Work Progress High CO_2 Gas Reservoir in INDONESIA (PERTAMINA)

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Outlines

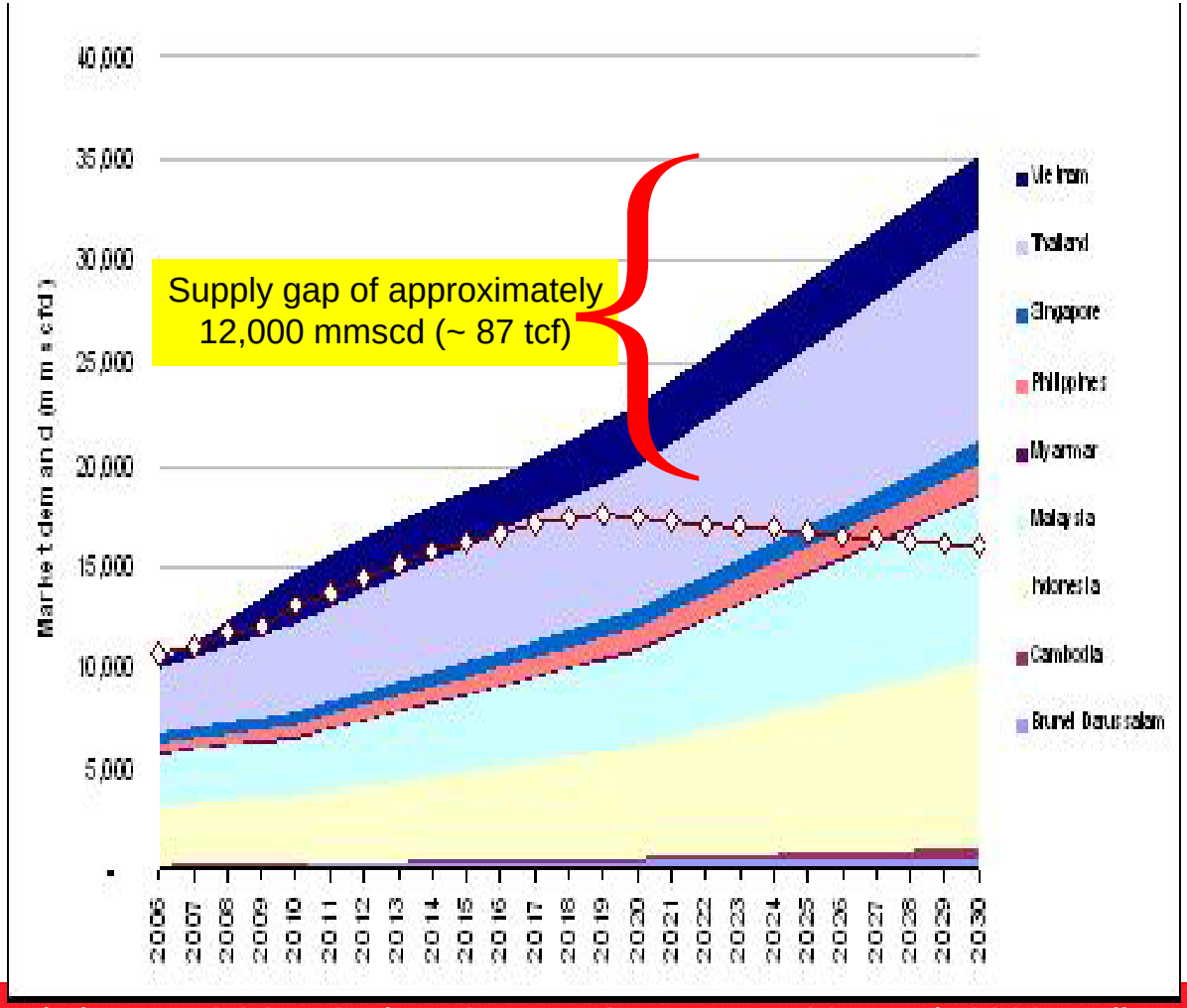
- Gas Supply & Demand in ASEAN Region
- High CO_2 Gas Reservoir Description
- Source of CO_2 gas Generation in Indonesia
- High CO_2 Gas Development

Deliverability

- To Report The High CO_2 Gas Reservoir Development In Indonesia (PERTAMINA)
- To Develop Gas Reservoir Which Contain High CO_2
- To Utilize The CO_2 To Increase The Production
- To Have environmental Benign

Observations on the data for TAGP Conceptual Masterplan 2007

Regional Supply Vs Demand (Base Case)
(inclusive supply from E Natuna)



Observations:

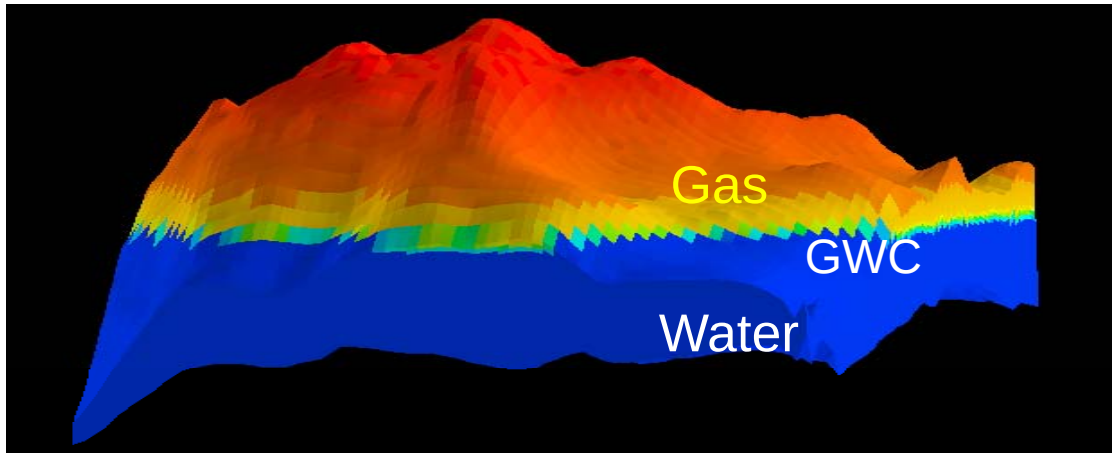
- **There is a widening supply gap from 2017 rising to more than 12,000 mmscfd by 2025.**
- **This shortfall reflects declining gas reserves causing gas supply to plateau and starts to decline while at the same time demand continues to rise strongly.**
- **This shortfall could be addressed by new discoveries in the region, or by increased imports of LNG Gas consumption.**

  (E&P BD has been informed to study at ASCOPE level how best can we further increase supply)

  (East Natuna commercialisation is key at ASCOPE level)
- **While finalising masterplan, demand figures constantly increases**

Alternative Sources of Gas Proposed by : ASCOPE BDC EP

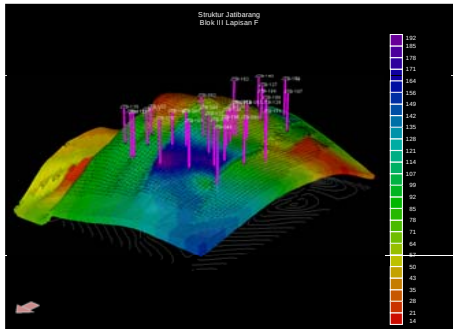
- High CO2 Gas Reservoir
- Coal Bed Methane (CBM)



High CO_2 Concentration Gas Field

- Marginal Field
- Non Hydrocarbon Reservoir
- Unconventional Reservoir
- Supercritical Reservoir

- High CO_2 Content Gas:
  - Incombustible Matter
  - Possible climate changes
  - Corrosion



Development Purposes of High CO_2 Gas Reservoir:

- To Produce Marketable Gas
- To Produce Feed Gas for LNG Plants
- To Produce Gas Oil, Kerosene, Naphtha
- Environmental Friendly Gas Fuel
- Producing - Unconventional Reservoir
- CO_2 Flooding

Considered Marginal Field

Considered as Marginal Field:

- Hydrocarbon Volume: .... BSCF ?
- Field Location : - Water Depth ?
  - Remote Area ?
  - Conflict Area ?
- Structure Complexity
- Fluid Contain: - High CO2 Concentration
  - High H2S Concentration
  - Heavy Oil, Gas,

Reservoir Fluid Classification

- WATER RESERVOIRS : “WATER” :H_2O + Cl-
- HYDROCARBON RESERVOIRS: C_1-C_{30}+ > 75 mol%,

Impurities:H_2S,CO_2

1. Black Oil
2. Volatile Oil
3. Condensate
4. Wet Gas
5. Dry Gas

- NON HYDROCARBON RESERVOIRS
  - **[CO_2] > 70 mol%**
  - [C_1-C_{30}+]< 30 mol%

Types of Reservoir Fluid

Type	Dry Gas	Wet Gas	Gas Condensat	Volatile Oil	Black Oil
Apperaance in Surface	Colourless Gas+some	Colourless Gas+some clear liquid	Colourless +significant clear/straw liquid	Brown Liquid some red/green colour	Black viscous liquid
Initial GOR (scf/stb)	no liquids >=100000	>15000	3000-15000	2500-3000	100-2500
^{0}API	-	60-70	50-70	40-50	<40
Gas S.G	0.60-0.65	0.65-0.85	0.65-0.85	0.65-0.85	0.65-0.8
Composition (mol%)					
C_1	96.3	88.7	72.7	66.7	52.6
C_2	3	6	10	9	5
C_3	0.4	3	6	6	3.5
C_4	0.17	1.3	2.5	3.3	1.8
C_5	0.04	0.6	1.8	2	0.8
C_6	0.02	0.2	2	2	0.9
C_{7+}	0	0.2	5	11	27.9

Example of High CO_2 Concentration

- Indonesia:

  Natuna Field: 71 mol% CO_2 - Gas Zone
  45 mol% CO_2 - Oil Zone

  West Java : 45% - 75% mol CO_2

- Argentina: El-Trapial Field 45-75% mol CO_2
- Romania: Up to 95 % mol CO_2

High-CO2-Concentration Reservoir
Unconventional Gas Reservoir

- Natuna Gas Main Composition:
  - CH4: 26 Mol%
  - CO2: 71 Mol%
- Non Marketable Gas:

  -Natuna Gas Heating Value: 350 Cals./scf

  -Marketable gas Heating Value: >1000Cals/scf

  <10 Mol%

  CO_2

  -Power Plant can accept: 17 Mol%
- Non Feed Gas for LNG Plant:

  - High CO2' Low Methane
  - Arun Gas: Methane: 68 Mol%
  - CO2 : 14 Mol%

High-CO_2-Concentration Reservoir
"Unconventional Gas Reservoir"

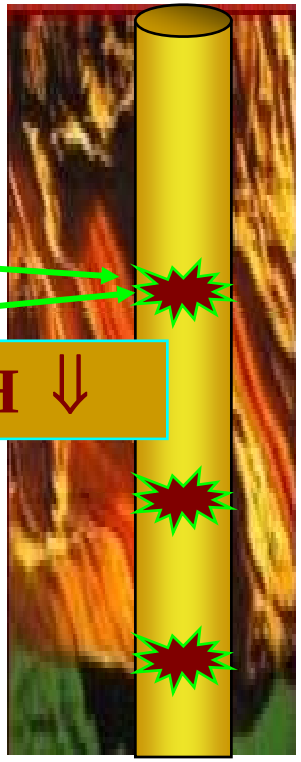
- High Technology to Handle the reservoir
- Additional treatment to put in the market

Corrosion Problem

$CO_2 + H_2O \rightarrow H_2CO_3$ (Carbonic Acid)

$H_2CO_3 \rightarrow H^+ + HCO_3^-$ (Bicarbonate Acid Ion)

$HCO_3^- \rightarrow H^+ + CO_3^{++}$ (Carbonic Ion)



Special Handling if there is H_2S

- Attention on Drilling, Testing, Production
- High CO_2 gas difficult to burn, H_2S will spread on surface

Is This Marginal Enough ?
Do we give up ?

CO_2 GENERATION

- Decarboxylation of Coal

  $C_cH_bO_o \rightarrow$

  $C_{(0.691c-x)}H_{(b-0806c-2y)}O_{(o-2x-y)} + (CH2)_{0.210c} +$

  $0.099c\ CH_4 + x\ CO_2 + y\ H_2O$

- Calcite Dissolution

  $CaCO_3 + 2\ H^+ \rightarrow Ca^{2+} + CO_2 + H_2O$

High CO2 Research – Pertamina

1. CO2 separation with Single Stage Cryogenic, CO2 injection to Separate Aquifer. ExxonMobil + Pertamina

   Field: Natuna, [CO2]: 72 mol%

2. CO2 separation with Multi Stage Cryogenic, CO2 recycling to the Reservoir. Pertamina+Texas A&M University

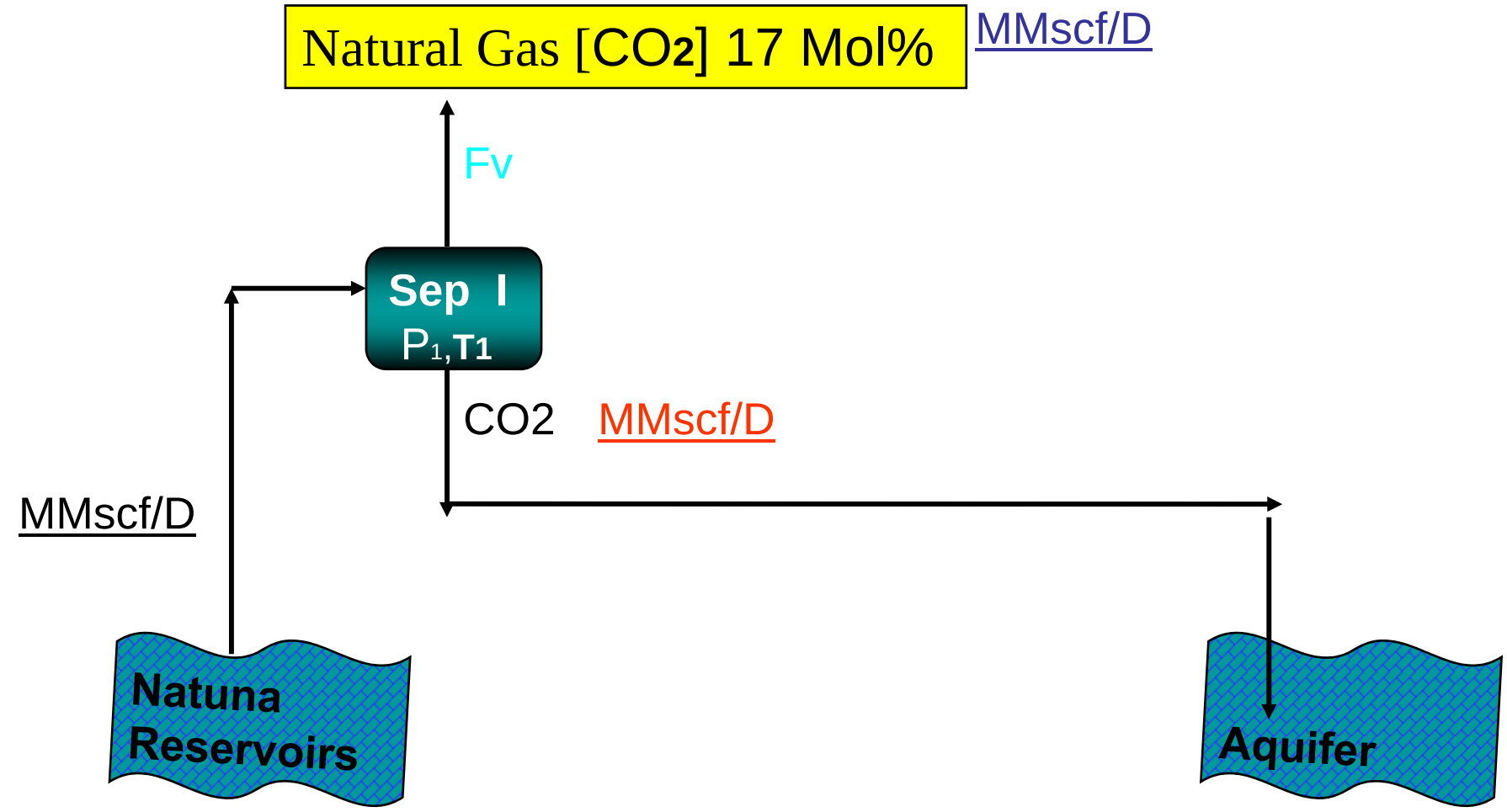
   Field: Natuna, [CO2]: 72 mol%

3. CO2 + Methane → Gas To Liquid (GTL). Pertamina + JNOC. Field: Muara Bulian, [CO2]: 40 Mol%.
4. CO2 Flooding. Pertamina+Lemigas+ITB. West Java Field
5. Future: Combination of 2 and 3.

Single Stage Cryogenic

- Producing Natural Gas with CO_2 72 Mol%
- CO_2 separation with Single Stage Cryogenic
- CO_2 injection to Separate Aquifer.
- Company: ExxonMobil + Pertamina
- Field: Natuna
- Initial Gas In Place: 222 TSCF Raw gas,
  40 TSCF C1
- Product: Natural Gas with CO_2 17 Mol%
- Market: Power Plant

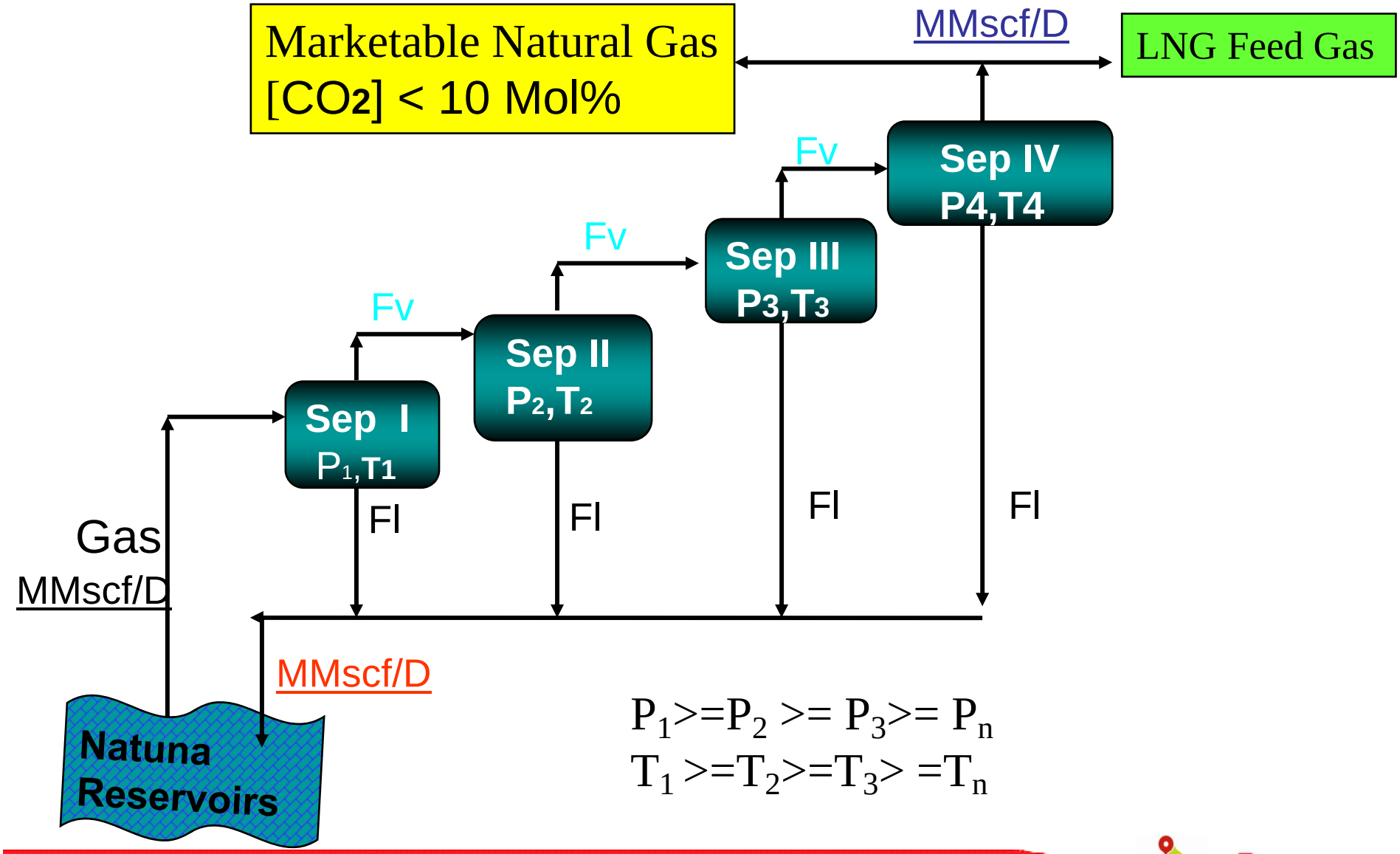
Single Stage Cryogenic



Multi Stage Cryogenic

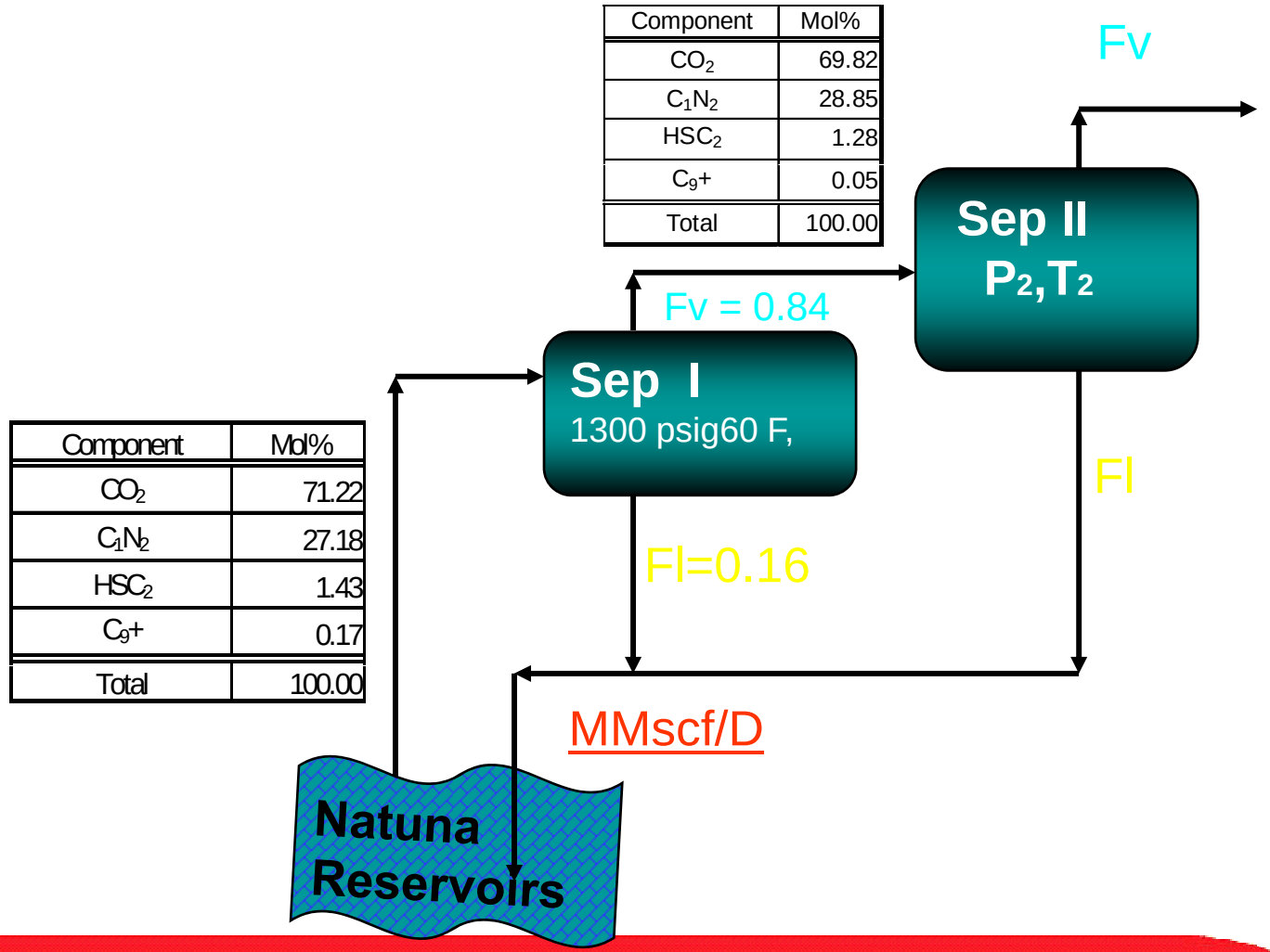
- Producing Natural Gas with CO_2 72 Mol%
- CO_2 separation with Multi Stage Cryogenic
- CO_2 Recycling
- Company: Pertamina + Texas A&M University
- Field: Natuna, West Java Field
- Initial Gas In Place: 222 TSCF Raw gas,
  40 TSCF C1
- Product: Natural Gas with CO_2 <<10 Mol%
- Market: Not Specific

Multi Stage Cryogenic



Natuna Gas Processing

- Selecting Second Stage Separator



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Gas To Liquid

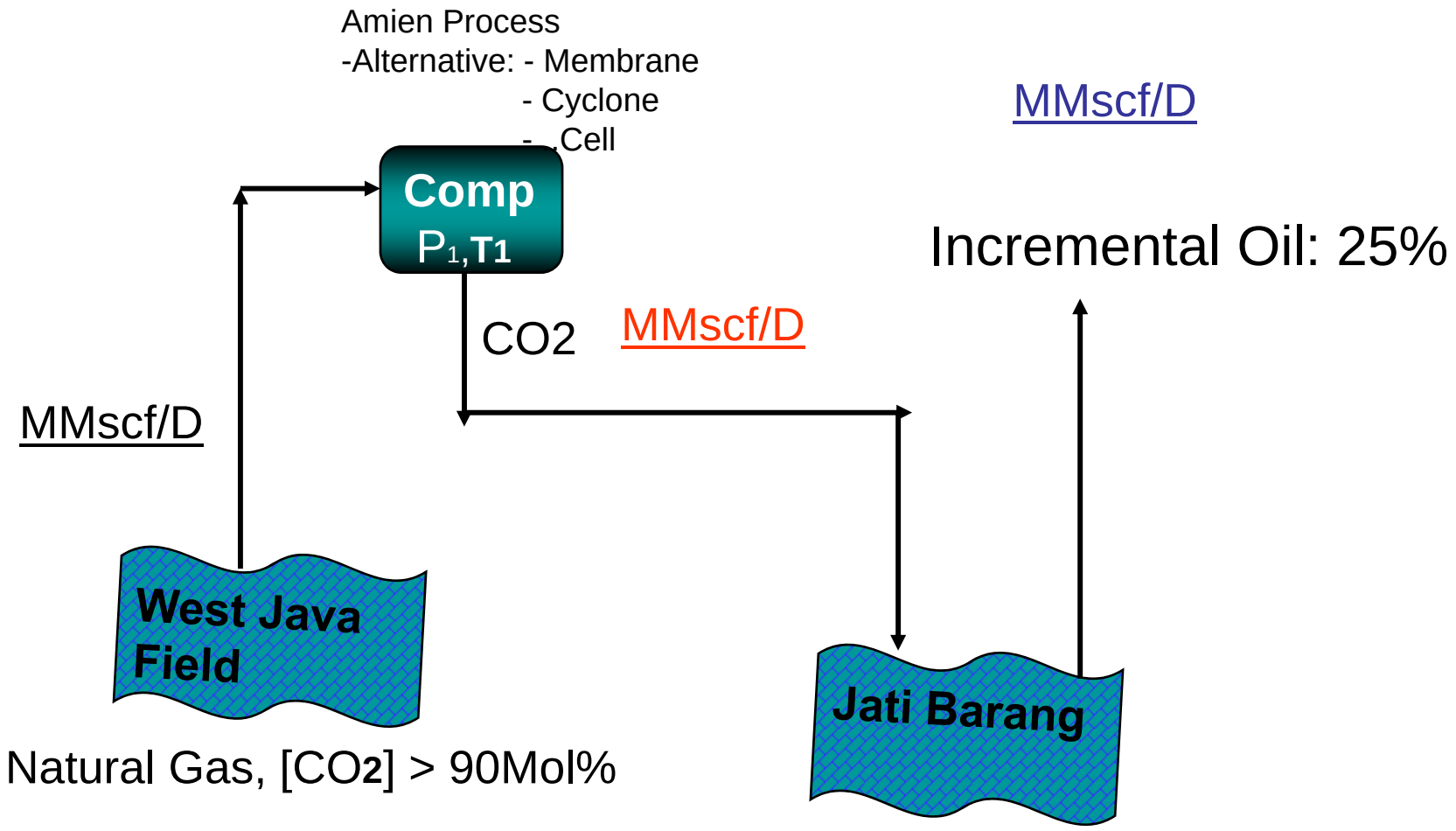
- Producing Natural Gas with CO_2 40 Mol%
- CO_2 + Methane → GTL
- Company: Pertamina + JNOC
- Field: Muara Bulian, Central Sumatra
- Initial Gas In Place: 541 BSCF Raw gas, 324 BSCF C1
- Product: Naphta, Kerosene, Gas Oil
- Market: Not Specific
- Pilot Project:
  - Feed Gas: 6 MMSCFD (incl. CO2 40%)
  - Product : 500 BPD

CO_2 Flooding

- Producing Natural Gas with CO_2 >80 Mol%
- CO_2 Injection to Oil Reservoir – Miscible Flooding
- Company: Pertamina, Lemigas, ITB
- Field: West Java Field (Jati Barang & Tugu Barat)
- Target: 25-30 % Oil Incremental

- Future Target: Kawengan Field Layer 2,
  - Gas Source from: Cepu Block

CO_2 Flooding

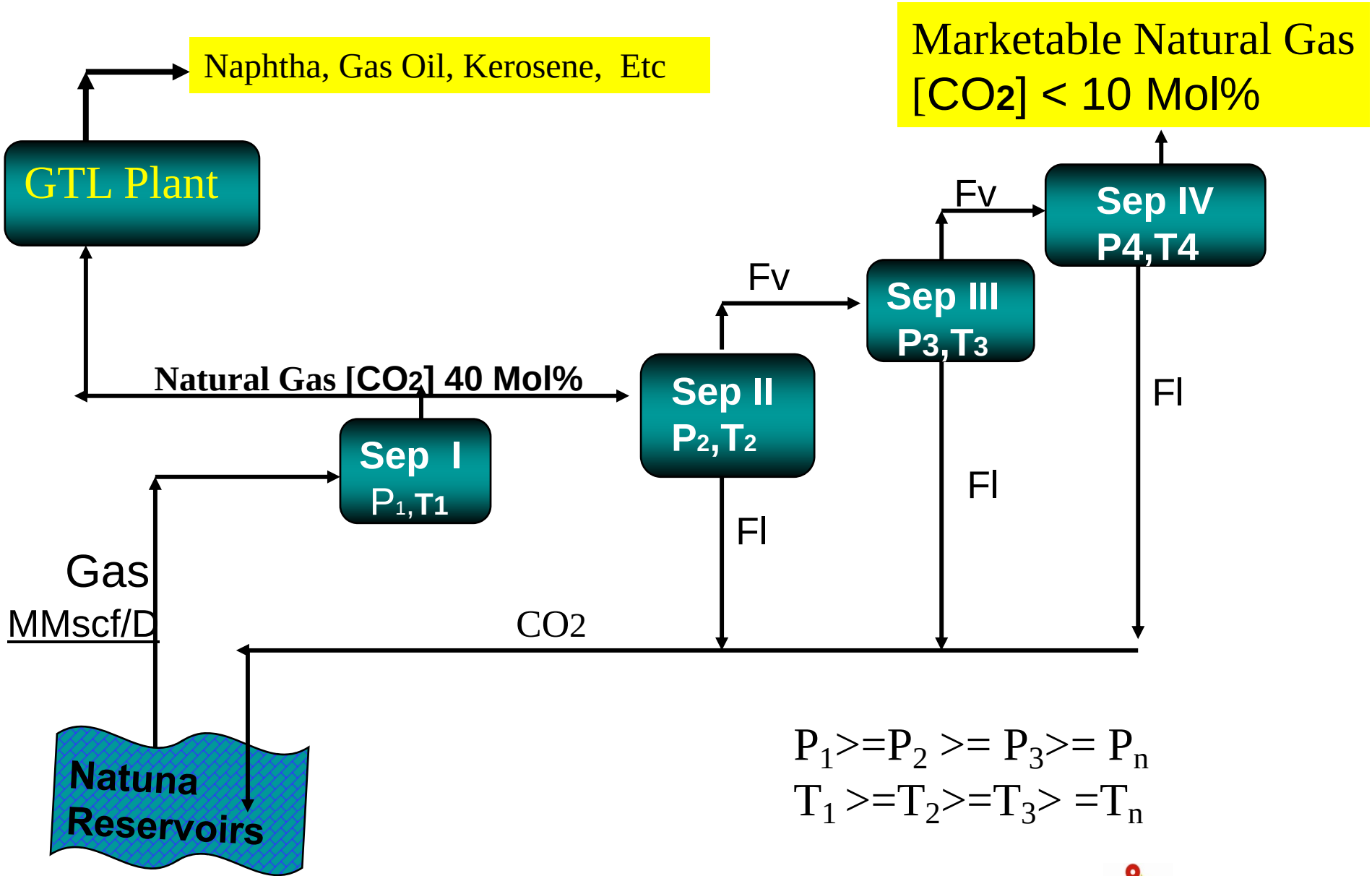


Future Plan: CO2 injection in Kawengan- Central Java, CO2 From Cepu Block Field

Proposed:
Multi Stage Cryogenic + GTL

- Producing Natural Gas with CO_2 72 Mol%
- First Stage CO_2 separation to 40 Mol%
- [CO_2] 40 mol% + C1 → GTL
- Next Stage CO_2 separation to 10 Mol%
- Company: Pertamina + JNOC + ExxonMobil
- Field: Natuna
- Initial Gas In Place: 222 TSCF Raw gas,
  40 TSCF C1
- Product:
  - Natural Gas with CO_2 <<10 Mol%
  - Naphtha , Kerosene, Gas Oil

Multi Stage Cryogenic + GTL



Conclusions

- High-CO2-Content Reservoir is considered as “Marginal Field”
- High-CO2-Content Reservoir has specific properties
- There several option processes to optimize the hydrocarbon production
- There are several fields Which contain high CO2 still undeveloped
- Combination of Multi Stage Cryogenic and Gas To Liquid is the best process for High-CO2-Content reservoir
- MSC produces marketable gas with CO2 content less than 10 mol%
- GTL produces Naphtha, kerosene, Gas Oil petrochemical product
- CO2 recycling can avoid global warming from excessive CO2 produced

Thanks