

Offshore CO₂-EOR Pilot Project in Vietnam

5th October 2016

© Yohei Kawahara

Atsushi Hatakeyama



The Future of Energy, Resources and Materials

JX Nippon Oil & Gas Exploration Corporation

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 - **Feasibility Study**
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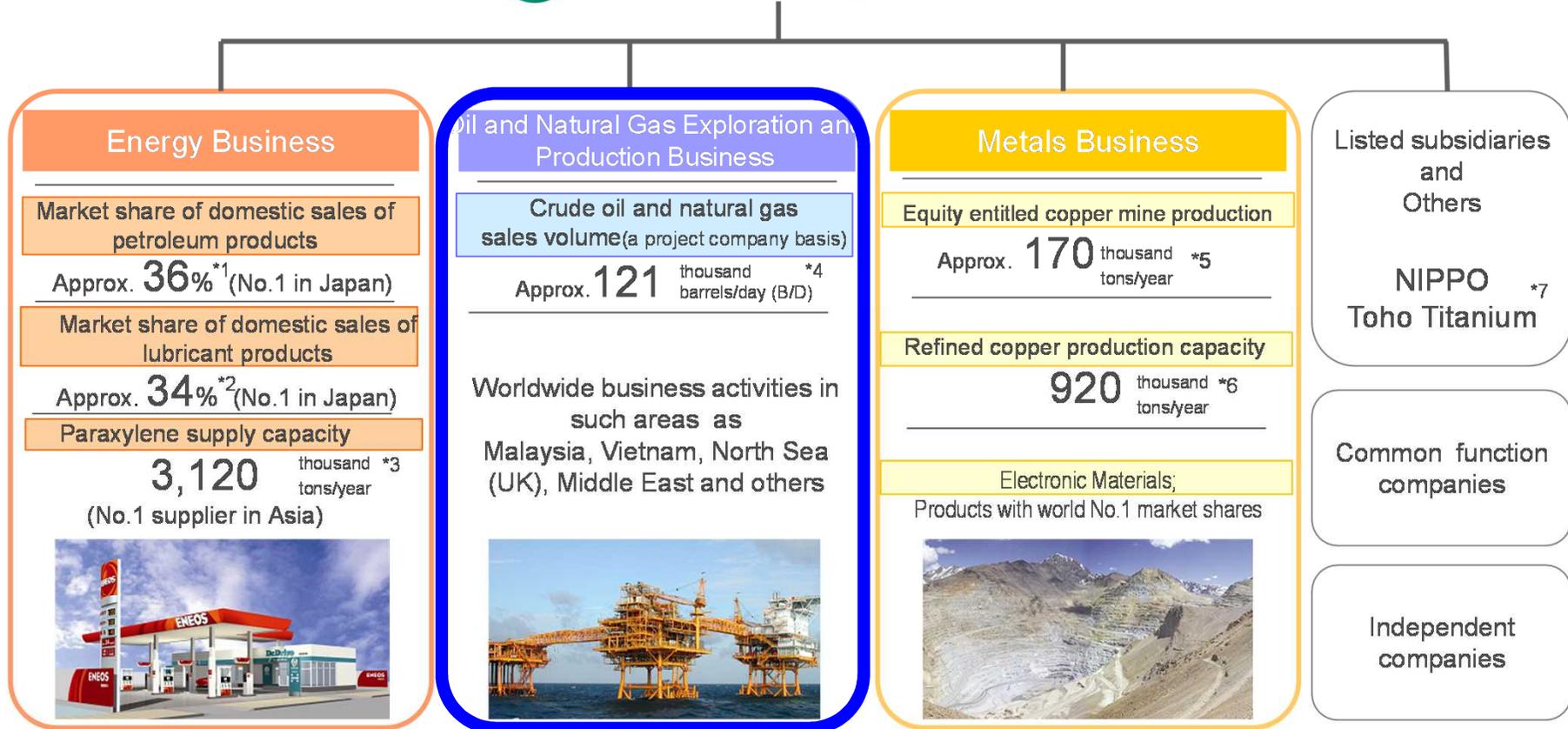


1. Introduction

Introduction -JX Nippon



JX Holdings, Inc.



*1 FY2015 actual

*2 FY2015 actual

*3 As of Mar. 2016

*4 Crude oil equivalent (average daily production from Jan. to Dec. 2015 actual)

*5 Equity entitled copper production contained in copper concentrate (FY2015 actual)

*6 Pan Pacific Copper (67.8% equity stake) ; 650 thousand tons/year + LS-Nikko Copper (39.9% equity stake) ;270 thousand tons/year (As of Mar. 2016)

*7 Profit and loss of Toho Titanium is included in the Metals Business.

JX Nippon Business Activities



JX Nippon Oil & Gas Exploration

Date of establishment : June 26, 1991
 Head office : 1-2 Otemachi 1-chome, Chiyoda-ku, Tokyo
 Paid-in capital : 9.8 Billion yen
 Number of employees : 949 (as of March 31st, 2016)



The UK North Sea	●	●	●
The U.S.	●	●	
Canada	●		
Thailand			●
Vietnam	●	●	●
Myanmar	●	●	●
Malaysia	●	●	●
Indonesia	●	●	●
Australia	●		●
Brazil			●
Papua New Guinea	●	●	●
UAE / Qatar	●	●	●
Japan	●	●	●

Challenges for CO₂ Reduction on JX Nippon's E&P Business Activities



JX Nippon continues “Challenges” in accordance with Company Mission Statement “**Harmony with the environment**”

2000~ Zero Flaring, Abu Dhabi

Re-inject CO₂ and Sour Gas to Reservoir

2007~ Zero Flaring & CDM Project, Vietnam

Before: Flare Associated Gas, Use Fuel for Electricity

After: Capture Associated Gas Transport to Power Plant, Reduce Fuel by utilizing Rang Dong gas

Pipeline

2011 CO₂ EOR Huff'n'Puff Pilot Test, Vietnam

Pioneering CO₂-EOR field application in SE Asia

2016~ Carbon Capture & CO₂-EOR Project, USA

WA Parish Electrical Generating Station, Virtually no CO₂ in exhaust, CO₂ Capture System, Separator, Flue gas with CO₂, Pure CO₂ for EOR, CO₂ return, Oil sales, Naturally sealed formation (Reservoir)

Texas, USA

WA Parish Coal Power Plant, West Ranch Oil Field, 130km

nrg

Acknowledged to DOE for this project granted as “Clean Coal Power Initiative Program”



2. Offshore CO₂-EOR Pilot Project in Vietnam

Rang Dong Field, Offshore Vietnam

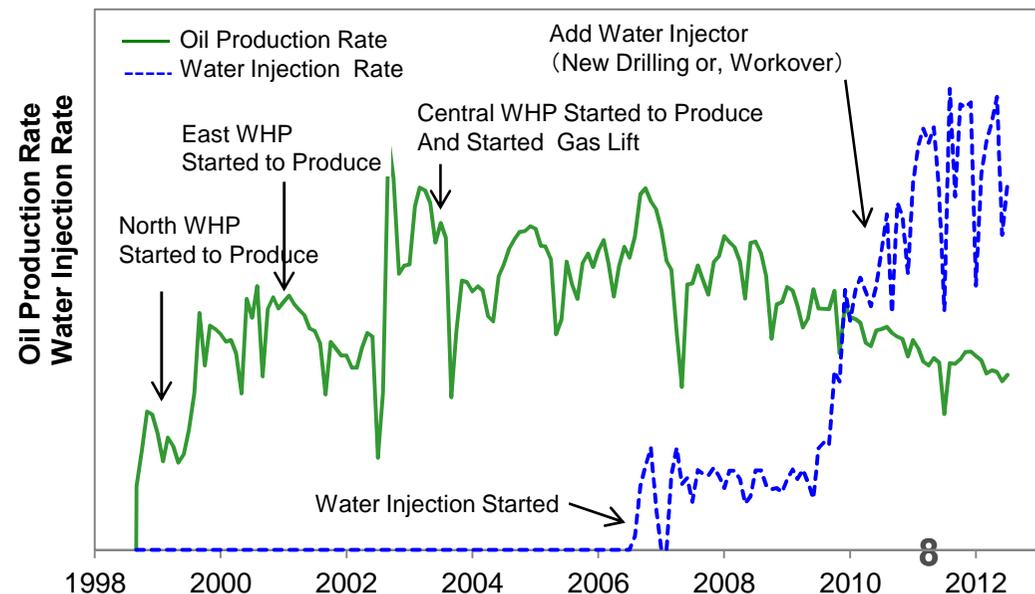
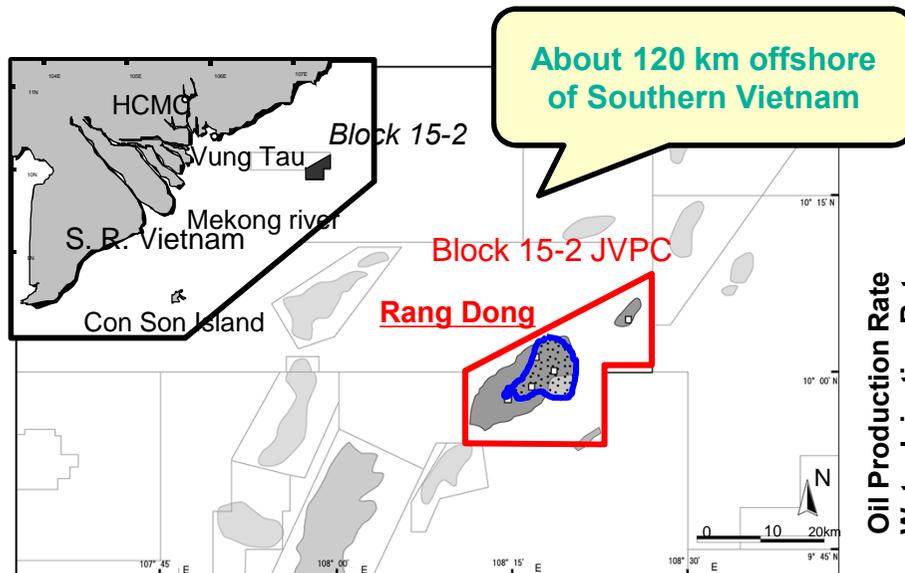


Rang Dong Field

- The field was discovered in 1994, and has been produced since 1998.
- Current cum. oil production is 200 Millionth bbl.

Reservoir Description

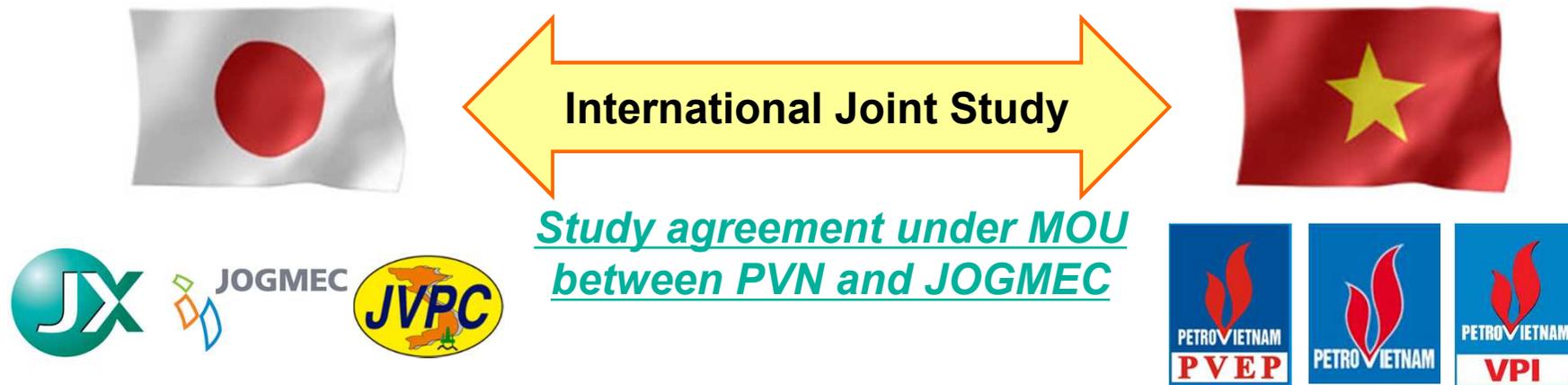
Reservoir Properties	Rang Dong LM Reservoir	Criteria for Gas EOR
Reservoir Depth [m]	2,100	>650
Reservoir Pressure [psi]	3,100	>1,030
Reservoir Temp. [degF]	196	>90
API Gravity [API]	38	>31
Oil Viscosity [cP]	0.76	<5
Oil Saturation [%]	50	>25
Permeability [mD]	1-3,000	>5



CO₂-EOR Project Scheme



To study the CO₂-EOR applicability to the offshore oil fields in Vietnam through an international joint study between Vietnam and Japan



CO₂-EOR Project History



2007-2010 Phase 1 Feasibility Study

To evaluate the potential and feasibility of CO₂-EOR to Rang Dong field

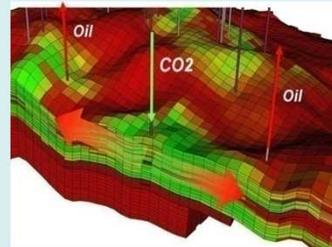
Laboratory Study

- Slimtube Test
- Interfacial Tension Test
- Swelling Test
- Coreflood Test



Simulation Study

- Geological Model Upscale
- History Match
- EOS Model
- Optimized CO₂ EOR



CO₂ Source Study

- Site Survey
- Facility Modification
- Cost Estimation



2011-2014 Phase 2 Pilot Test

To confirm CO₂-EOR effects in actual reservoir



Phase 1: Laboratory Study



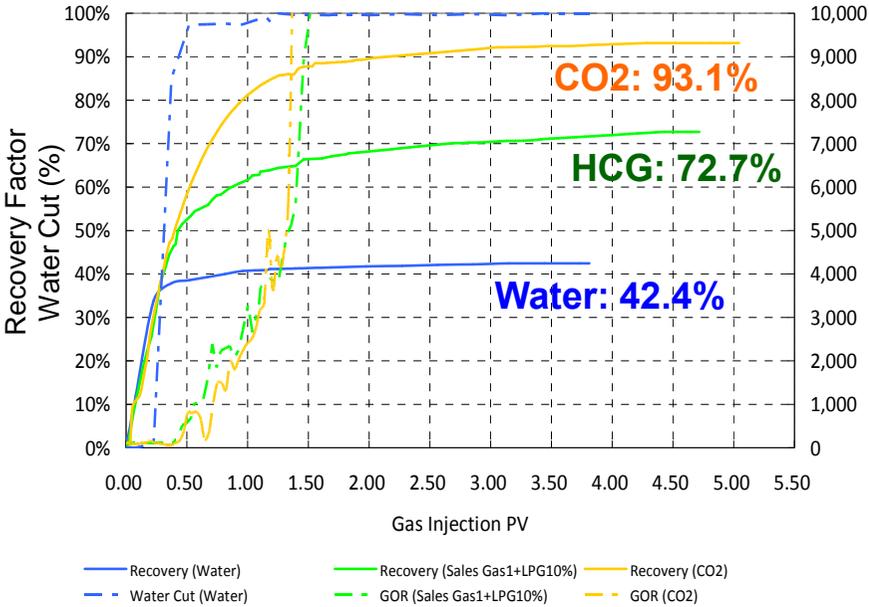
1st Feasibility Study

- Slim-tube Test
- IFT Test
- Solubility Swelling Test
- Core-flood Test

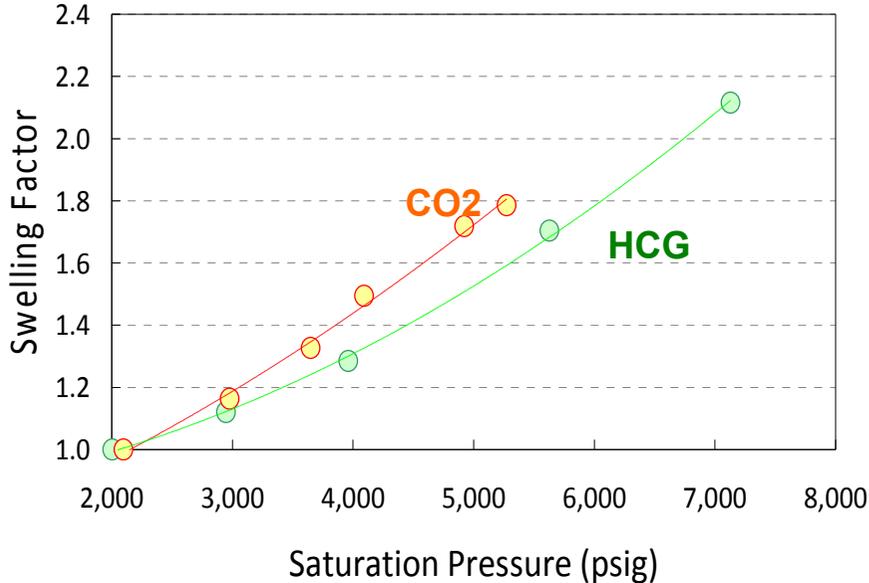


- Injected CO₂ and crude form “Miscible (completely mixed and form single phase)” under reservoir condition
- CO₂ flooding yield **2.2 times** recovery factor against Water Flooding in Core Scale

Core-flood Test



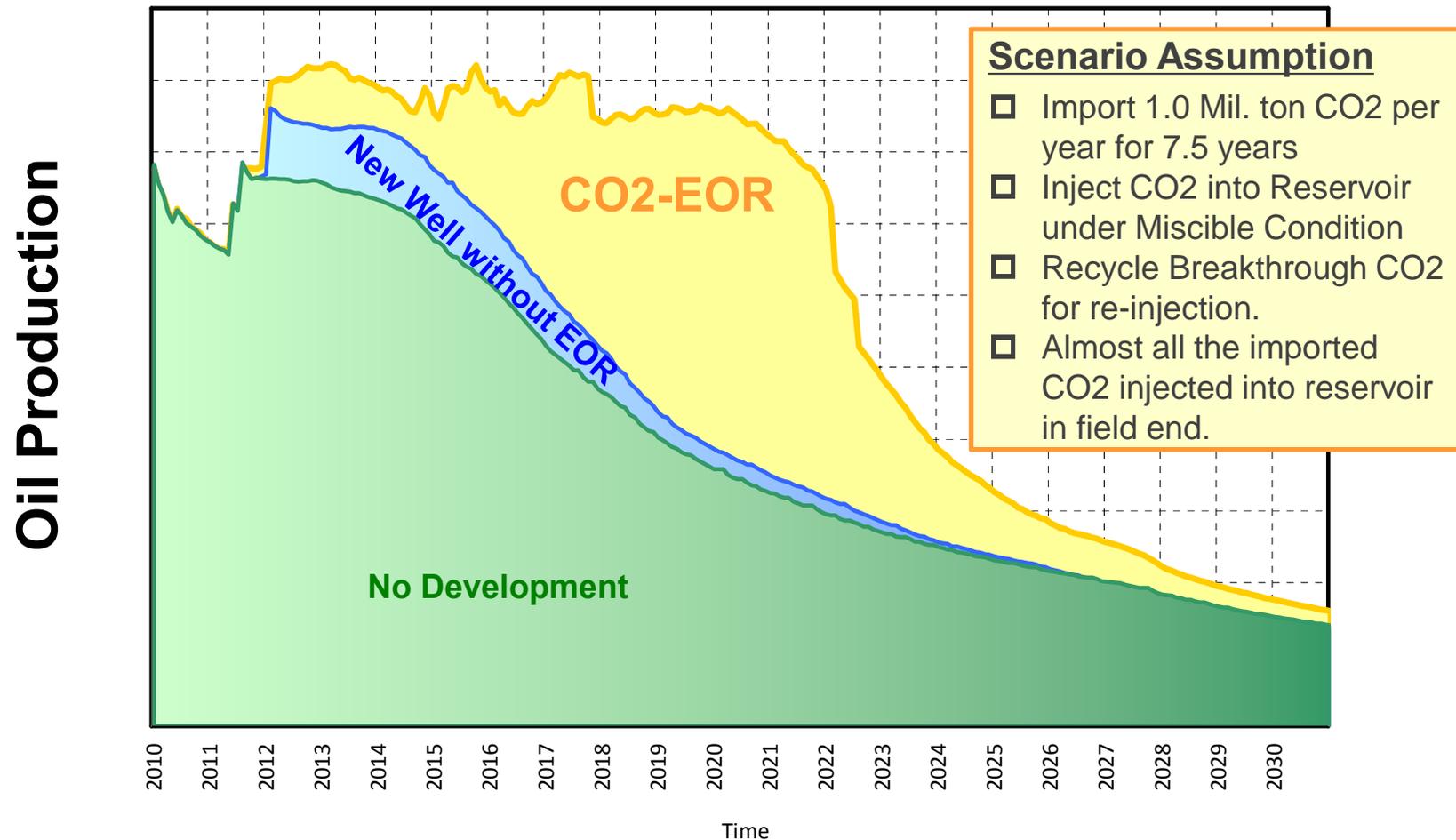
Swelling Test



Phase 1: CO2-EOR Incremental Oil



Special reservoir model constructed with Laboratory Study results for Evaluation of CO2-EOR Incremental Reserves.



Phase 1: Studies for CO₂ Source and Facility Development/Modifications

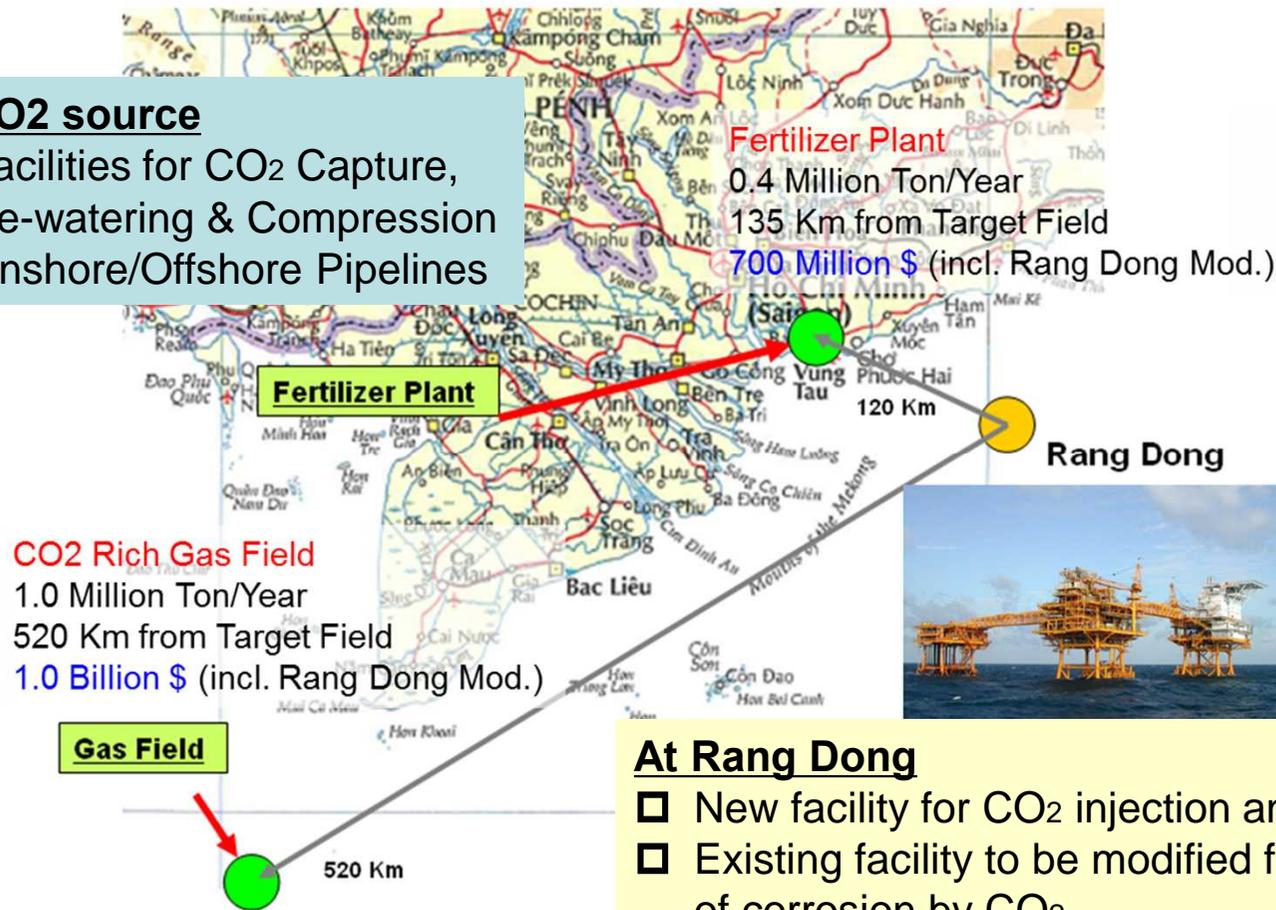


1st Feasibility Study

CO₂ Source Study & Cost Estimation

At CO₂ source

- ❑ Facilities for CO₂ Capture, De-watering & Compression
- ❑ Onshore/Offshore Pipelines



- ### At Rang Dong
- ❑ New facility for CO₂ injection and Recycling
 - ❑ Existing facility to be modified for prevention of corrosion by CO₂.

CO₂-EOR Project History



2007-2010 Phase 1 Feasibility Study

To evaluate the potential and feasibility of CO₂-EOR to Rang Dong field

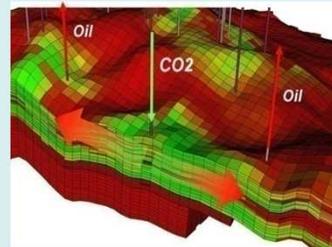
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Simulation Study

- Geological Model Upscale
- History Match
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- Optimized CO₂ EOR



CO₂ Source Study

- Site Survey
- Facility Modification
- Cost Estimation



2011-2014 Phase 2 Pilot Test

To confirm CO₂-EOR effects in actual reservoir



CO₂ Huff'n'Puff Test -Objectives

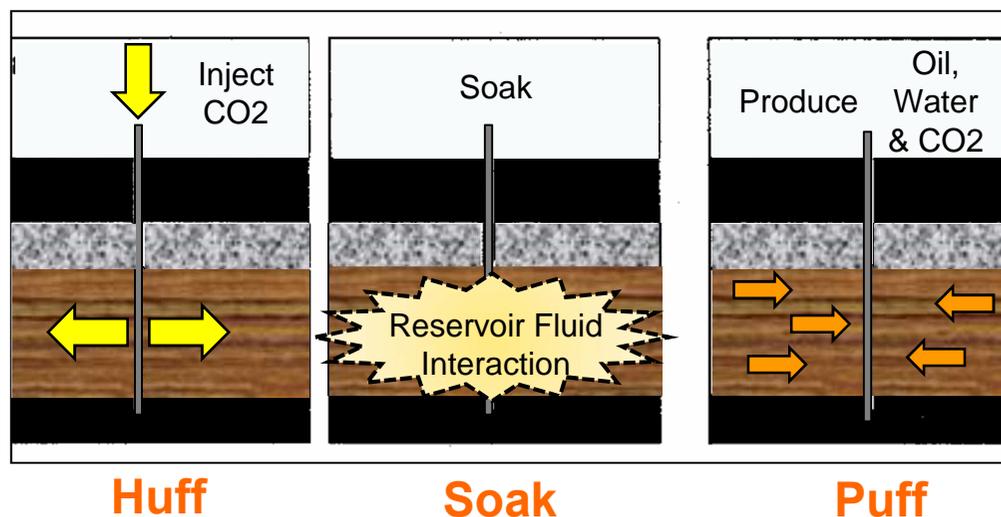


Objectives of H&P pilot test

In order to confirm an effectiveness of CO₂-EOR, a small CO₂-EOR pilot test was conducted.

- To Confirm *CO₂ Injectivity*
- To Confirm *Increased Oil Production*
- To Confirm *Mechanisms of CO₂-EOR*

Three Stage Actions



Merits on Huff'n'Puff

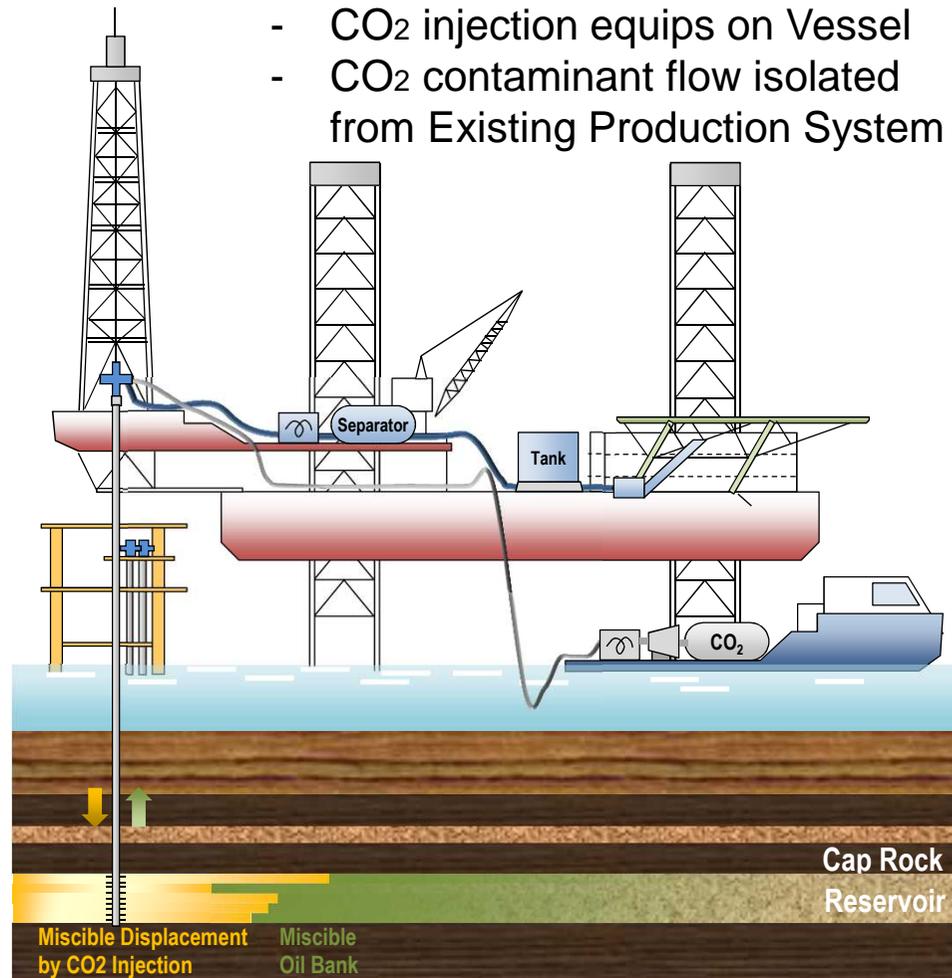
- *Single Well*
- *Short Test*
- *Small CO₂ Requirement*
- *Minimum Impact to Facility*

CO₂ Huff'n'Puff Test -Operation

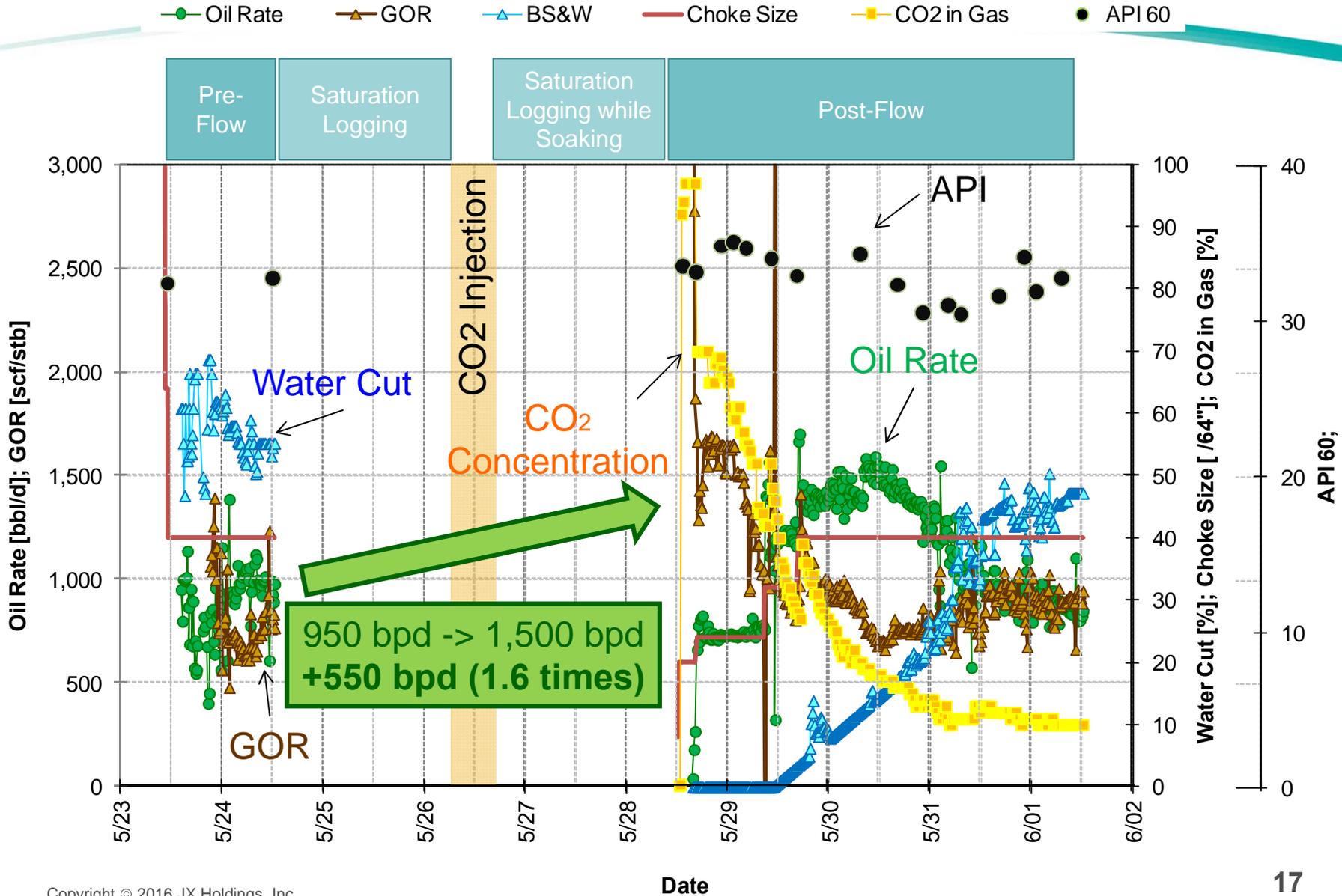


Test Operation

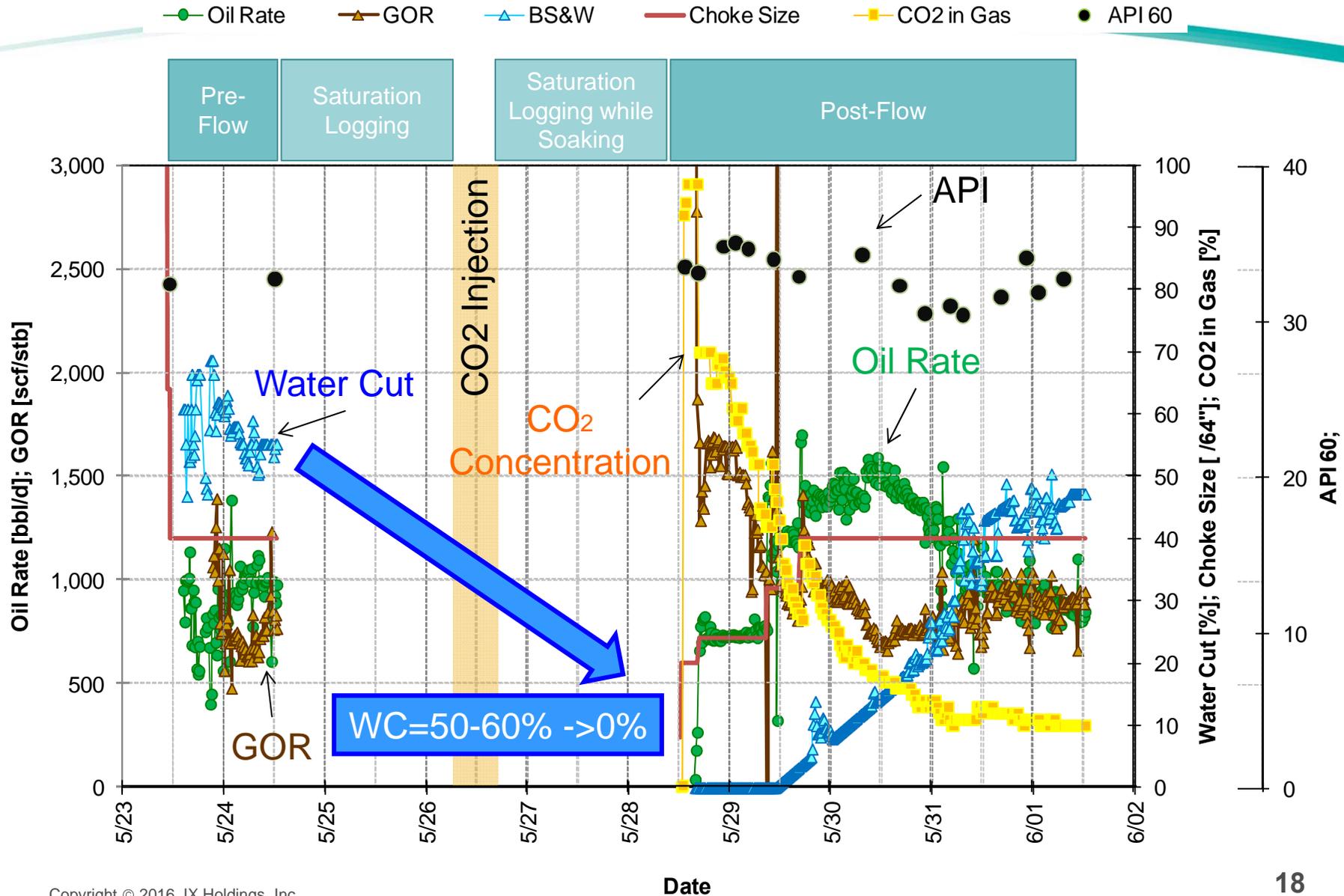
- DST equipments on Rig
- CO₂ injection equipments on Vessel
- CO₂ contaminant flow isolated from Existing Production System



Oil Increment by CO₂ Huff'n'Puff



Water Cut Reduction by CO₂ Huff'n'Puff



CO₂ Huff'n'Puff Test Results



Operation was successfully completed without any operational trouble and HSE issues

CO₂ Huff'n'Puff Test provided following results;

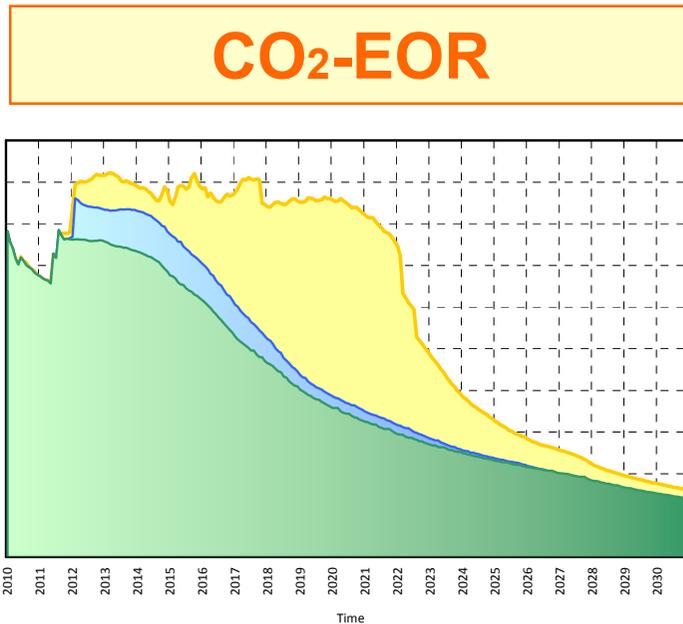
- CO₂ Injectivity
- Oil Production Increase
- Water Cut Reduction
- Oil Property Changes by CO₂ injection
- Oil Saturation Changes before / after CO₂ injection

Feasibility Study and CO₂ Huff'n'Puff test results indicated CO₂-EOR is technically applicable for Rang Dong Field

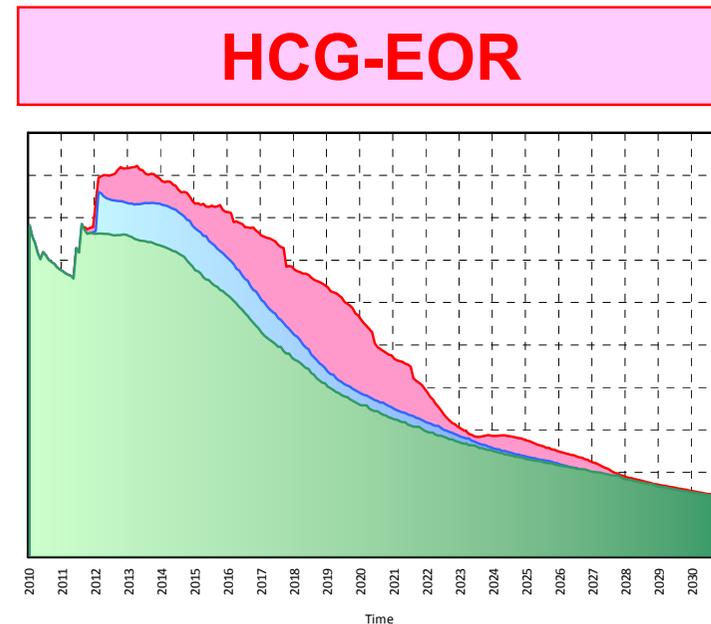
Alternative EOR Application ~HCG-EOR~



CO₂-EOR can maximize ultimate recovery. However, HCG-EOR is more cost-effective application.



CAPEX: US\$ 1 Bil.



CAPEX: US\$100 Mil.

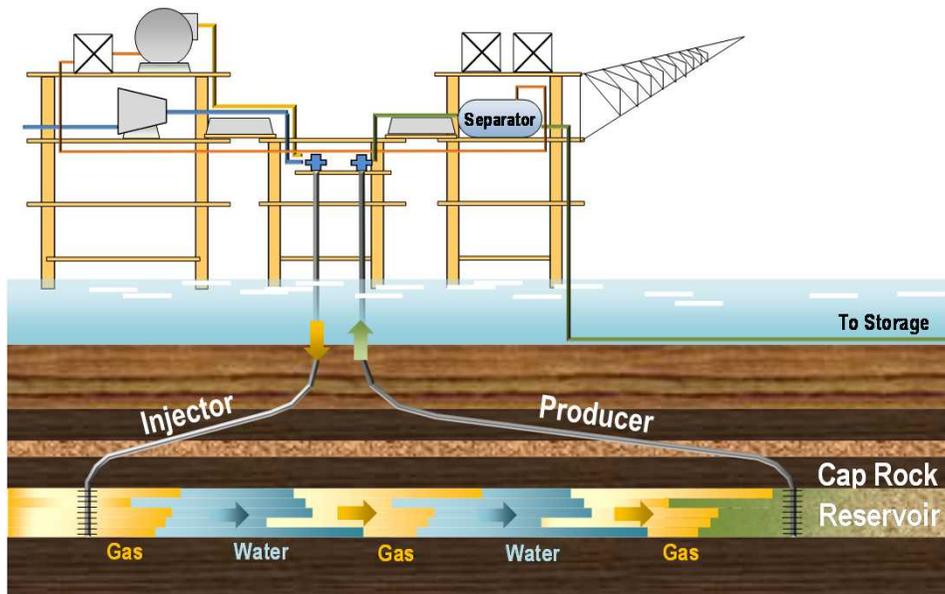
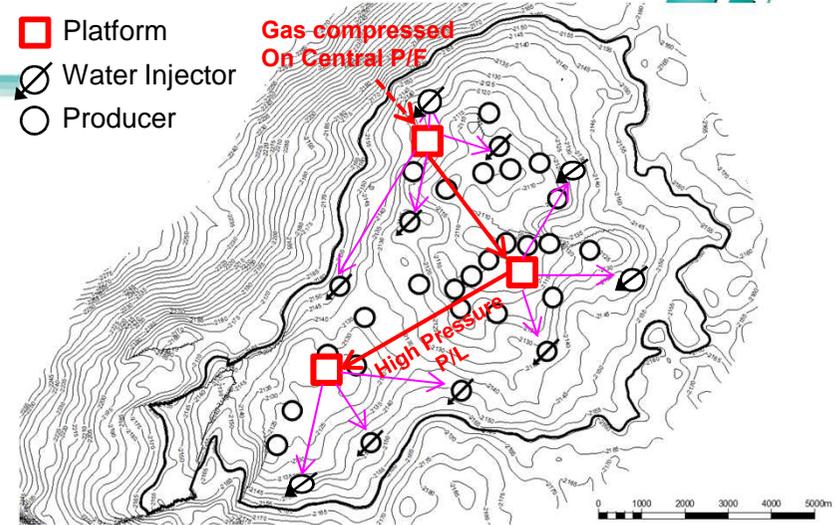
CO₂-EOR project is temporary suspended. JX proceeded HCG-EOR toward commercial application.

HCG-EOR Application in Rang Dong Field

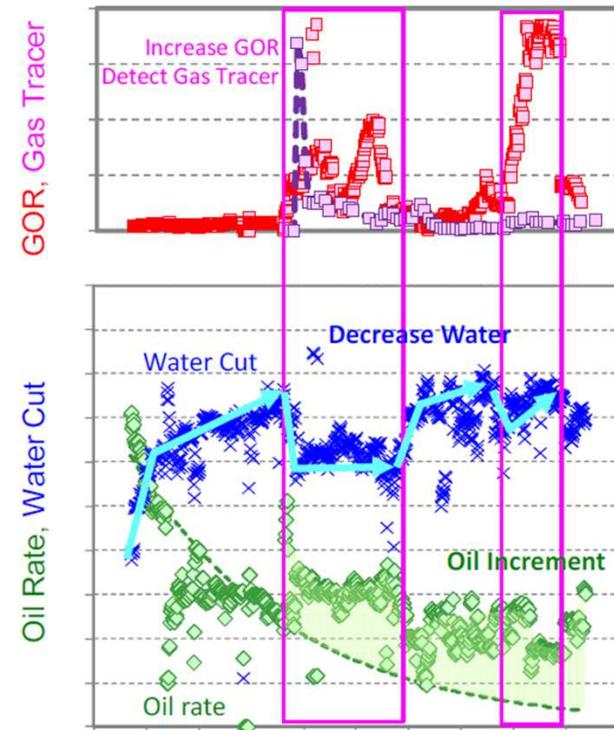
JX also succeeded HCG-EOR Pilot Test since 2012.

JX implemented HCG-EOR as the first commercial EOR since 2014.

- Platform
- ⊗ Water Injector
- Producer



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3. CONCLUSIONS

3. Conclusions



- JX planned and conducted 1st Offshore CO₂-EOR Pilot Test in SE Asia, jointly with JOGMEC/PVN in 2011.
- CO₂-EOR is technically applicable, but economically challenging for Rang Dong due to inconveniently located offshore project. Alternatively, JX has applied commercial HCG–EOR since 2014.
- Technical experiences in Rang Dong Field highly encourage CO₂-EOR business expansion. JX could achieve FID for Carbon Capture & CO₂-EOR Project in United States, under “Clean Coal Power Initiative Program” granted by DOE.
- JX continues development of CO₂-EOR technology for maximizing oil production and reduction of CO₂.

Thank you for your attention



The Future of Energy, Resources and Materials

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