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TECHNOLOGY ENABLING HIGH CO2 GAS FIELD DEVELOPMENT

Hatarmizi Hassan
PETRONAS Carigali Sdn Bhd

Co-Author:
M Faudzi Mat Isa
Nor Liyana Ramli
M Azfar M Zuber

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2. Technical Challenges
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4. K5 Technology Development Concept
5. CO2 Technologies
6. Subsurface Technologies
7. CO2 Storage
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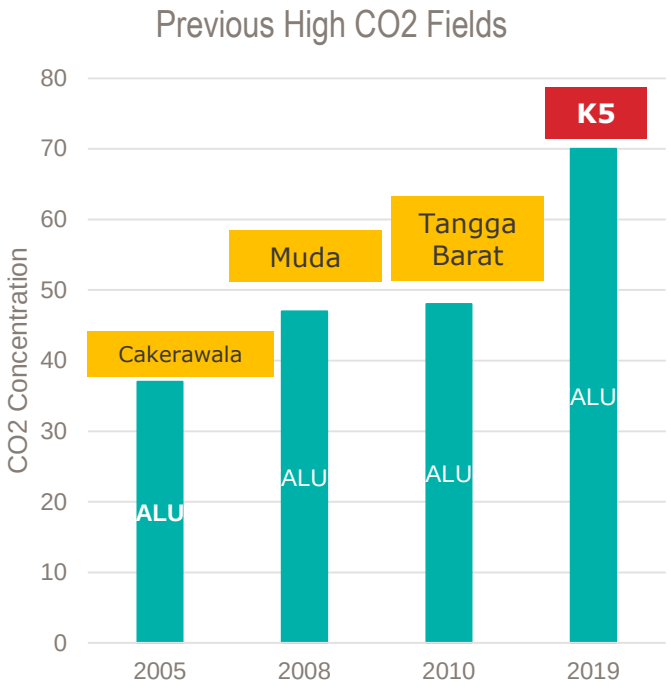
Building on our experience with high CO2 fields



With several high concentration CO2 projects under our belt, we are developing a field that's bigger, with a higher concentration of contaminants

K5: 250km offshore, 80m water depth, 21Tscf Gas in Place, 4Tscf recoverable, approximately 70% CO2 concentration

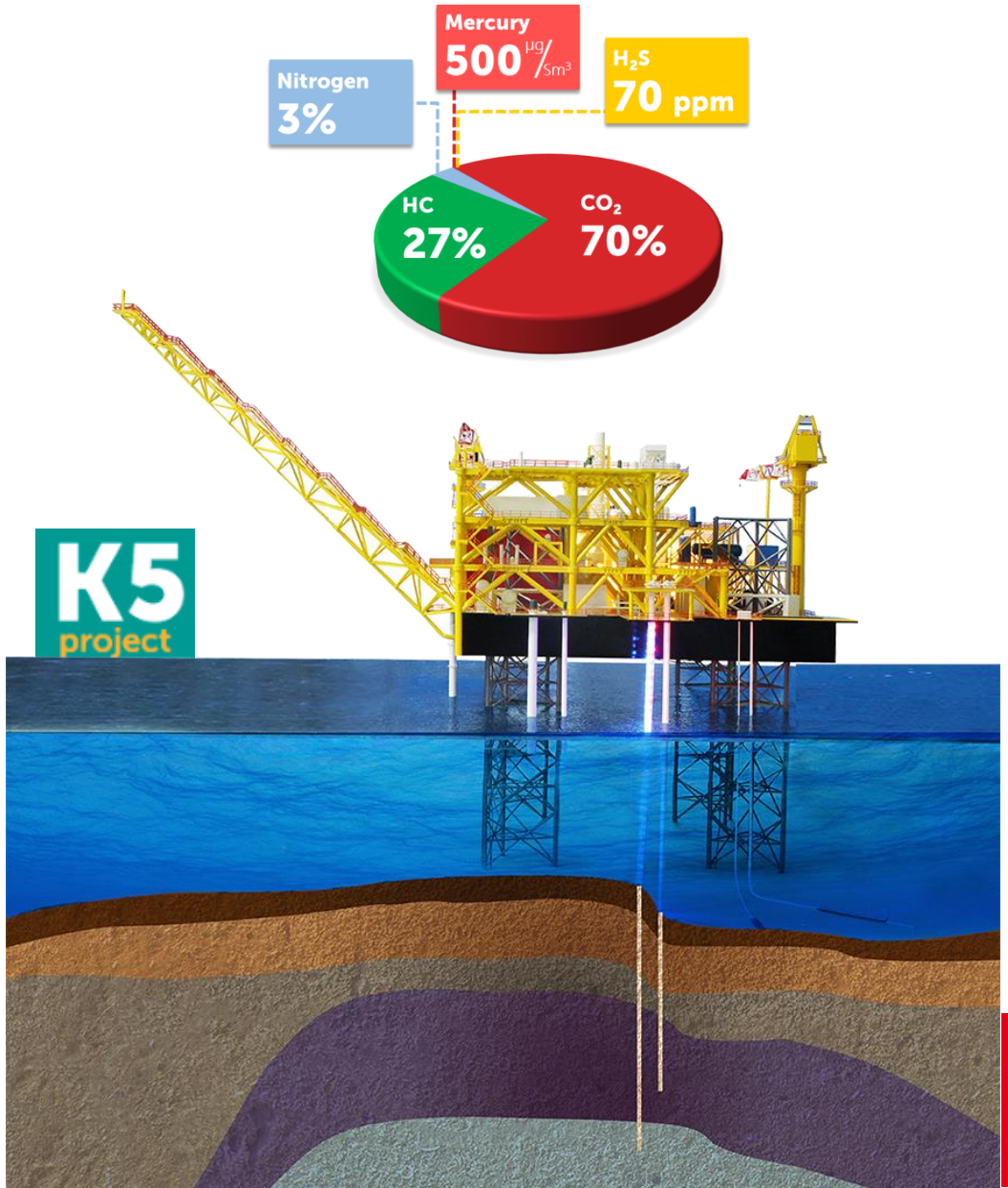
World's First Offshore CO2 Cyrogenic Distillation Facility

World's Highest CO2 Concentration Gas Development Project Offshore

Monetization of high CO_2 fields such as K5 is technically challenging

Technical Challenges

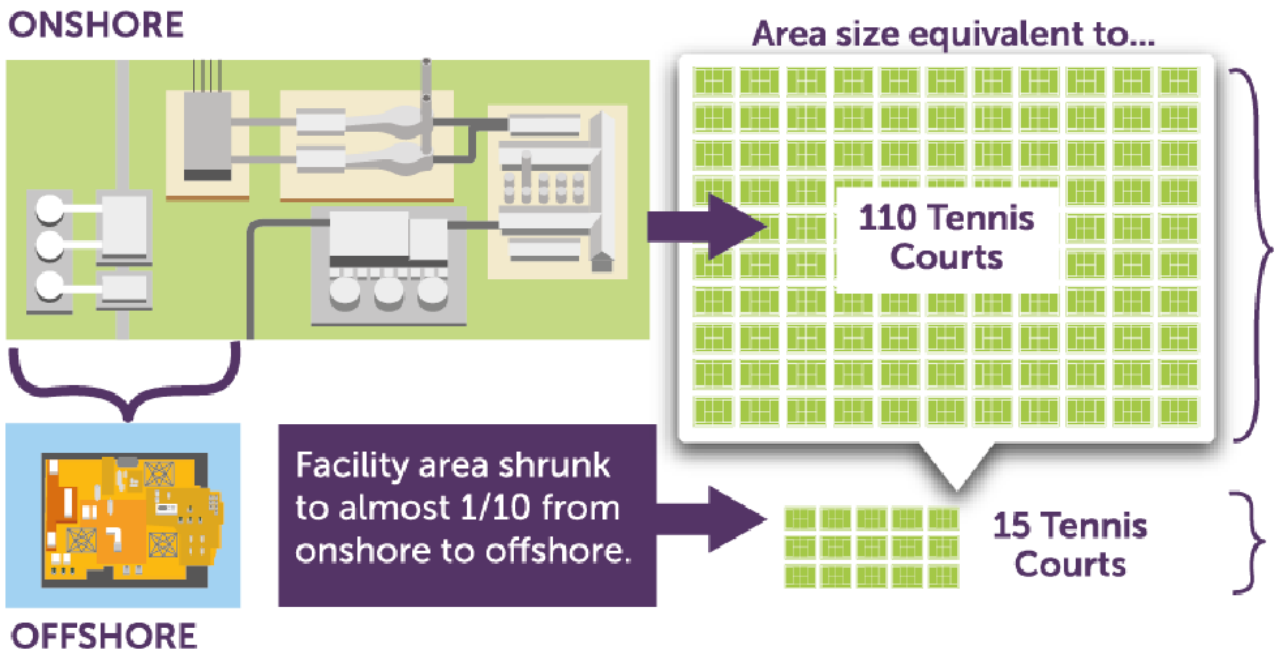
- No process system and AGRU for the removal of high CO_2 gas (70% CO_2) at offshore.
- Complex fluid requires multiple gas treatment systems.
- Process systems using different types and combination of AGRU have posed issues and constraints in terms of topside weight, hydrocarbon loss, and energy consumption.
- To protect environment, CO2 produced has to be injected and stored in the reservoir.



Innovations of process engineering and design are required to overcome economic challenges

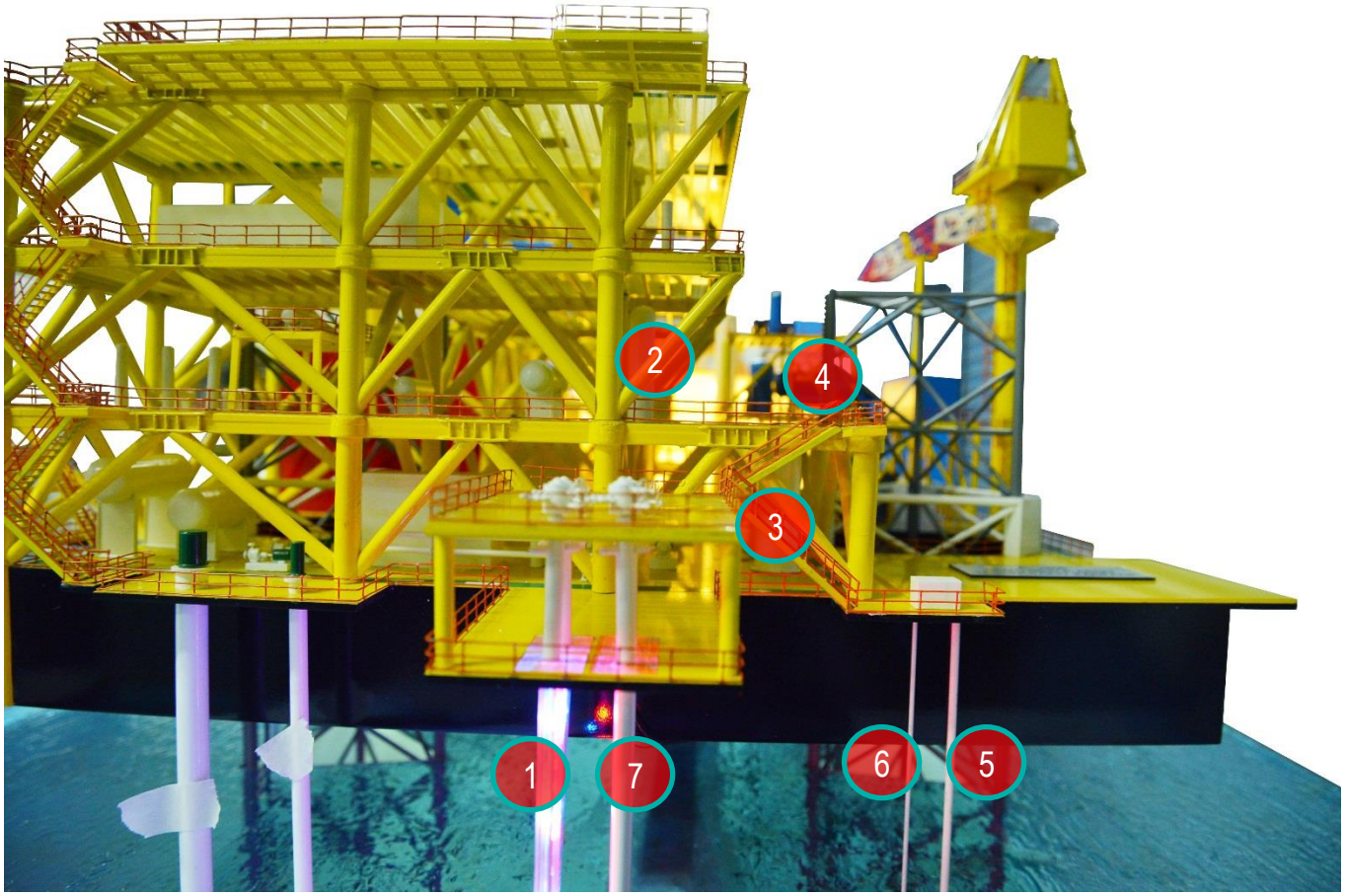
Economic Challenges

- Due to the complex gas treatment and processing required, the process scheme and number of equipment have translated to a high topside weight.
- As a result, this incurs a high capital expenditure (CAPEX) for high CO2 gas field development, causing the development to be economically challenging.



K5 Technology Development Concept

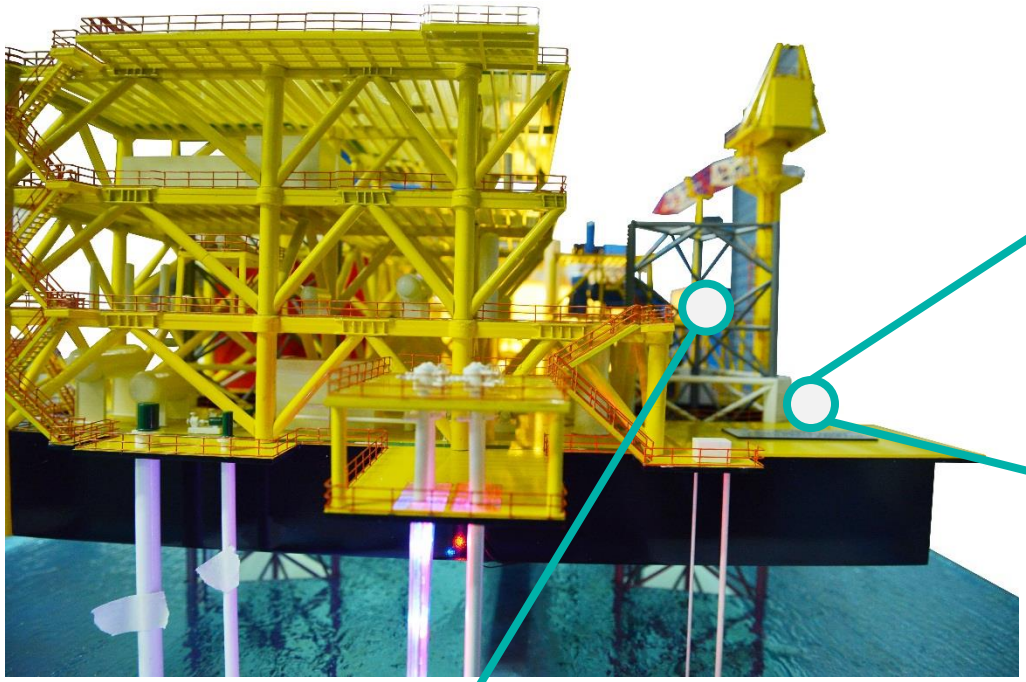
Overview of Gas Processing Facilities
1. Well Head Producer
2. Inlet Separation
3. Pre-Treatment Unit
4. Cryogenic Distillation Unit
5. Gas Export Pipeline
6. Condensate Processing and Export
7. Reinjection Well



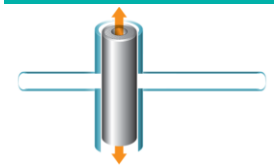
CO2 technologies are being matured at K5 offshore facilities towards future application and monetization of K5 and other high CO2 fields in Malaysia and internationally.

Maturing CO2 technologies via deployment of technology at K5 offshore facilities while producing hydrocarbon

- **PN2 Membrane, Supersonic Gas Separation & Cryogenic Distillation**

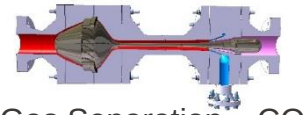


PN2 Membrane



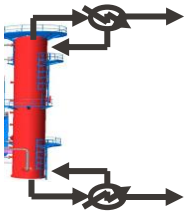
PN2 Membrane – CO2 and Hydrocarbon are separated based on their molecule size and ability to select only CO2 to be absorbed.

Supersonic Gas Separation



Supersonic Gas Separation – CO2 and Hydrocarbon are separated based on phase separation, CO2 in liquid and Hydrocarbon in gaseous form.

Cryogenic Distillation (PeCro™)



- CO2 and hydrocarbon gas is separated by its boiling point difference.
- CO2 concentration is reduced to 20%.
- CO2 will be in liquid form while hydrocarbon gas will be in gas form.

Subsurface technologies are being developed for high concentration CO2 fields

Some of these technologies are being qualified / to be applied at K5 field.

1 Wells Drilling

- Pore Pressure and Fracture Gradient (PPFG)
- High risk K5-1 P&A remediation
- Shallow gas presence study
- Optimize drilling design

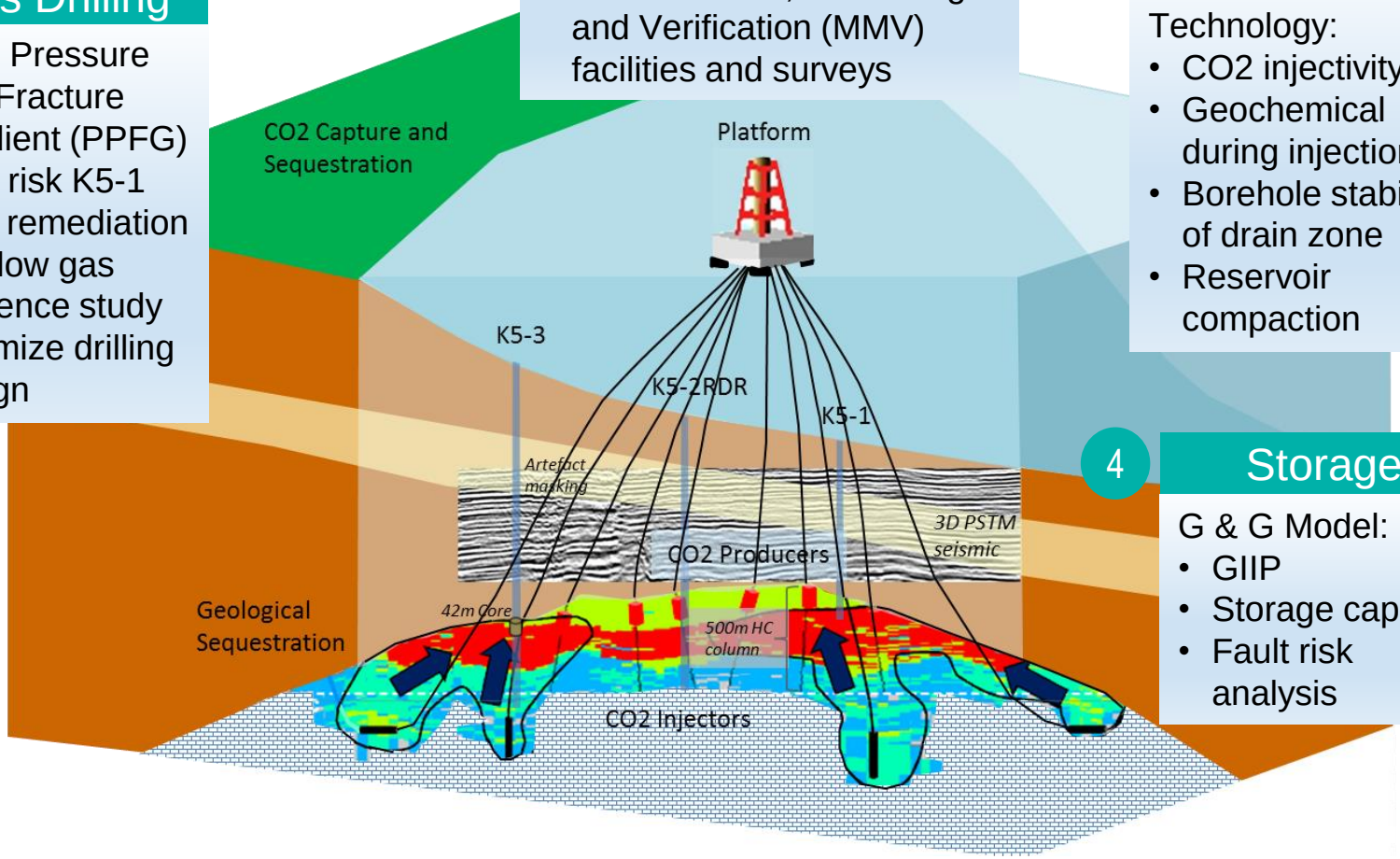
2 MMV

- Well monitoring
- Time lapse seismic
- Measurement, Monitoring and Verification (MMV) facilities and surveys

3 Production Technology

Production Technology:

- CO2 injectivity
- Geochemical during injection
- Borehole stability of drain zone
- Reservoir compaction



4 Storage

G & G Model:

- GIIP
- Storage capacity
- Fault risk analysis

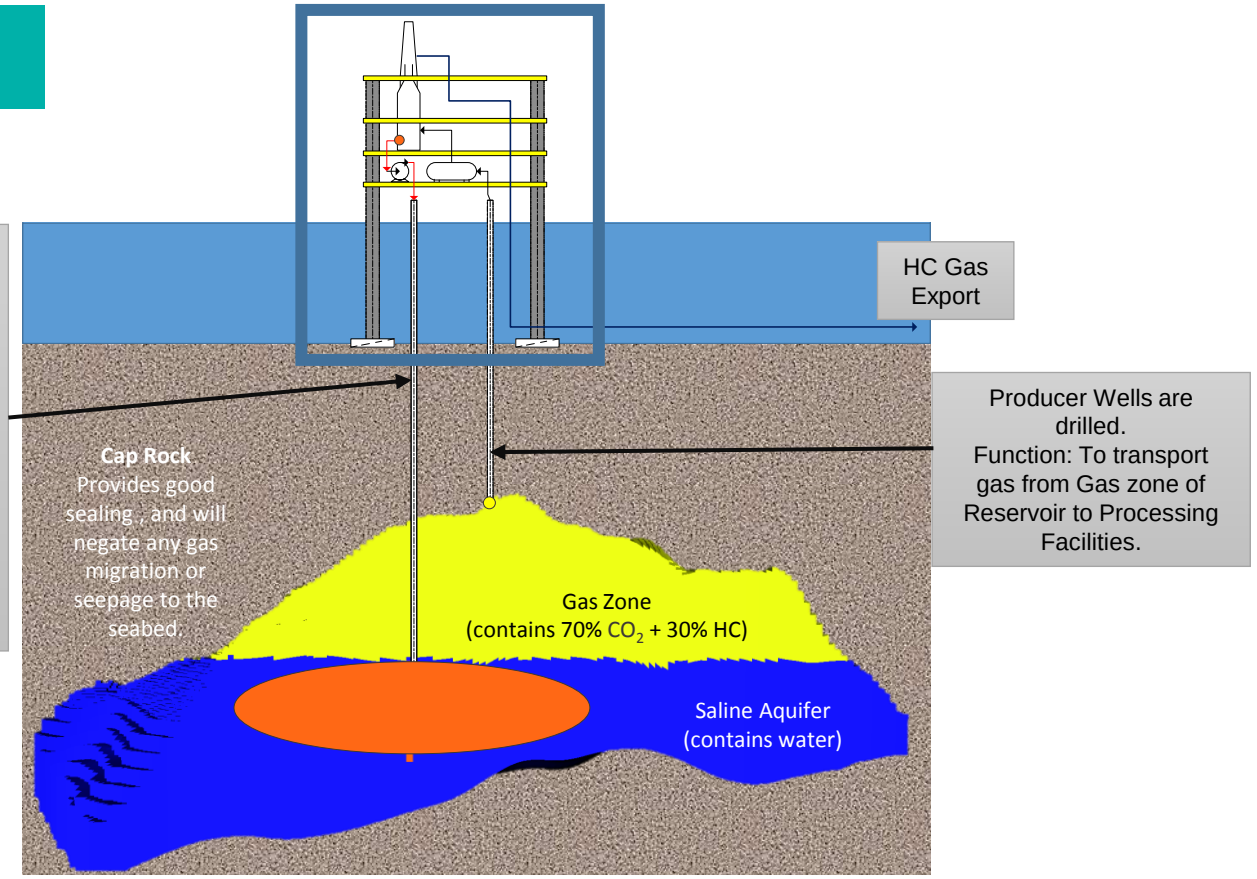
CO2 Storage

- K5 is an environmentally friendly project as all CO2 produced is permanently stored in the reservoir 2.2km beneath seabed.

Zero emissions

Liquidified CO_2 will then be injected through Injector wells, which penetrates, below the gas zone, into the saline aquifer.

Injecting close to pure CO_2
At rate 115 MMscf/d
New material (17 Cr)
Injecting in Supercritical CO_2



Conclusion

- **Technologies to Unlock Hydrocarbon Potential:**
  - Building on PETRONAS' experience in developing high CO2 fields, CO2 technologies are being matured at K5 offshore facilities towards future application and monetization of high CO2 fields in Malaysia and internationally.
  - Comprehensive approach
    - Surface & Subsurface
    - Carbon Separation, Transportation, Storage
    - Commercially viable
    - Environmentally sustainable

- Cryogenic distillation, advanced membrane and supersonic gas separation are **the new technologies** which can be the game changer to commercially develop high CO2 fields.

- K5: first project to incorporate the extraction of CO2 gas, contaminant removal until end of field life

- K5 is an environmentally friendly project as all CO2 produced is permanently stored in the reservoir.

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Thank you