Research and Development Centre for Oil and Gas Technology "LEMIGAS"
Ministry of Energy & Mineral Resources (MEMR)

CCS-RESEARCH PROJECTS IN INDONESIA

Workshop on development natural gas resources with high CO2 & CCS in CCOP
Bali 17-20 March 2009

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OUTLINE

- INTRODUCTION
- CCS - CO_2 EOR POTENTIAL
- EAST KALIMANTAN CASE STUDY
- SOUT SUMATERA CASE STUDY
- CONCLUSIONS

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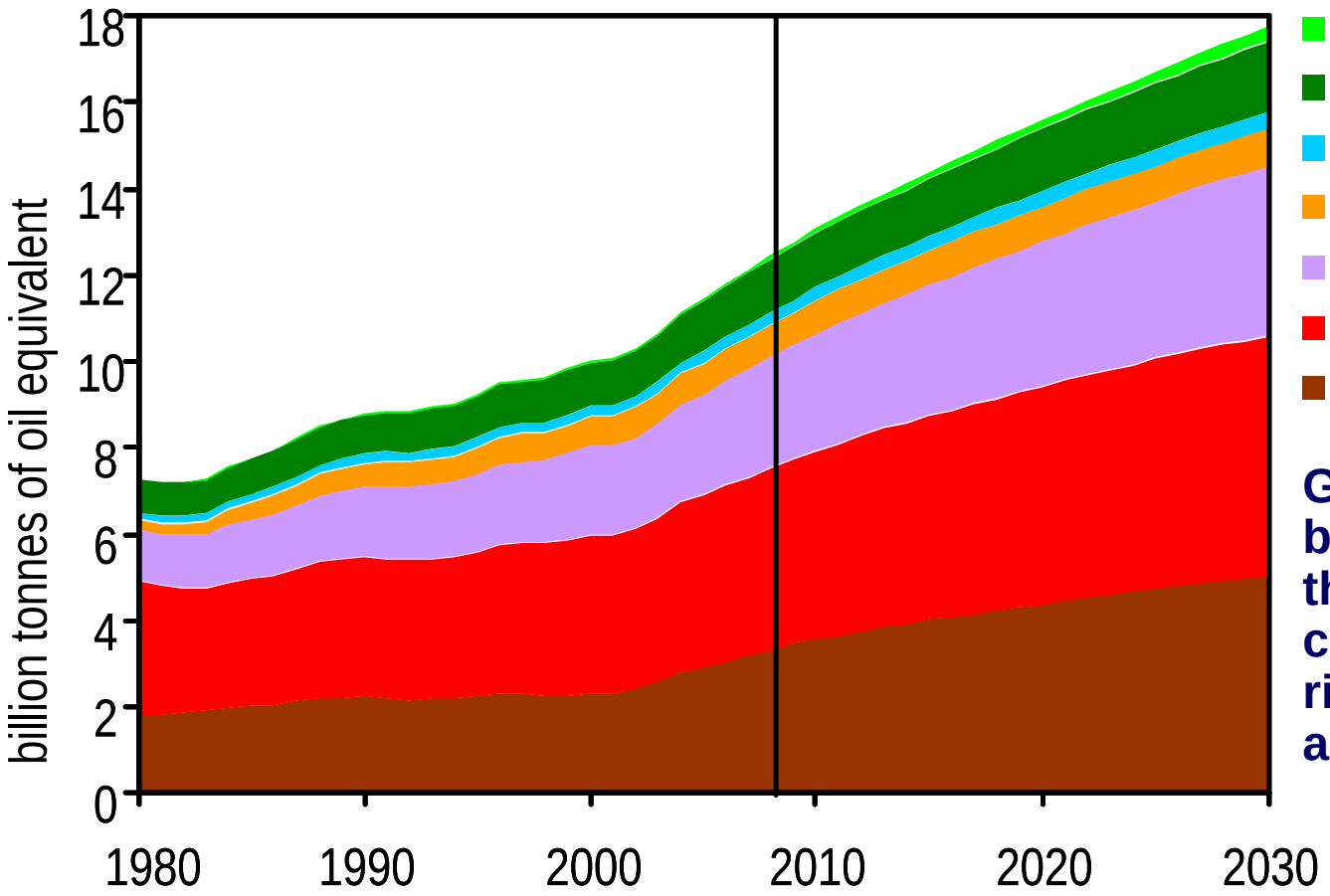
WORD PRIMARY ENERGY DEMAND

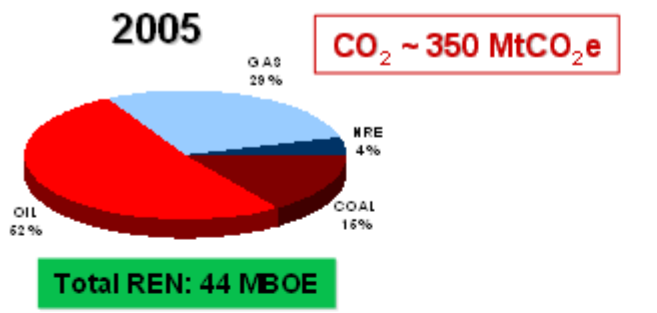


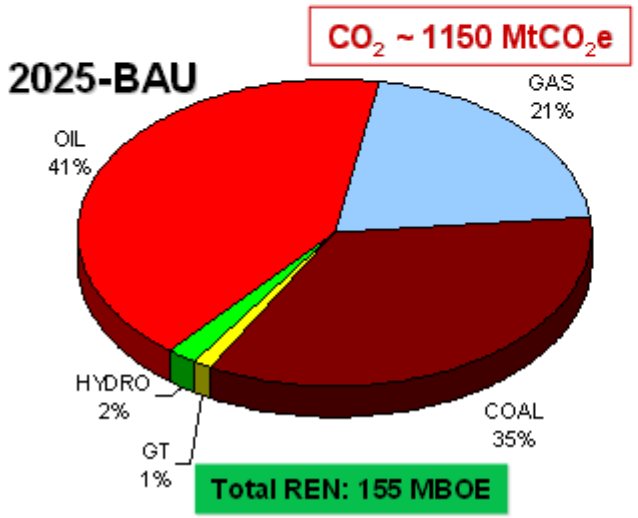
Global demand grows by more than half over the next quarter of a century, with coal use rising most in absolute terms

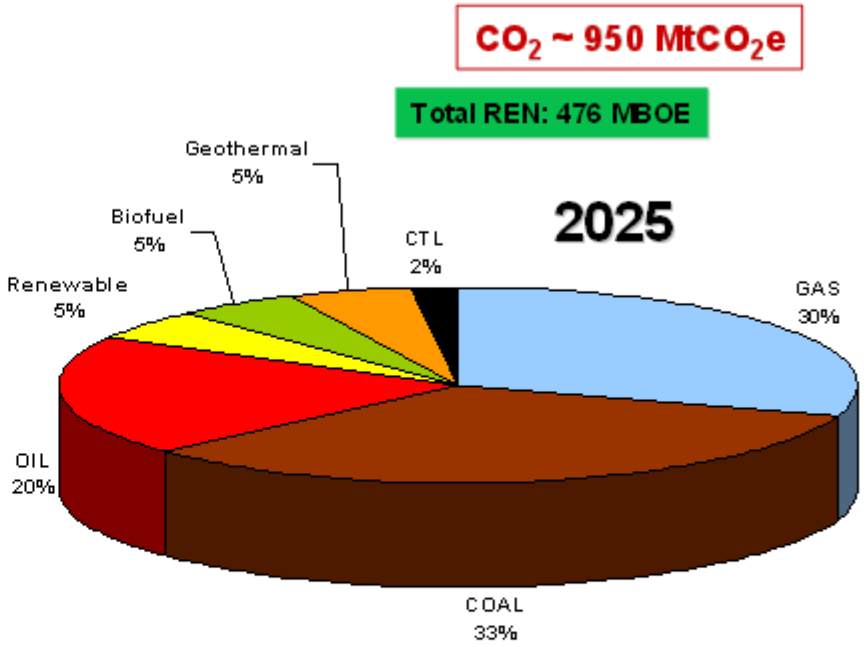
Source: IEA/OECD, World Energy Outlook 2007

INDONESIA'S ENERGY MIX TARGET

Peraturan Presiden No. 5 Tahun 2006

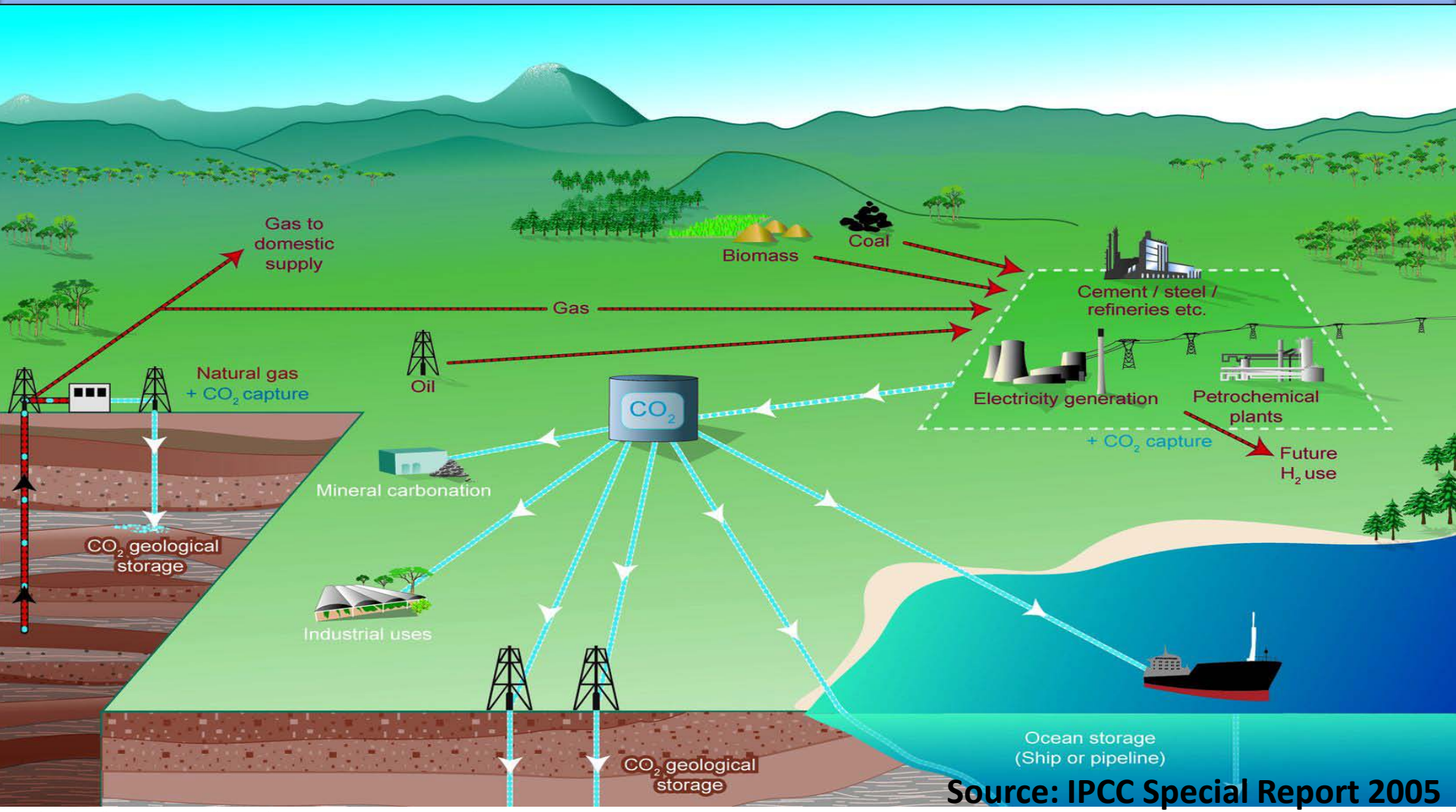






- Reduce Oil Dependency
- Improve Diversification (REN)
- Reduce CO_2 Emission

POSSIBLE CCS SYSTEM



Source: IPCC Special Report 2005

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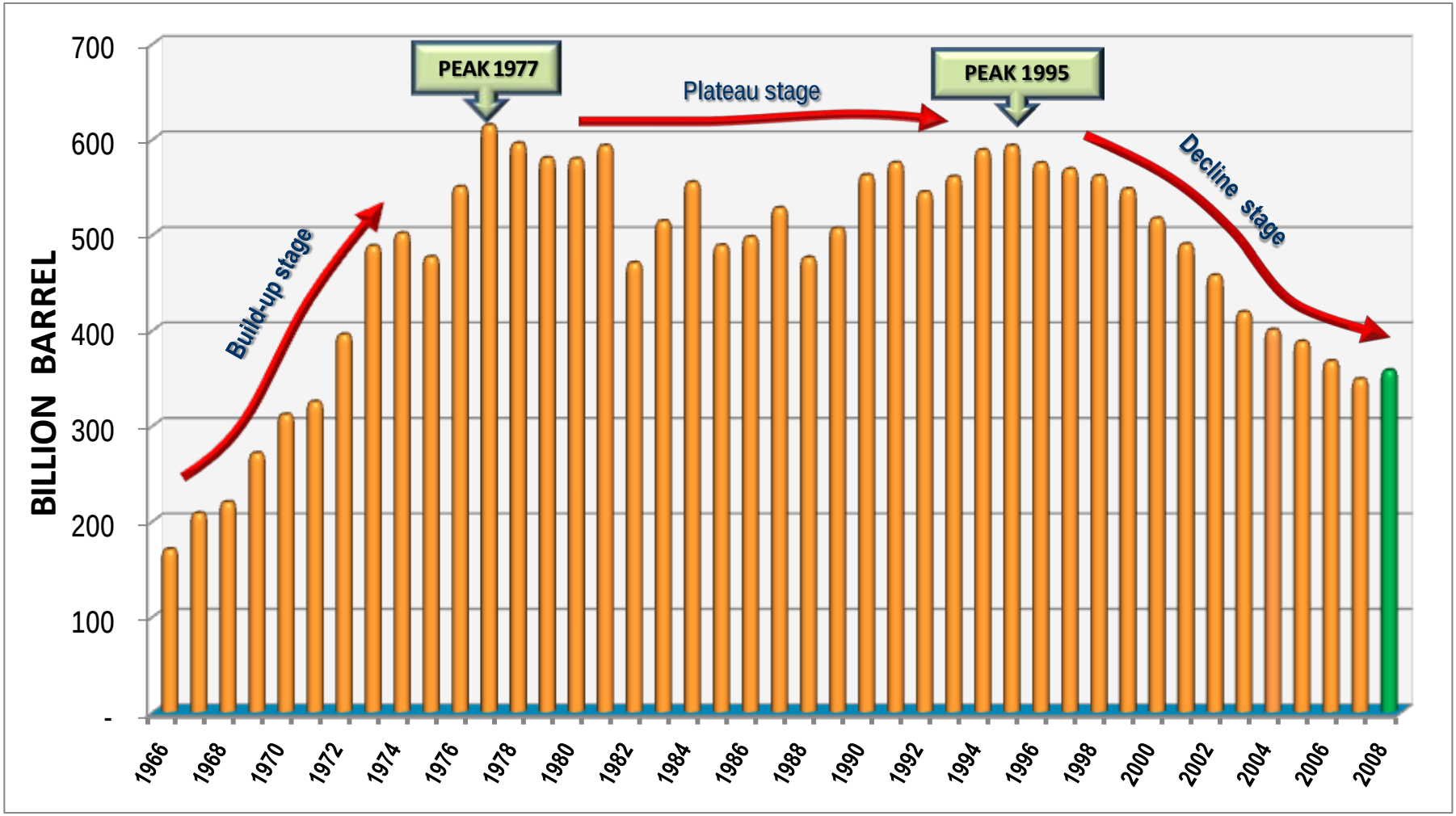
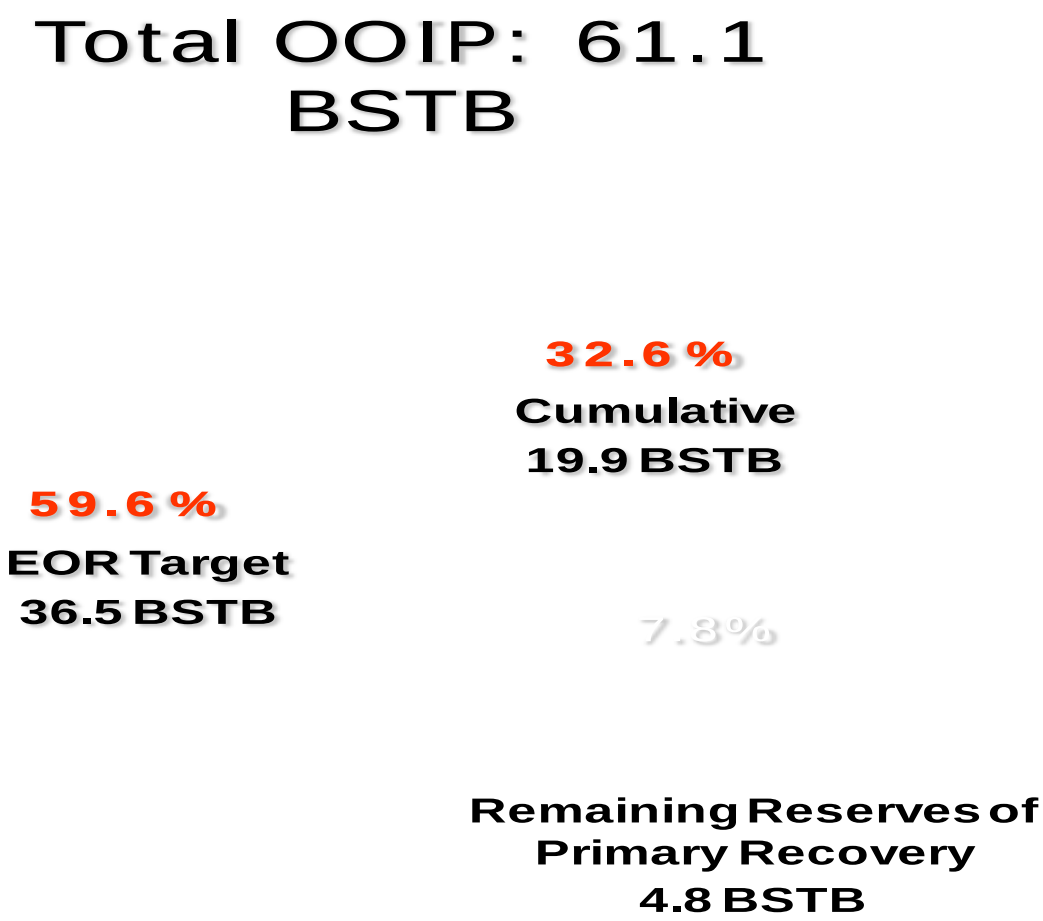
HISTORY OF INDONESIA OIL PRODUCTION

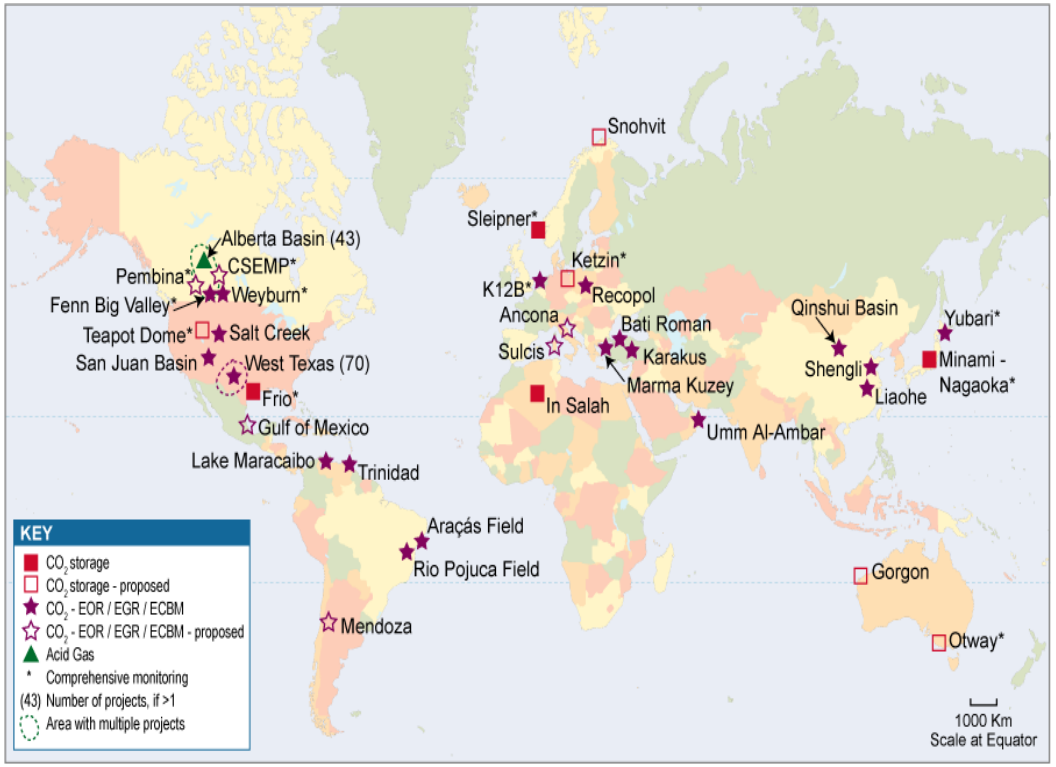


GLOBAL EOR TARGET IN INDONESIA



CCS - CO2 EOR

- CO_2 injection is proven EOR method to increase oil recovery (incremental up to 10-15% OOIP)
- Some of injected CO_2 can be trapped in reservoirs

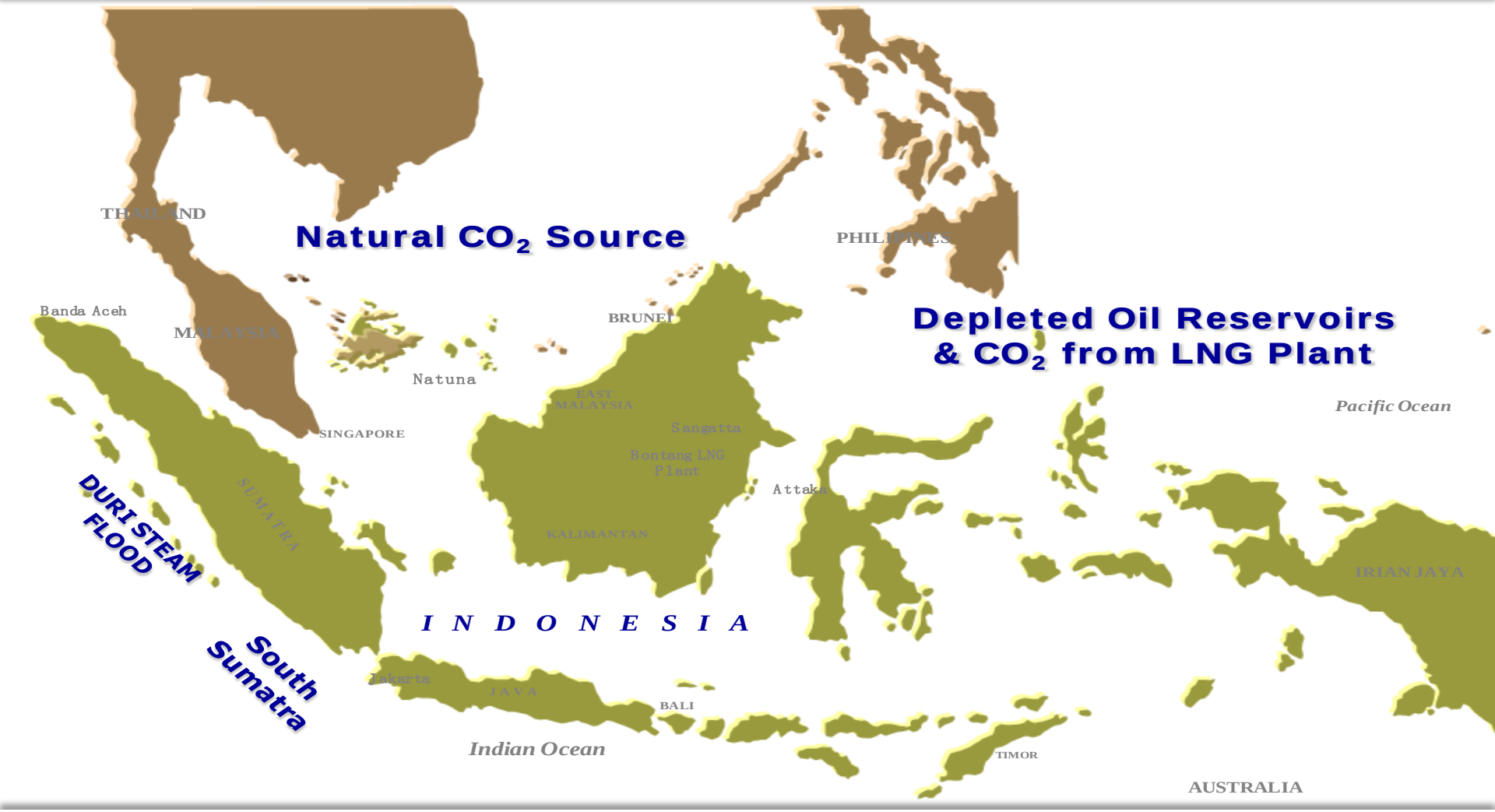


Source: IPCC Special Report 2005

CO_2 INJECTION IN DEPLETED RESERVOIR

- A process whereby CO_2 is Injected into an oil depleted reservoir in order to reduce oil viscosity and density due to swelling effect
- Environmental Purposes ➡Carbon Disposal
- Method:
  1. Miscible
     (Incremental RF = 10-15% OOIP)
     - WAG
     - Continuous
     - Huff and puff
  2. Immiscible
     (Incremental RF = 3 - 9 % OOIP)

AREA FOR CCS POTENTIAL



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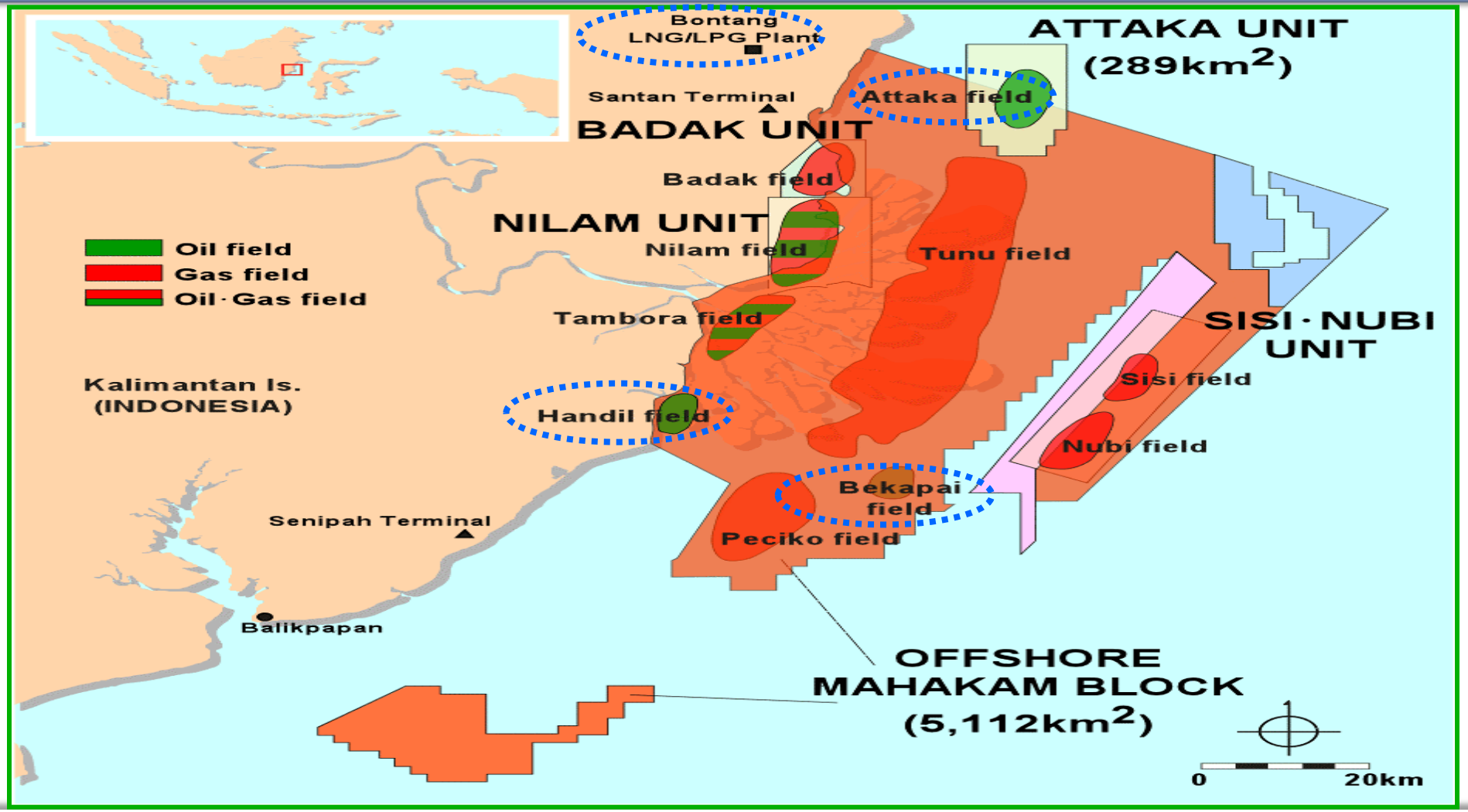
EAST KALIMANTAN CASE STUDY

- Potential
  - Sources: Bontang LNG/LPG Plant
  - Storages: Depleted Reservoir in Handil, Attaka, Bekapai, Sangata
- Reservoir Screening for CO_2 EOR
- Laboratory Works
- CO_2 Sequestration Modeling @ Depleted Reservoir

CO_2 STORAGE – EOR POTENTIAL IN EAST KALIMANTAN

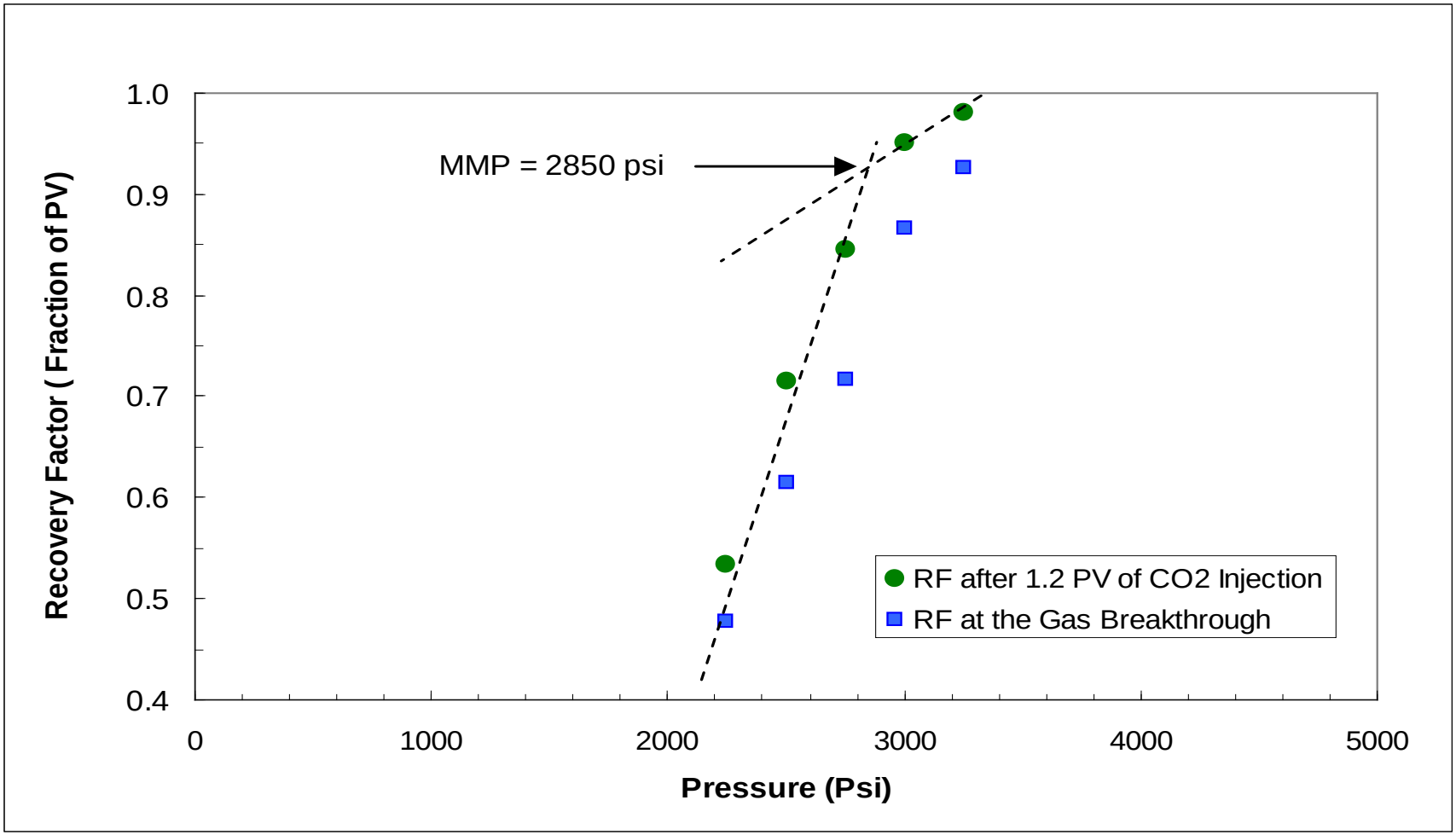


CO_2 STORAGE – EOR POTENTIAL IN EAST KALIMANTAN

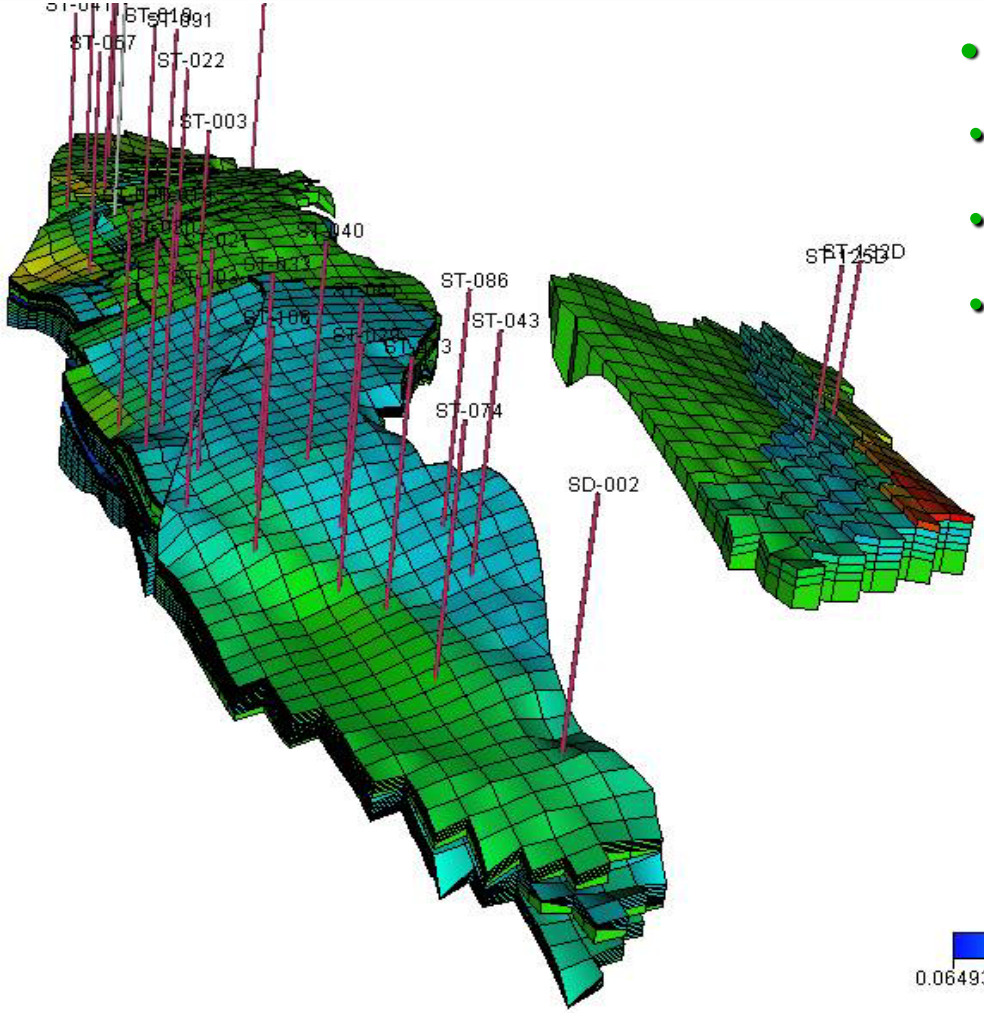
Rule-of-Thumb Approach (historical experience)

- Incremental Oil Recovery (% OOIP)
  - 8-16 %
- Gross CO_2 Utilization (Mcf/Bbl)
  - 5-10 Mcf/Bbl
- Net/Gross Utilization Ratio (fraction)
  - 0.5

LABORATORY WORK FOR MMP DETERMINATAION



GEO – RESERVOIR MODELING



- Grid System: 29 x 80 x 49
- Porosity
- Water Saturation
- Permeability

GEO – RESERVOIR MODELING

- Objectives:
  - Increase oil recovery
  - Volume of CO_2 sequestered
- Implement after primary recovery reached 13.3 % OOIP
- Use 20 injection wells

CO2 Injection Scenario

Injection Scenario	Maximum Injection Rate (MSCF/D)	Injection Pressure (Psia)
Continuous CO_2 Injection (Down Dip Injector)	40,000	2860
Continuous CO_2 Injection (Up Dip Injector)	40,000	2860
1:1 WAG CO_2 Injection	40,000	2860

RESULTS (1 of 2)

1. 10 reservoirs are suitable for CO_2-EOR
2. Screening Reservoirs from MMP
   - MMP > current reservoir pressure
   - 3 reservoirs above 0.8 psi/ft were eliminated (above p_f)
3. Rule of Thumb Method:
   - Potential Oil Recoveries of 3.6 – 7.2 MMSTB
   - Sequestration volumes of 0.5 – 2.1 Million tons

RESULTS (2 of 2)

4. The Results of Laboratory Study:

- The MMP was 2850 psig
- The result of CO_2 injection at 3000 psig reveals that the recovery factor was 93.3% OOIP after 1.2 PV CO_2 injected.
- The recovery factor of 2500 psig CO_2 injection after waterflooding was only 21.3% OOIP

5. The Simulation Results:

- Continues CO_2 injection
  - Potential oil recoveries of 2.6 – 3.3 MMSTB
  - Sequestration volumes of 4.7 – 4.9 Million tons
- 1 : 1 WAG
  - Potential oil recoveries of 2.4 MMSTB
  - Sequestration volumes of 2.2 Million tons

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SOUT SUMATERA CASE STUDY

1. Reservoirs screening
2. Laboratory study
3. Compositional simulation study using:
   - Hypothetic reservoir data
   - "X" Field reservoir fluid data
4. Define the most promising CO_2 injections method and determine the amount of CO_2 stored

CO_2 INJECTION METHODS

1. **Miscible**

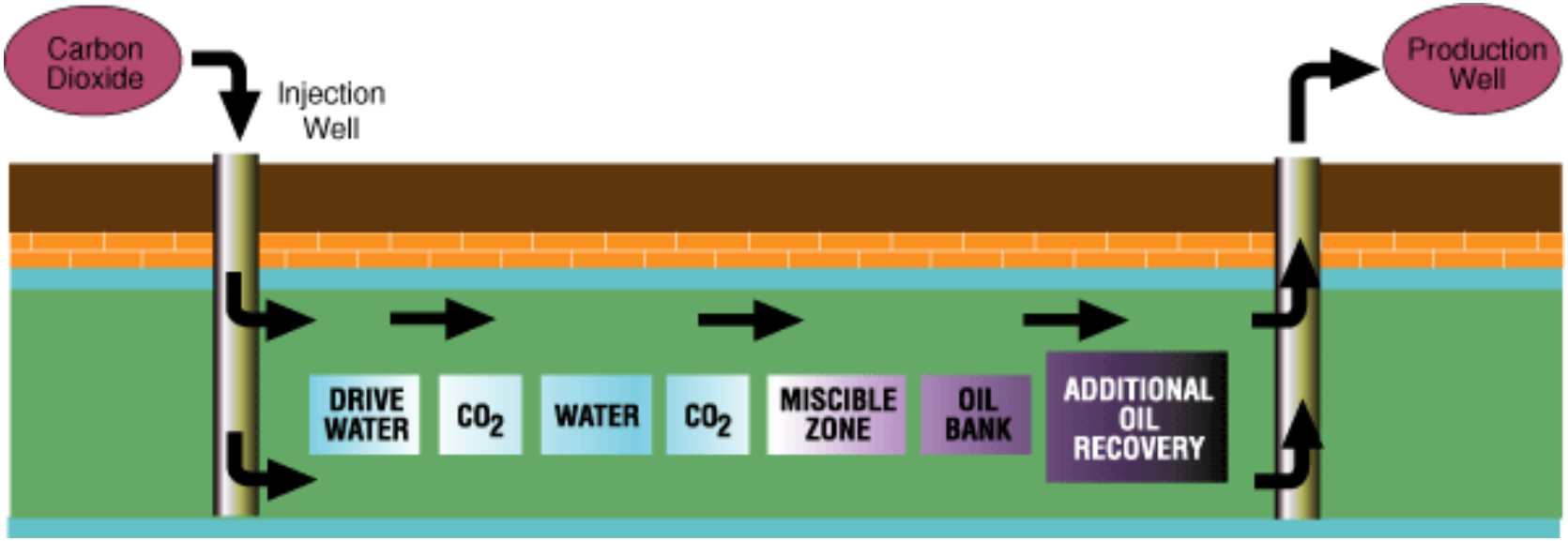
   (Incremental RF = 10-15% OOIP)

   - **WAG**
   - **Continuous**
   - **Huff and puff**

2. **Immiscible**

   (Incremental RF = 3 - 9 % OOIP)

WATER ALTERNATE GAS (WAG)



WAG: CO2 Injection Process whereby the water is being injected behind CO_2 Slug (as illustrated above)

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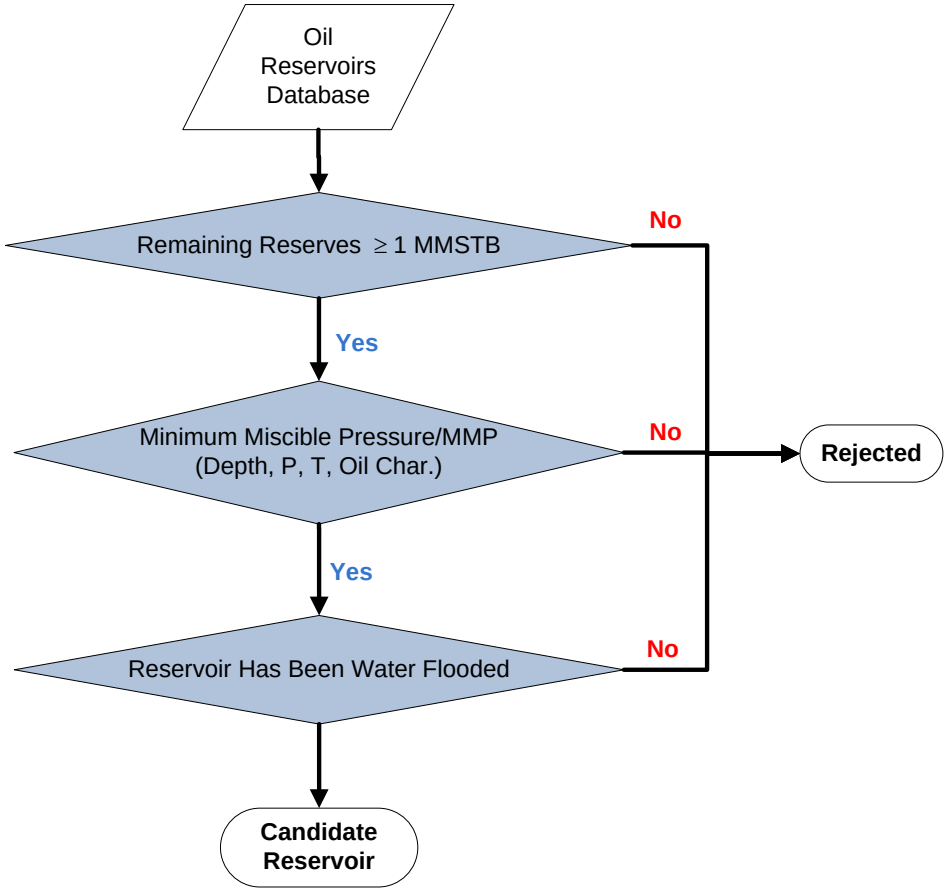
SCREENING FOR WAG CANDIDATES

Parameter	Optimum	Weight
API Gravity	37	0.24
Oil Saturation %	60	0.2
Pressure/MMP	1.3	0.19
Temperature, ^{0}F	160	0.14
Net Oil Thickness, ft	50	0.11
Permeability, mD	300	0.07
Dip, ^{0}	20	0.03
Porosity, %	20	0.02



RESERVOIR FLUID DATA

- Carbonate reservoir
- Fluid properties:
  - P_b = 1553 psig
  - Gravity =35.5 ^oAPI
  - T_{resv} = 265^oF @ 5880 ft

CALCULATED WELLSTREAM COMPOSITION

Component		Mole Percent	Weight Percent
Hydrogen Sulfide	H_2S	0.01	0
Carbon Dioxide	CO_2	3.51	1.11
Nitrogen	N_2	0.29	0.06
Methane	C_1	31.3	3.62
Ethane	C_2	3.74	0.81
Propane	C_3	5.45	1.73
Iso-Butane	$i\text{-}C_4$	1.62	0.68
n-Butane	$n\text{-}C_4$	2.43	1.02
Iso-Pentane	$i\text{-}C_5$	1.66	0.86
n-Pentane	$n\text{-}C_5$	1.45	0.75
Hexanes	C_6	2.45	1.52
Heptanes Plus	C_{7+}	46.09	87.84
Total		100	100

Properties of Heptanes Plus:

API Gravity @ 60 ^oF	:	32.31
Specific Gravity @ 60/60 ^oF	:	0.8613
Molecular Weight	:	264.74

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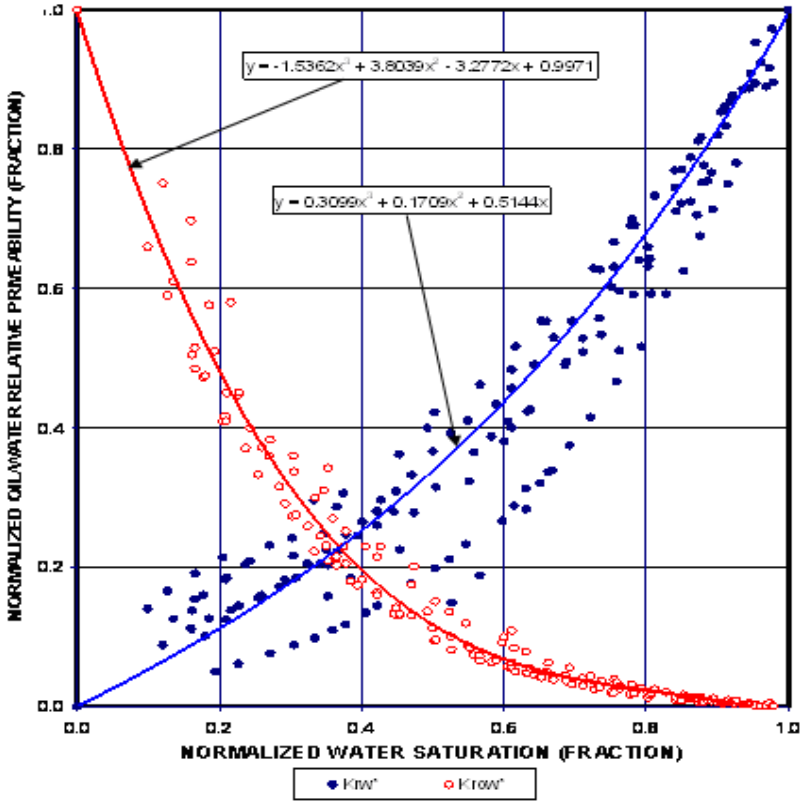
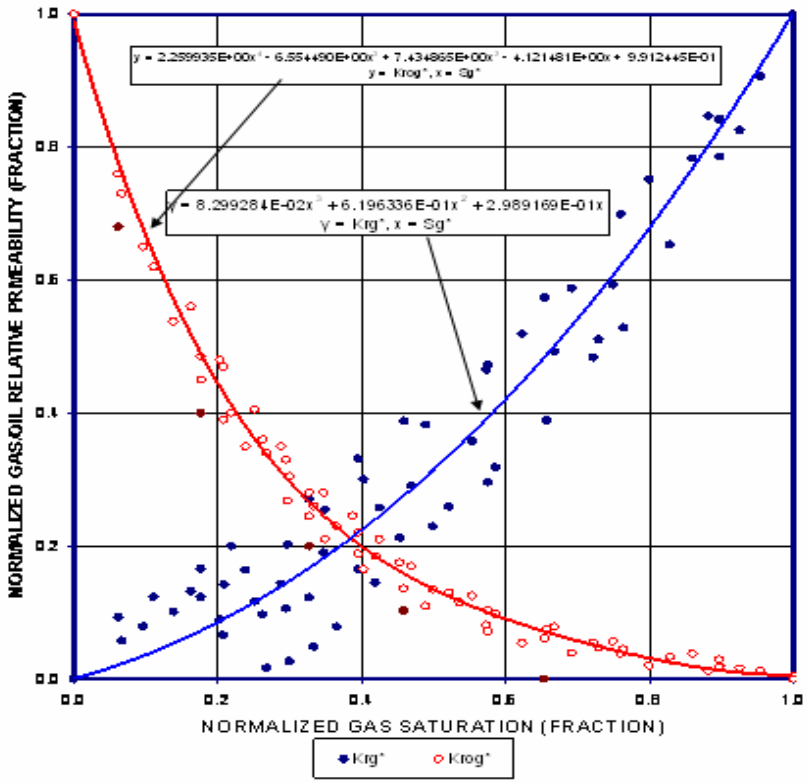
RELATIVE PERMEABILITY DATA





PVTi CHARACTERIZATION

- To generate PVT data from the laboratory analysis of oil and gas samples
- Correlations:
  - EOS = 3-Parameter Peng-Robinson
  - Viscosity = Lohrenz-BrayClark
- Standard conditions:
  - T = 60.0000 ^{o}F
  - P = 14.6959 Psig

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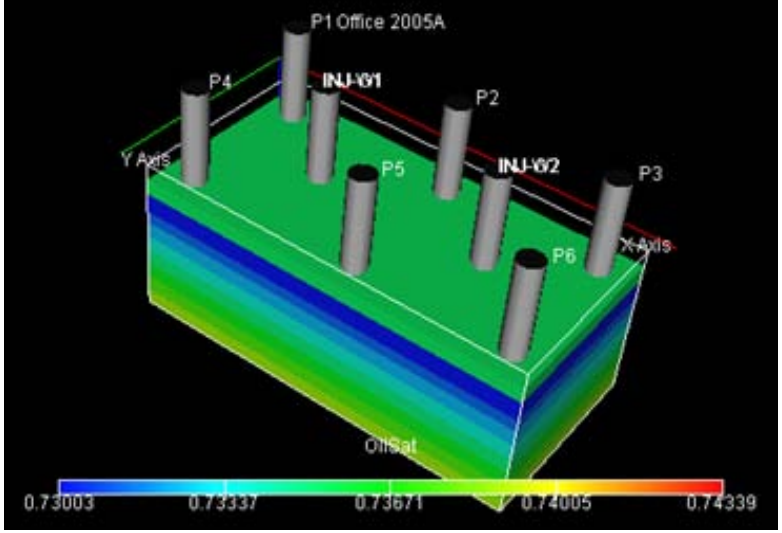
SIMULATION DATA

PARAMETERS	QUANTITY
Grid Dimension	20 x 10 x 10
Model Dimension	2000 x 1000 x 400 (ft^3)
Average Porosity	0.2 (fraction)
Average Horizontal Permeability	134 mD
Average Vertical Permeability	14.7 mD
Datum	5813 ft
Pressure @ Datum	2230 psia
Base Case : •Injection Gas Rate • Injection Water Rate	1000 Mscfd 3000 stb/day
Injection Period Interval	91.25 days
BHP Target	3100 Psia
Production Well Economic Limit •Max. Water cut •Max. GOR	 100 % 10 MMscf/STB

INTIALIZATION

- Oil = 13.47 MMSTB
- Water = 3.97 MMSTB
- GAS = 5.72 BSCF



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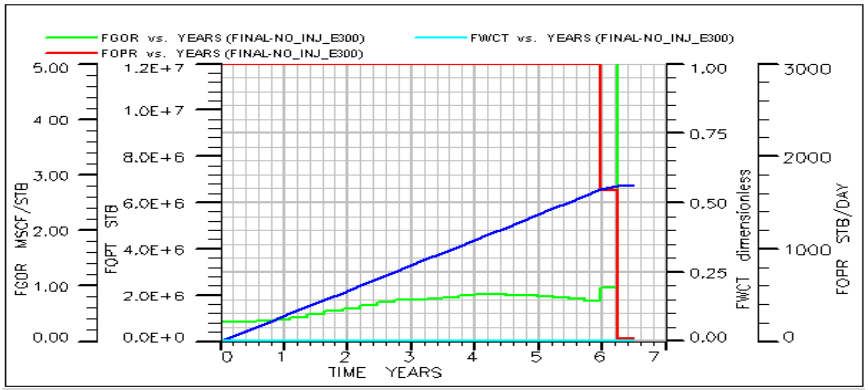
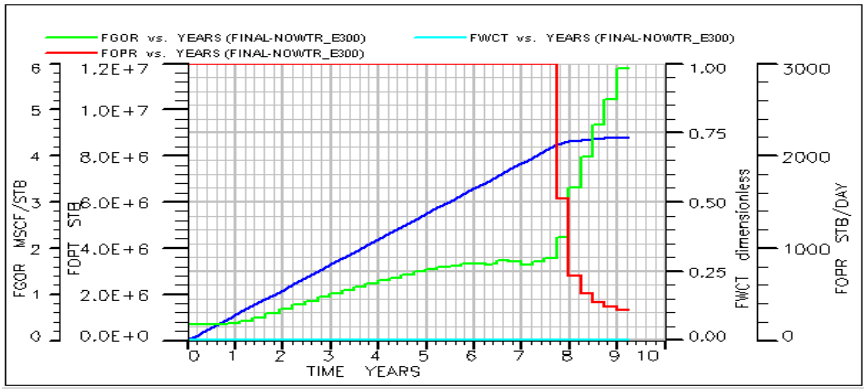
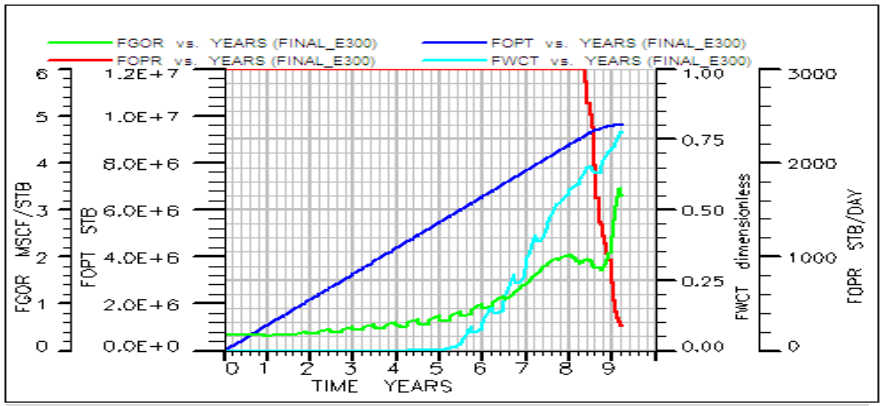
PRODUCTION PROFILE COMPARISON



Primary



CO_2 Flooding



WAG Flooding

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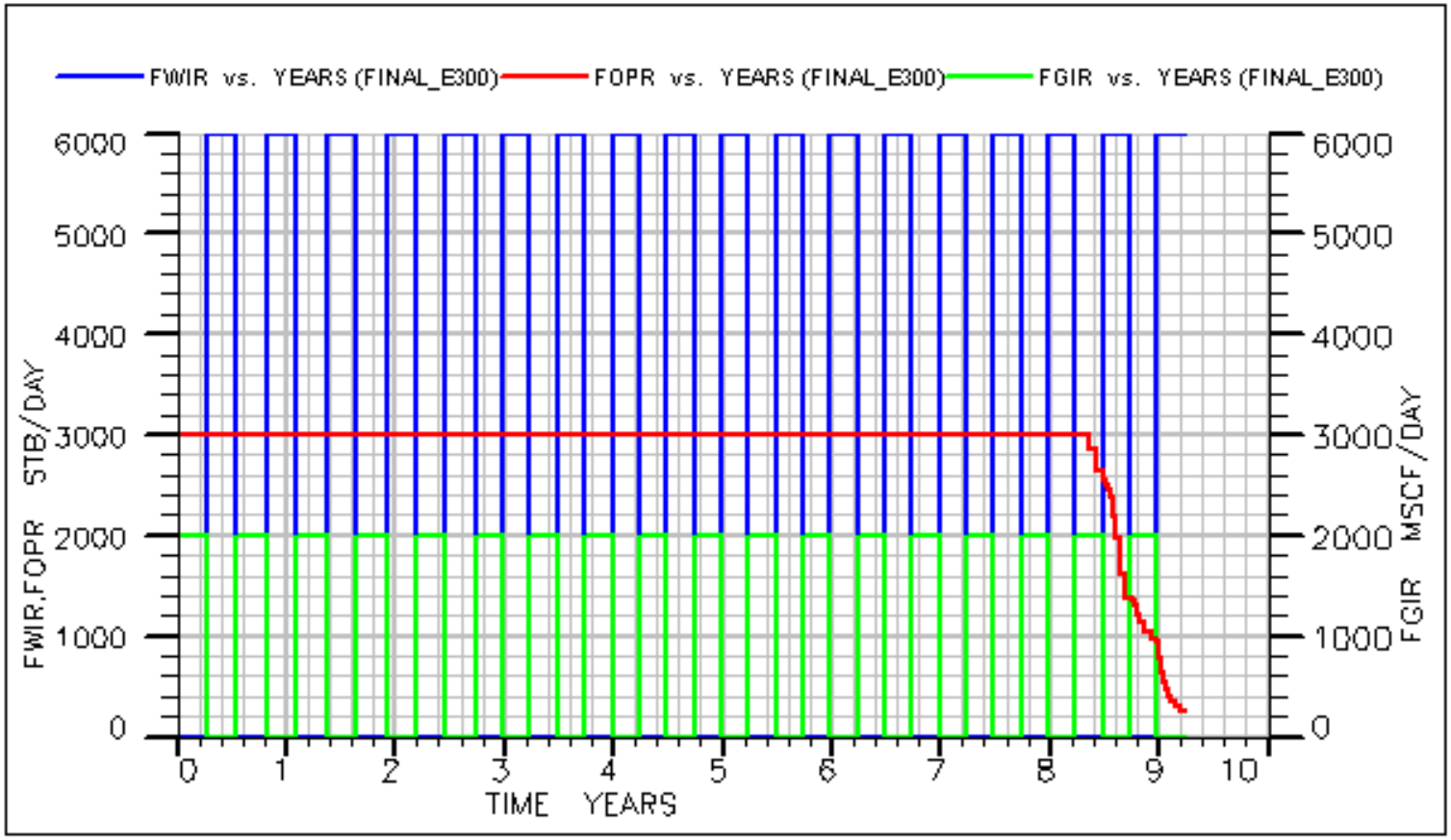
WAG BASE SCENARIO



SIMULATION RESULTS

PARAMETERS	BASE -CASE	GAS = 1000 MSCFD			WATER = 3000 STBD		
	GAS = 1000 MSCFD WTR = 3000 STBD	WTR 2000 STBD	WTR 1000 STBD	WTR 500 STBD	GAS 3000 MSCFD	GAS 2000 MSCFD	GAS 500 MSCFD
Prod. Period (YEARS)	9.23	9.23	8.73	8.23	8.98	9.48	9.23
Injected CO_2 (BSCF)	3.373	3.373	3.190	3.008	10.118	7.110	1.686
Produced CO_2 (BSCF)	0.569	0.557	0.529	0.510	1.001	0.810	0.459
Trapped CO_2 (BSCF)	2.803	2.815	2.661	2.498	9.117	6.300	1.227
Cuml. Oil.Prod (MMSTB)	9.611	9.540	9.168	8.590	9.769	9.807	9.482

SUMMARY
SOUTH SUMATERA CASE STUDY

1. WAG enhanced oil recovery to 22% OOIP
2. WAG was the best production profile compared to CO_2 continuous flooding
3. Slug ratio was critical parameter in WAG injection
4. Almost 90 % of injected CO_2 trapped in reservoir therefore CO_2 EOR is promising as **carbon disposal**

CONCLUSIONS

- CCS-EOR will be high on agenda
- Huge potential of oil recoveries and CO_2 sequestration volumes is in East Kalimantan and South Sumatra
- CCS on saline aquifer in Natuna
- Demonstration projects are needed funded by international sources
- National regulatory framework is needed

MAIN ISSUES AND CHALLENGES

- No public awareness of CCS and little technical CCS capacity in Indonesia
- CCS costs must be reduced
- No legal and regulatory frameworks
- Need accelerating investment R&D
- Demonstration projects are needed funded by international sources

AREA FOR COOPERATION

- Knowledge sharing and capacity building
- Study on site of geological storage and CO_2 sources
- CCS – CO_2 EOR
- Study on CCS in Natuna
- Pilot demonstration project
- Established national regulatory framework for CCS
- Enhanced Coalbed Methane Recovery (ECBM)

END

Thank you for your attention!

CO_2 STORAGE – EOR POTENTIAL IN EAST KALIMANTAN

Reservoirs Selection:

- Based on the availability data
- Meet the screening criteria and remaining oil reserves > 10 MMSTB
- 110 reservoirs at Attaka-Handil-Bekapai fields with total OOIP of 3,317 MMSTB

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OIL RECOVERY AND STORAGE VOLUME ESTIMATE BY RULE OF THUMB - EAST KALIMANTAN

Gross CO_2 Utilization	Incremental Oil Recovery (%OOIP)		
	8%	12%	16%
5 MCF/BBL	265 MMSTB 38 MMtons	398 MMSTB 57 MMtons	531 MMSTB 76 MMtons
7.5 MCF/BBL	265 MMSTB 57 MMtons	398 MMSTB 85 MMtons	531 MMSTB 114 MMtons
10 MCF/BBL	265 MMSTB 76 MMtons	398 MMSTB 114 MMtons	531 MMSTB 152 MMtons

✓ **Oil recoveries of 265 – 531 MMstb**

✓ **Storage volume of 38 -152 MMtons**