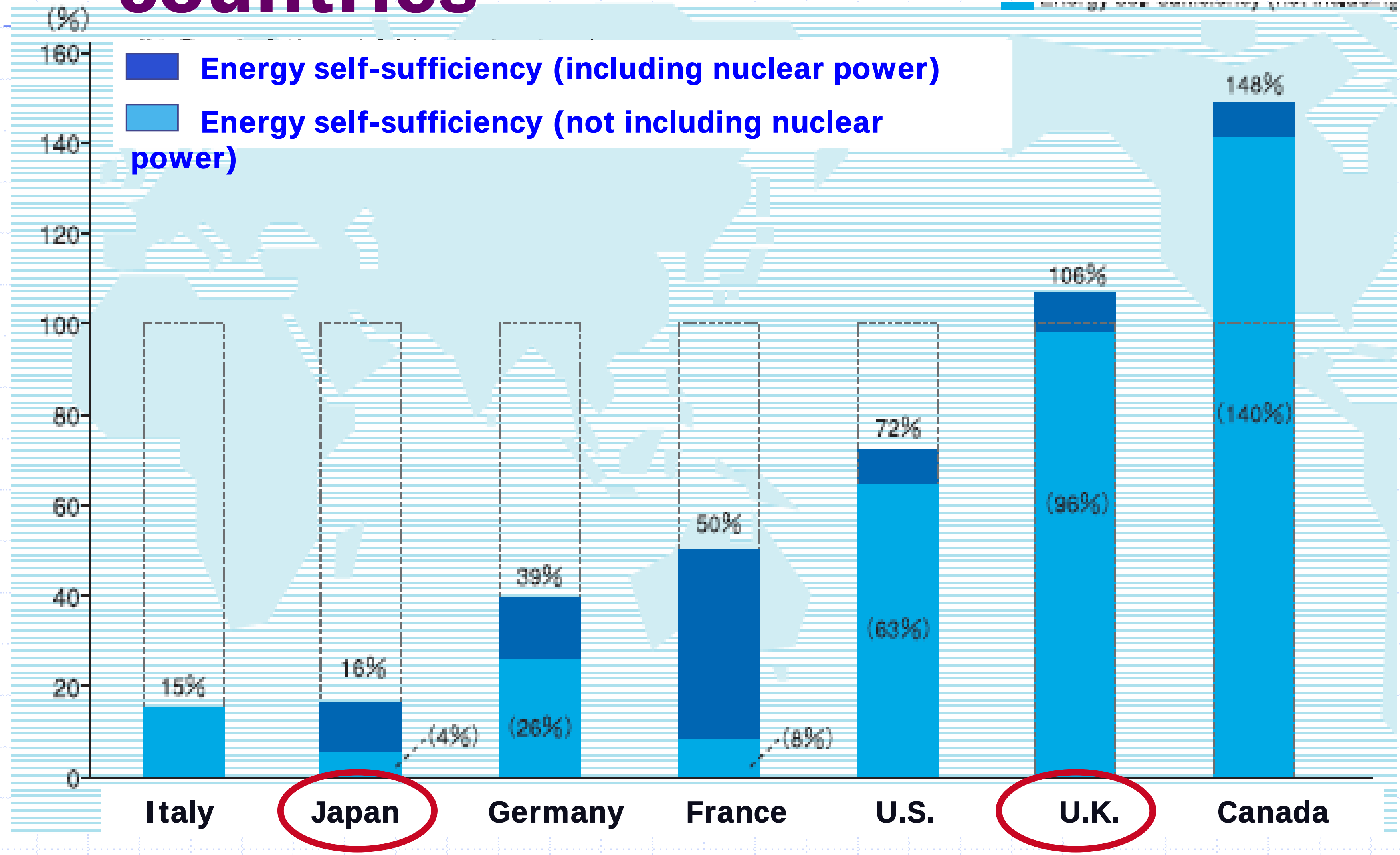
- Japanese issues on energy supply and GHG emission

1) Stable supply of primary energy resources

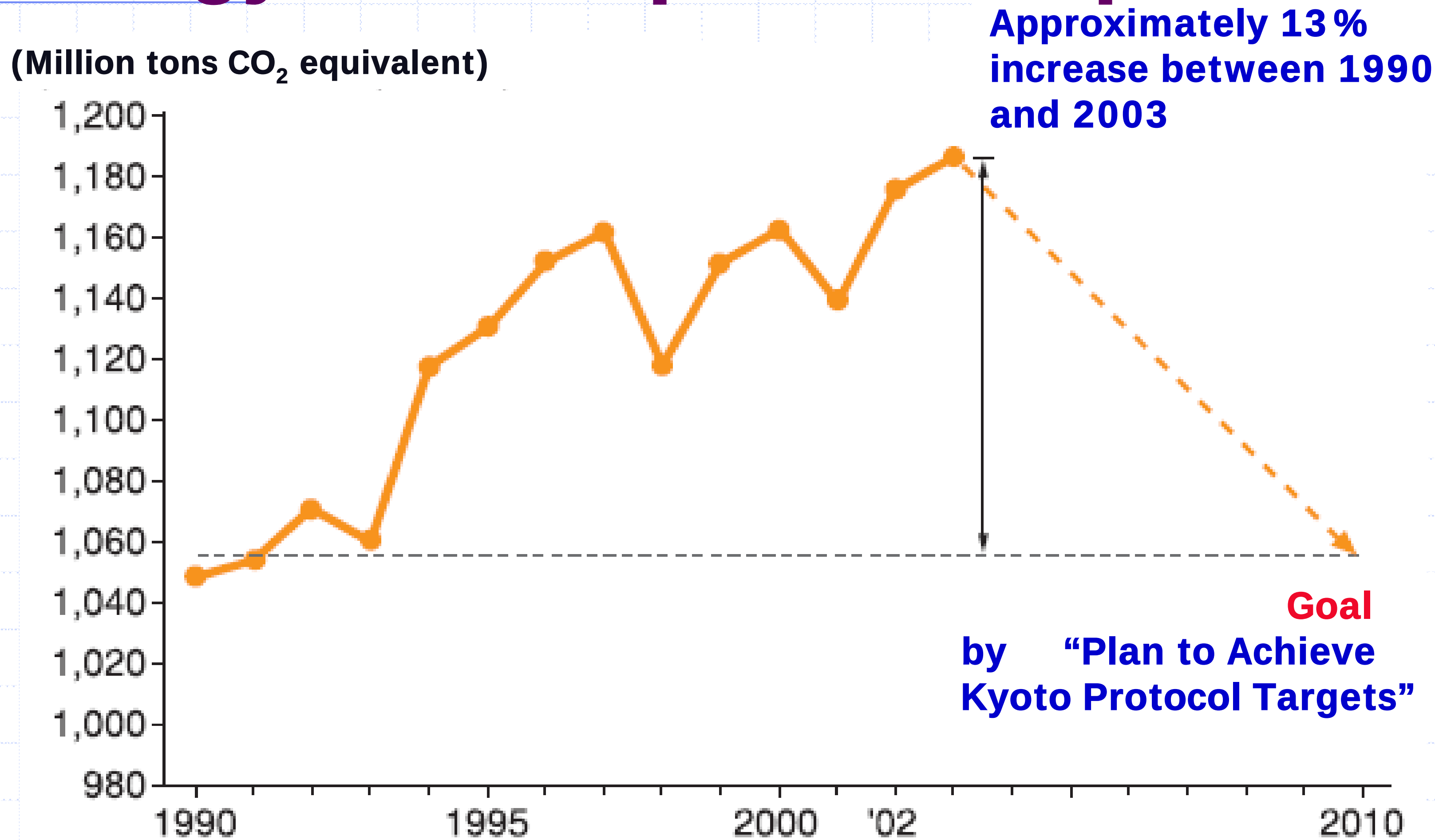
2) Increase energy self-sufficiency rate

3) GHG emission reduction (Kyoto protocol: GHG emission reduction by 6% against 1990 levels between 2008 and 2012)

Energy self-sufficiency of major countries



CO_2 emissions produced by energy consumption in Japan



Geological Storage of CO_2 in Aquifer at NAGAOKA

- Project sponsored by METI (Ministry of Economy, Trade and Industry)
- Project managed by:

*RITE (Research Institute of Innovative Technology for the Earth)

*ENAA (Engineering Advanced Association of Japan)

Project Outline

Objectives:

Establish a technology that provides stable, safe and long-term underground storage of CO_2 emitted from large-scale sources in Japan

Period:

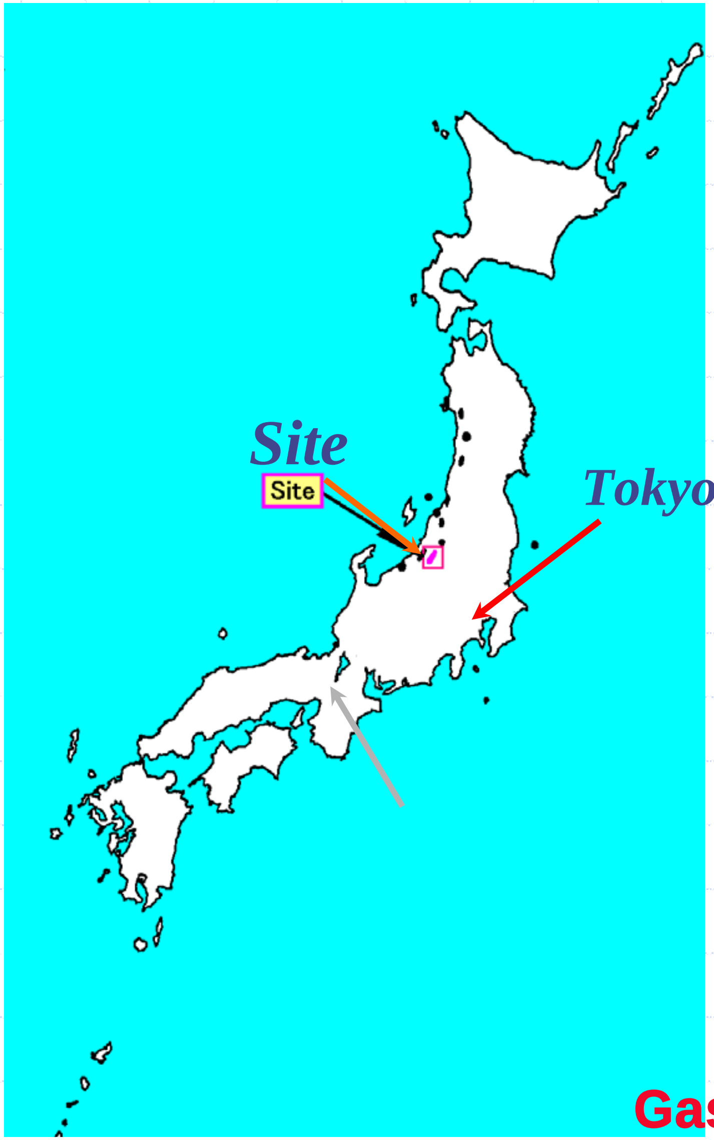
originally Planned for
2000 – 2004 (5 years)
now Extended until 2007
for more 3 years

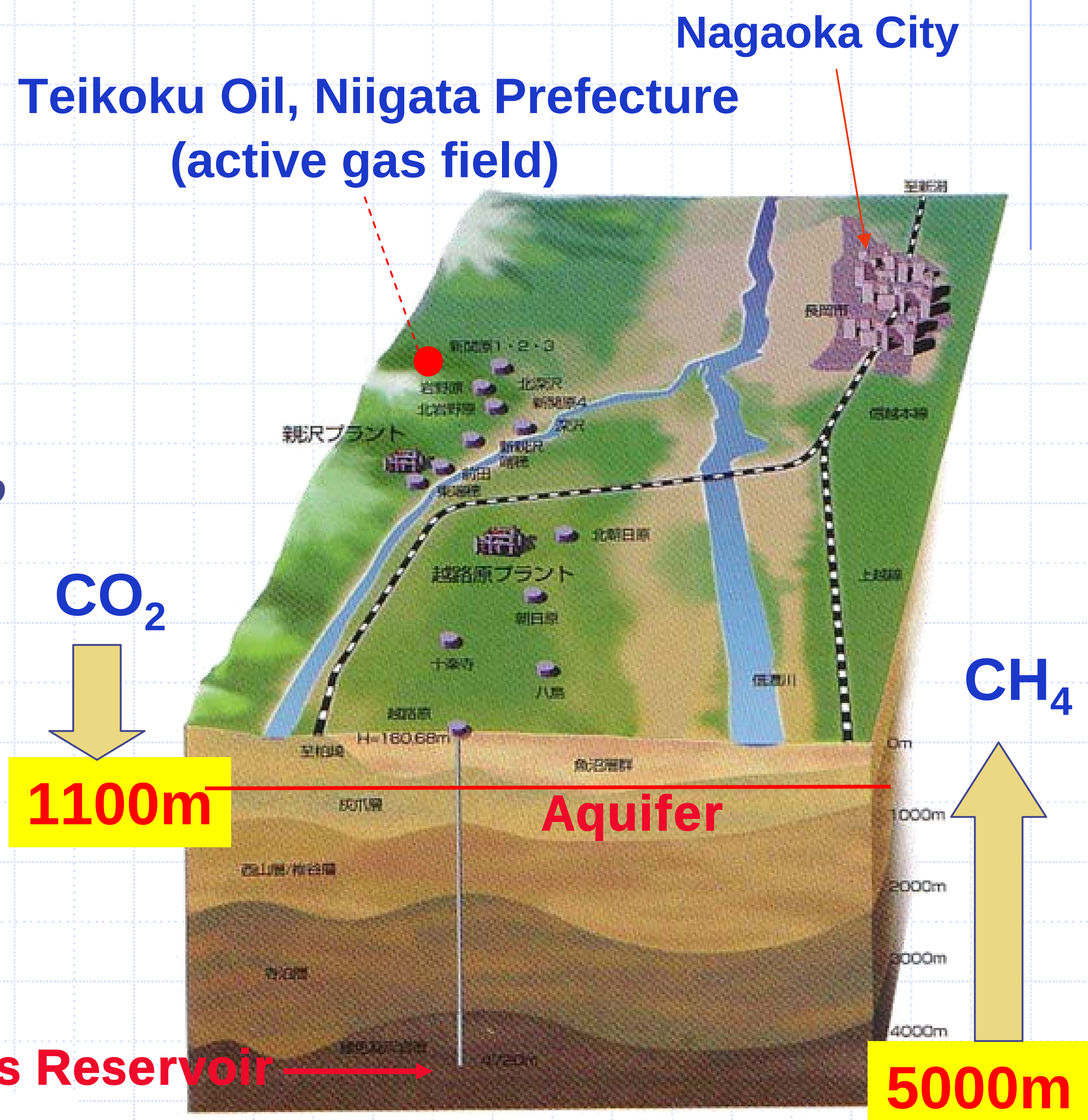
(Courtesy of RITE)

Budget/Expenditures

ca US$ 32 M for 2000 – 2004
ca US$ 30 M for 2005 – 2007

Field test site for CO_2 injection





Chronicle of Field Test

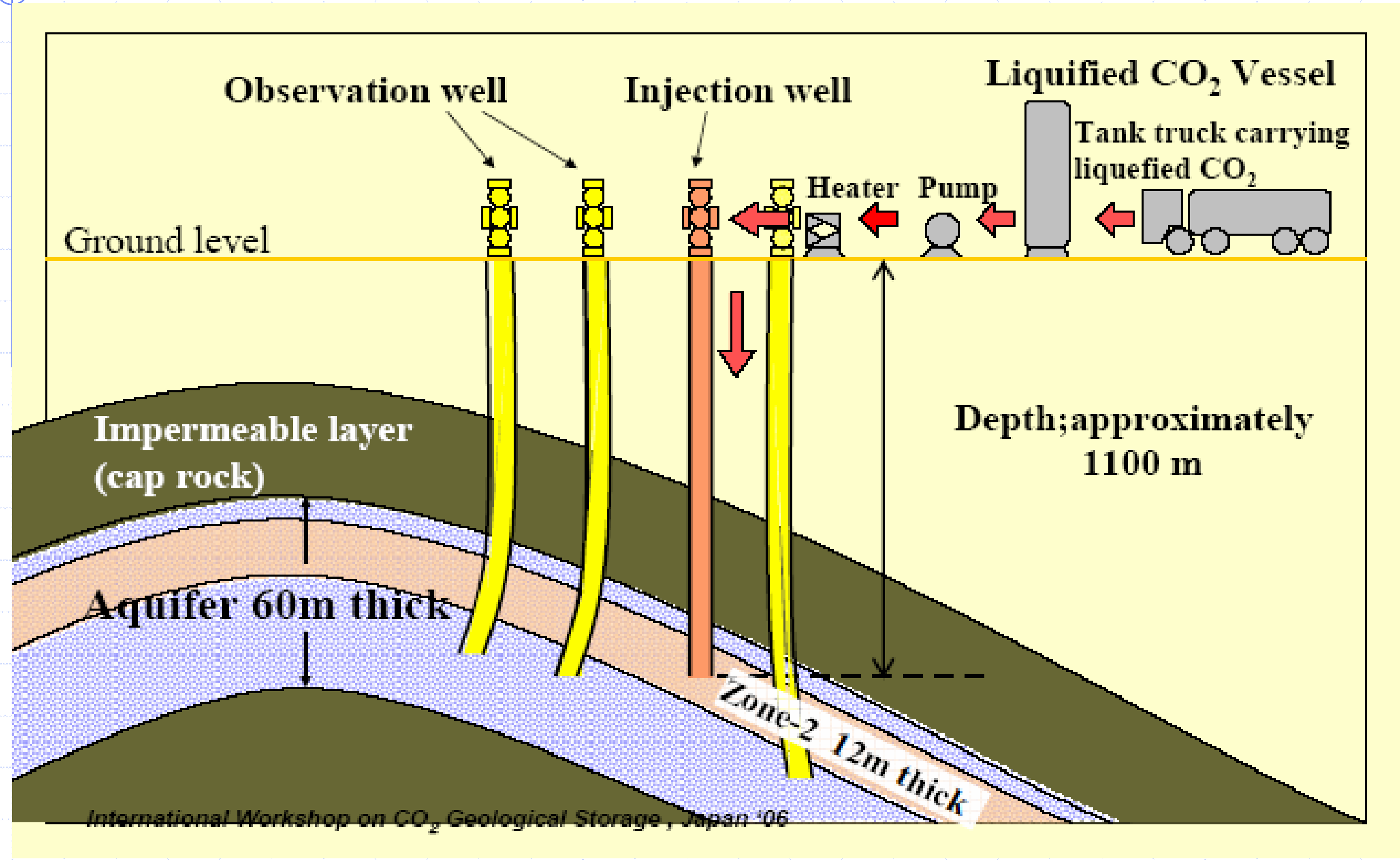
- FY 2000 : Site Selection - South Nagaoka Gas Field
- Drilling of Wells, Well logging and Test of Core Sample

  FY 2000 : Injection well (IW-1) drilled

  FY 2001 : Two observation wells (OB-2, OB-3) drilled

  FY 2002 : One observation well (OB-4) drilled
- FY 2003 : Construction of the Facilities
- FY 2003 – 2004 : Injection of CO_2・・・・ 10,405t
- FY 2002 – present :Monitoring of CO_2

Sketch of CO_2 Injection



Monitoring

- **Measurement** (continuously)

  Pressure & Temperature (well bottom and well head)
- **Time- lapse Logging** (at about one month interval)

  Induction Log

  Neutron Log

  Acoustic Log

  Gamma Ray Log
- **Time- lapse Cross- well Seismic Tomography**

  Six times : Before the injection – After the injection
- **Observation** (continuously)

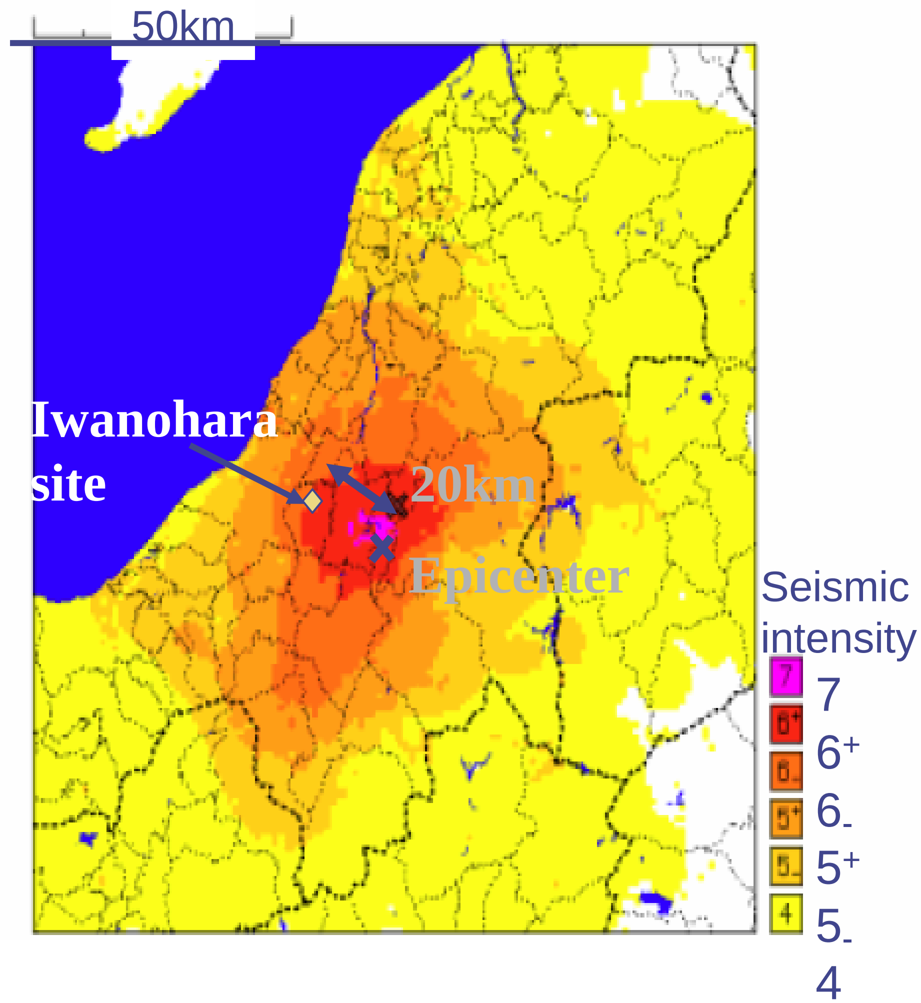
  Micro earthquake

Effect of Earthquake

<u>Niigata Chuetsu Earthquake</u>
Main shock: 23 Oct 2004
M6.8 at 10km depth
Seismic intensity: 7

Injection was automatically stopped at the main shock.
Safety inspection was made:
- Surface Inspection
- Pressure & Temperature
- Geophysical Logging
- Acoustic Borehole Televiewer
- Cross Well Seismic Tomography

Injection was carefully resumed after confirming safety (6 Dec 2004)
injection rate: 40t-CO_2/day



(GSJ, 2004 http://www.gsj.jp/jishin/chuetsu_1023/)

Results of Field Test

- 10,400 tons of CO_2 was injected into an onshore saline aquifer within eighteen months in Nagaoka, Japan.
- CO_2 breakthrough was detected and CO_2 saturation history was estimated by time-lapse logging.
- CO_2 distribution in the aquifer was recognized by crosswell seismic tomography.
- Using the final reservoir model of history matching, long-term fate of the injected CO_2 was predicted.
- The follow-up monitoring in Nagaoka will be continued till 2007.

Geological CO_2 Storage in Coal Seam at ISHIKARI

- Project sponsored by METI
- Project managed by

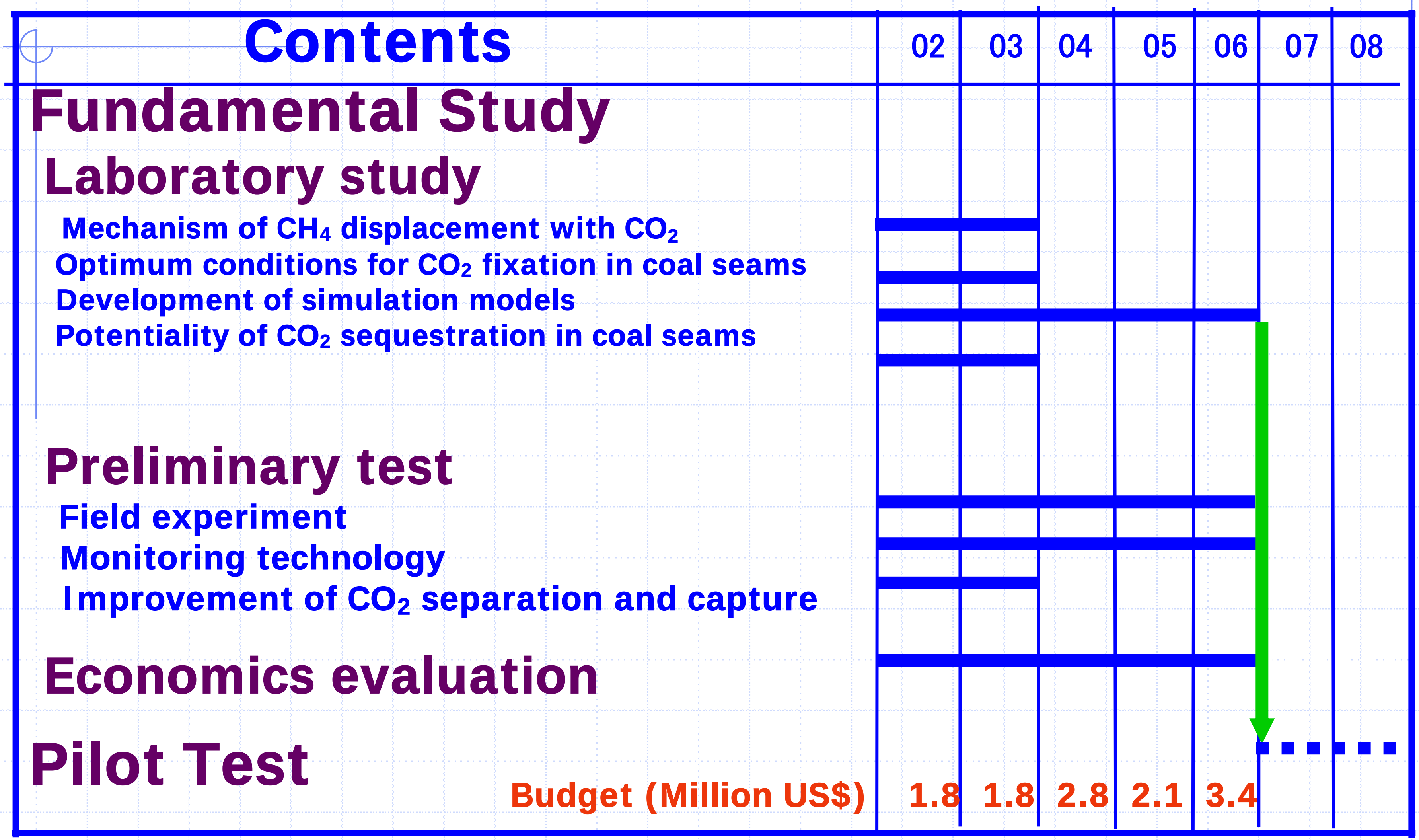
  JCOAL (Japan Coal Energy Center)

  KANSO (The General Environmental Technos Co., Ltd.)

Objectives

- Verify the CO_2 injection in Japanese coal seams in an efficient and safe manner
- Monitor the behavior of CO_2 injected in coal seams
- Identify Enhanced CH_4 Production
- Economic study of CCS using coal seams (ECBMR system)

Schedule of Project



Field Experiment Site Selection Criteria

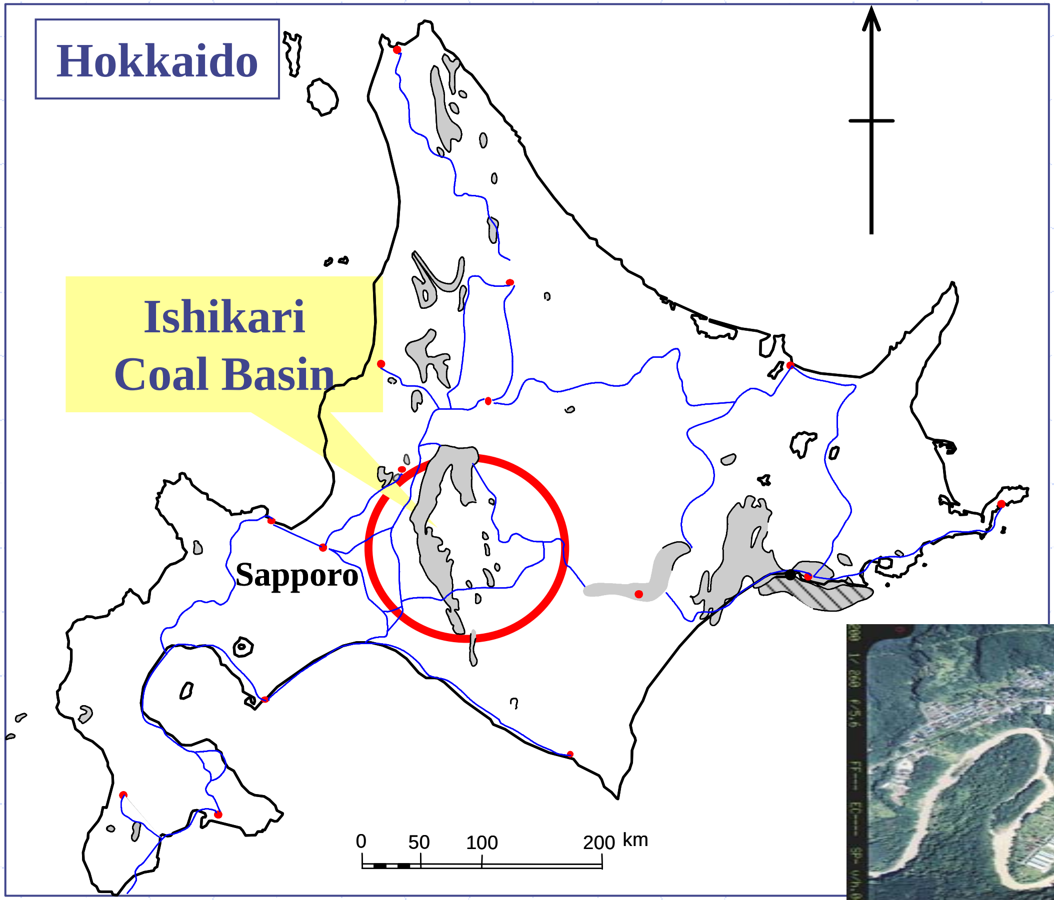
Field Condition:

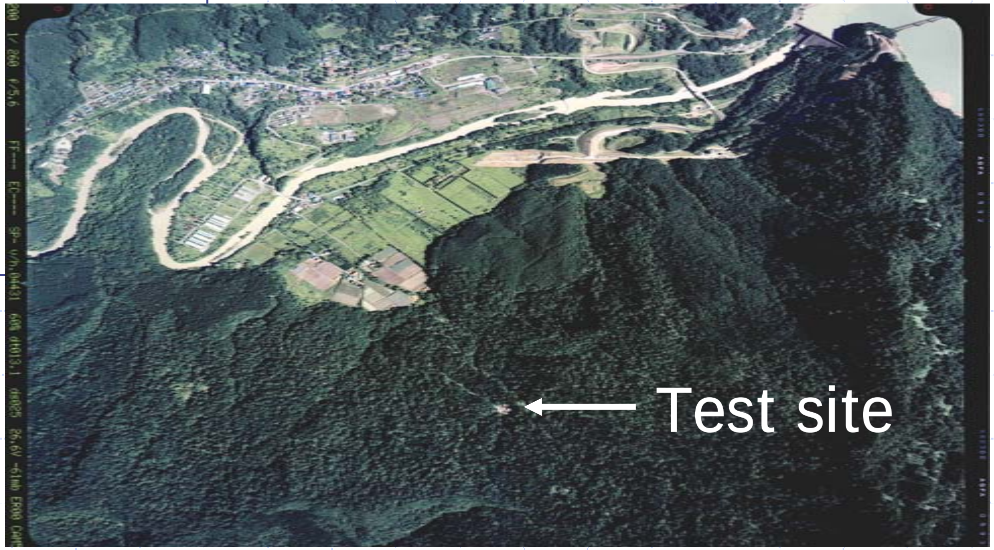
- Separated from mined-out area
- Detailed data on geological structure available

Geological Condition:

- Depth of coal seam: more than 500m deep
- Thickness of coal seam: more than 5 m
- Cap rocks: more than 250 m thick
- Detailed geological data available

Site Location



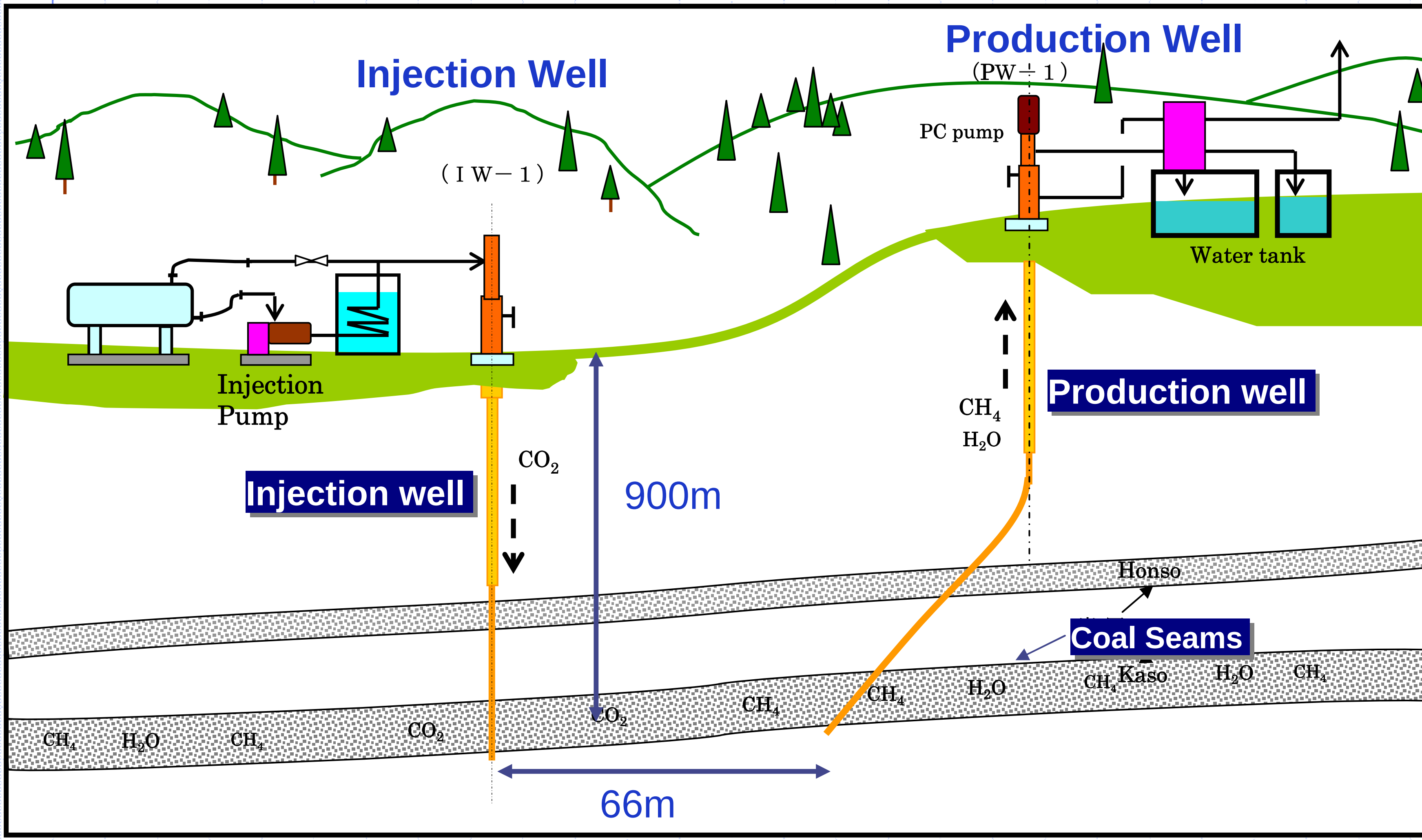


(Courtesy of KANSO)

Geological Formation

Formation	Depth(m) <Thickness>	Lithology
Horonai	0.00 - 678.00 <678.00>	Dark gray mudstone, dark brown mudstone
Yubari **(Main Coal Seams)**	678.00 - 916.20 <238.20>	Dark brown mudstone, siltstone, very fine to coarse sandstone, coal, coaly shale, black shale
Upper	**742.00 - 743.75**	True Thickness (1.52)
Middle	**851.20 - 853.70**	True Thickness (2.35)
Lower	**890.08 - 896.30**	True Thickness (5.64)
Horokabetsu	916.20 - 932.60 <16.40>	Dark mudstone

Outline of CO_2 Injection Tests



CO_2 Injection Site

Production Well Site

Monitoring in Field Experiment

Subject		Content	Method
Ground	Leveling	Geological Structure	Grade 1 measurement at the spots
	Tiltmeter	Near the surface	Measurement of tilting
Gas	Gas Concent-ration	Fixed point observation of ground gas	CO_2 & CH_4 gas concent. of ground gas by gas sampler
	Groundwater	Fixed point observation of groundwater	Water temperature, pH and conductivity at spring water
	Vegetation	Vegetation monitoring around well site	Survey of vegetation distribution

Summary of Field Experiment

- From the water injection test, the average permeability of coal seam was about 1.0 md. But, very low gas and water production rates were observed.
- Production damages was observed. This might be due to plugged perforation holes with fine coal particles.
- The gas production rate reached the peak at four weeks after CO_2 injection. This increase was due to CO_2 injection.
- Injectivity is lower than expected. This caused by mainly by the swelling of coal by CO_2 injection.
- 115 tons of CO_2 was injected between 2004-2005. In this year, 300 tons of CO_2 will be planned to inject into the IW-1.

Methane Hydrate Resources in Japan

BSW (Bottom Simulating Reflector) was found by exploration

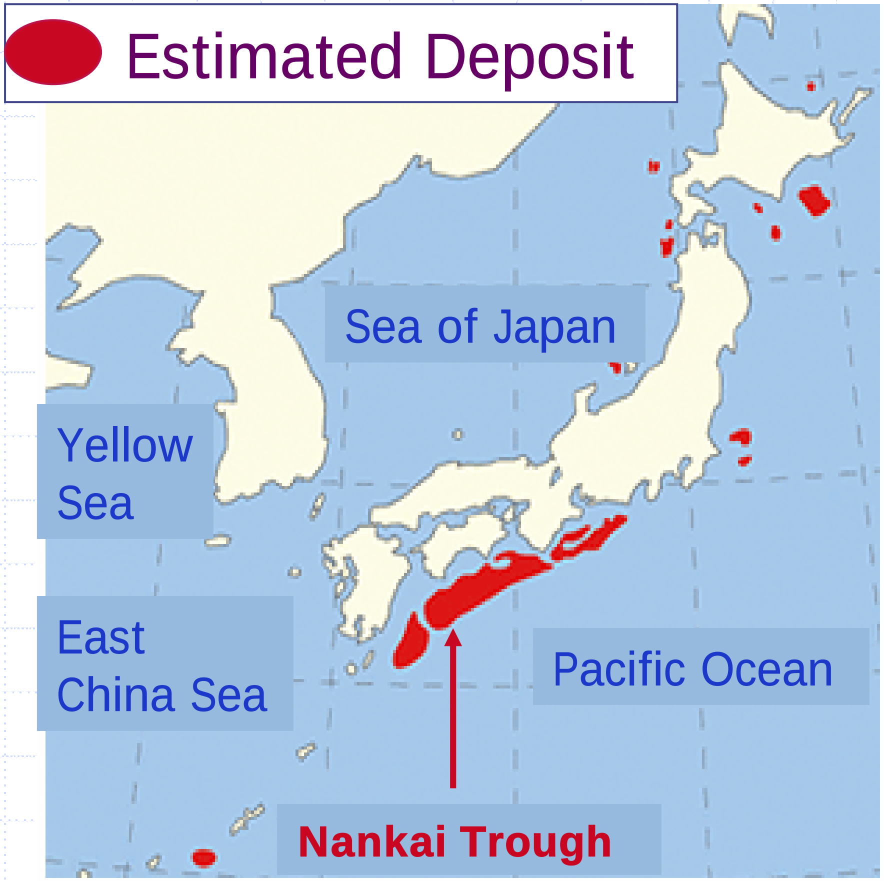
Resources estimate by Dr. Sato (Geological Survey, Japan)

7,350 billion m^3 ---- (a)

Japanese natural gas consumption in 2003:

76.5 billion m^3 ---- (b)

(a)/(b) = 96 (years' supply)



Exploration of Methane Hydrate

Nankai Trough:

Drilling up to 3300m deep

MH layer of total thickness 11m was proved at 1140-1210 m

MH content: 30-80%

Deep sea drilling ship
“JOIDE Resolution”

(courtesy of JOGMEC)

Core Sample

Block type

Pore filling type

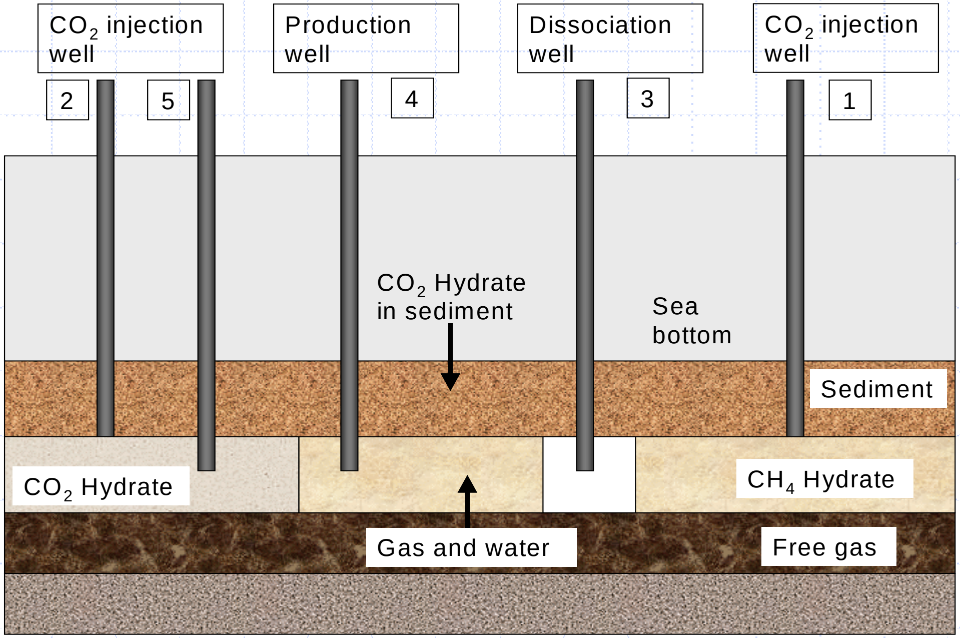
Methane Hydrate Production by CO_2 Injection

- Stage of fundamental research
- MH formation has the soft strata, which promote the reduction of strength by the production of MH.
- This may cause the outburst of methane from MH formation by collapse of the soft strata.
- Need to construct the stable roof in order to control the dissociation rate.
- CO_2 hydrate is formed in lower pressure condition than CH_4 hydrate.

Methane Hydrate Production by CO_2 Injection

Objectives:

1) Construct stable artificial roof
2) Displace methane with carbon dioxide

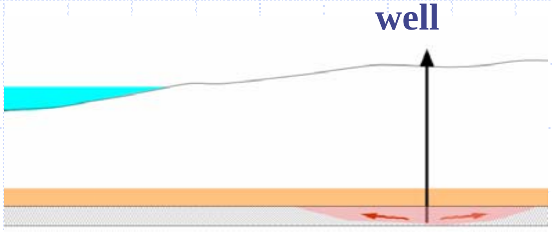


Process:

1) CO_2 injection through wells #1 and #2 to form stable CO_2 hydrate in the sediment.
2) Introduction of sea water through well #3 to dissociate CH_4 hydrate by increasing temperature.
3) CO_2 injection dissociated zone through well #5 to construct the CO_2 hydrate.
4) CH_4 production through well #4.

Potential of Geological CO_2 Storage in Japan

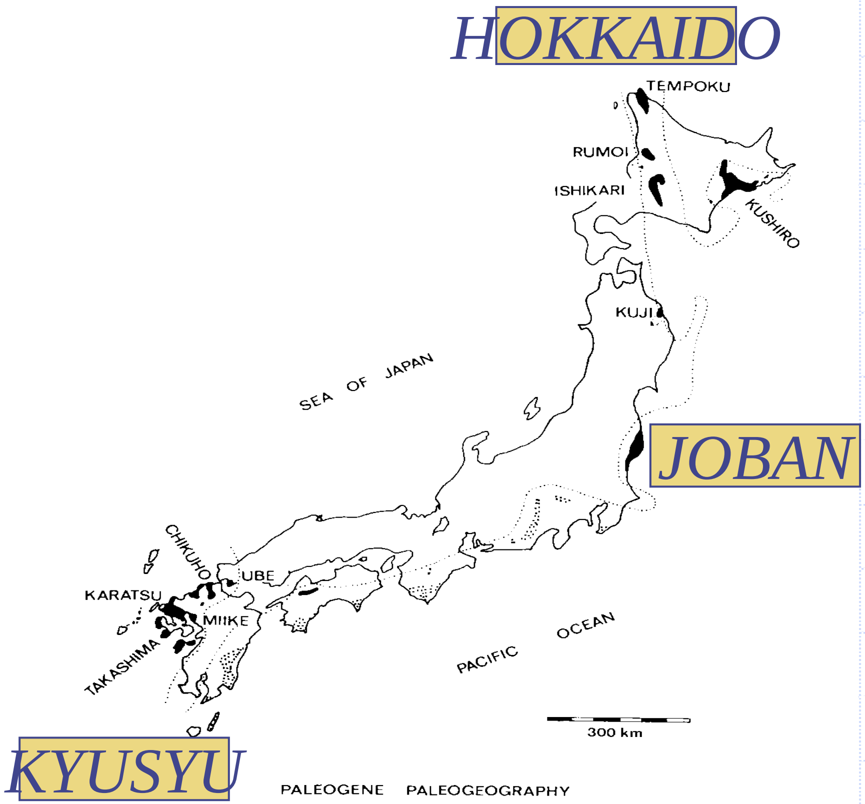
Potential for Aquifer Storage in Japan

data source		Aquifer with Closure structure (A Category)	Open Aquifer (B*Category)
depleted oil & gas	data obtained during operation	A1: 3.5 Billion t-CO_2	B1: 27.5 Billion t-CO_2
identified aquifer	public domain data by seismic and drillhole	A2: 5.2 Billion t-CO_2	
identified closure	public domain data by seismic only	A3: 21.4 Billion t-CO_2	B2: 88.5 Billion t-CO_2
schematic illustration			
sum		30.1 Billion t-CO_2	116.0 Billion t-CO_2
total		146.1 Billion t-CO_2	

NOTE) Inland basins, such as Seto In-land sea, Osaka Bay are excluded.

＊only those located in waters shallower than 200m.

Potential of CO_2 Storage Capacity in Coal Seams



Huge amount of unmineable coal resources in Japan

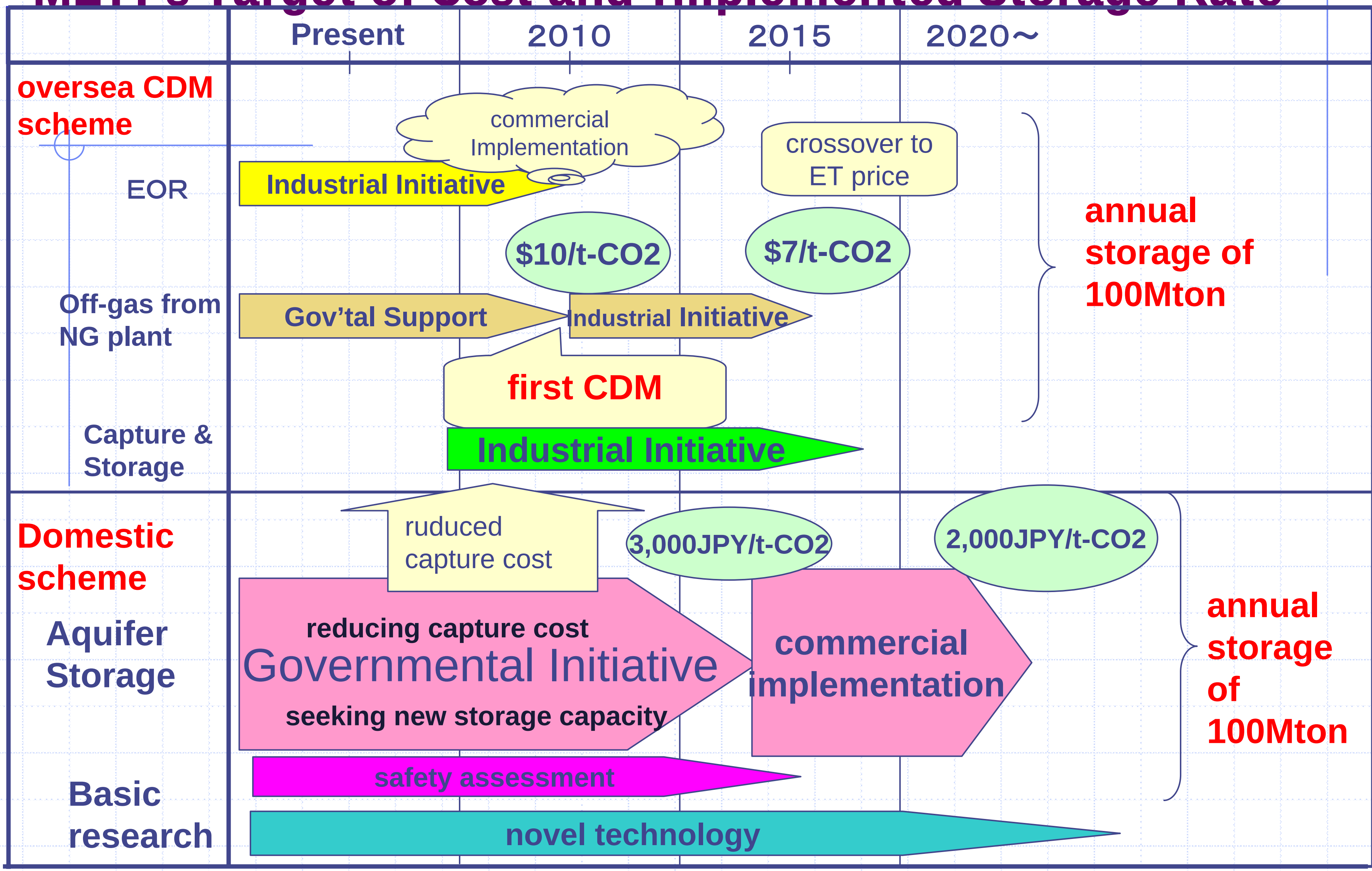
(Onshore & Offshore)

Estimated coal resources : 182 billion tons

CBM potential: 2,540 billion m^3

CO_2 storage capacity: 5,000 billion m^3 (10 billion tons)

METI's Target of Cost and Implemented Storage Rate



Conclusion

- CO_2 emission reduction and measures against it : Japanese important issue
- Japan is trying to develop geological CO2 storage technology as one of the measures
- CO_2 storage in Aquifer : perspective domestic geological CO_2 storage option
- ECBMR: mainly overseas geological storage option
- Methane Hydrate: expected to be a promising domestic primary energy resources. Need further researches and technological innovation for commercialization.

Acknowledgement

Photos in this presentation;

- on NAGAOKA project (CO_2 storage in aquifer) was provided by RITE
- on ISHIKARI project (Enhanced CBM Recovery by CO_2 injection) was provided by KANSO
- on Methane Hydrate was provided by JOGMEC (Japan Oil and Gas, Metals National Corporation)

Thank you for your attention!