Gas Field Development - Challenges and Current Best Practices to Maximise Value

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Opportunities and Challenges for Development of a CO2-Rich Offshore Gas Field – Block VN, Malay – Tho Chu Basin, Vietnam

Nguyen Van Sang

PetroVietnam Exploration Production Corporation

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2. Subsurface Study
3. Development Concepts
4. Challenges & Opportunities Summary

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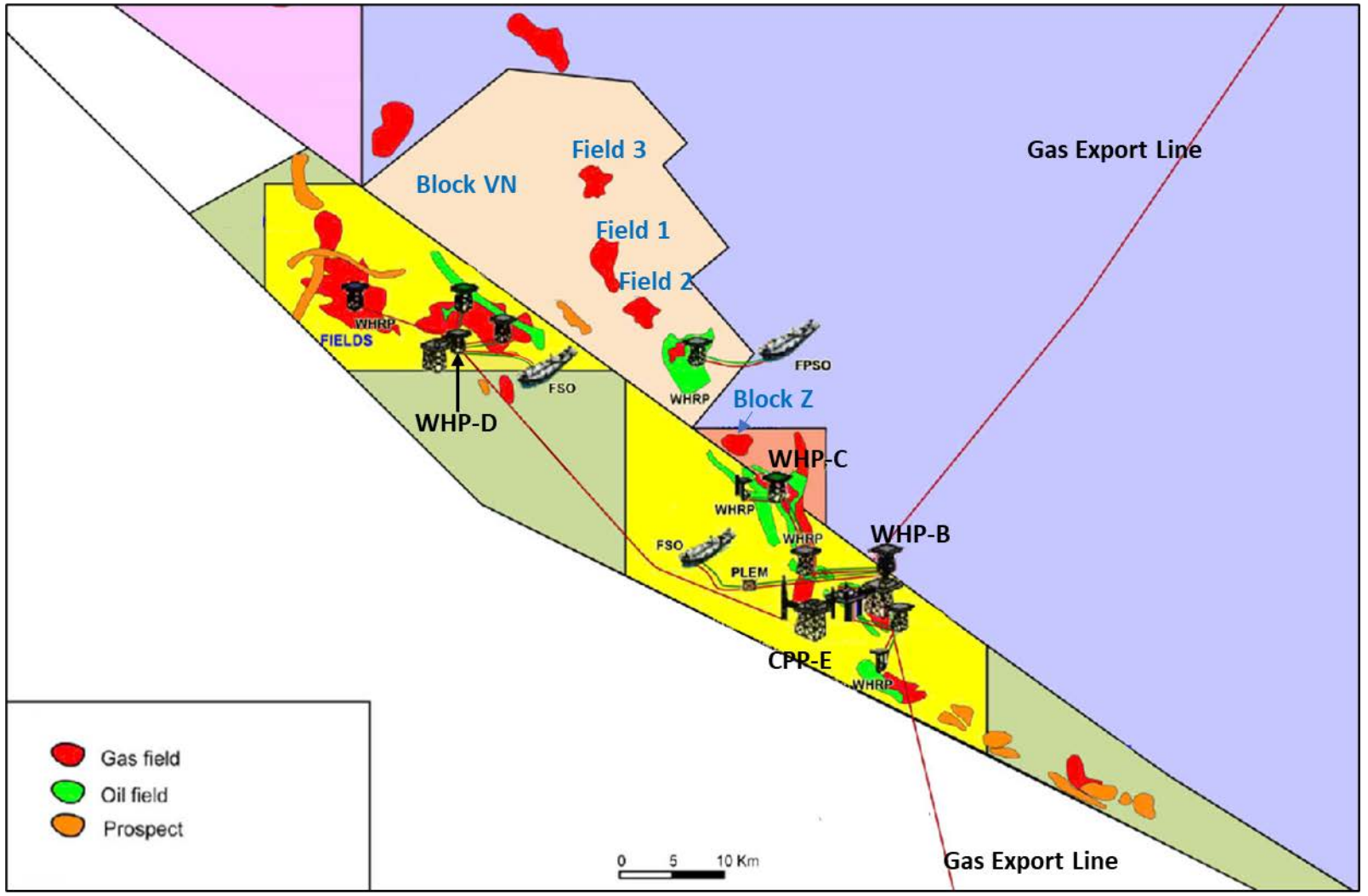
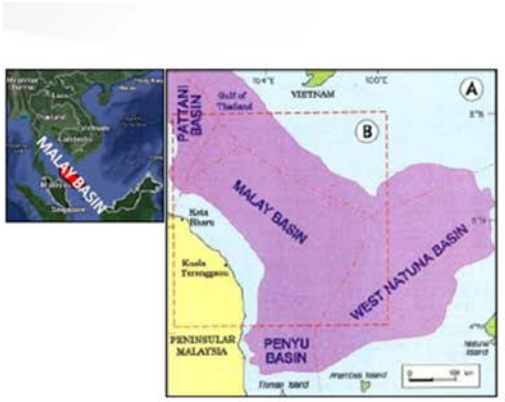
Block VN Overview

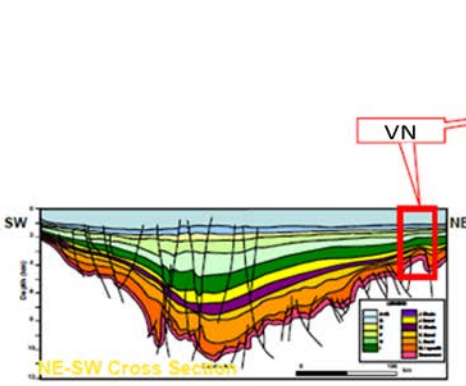
- Location: Northeast Malay – Tho Chu Basin, ~ 205 km from Ca Mau province, Vietnam; water depth 45 - 65 m.
- Current Operator: PVEP (100%), effective from 25/11/2013. PSC is signed in Jun 2014, expired in 2038.
- Status: 03 gas discoveries in the 1990s: Field 1 (1998), Field 2 (1996) & Field 3 (1997). Fields 1 & 2 are on development state (Field 3: insignificant GIIP).
- Total Resource of 3 fields: ~ 480 Bcf (250 Bcf Net HC); ~ 2.2 MMbbls condensate; 10 MMbbls oil.

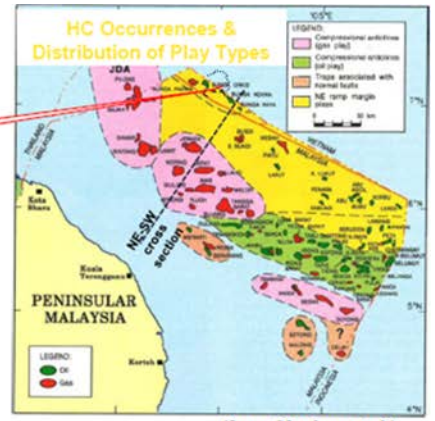


Petroleum System

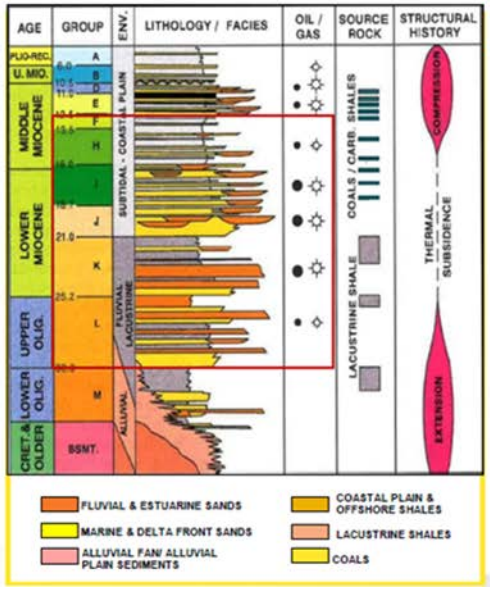
- Source Rock:
  - Main source rocks: coal/shale limestone from Early to Middle Miocene.
  - The source rocks have reached mature to over-mature stages yielding both oil and gas.
- Reservoir Rock:
  - The reservoir rocks are sandstone layers formed in fluvial to tidal channel/coastal plain environments - Upper Oligocene to Middle Miocene formations.
- Seal Rock:
  - Seal rocks are shale layers interbedded with the reservoir layers, fault and stratigraphic seals.
- Trap Types:
  - Proven hydrocarbon traps in the block and the entire Malay Basin include structural, stratigraphic, and combination traps.

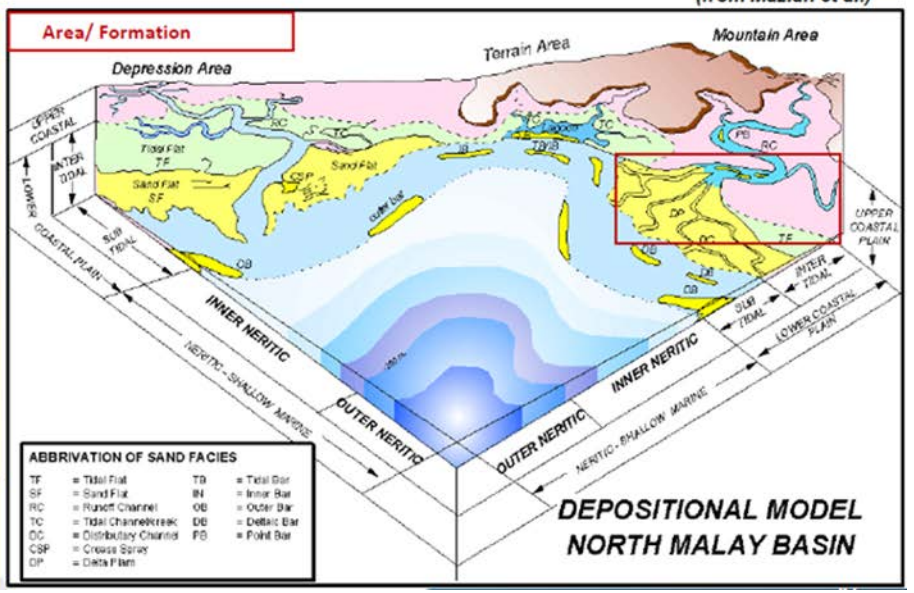






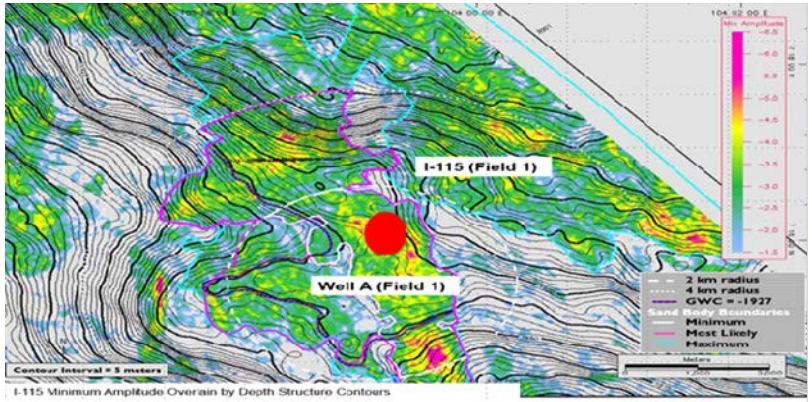
(from Mazlan et al.)

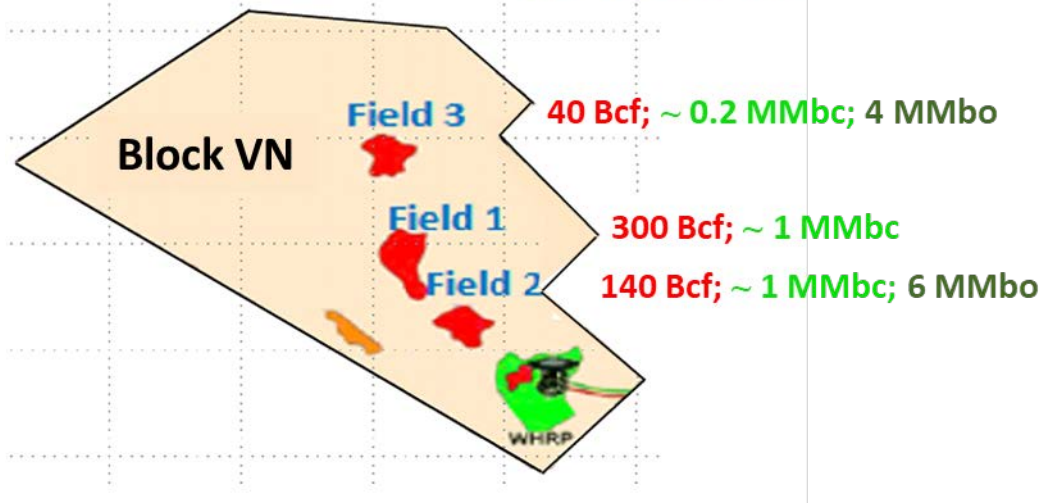


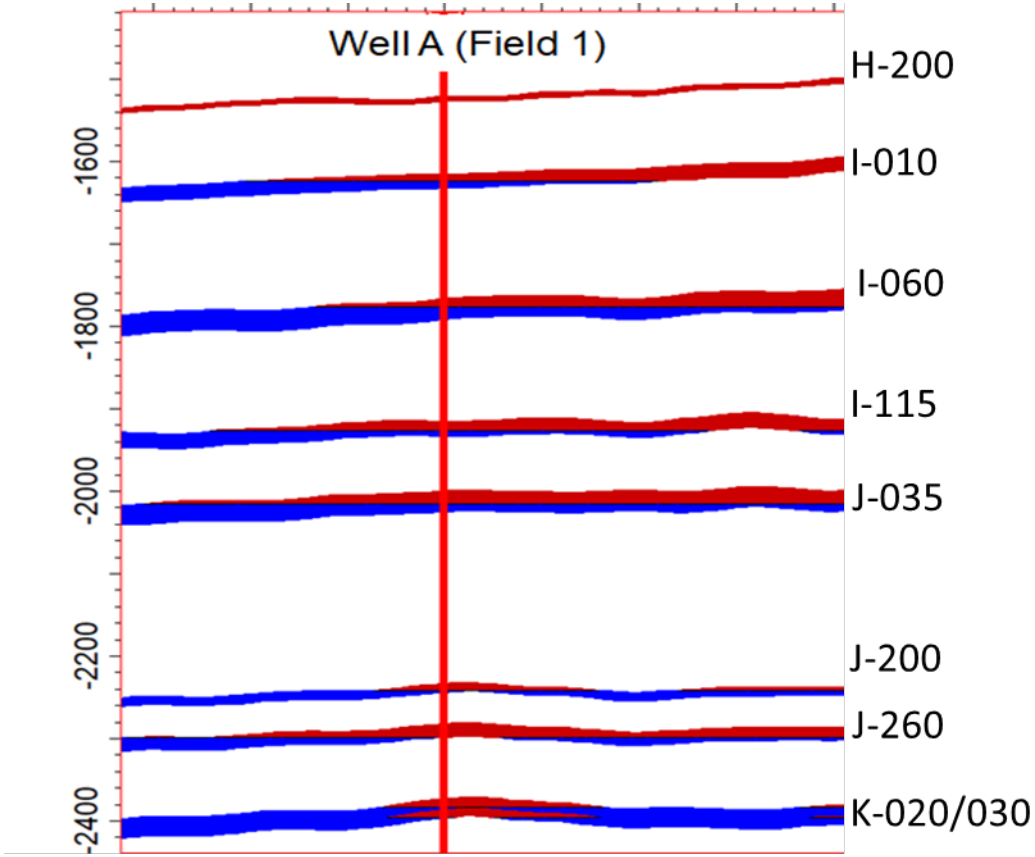


Objects and Resources

- Multi-reservoir structure



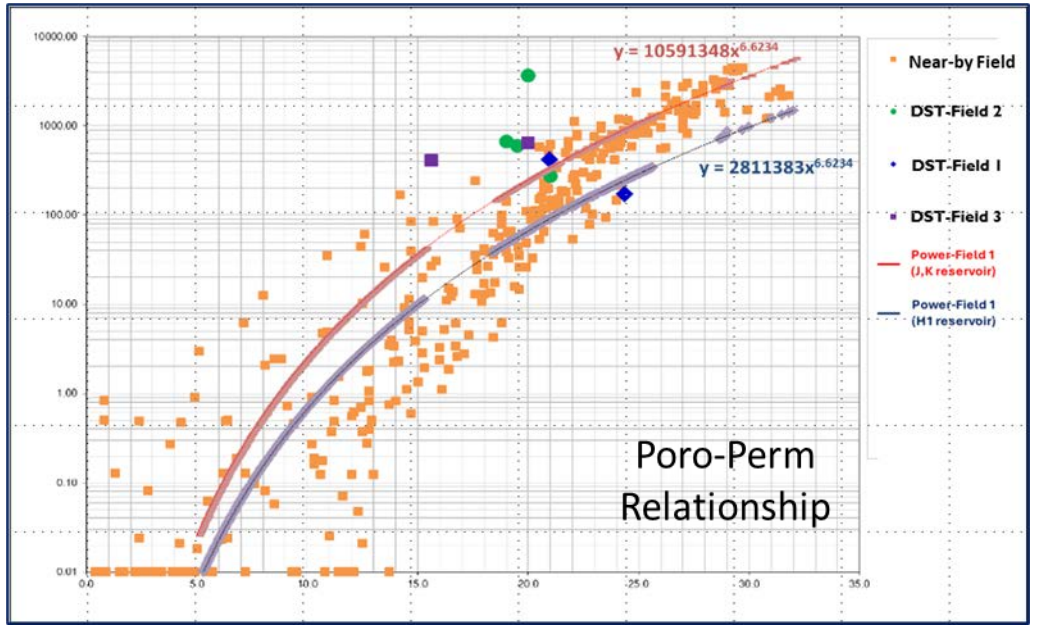




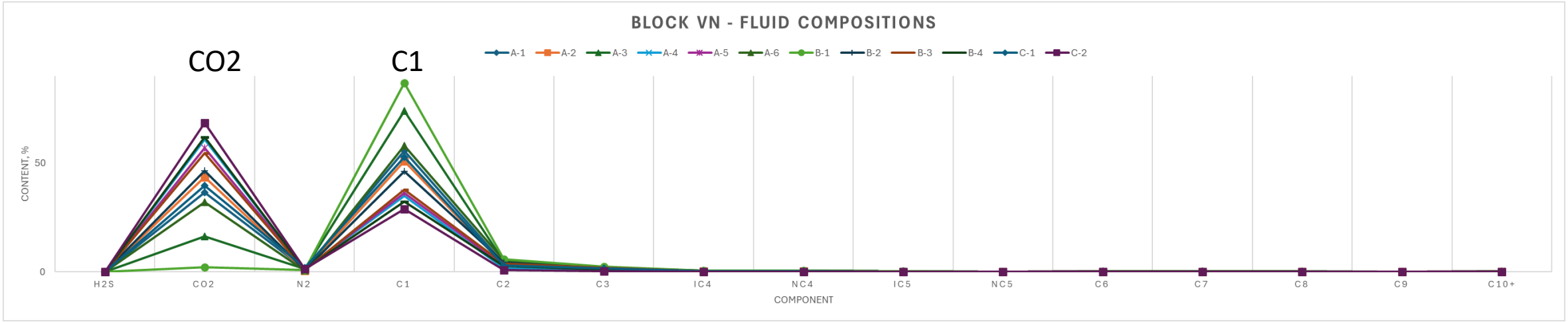
- Data source: latest RAR
- Resources in 2P category
- Field 3: Considered undeveloped at the moment due to insignificant resource.

Reservoir Rock & Fluid Properties

- **Reservoir Rock Properties**:
  - Reservoir: sandstone in Lower to Middle Miocene
  - Reservoir depth: 1,500 – 2,400 mTVDSS
  - Total Netpay: ~ 100 m
  - Porosity: 16 – 29%; Permeability: 180 – 3,700 mD
  - Initial Gas saturation: 45 – 86%



- **Fluid Properties**: Several fluid samples have been collected from DST & MDT operations of Well A (Field 1), Well B (Field 2) and Well C (Field 3):
  - Avg. C1 content: ~ 50%
  - Avg. C5+ content: ~ 0.6%
  - Avg. CO2 content: **~ 48%**
  - Avg. CGR: ~ 5 Bbl/MMscf



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2. **Subsurface Study**
   - ❖ Key input parameters for 3D Geological and Dynamic models
   - ❖ Production Profiles
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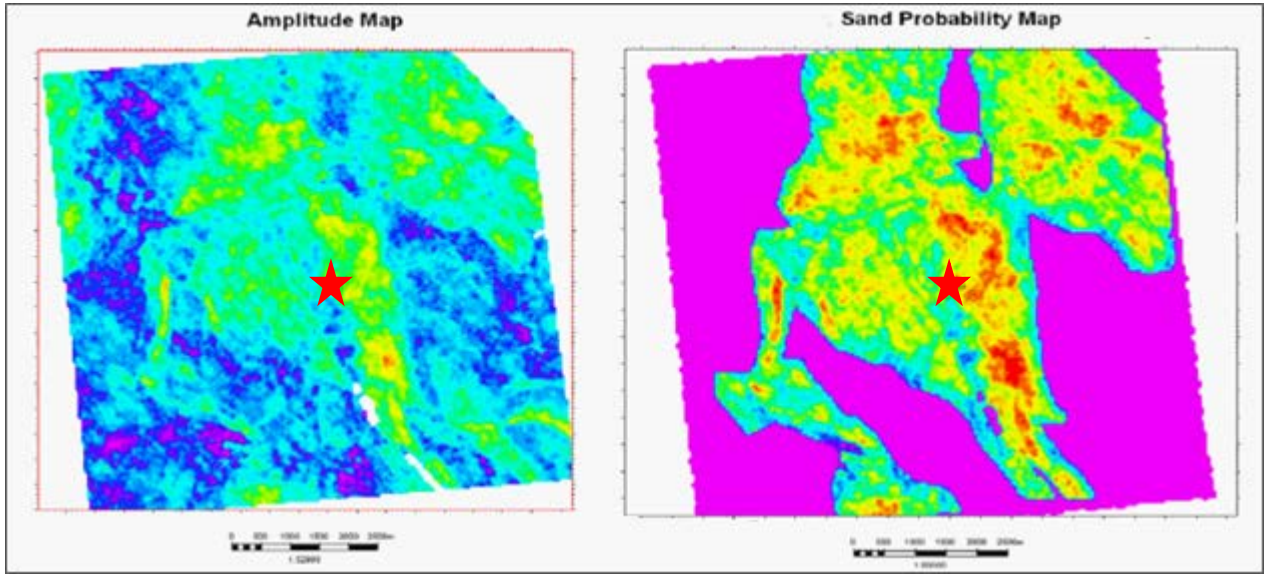
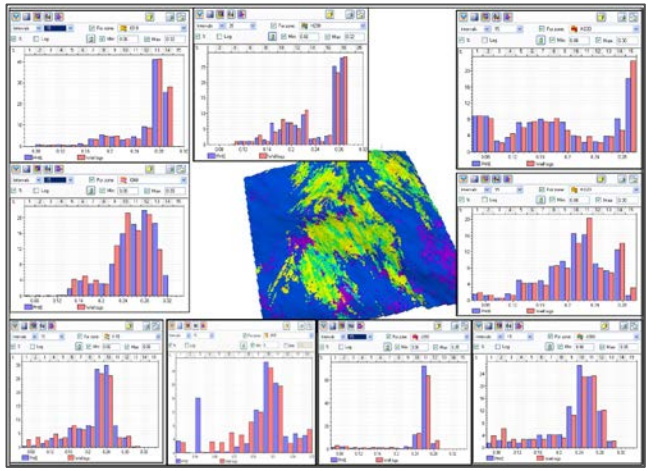
Subsurface Study

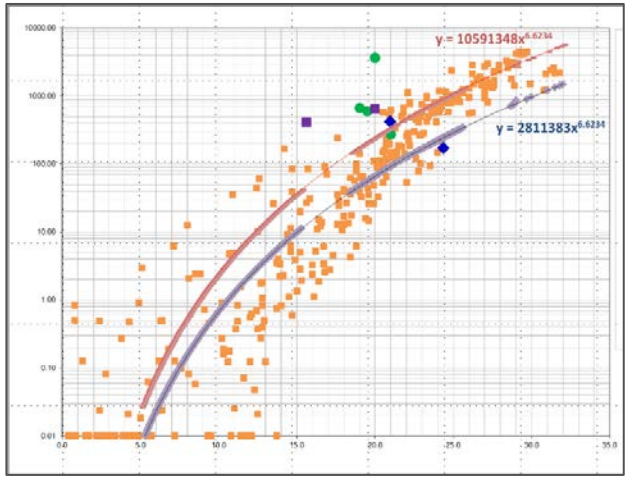
Geological and Dynamic models have been built and validated to determine and evaluate the potential of 2 gas fields.



❖ **Key input parameters for 3D Geological model:**

- Seismic Data: Reprocessed in 2004/2005
- Well Data: 02 exploration wells
- Reservoir: 09 sandstone reservoirs in each field
- Testing Data: MDT, PVT
- Core Data: No core samples were collected; properties are analogue from nearby fields.

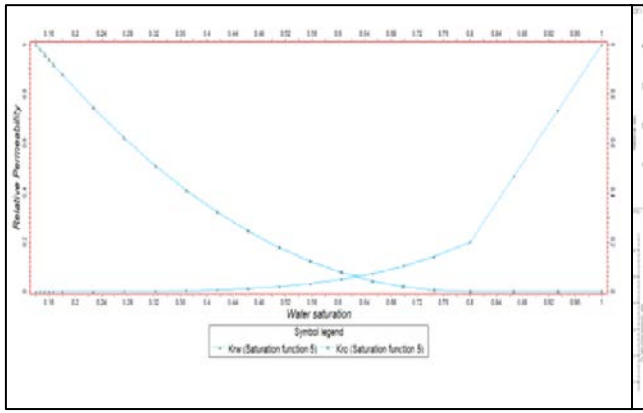




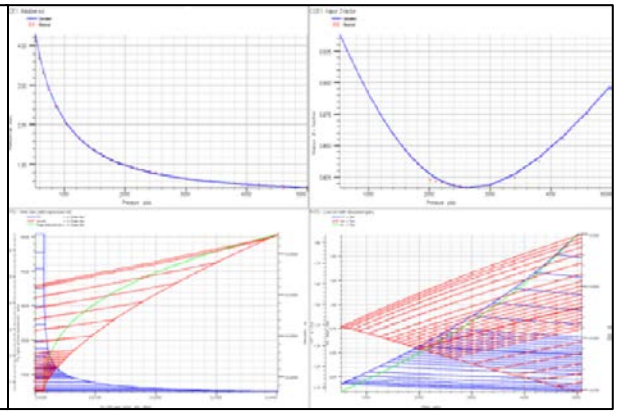
Subsurface Study

❖ **Key input parameters for Dynamic models:**

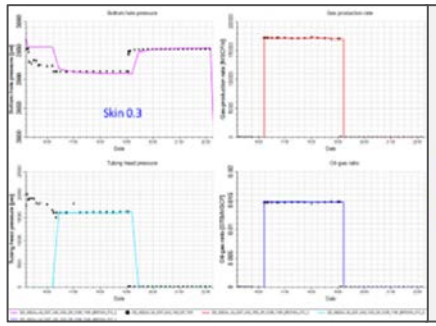
- Geological model
- Testing Data: DST, MDT, PVT
- Core Data: No core samples were collected, SCAL was analogue from nearby fields.
- DST Results:
  - ➢ Well-A, Field 1: 02 DSTs show gas - condensate production with flow rates ~ 15 MMscf/d. CO2 content up to 45%.
  - ➢ Well-B, Field 2: 03 DSTs show gas - condensate production with flow rates ~ 17 - 26 MMscf/d. CO2 content up to 60%. 01 DST indicates oil production (~ 1,000 stb/d during Main flow period).



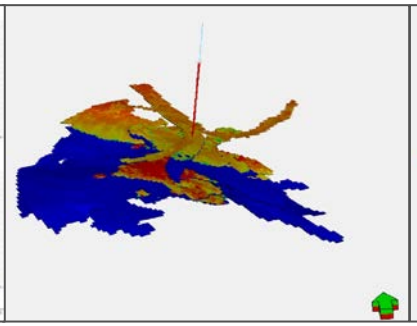
SCAL



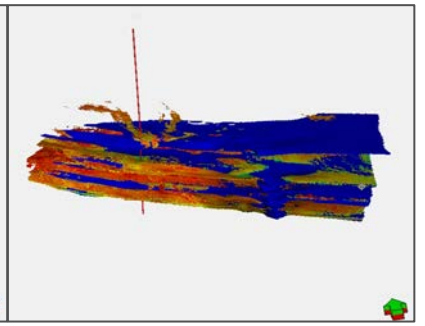
PVT



DST



Field 1



Field 2

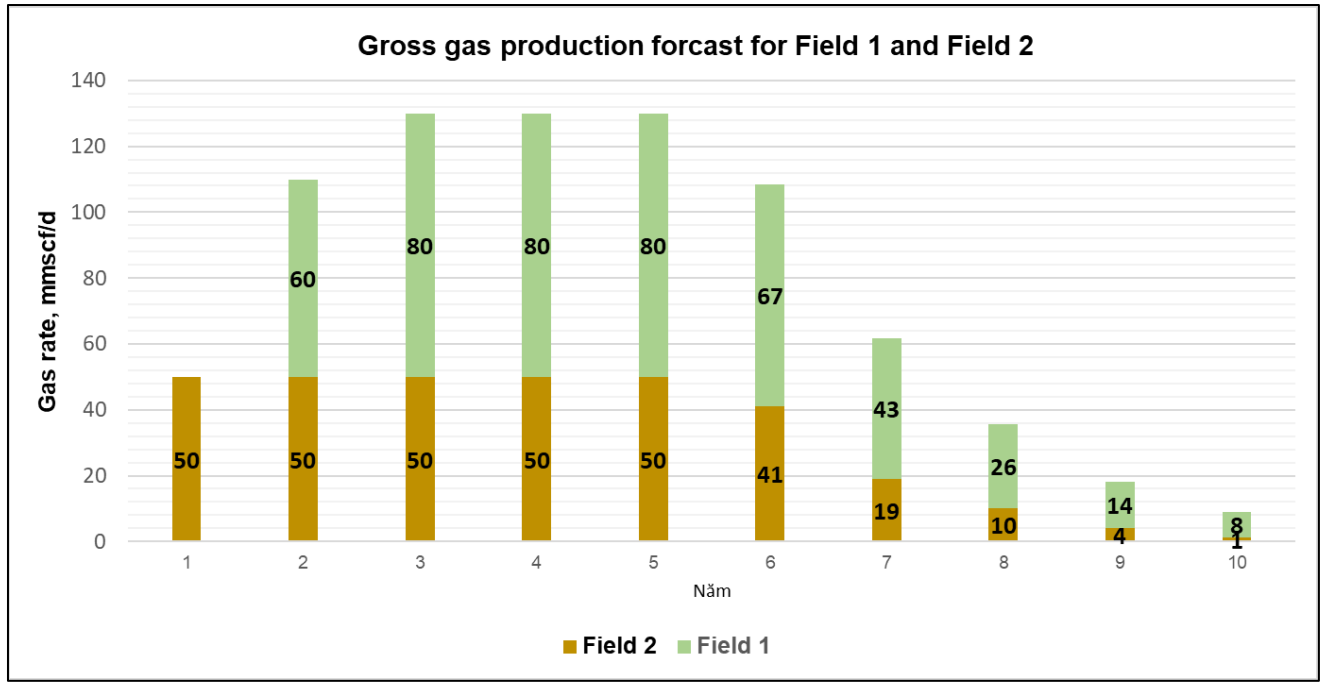
Production Profiles for Field 1 and Field 2

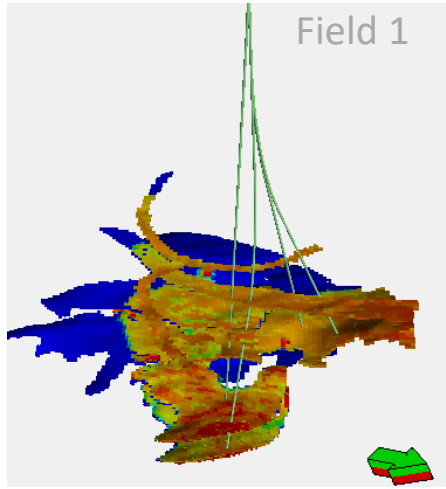
Validated Simulation Model

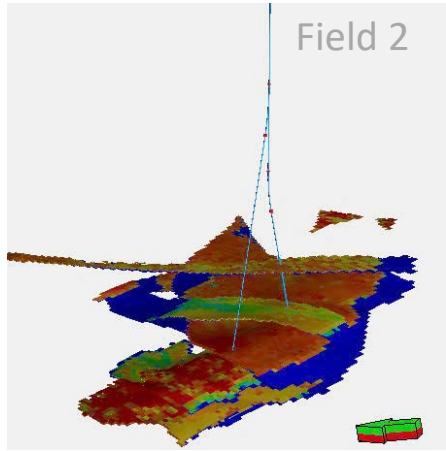
Sensitivity runs

- Tubing Size
- Well Location/Count
- Well Type
- Minimum Well Head Pressure
- Field Production Rate
- Aquifer Size

Propose Optimal Production Scenario







❖ **Optimal Production Scenario for Field 1 and Field 2:**

- Natural Depletion
- 6 Single Gas Production wells (4 for field 1 & 2 for filed 2)
- Plateau: 3 - 4 years
- Recover factor: ~ 65% at the end of PSC.

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   - ❖ Development Ideas
   - ❖ Development Options
   - ❖ Development Cost & Economic Efficiency
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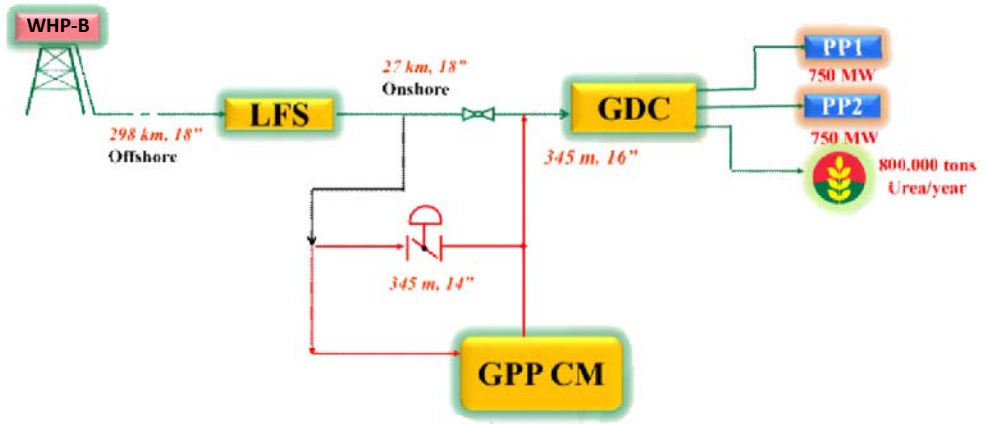
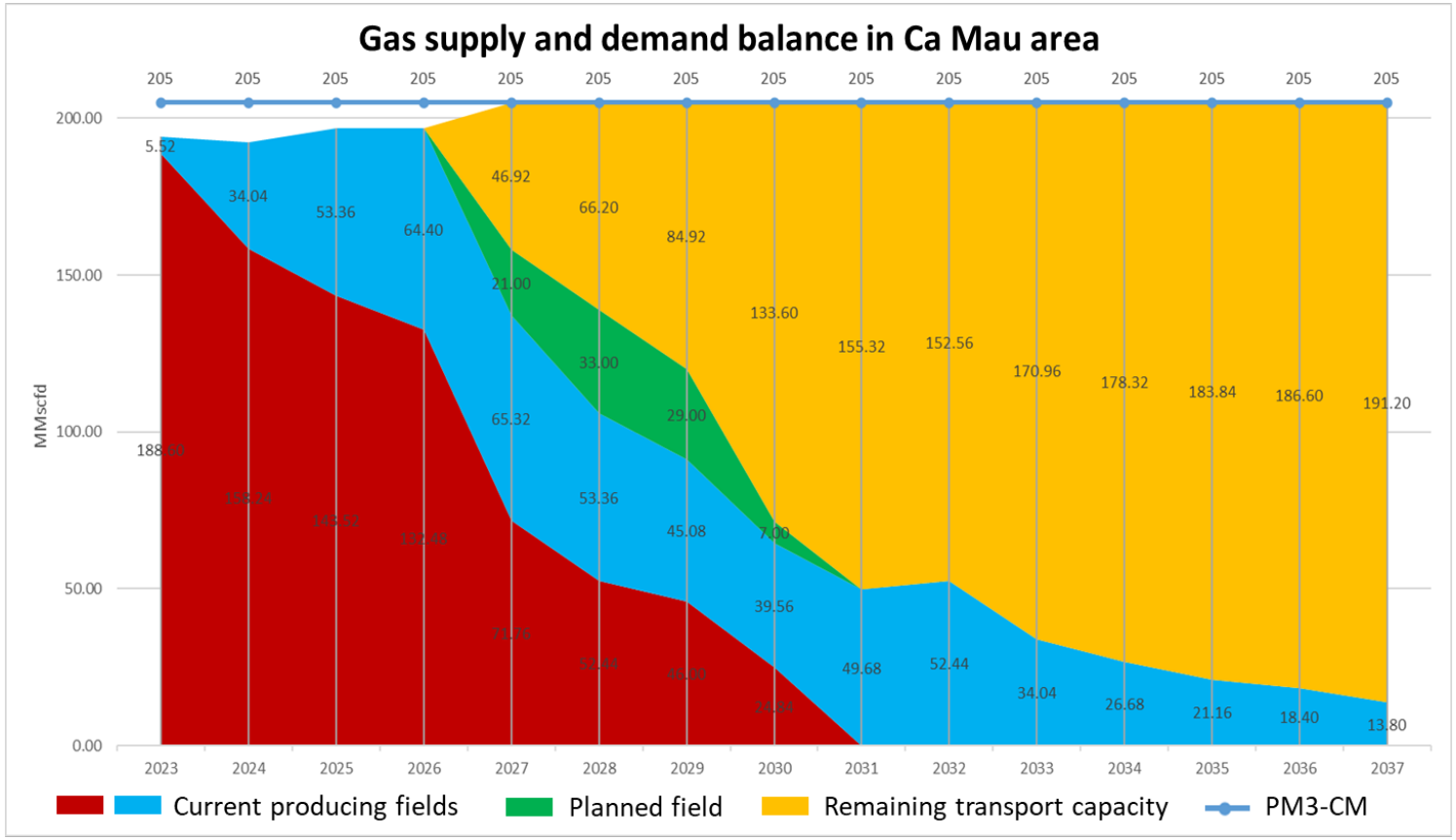
Gas Market Survey

- Gas supply from current and planned development fields is expected to decrease significantly after 2027.
- Development of the discovered gas fields in this Block VN will play an important role in compensating for the forecasted gas supply shortage after 2027.



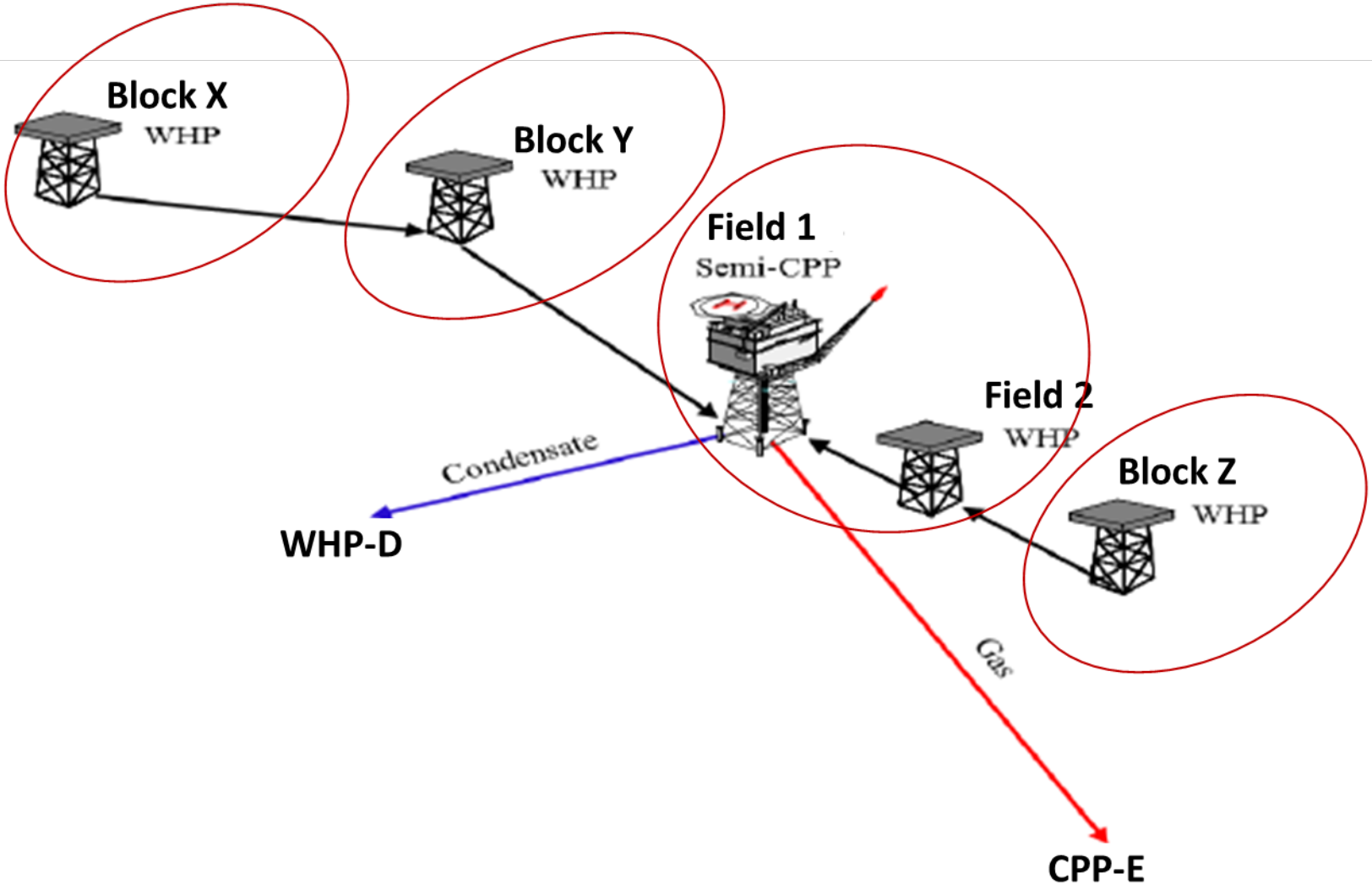
* Pipeline capacity ~ 230 MMscf/d



Development Ideas

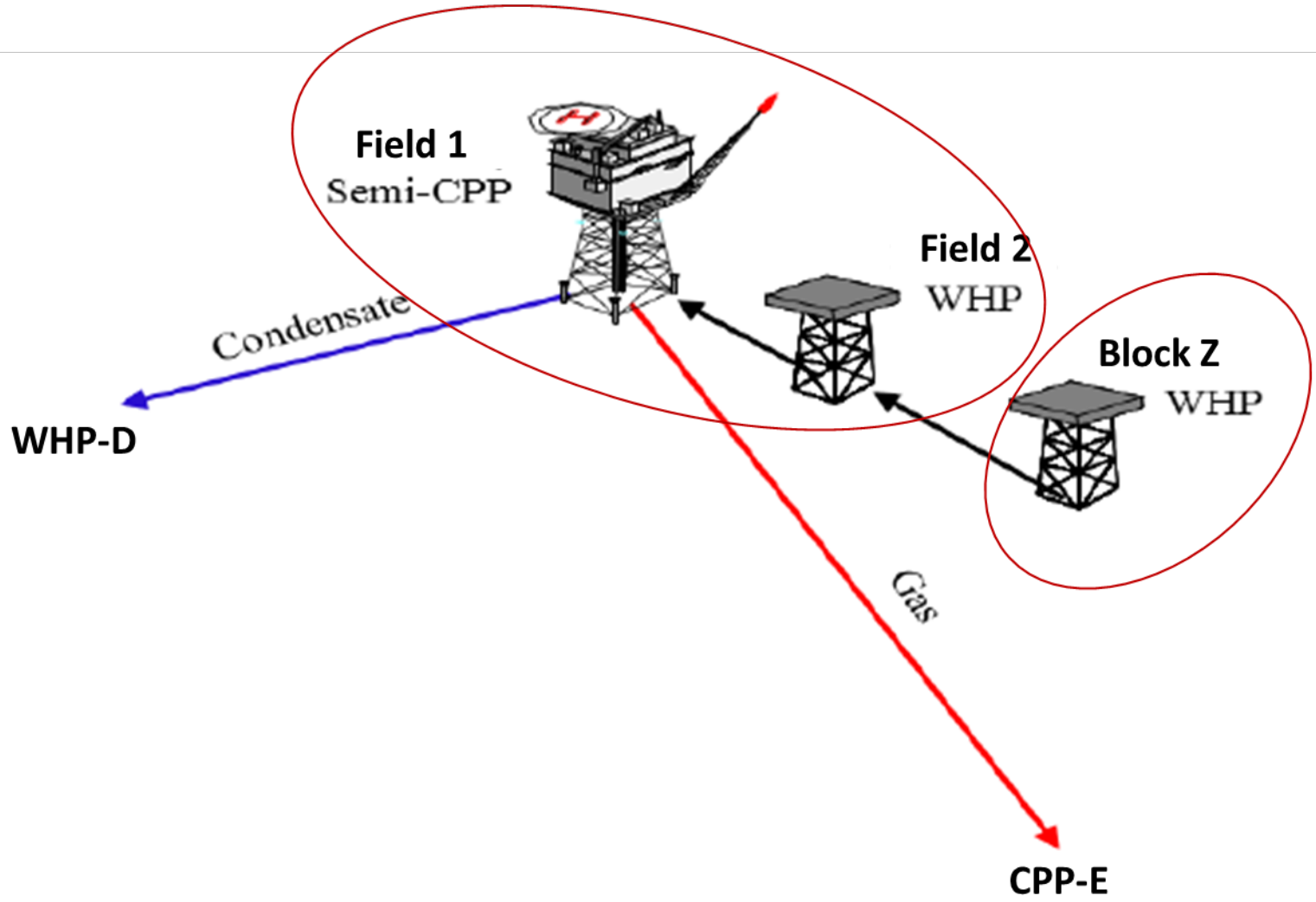
With a limited HCIIP of ~ 230 Bcf net HC, development requires exploring **Tie-in options** to utilize existing infrastructure, including:

Idea 1: Tie-in to nearby Block M production facilities (WHP-D, CPP-E), with Field 1 Semi-CPP as a hub for gathering production from Field 2 and three other gas fields in Blocks X, Block Y and Block Z.



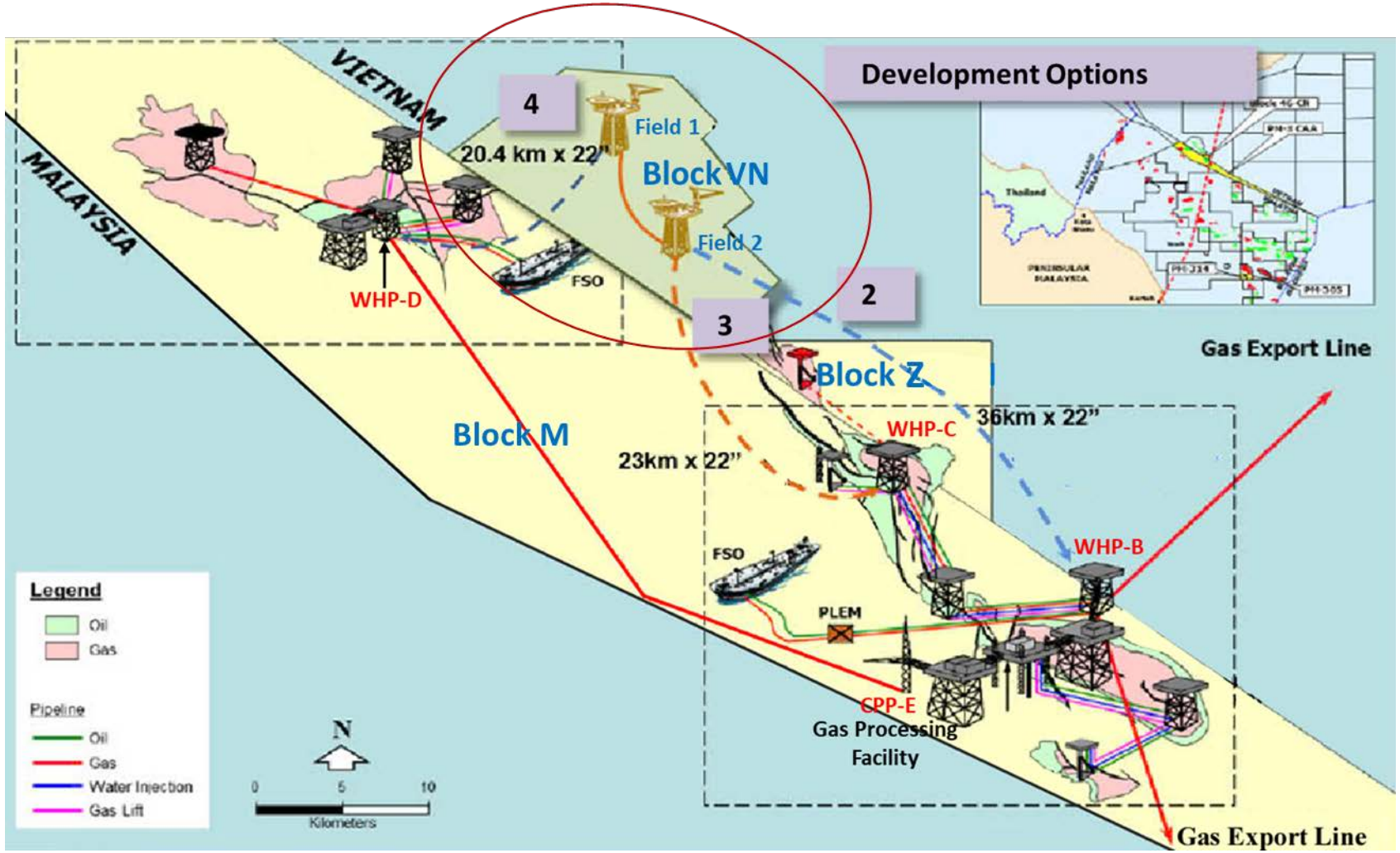
Development Ideas (cont.)

Idea 2: the gas development plan for Block VN in combination with gas field in Block Z, connected to Block M production facilities (WHP-D & CPP-E).



Development Ideas (cont.)

Idea 3: Direct tie-in of Fields 1 & 2 of Block VN with Block M production facilities (WHP-B, WHP-C or WHP-D for condensate and to CPP-E for CO2 separation).

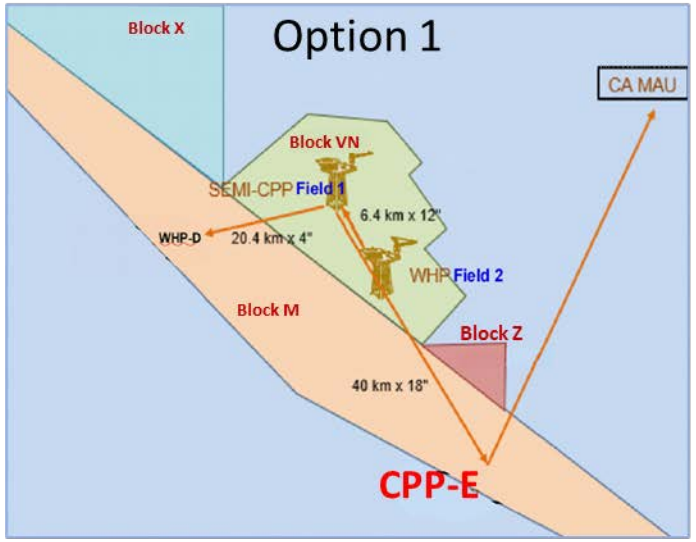


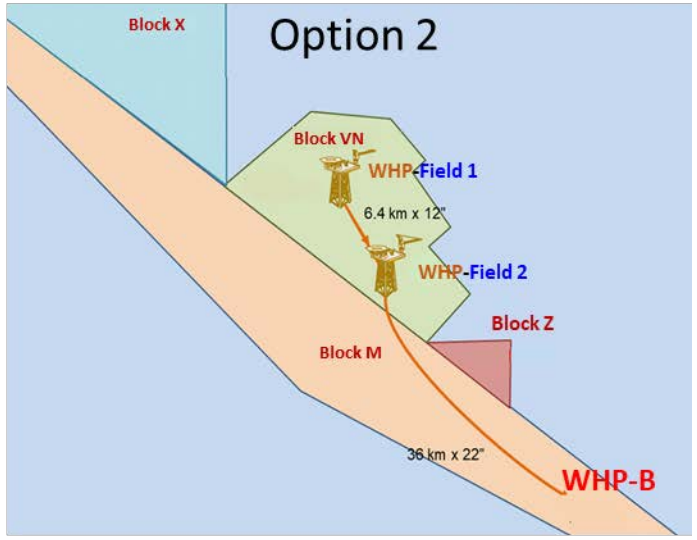
Development Options

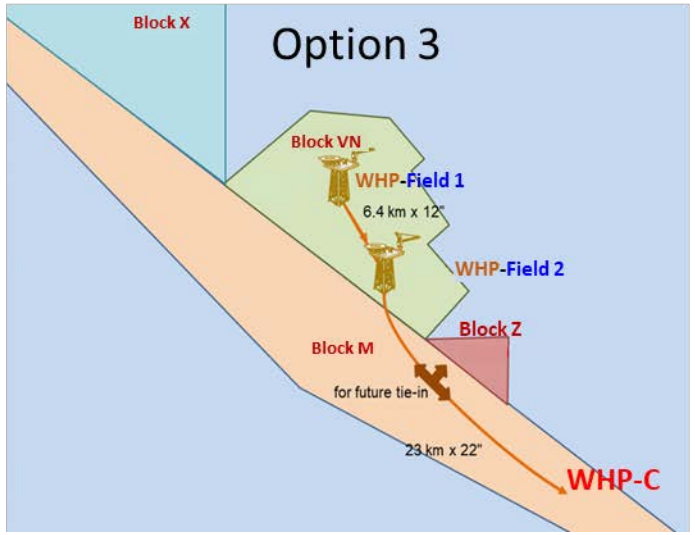
- From the analysis results of:
  - *Gas demand;*
  - *Equipment processing capacity;*
  - *Receiving capacity of the gas sales system;*
  - *Ability to meet the technical requirements of the sale gas.*

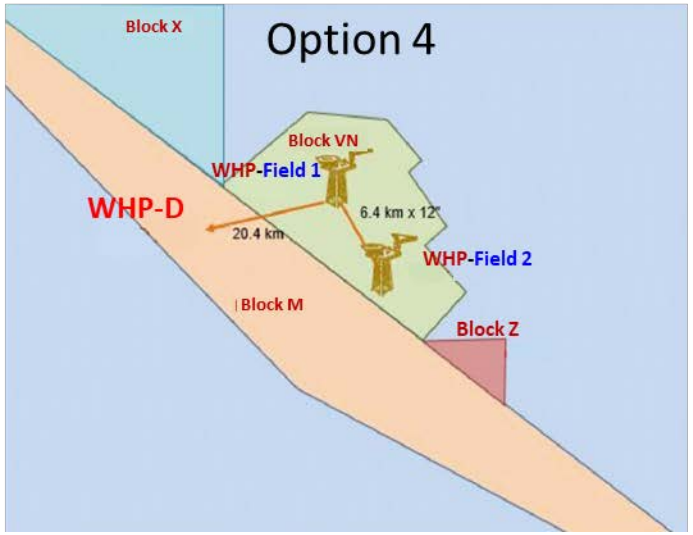
04 development options have been considered and evaluated as follows:

Option	Description
1	**The Semi-CPP platform** is installed at Field 1 for gas to be dehydrated before being transported to CPP-E (Central Processing Platform) of the Block M for CO2 separation and sale, and condensate is transported to WHP-D.
2	**Tie-in to Block M**: Full wellstream (FWS) is transported to Block M for processing with the connection point at the **WHP-B**.
3	**Tie-in to Block M**: Full wellstream (FWS) is transported to Block M for processing with the connection point at the **WHP-C**.
4	**Tie-in to Block M**: Full wellstream (FWS) is transported to Block M for processing with the connection point at the **WHP-D**.









Development Cost & Economic Efficiency

❖ Economic efficiency

- **Option 3** (FWS connecting to platform C, 6 single production wells) brings the best efficiency for the Project and ***is proposed as the Basecase option to develop gas fields 1 & 2 of Block VN.***
- Options 2 & 4 - connecting to platform B & D respectively will continue to be studied and served as backup options.
- Based on the results of the feasibility study and reaching consensus on tariff costs, the connection point location will be revisited and selected for detailed study during the FDP phase.

Development Cost					
Item	**Unit**	**Option 1**	**Option 2**	**Option 3**	**Option 4**
		Semi-CPP	Tie-in Platform B	**Tie-in Platform C**	Tie-in Platform D
Profile		2027-2037	2027-2037	**2027-2037**	2027-2037
Production well	well	6	6	**6**	6
Sale gas	Bcf	~160	~140	**~140**	~140
Condensate	MMbbl	~1	~1	**~1**	~1
CAPEX	Rank	#4	#2	**#1**	#3
OPEX	Rank	#4	#1	**#1**	#3
ABEX	Rank	#4	#3	**#1**	#2
Breakeven gas price (LF)	Rank	#4	#2	**#1**	#3
Total	Rank	#4	#2	**#1**	#3

Content

Challenges & Opportunities Summary

Challenges	Opportunities
Subsurface	
▪ Small resource: ~ 230 Bcf Net HCIIP for both fields ▪ Limited well and core data; Uncertainties in sand distribution with stratigraphic traps ▪ Cross-flow during commingled production ▪ Water production	▪ Shares the same petroleum system as the nearby fields; applicable lessons and experience ▪ Specialized seismic data used to mitigate risks in sand distribution ▪ Core properties from the nearby field used due to similar geological conditions ▪ Reservoir shows good permeability and acceptable gas flow capacity.
Facility & Gas development	
▪ High CO2 content (> 40%): Corrosion, processing, etc. ▪ Tie-in agreement with nearby field(s) ▪ Gas sales agreements (GSA) ▪ Emission compliance	▪ Gas supply will significantly decrease after 2027 ▪ Co-development with neighboring Block and tie-in to existing infrastructure are key for Block VN development. ▪ The development of these gas fields aligns with Vietnam's strategy for Gas-Power-Fertilizer complex in the Southwest region.

THANK YOU !