KUALA LUMPUR 2012 WORLD GAS CONFERENCE

25th world gas conference

"Gas: Sustaining Future Global Growth"

Development of Natural Gas Hydrate (NGH) Supply Chain

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EF6A

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Host MALAYSIAN Gas ASSOCIATION

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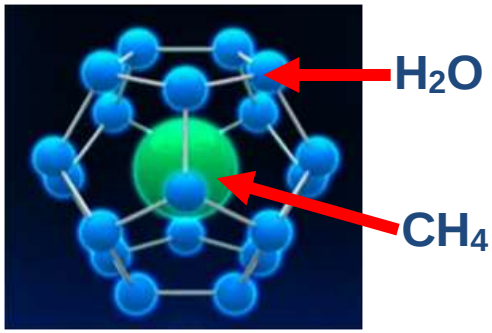
Natural Gas Hydrates (NGH)

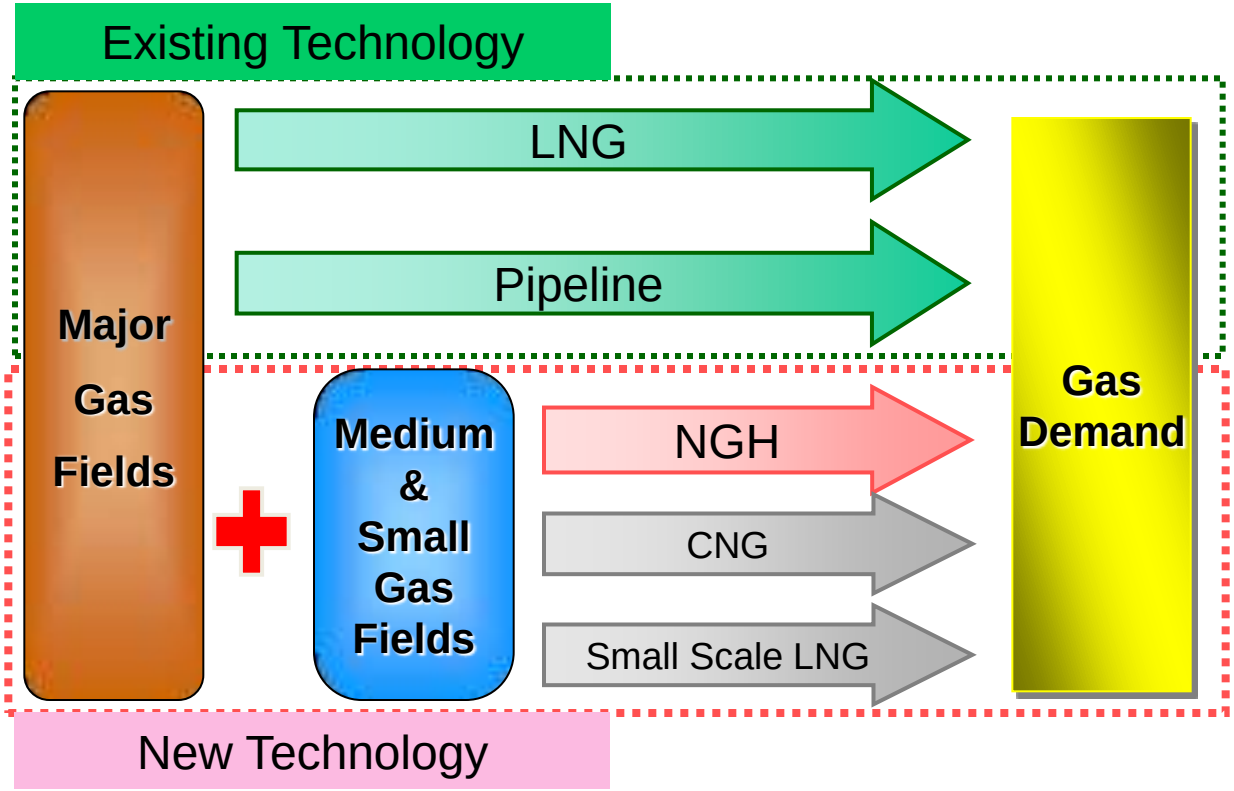
- **Solid Material** (natural gas captured in an H2O molecular cage)
- **Contains natural gas of 165 times its volume**
- **Stabilized at – 20 deg C under atmospheric pressure**

			
"Fiery Ice"	NGH Molecule Structure	NGH powder	NGH pellets

	NGH	LNG
Physical State	Solid	Liquid
Energy Density	165 Nm^3/m^3 (+0.8m^3 Water)	600 Nm^3/m^3
Temperature	-20 deg C	-162 deg C
Pressure	Atmospheric Pressure	Atmospheric Pressure

Demand for New Natural Gas Supply Chain

- **Global natural gas demand will increase by 1~2% annually until 2025**
- **Many medium and small-size gas fields remain undeveloped**
- **NGH can become an effective solution to unlock such gas fields.**



Size of Discovered Gas Fields
(Including developed fields)

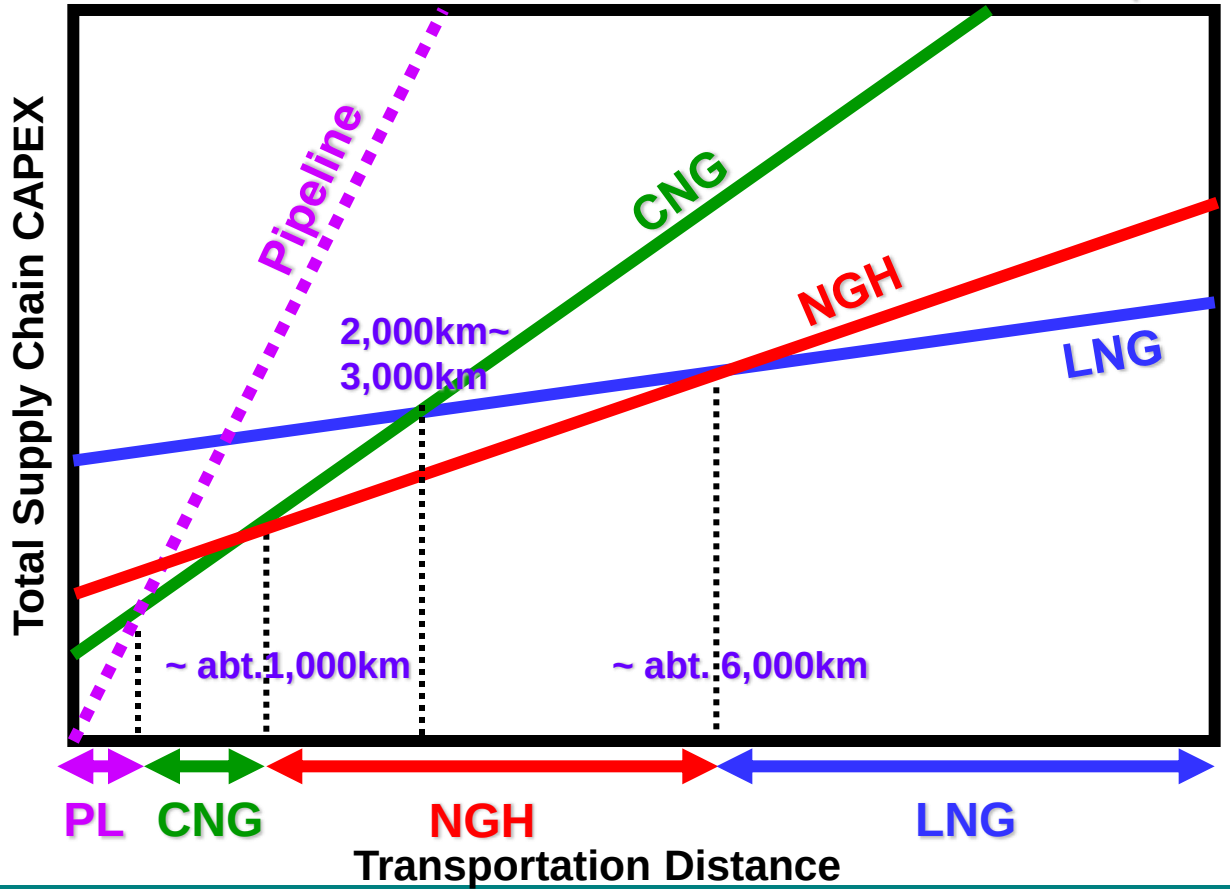
Size	Number of Fields
Below 0.01 tcf	3,338
0.01-0.1 tcf	5,079
0.1-0.25 tcf	1,914
0.25-0.5 tcf	1,095
0.5-1.0 tcf	767
1.0-5.0 tcf	912
5.0-50.0 tcf	330
Over 50.0 tcf	22

NGH Supply Chain Target Segment

NGH Supply Chain has economical advantage in

Transportation Distance: 1000 - 6000km

Natural Gas Volume: 1.0 - 1.5 million ton (LNG) per annual



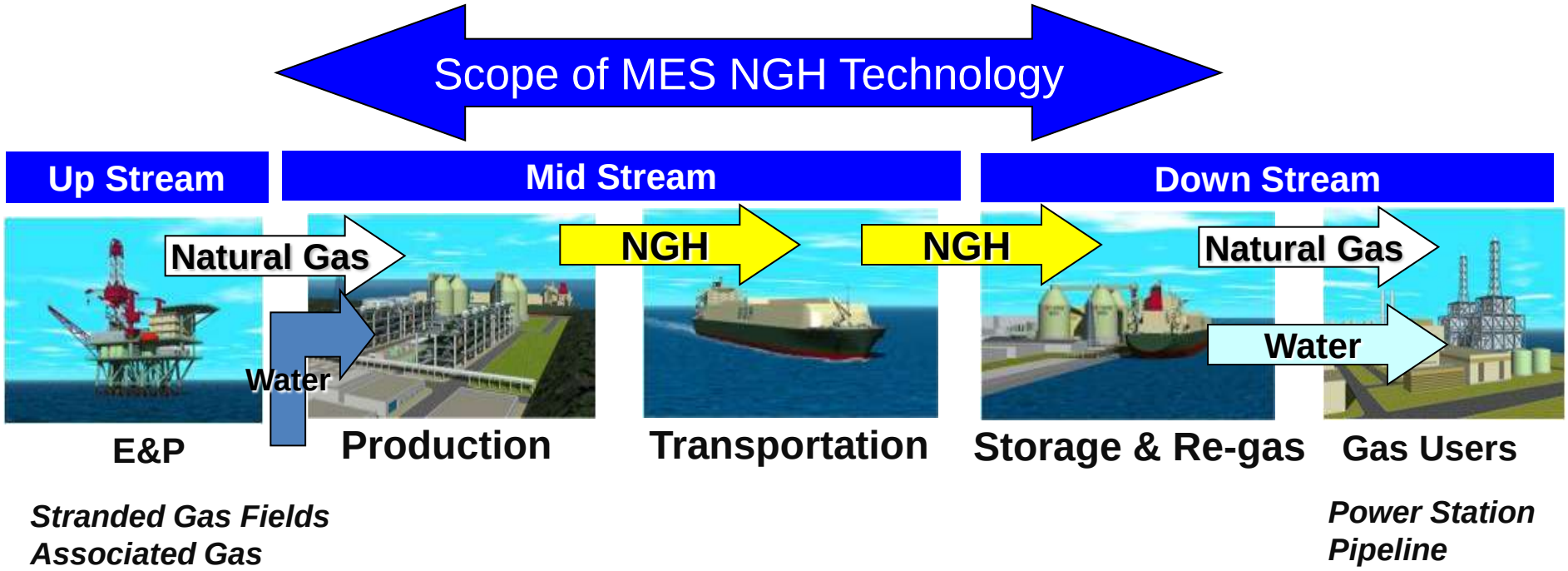
Suitable for

-monetizing small-medium gas fields

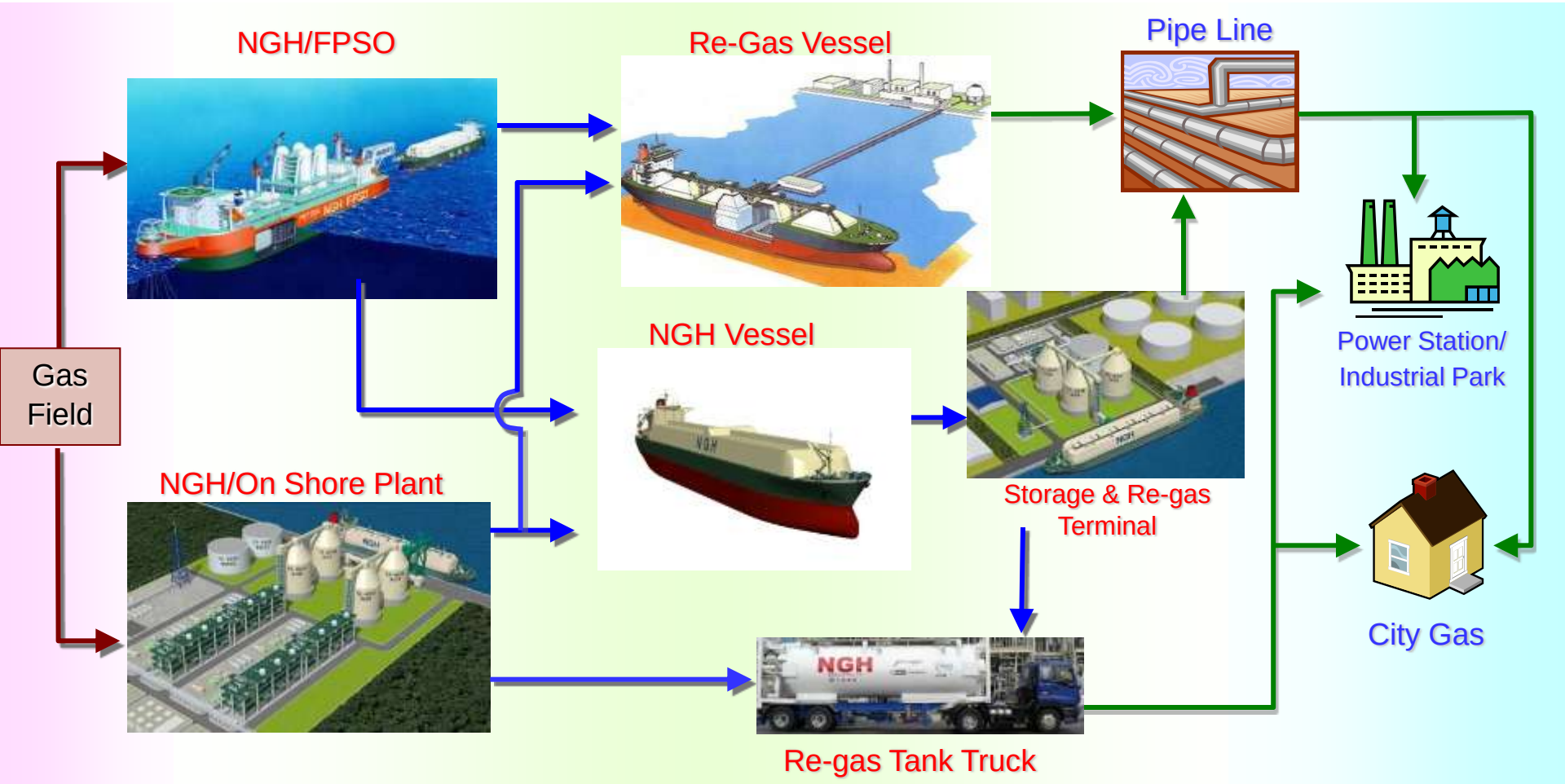
-meeting regional gas demand

NGH Supply Chain

MES is developing the entire NGH Supply Chain including Production, Transportation, and Storage & Re-gas of NGH.



NGH Supply Chain

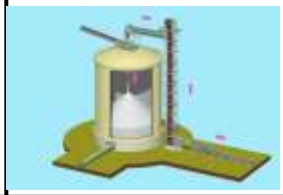


Feed Gas NGH Natural Gas After Re-gasification of NGH

MES's NGH Technological Development History

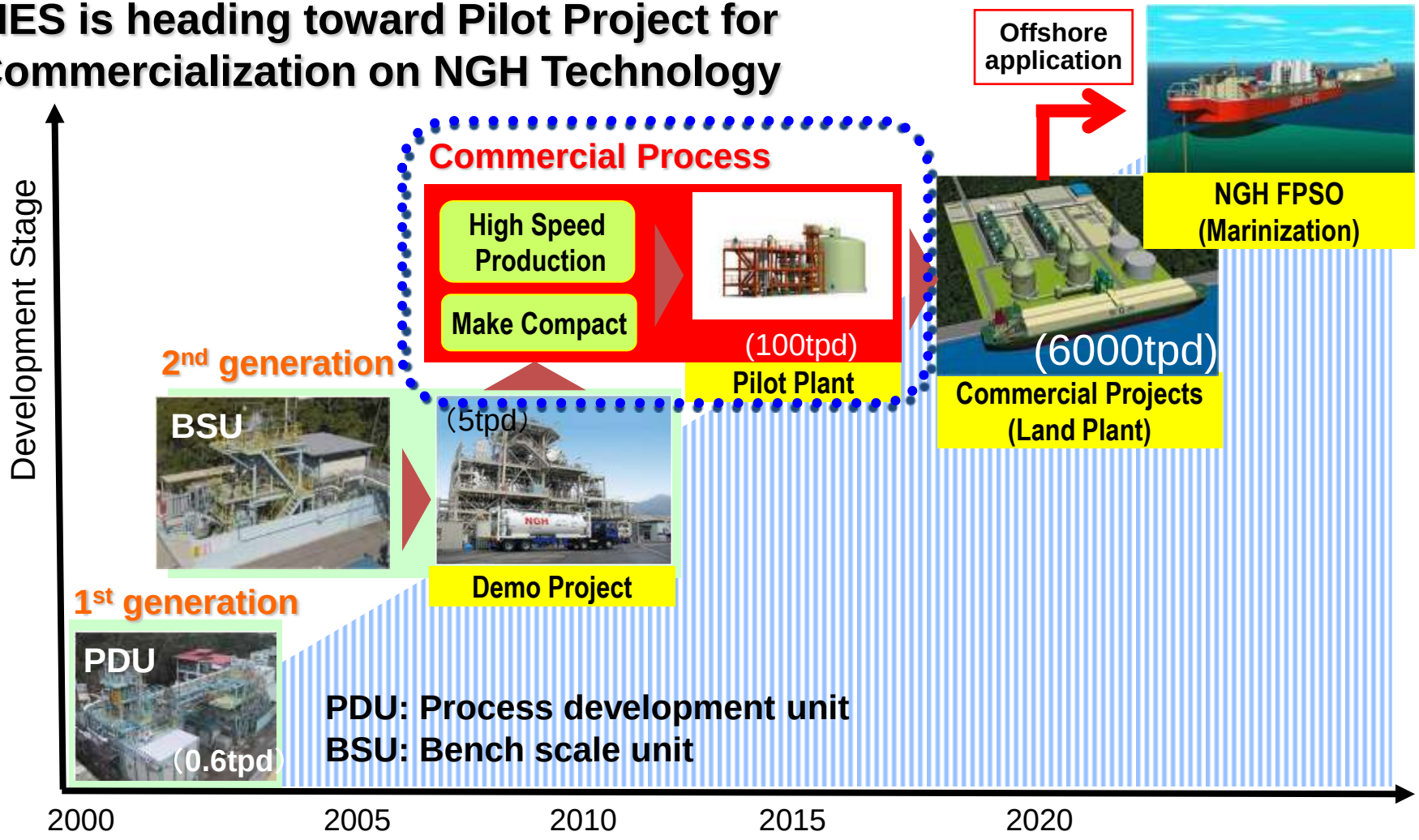
FY	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
NGH Production	small batch test	PDU			BSU			5-ton Production (Yanai Project)		Development of Commercial Process
NGH Carrier					Development of Hold Tanks & Unloading System			Extended R&D		
	Concept Design						IMO Provisional Safety Approval			
NGH Storage Tank			Concept Design					Extended R&D		
						Development of Conveying and Discharging Machine				
NGH Re-gasification				Concept Design				Extended R&D		
						Development of Continuous Re-gasification System				

PDU: Process Development Unit
BSU: Bench Scale Unit



Roadmap toward Commercialization

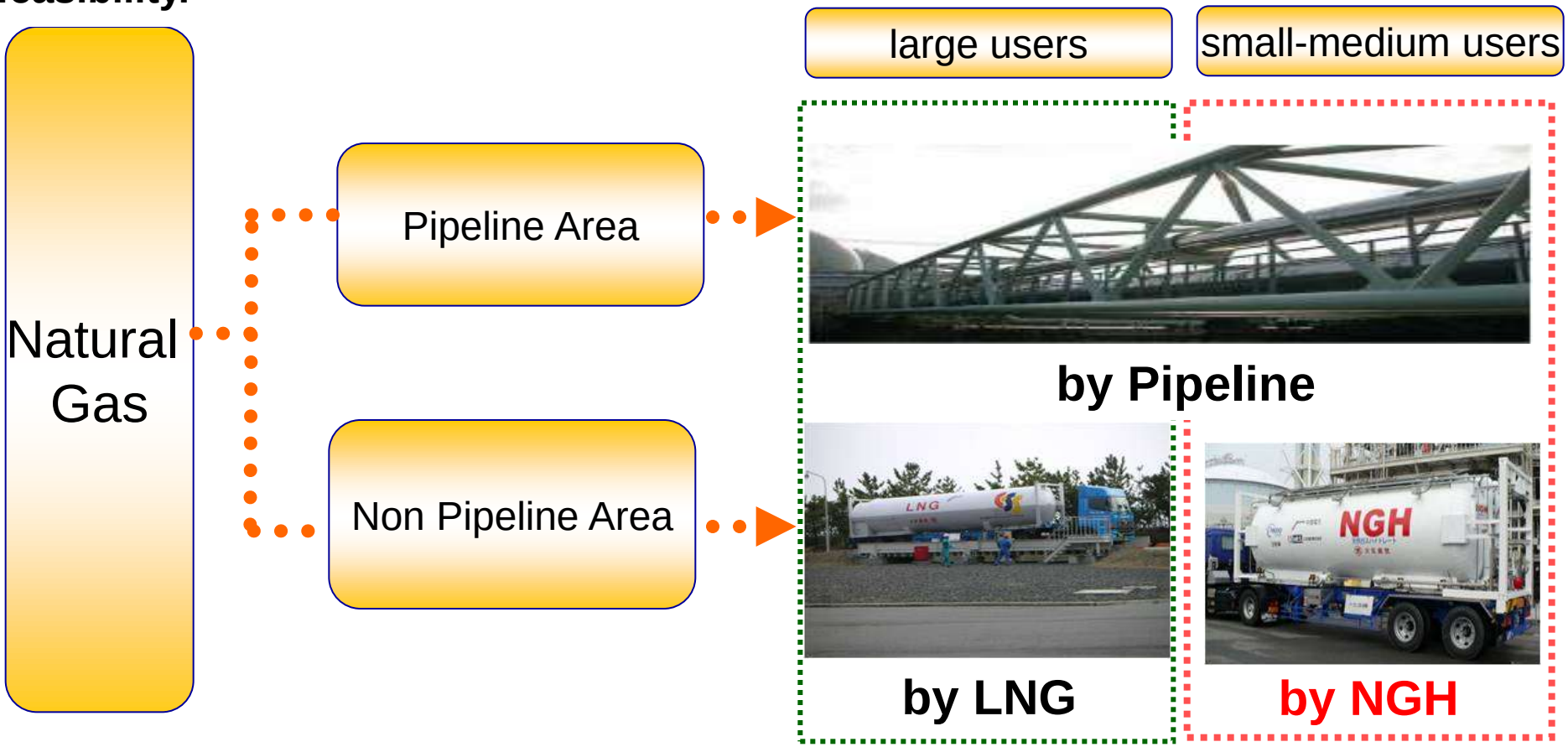
MES is heading toward Pilot Project for Commercialization on NGH Technology



Overland Transportation Demo Project

Background of Demo Project

NGH can play a role in inland natural gas transportation to small-medium gas users in non pipeline area, who cannot be covered by LNG due to its economical feasibility.



Overview of Demo Project

Goals of Demo Project

Demonstrate NGH Overland Transport Chain

Verify Production Capacity of 5 ton per day (NGH)

NGH Demo Production Plant (in Yanai Power Station)

NGH Lorry

NGH Re-Gasification

Project structure

MES — **Management R&D EPC**

NEDO — **Financial support**

Energia — **Plant Operation**

NEDO: New Energy and Industrial Technology Development Organization

Project schedule

2006 – 2007	**R&D and Plant Design**
2007 – 2008	**EPC**
2008 – 2011	**Commissioning, Test-Operation and Demonstrations**

Demo Project Supply Chain

Production (5 ton per day of NGH)

LNG Receiving Terminal

Natural Gas

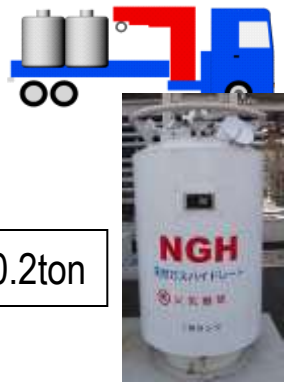
LNG Cold Heat

Water

Production Plant

Delivery (100km)

Capacity
5.0ton
7.5ton



Capacity: 0.2ton X 2

Storage & Re-gasification

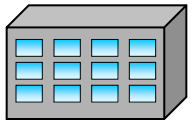
User 1

Natural gas

Gas engine

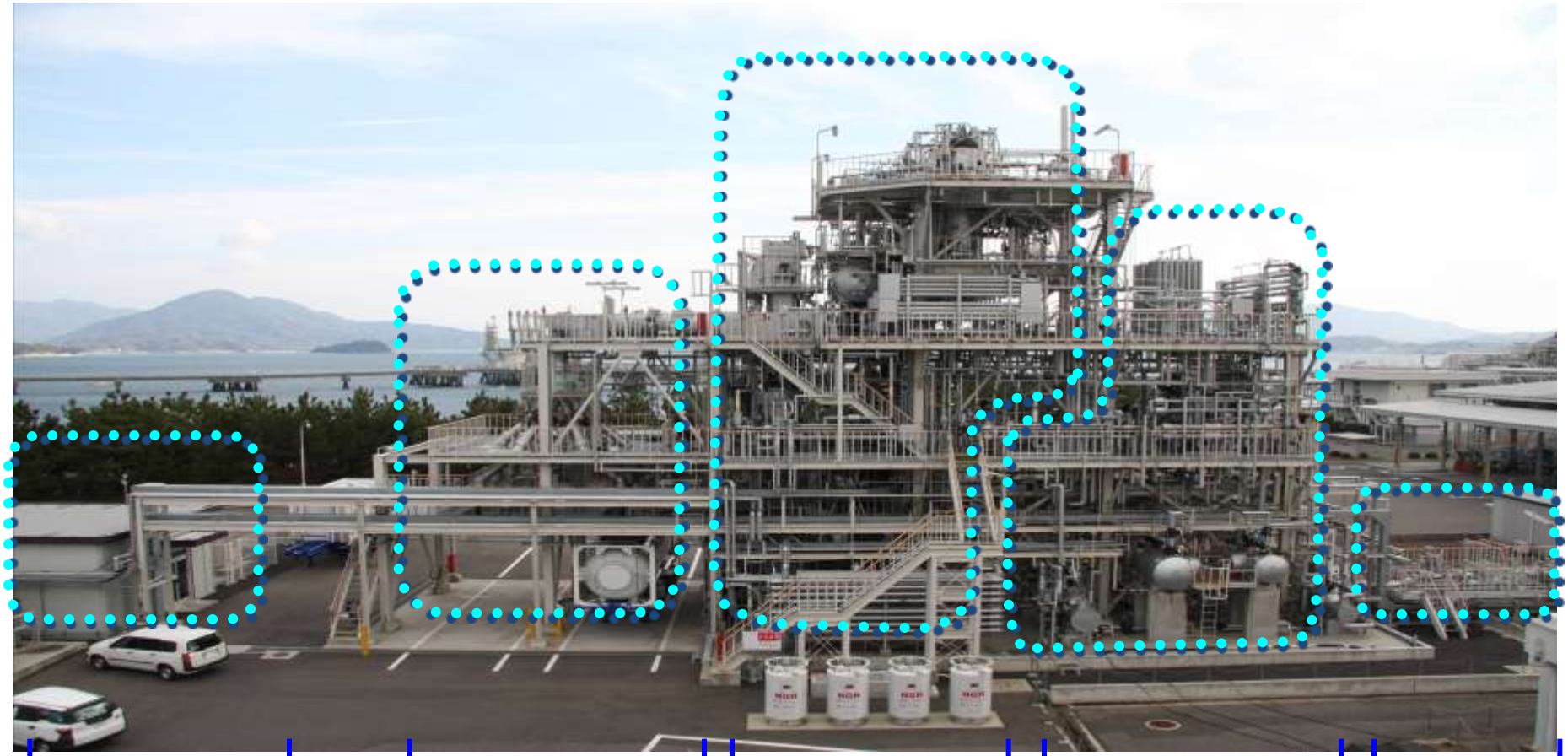
User 2

Natural gas

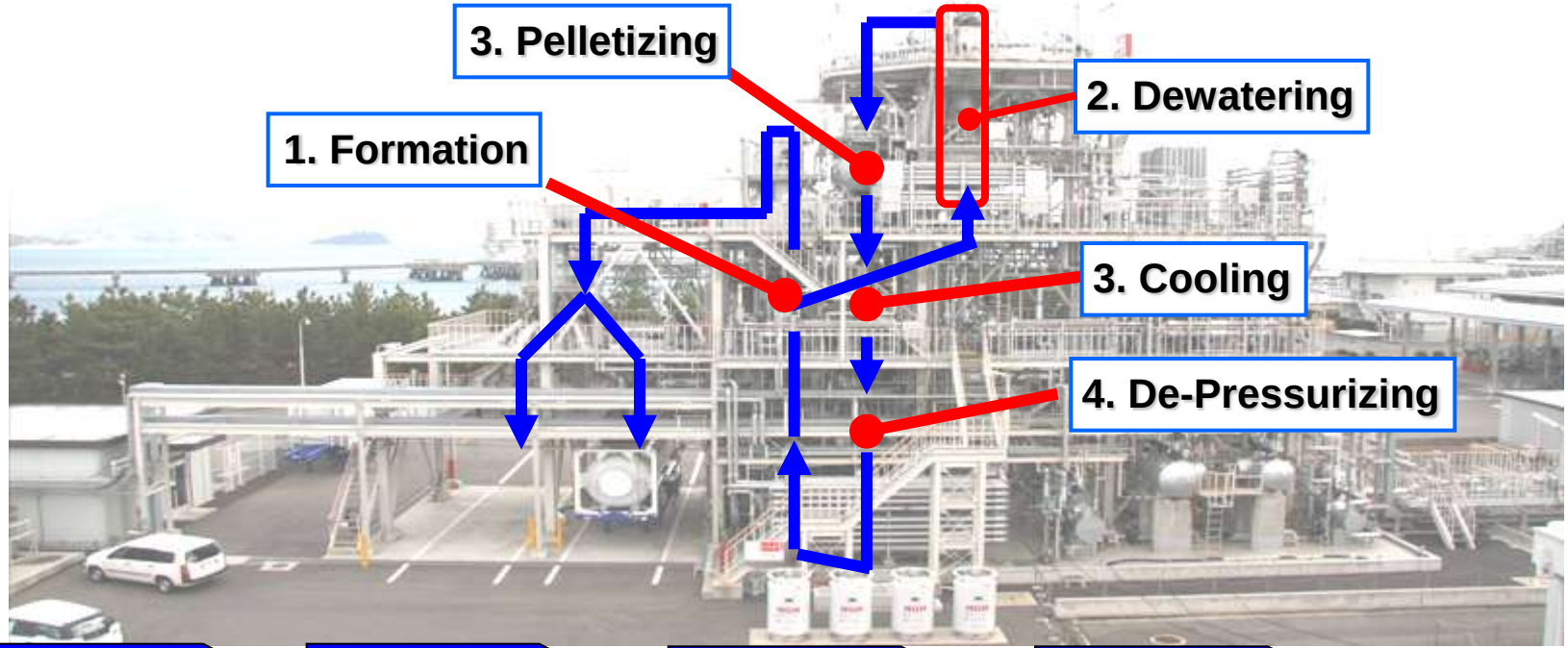


City Gas

Demo Plant Bird-Eye View



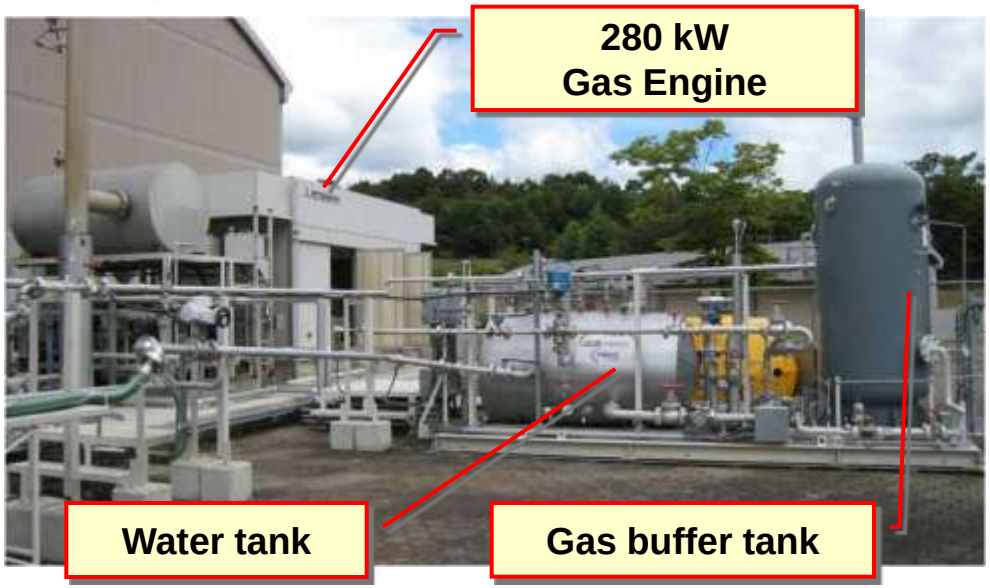
NGH Production Process



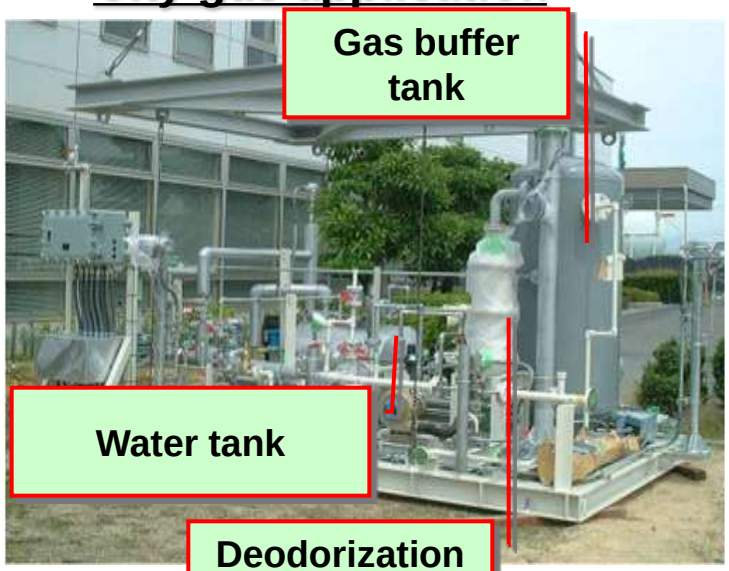
Formation → Dewatering → Pelletizing → Cooling → De-Pressurizing

Regasification at Users

(User 1)
Application as Power Generation Fuel



(User 2)
City gas application



Toward Commercialization

NGH Japan Co., Ltd.

	MES (MITSUI ENGINEERING & SHIPBUILDING CO.,LTD.)	MITSUI & CO., LTD.
Expertise	• Track record and know-how of NGH Technology Development • Capability to be a EPC contractor	• Track record in LNG business • Finance Arrangements • Project Management
Role	• NGH Technology Development	• Development and promotion for NGH commercialization

Synergy

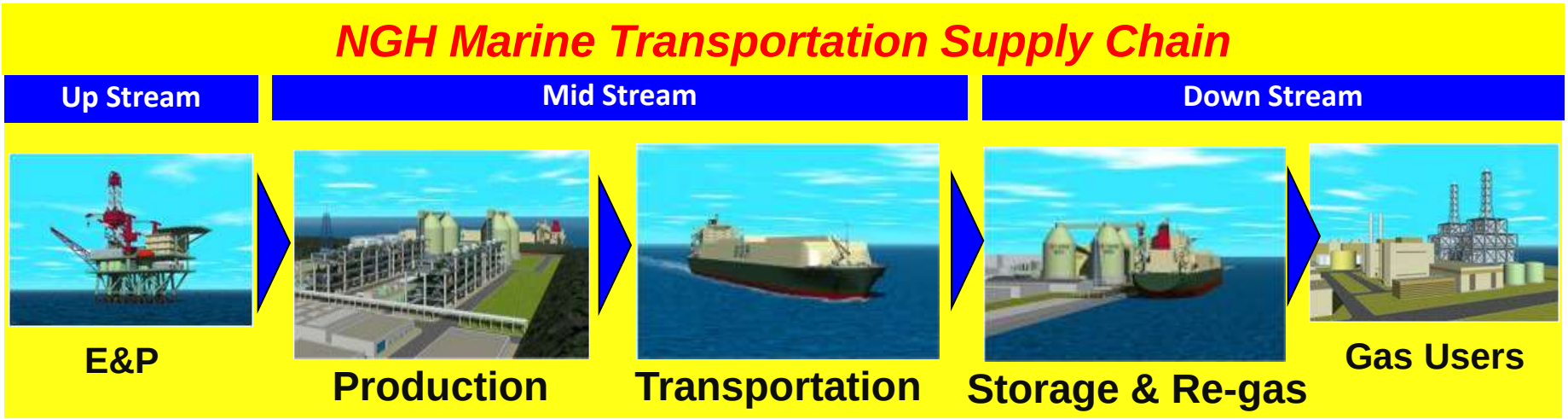
Company Name	NGH Japan Co., Ltd.
Establishment	April, 2007
Business Objectives	Technology development and business development of NGH
Shareholders	MES:80%　Mitsui:20%

Summary

1. MES verified a technical viability of the entire NGH overland transportation including utilization, and achieved necessary production capacity at this stage of development.

2. Through the Demo Project, MES accumulated sufficient amount of data to develop commercially viable process for Pilot Project.

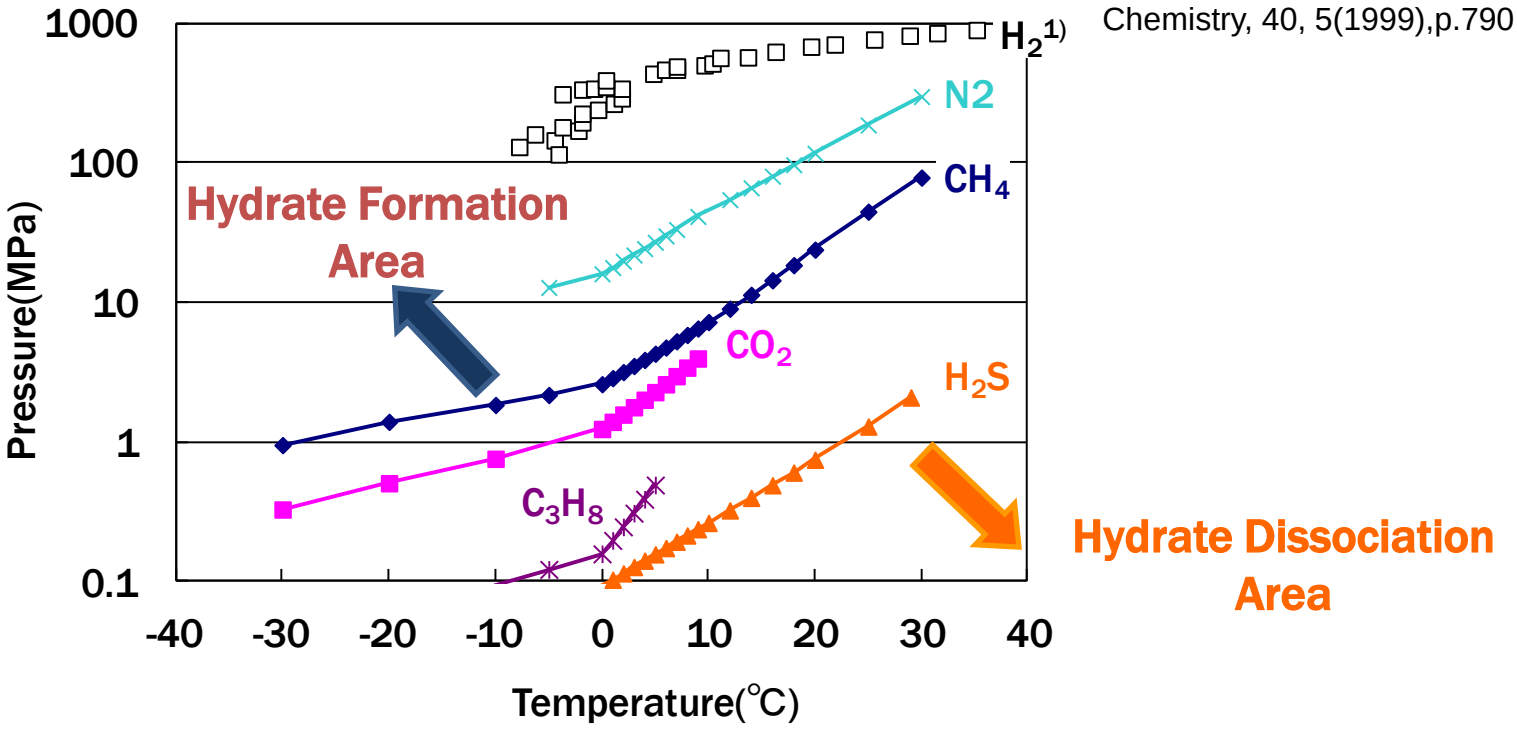
3. MES is currently planning and preparing for Pilot Project to realize commercialization of NGH marine transportation chain.



Other Application: CO2 separation by hydrate

Monetizing high CO2-rich content gas fields by separating CO2 by using difference of CO2 and other gases (N2,H2,etc) phase equilibrium (condition of hydrate)

1)Y. A. Dyadin, et al., Journal of Structural Chemistry, 40, 5(1999),p.790

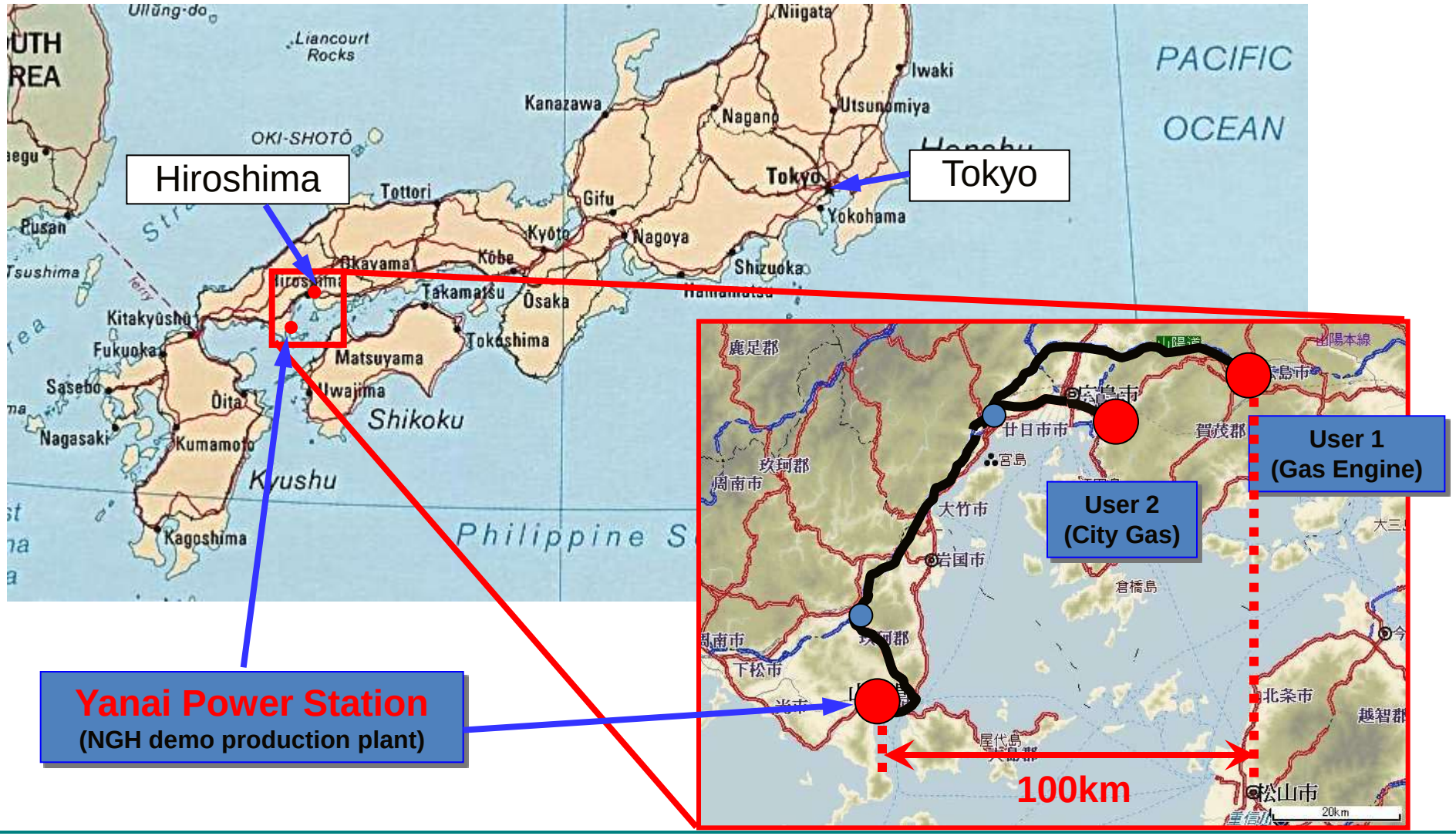


Phase equilibrium of gases

Source: MES Chiba R&D Center

Appendix

Location of Demo Project



Spec. of NGH containers for overland transportation

Three types of Containers for transportation & storage were developed.
Each container is equipped with a re-gasification device.

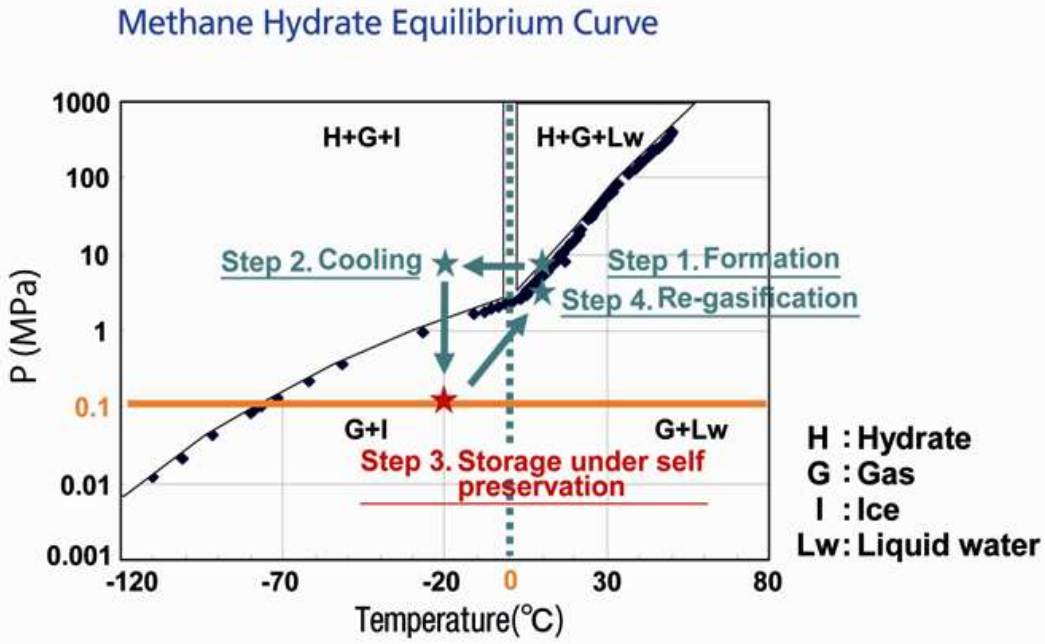
Type A **(5.0 tons)**

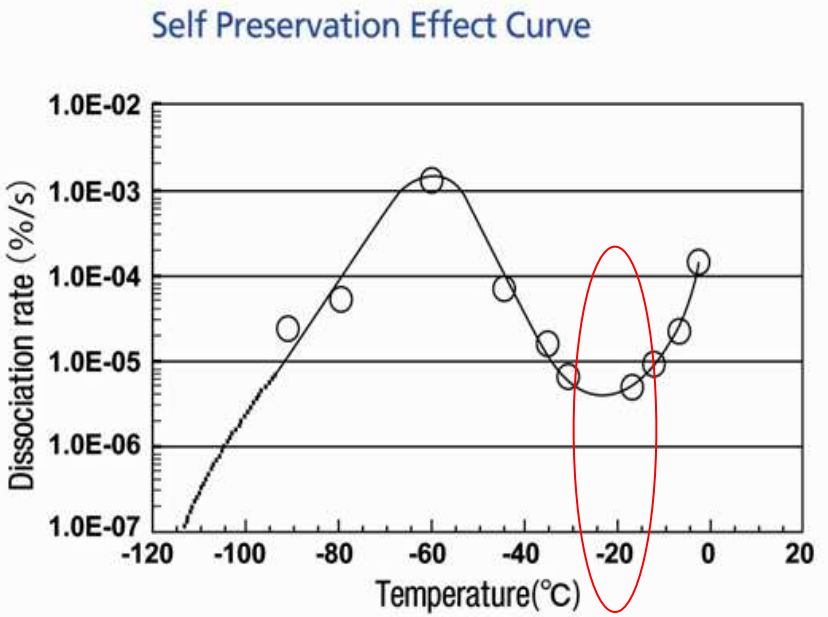
Type B **(7.5 tons)**

Type C **(0.2 tons)**

Users	User 1 (Gas Engine)		User 2 (City Gas)
Container Capacity (in NGH Pellet)	Type A	Type B	Type C
	5 tons	7.5 tons	0.2 tons/
Gas Volume	650 Nm^3	910 Nm^3	50 Nm^3
Design Pressure	0.8 MPa	0.8 MPa	0.8 MPa

NGH Equilibrium Curve & Self Preservation Effect





- **Hydrate is formed at high pressure and temperature slightly above water freezing point**
- **Formed hydrate is cooled down to around - 20 deg C, where Self Preservation Effect manifests itself.**
- **Depressurized to atmospheric pressure.**