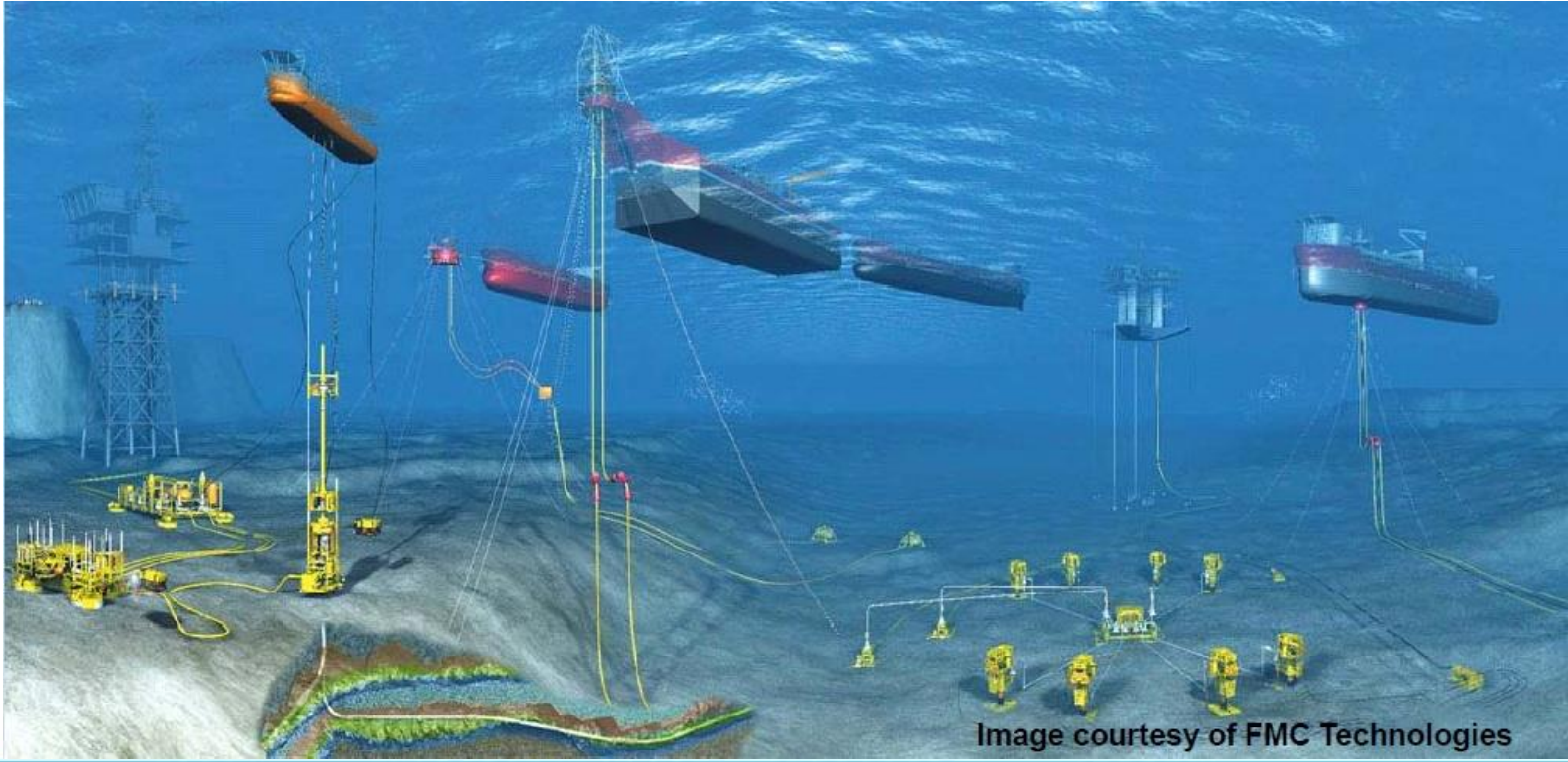
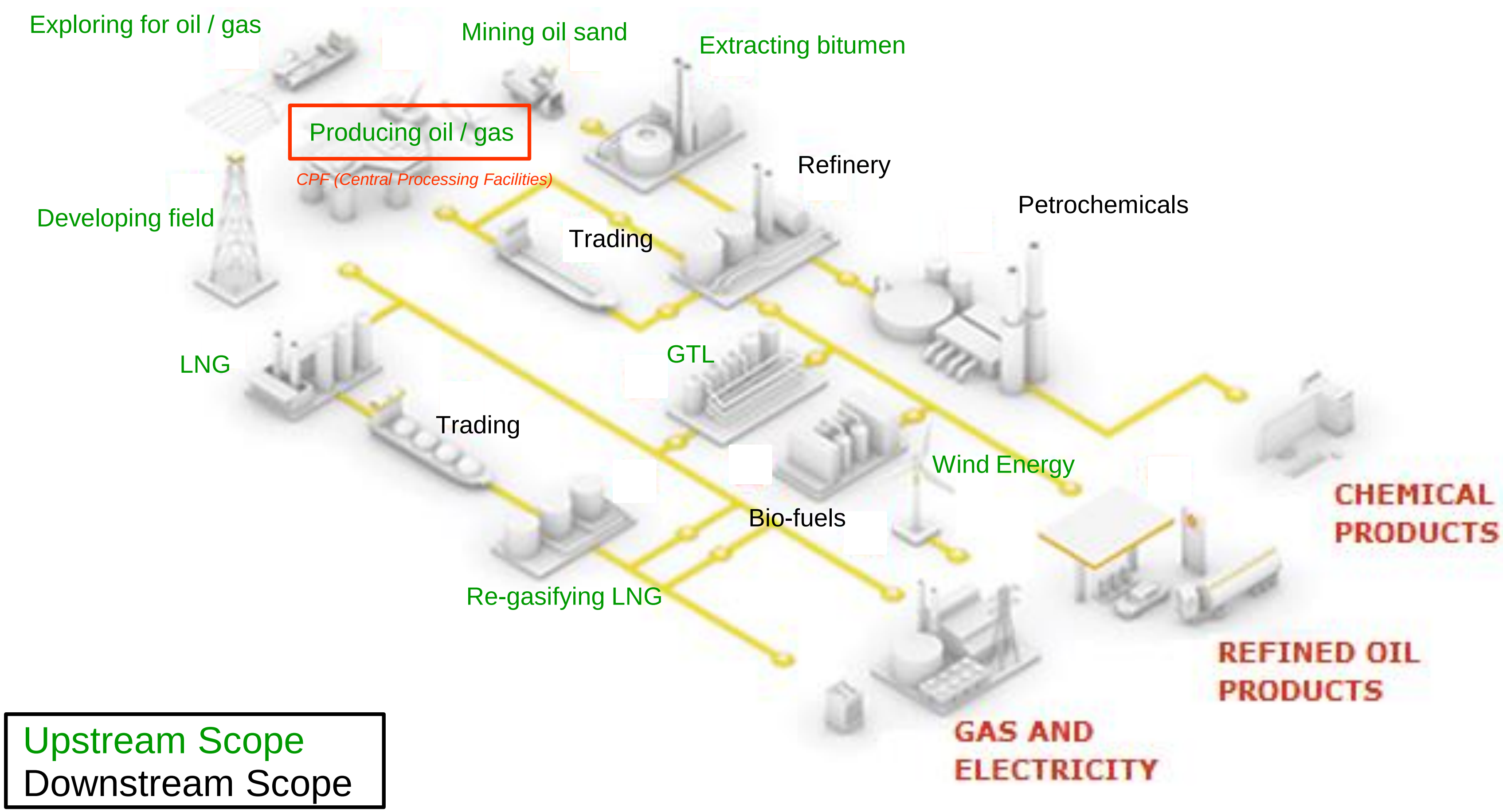


해양플랜트 공학 입문

서유택

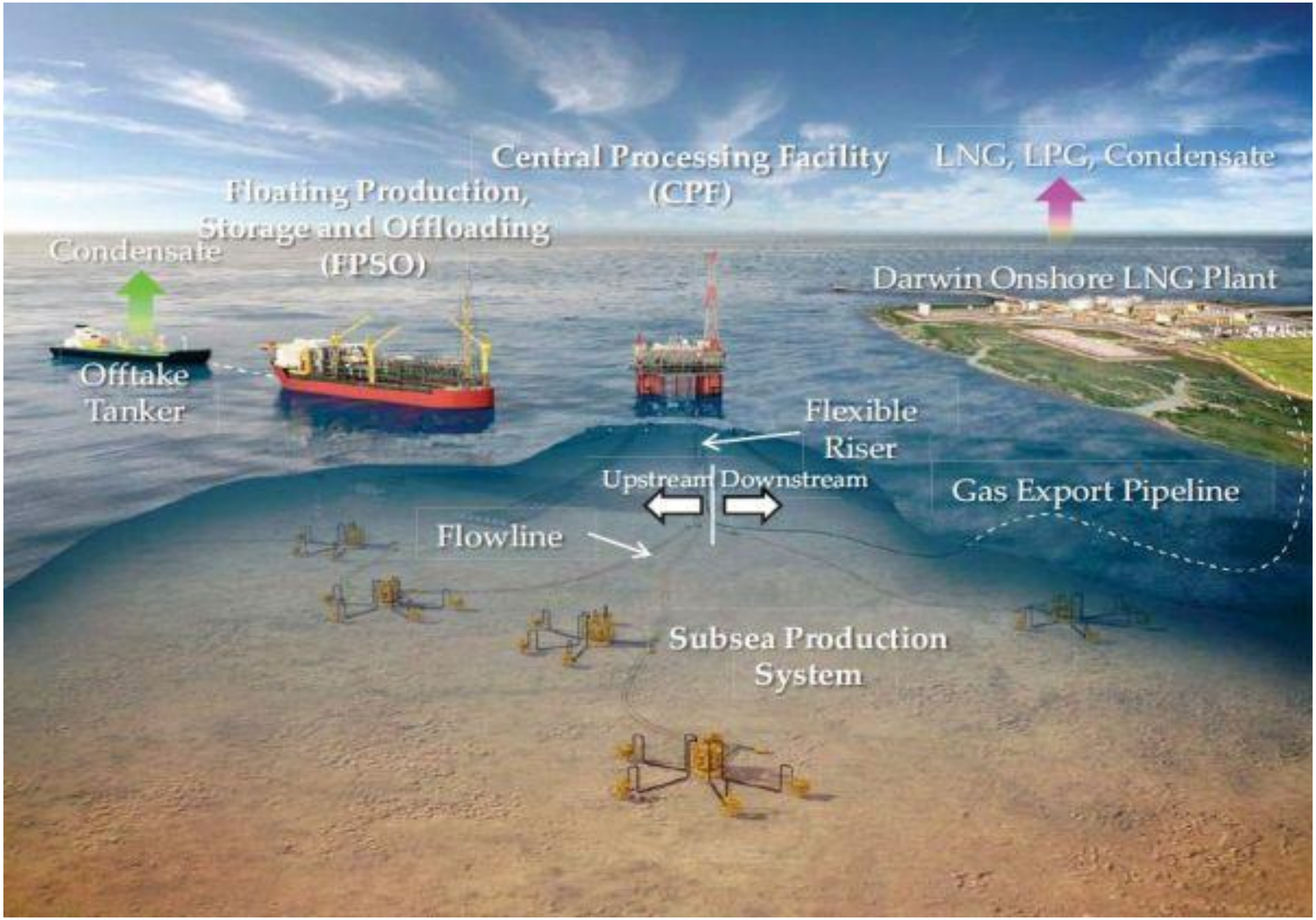
Upstream & Downstream



Source : Dutch-SHELL Website (SHELL's Business Scope)

CPF (Central Processing Facilities)?

Gas / Condensate Production for Dawin LNG Project (AU)



Design process

Subsea production system

① Well fluid characteristics
② Flow-stability free of erosion & corrosion
③ Flow assurance study (multiphase flow)
④ Chemical inhibitor (HI, CI) consumption
⑤ Analysis on max. liquid surge volume in slug catcher

Topside process design

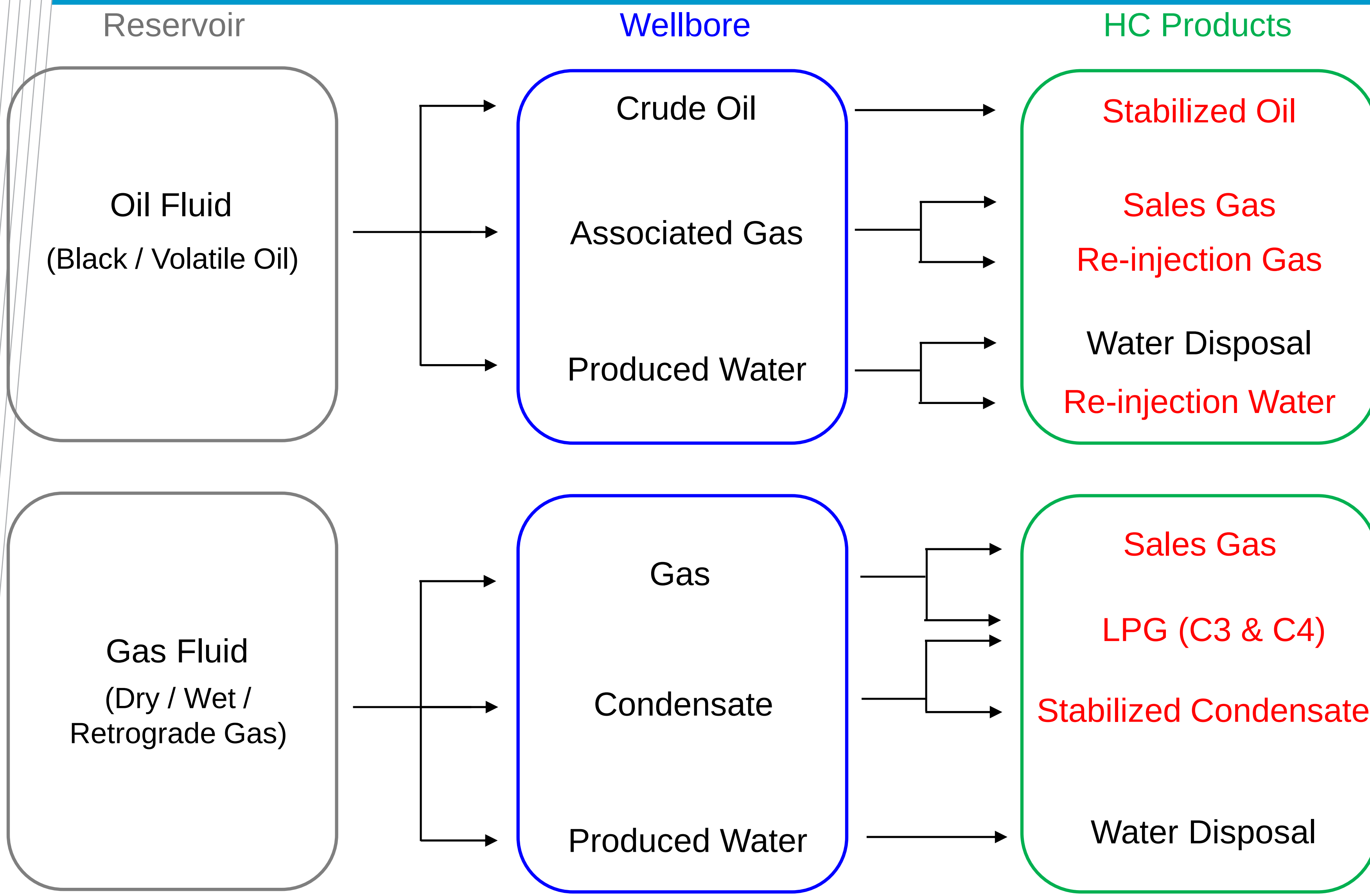
① Slug catcher & G/L separator design
② Gas sweetening unit design
③ Mercury removal unit design
④ Gas dehydration unit design
⑤ Gas compression unit design
⑥ Oil/condensate stabilization unit design
⑦ Oil / condensate storage tank design
⑧ Produced water treating unit design
⑨ Utility design (Hot oil / Fuel gas)

Export Pipeline Design

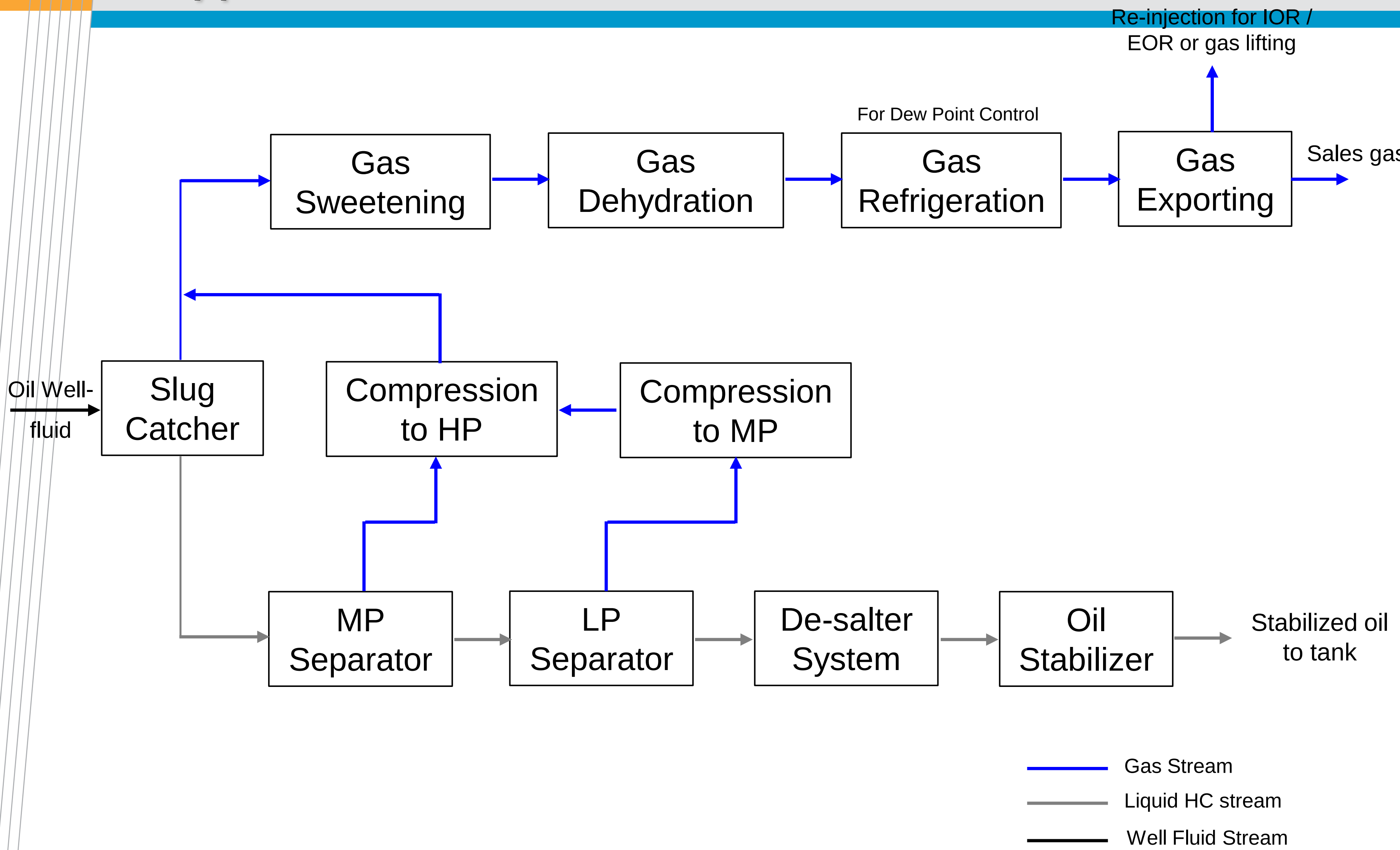
① Flow stability (ex. Two phase formation?)
② Flow assurance study
③ Surge analysis

Sale Gas & Sales Oil
(enough for sales spec.)

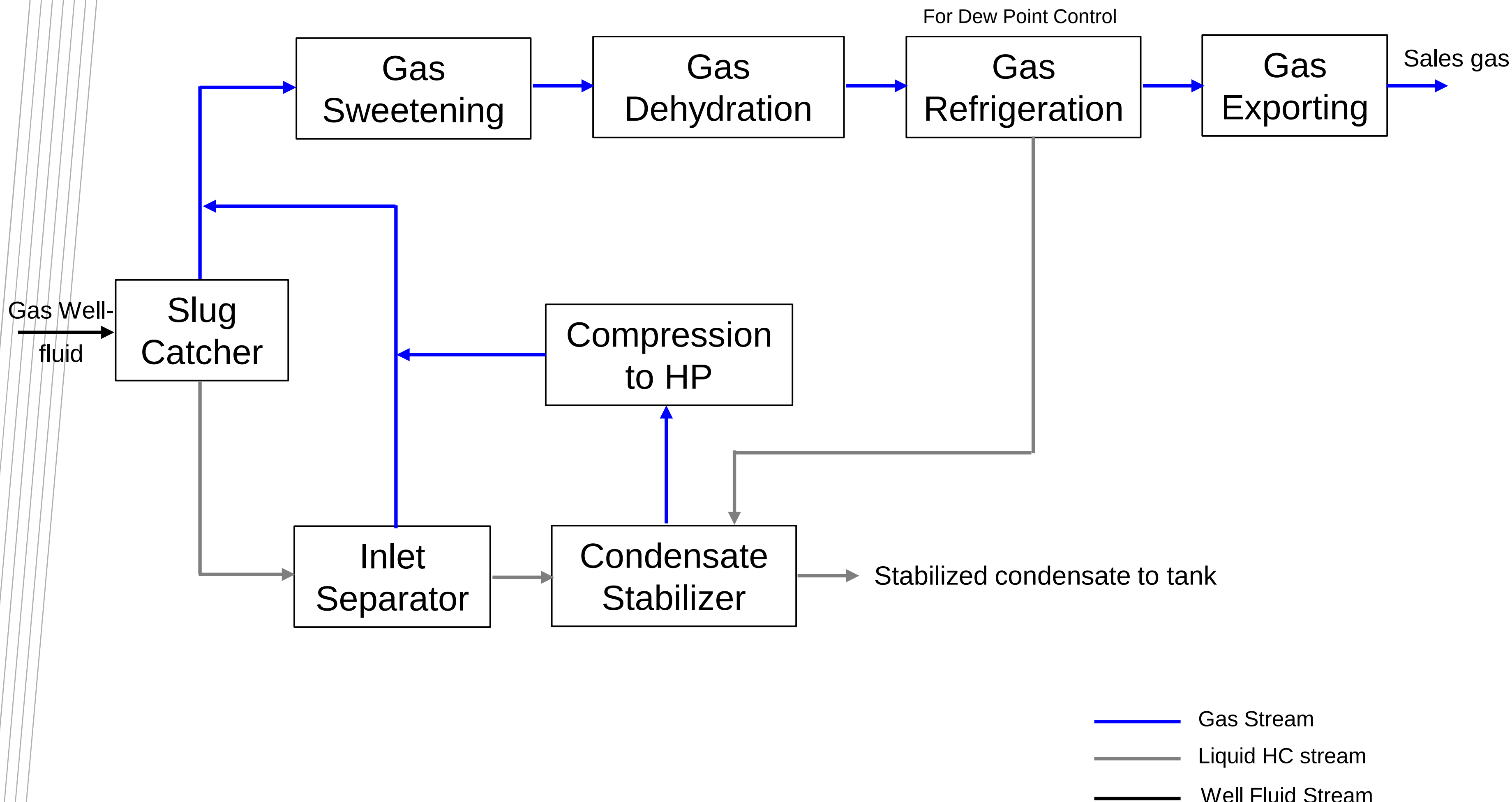
Form Reservoir To Products



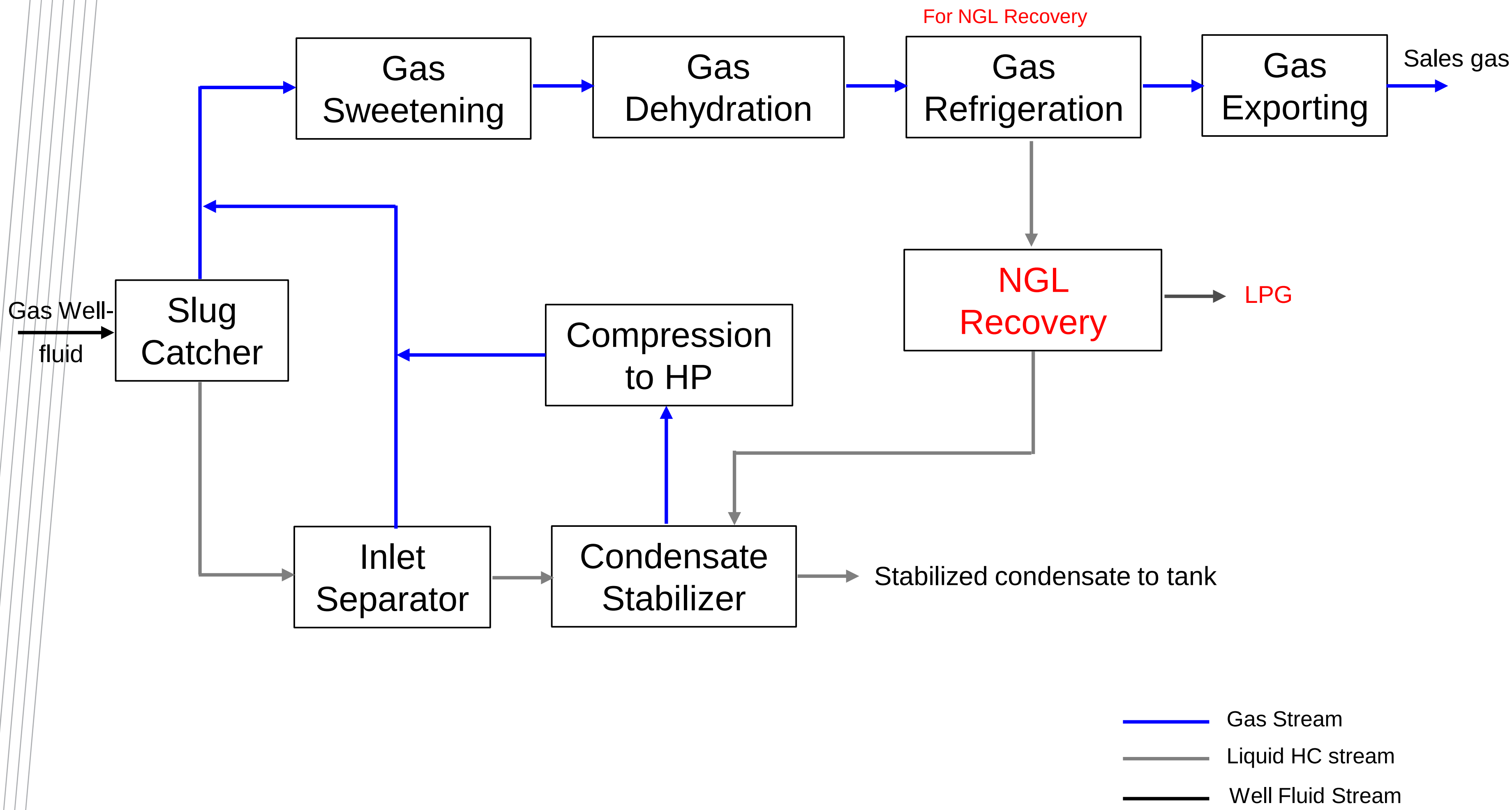
Typical CPF : Oil Field



Typical CPF : Gas Field (1)



Typical CPF : Gas Field (2)



Design Process

Client Requirements & Onshore or Offshore?

Main Product (sales gas / stabilized oil / LPG) & EOR (or IOR) & CCS?

1) EOR : Enhanced Oil Recovery
2) IOR : Improved Oil Recovery

Well Test Data Analysis
(Fluid / Flowing P & T)

Block Flow Diagram Completion

Process and Equipment Design / PFD & PID …

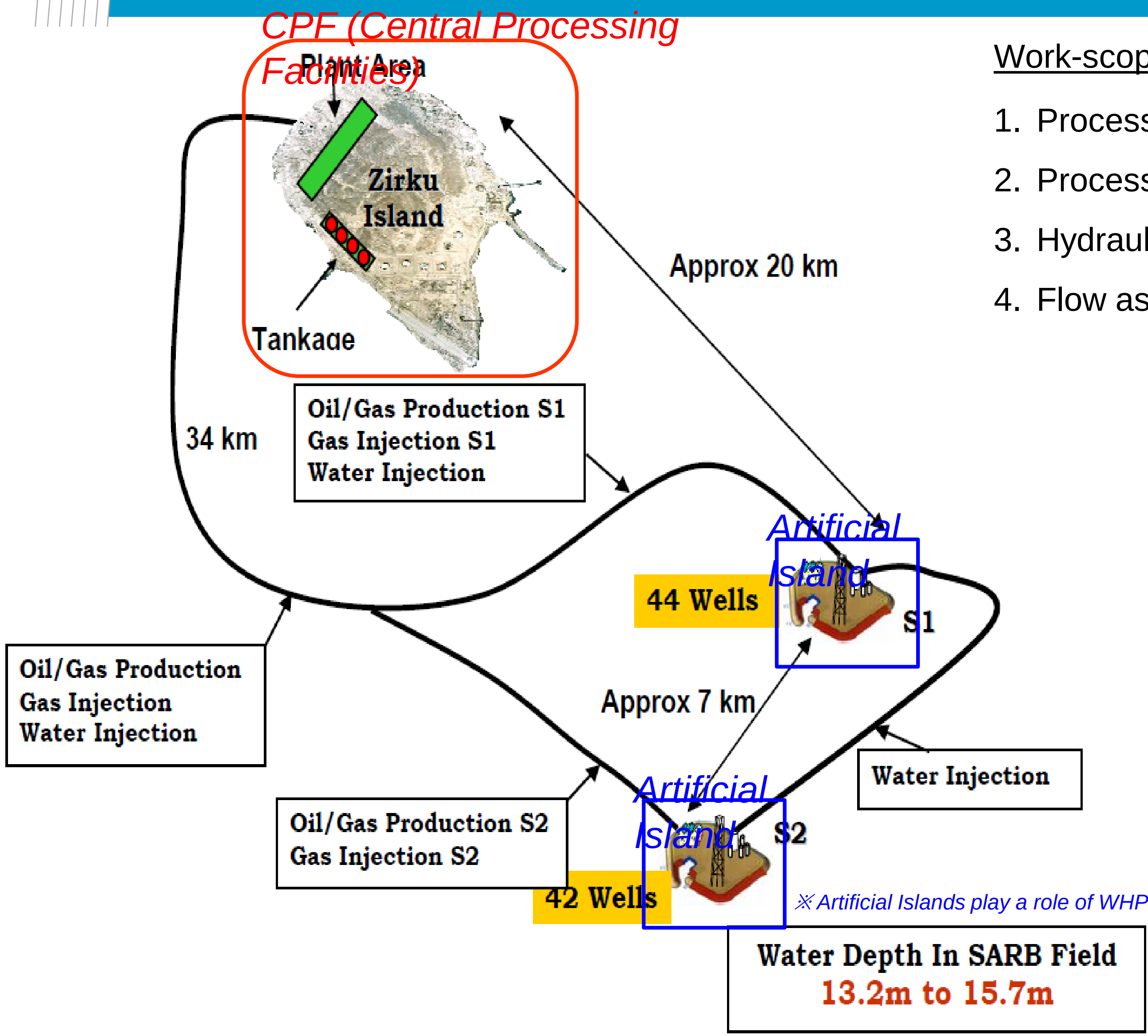
CPF Design Completion

Project comparison

Project	Reservoir Fluid	Product	IOR [1] / EOR [2]	CCS [3]
SARB-4 (UAE_Abu dhabi)	Oil	Stabilized Oil Reinjection Gas	Y (Gas/Water Injection)	N
TouatGaz (Algeria)	Gas	Sales Gas Stabilized Condensate	N	Y
MIDYAN (Saudi)	Gas	Sales Gas	N	N
AKKAS (Iraq)	Gas	Sales Gas Stabilized Condensate	N	N
RHIP (Omen)	Gas	Sales Gas Stabilized Condensate LPG	Y (SG Injection)	Y [4]

Note 1> IOR means "Improved Oil Recovery" as technology for 2nd and 3rd recovery
2> EOR means "Enhanced Oil Recovery" as technology for 3rd recovery
3> CCS means "Carbon Capture & Storage"
4> RHIP process includes CO_2 EOR facilities for another oil field. CO_2 EOR plays a role of CO_2 storage role as well as enhanced production.

Ex. SARB-4 (Client : ADMO-OPCO / Abu Dahbi)

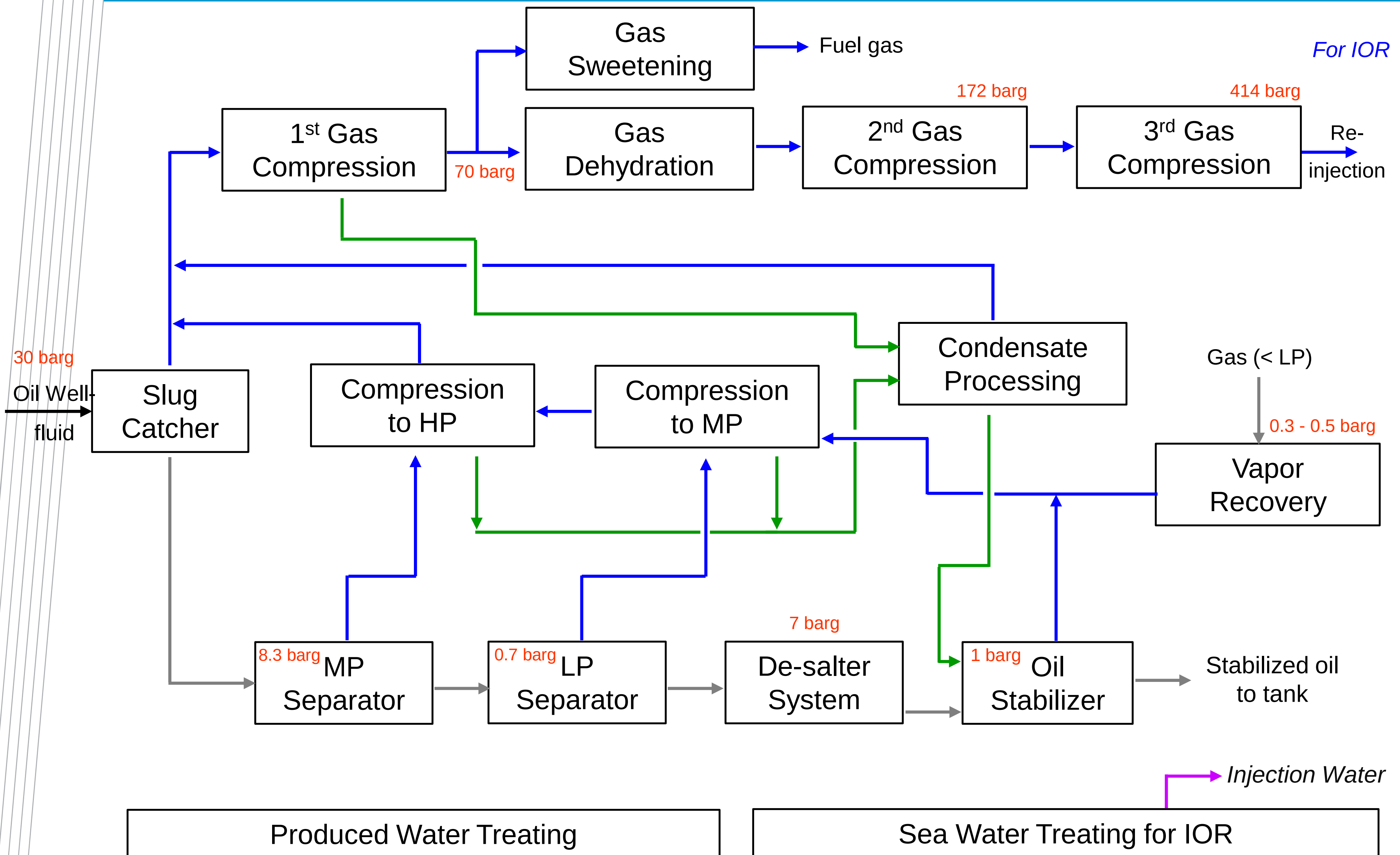


Work-scope

1. Process Design on CPF (Zirku Island)
2. Process Design on Artificial Islands
3. Hydraulics on subsea pipeline
4. Flow assurance on subsea pipelines

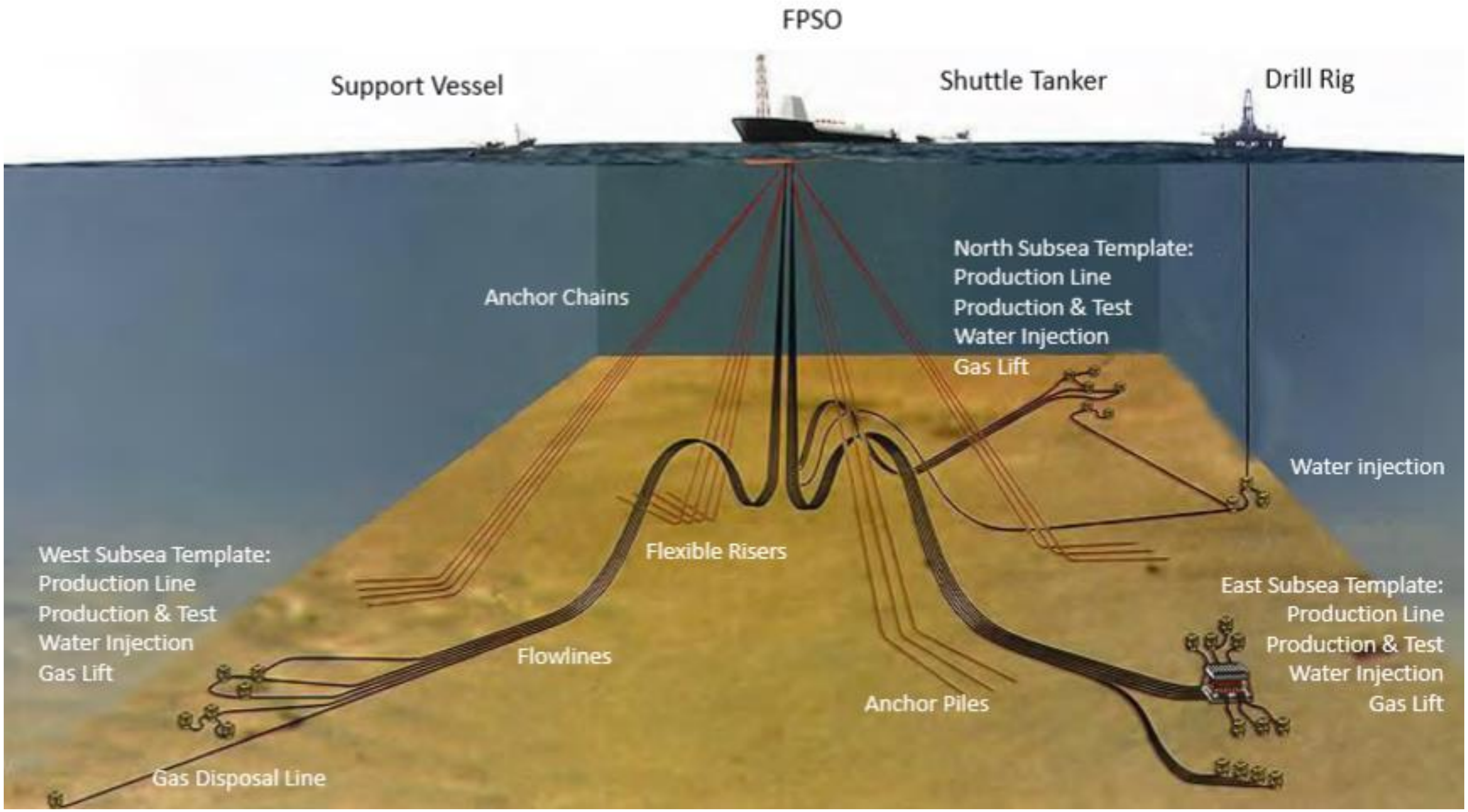
Product (CPF)

1. Stabilized oil (200,000 stb/d)
2. Reinjection gas and fuel gas
3. Reinjection water (sea water)

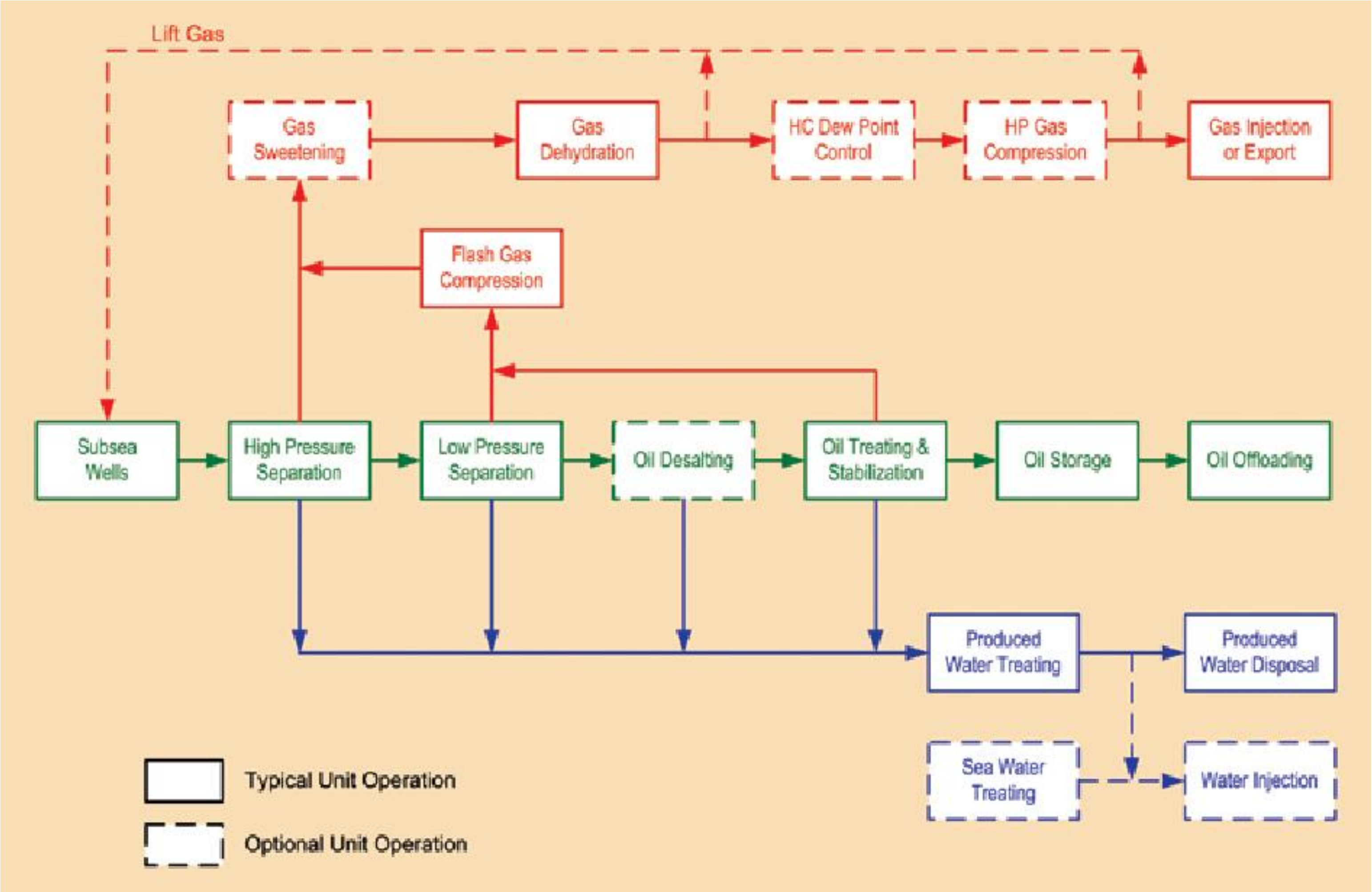

Gas Sweetening
Fuel gas
For IOR
172 barg
414 barg
1st Gas Compression
70 barg
Gas Dehydration
2nd Gas Compression
3rd Gas Compression
Re-injection
Condensate Processing
30 barg
Oil Well-fluid
Slug Catcher
Compression to HP
Compression to MP
Gas (< LP)
0.3 - 0.5 barg
Vapor Recovery
7 barg
8.3 barg MP Separator
0.7 barg LP Separator
De-salter System
1 barg Oil Stabilizer
Stabilized oil to tank
Injection Water
Produced Water Treating
Sea Water Treating for IOR

Oil FPSO

- Processes hydrocarbons from subsea template into oil, LPG, sales gas, etc.
- A converted tanker or purpose built vessel – may be ship shaped
- Eliminate the need for costly long-distance pipelines, which is effective in remote or deep water developments

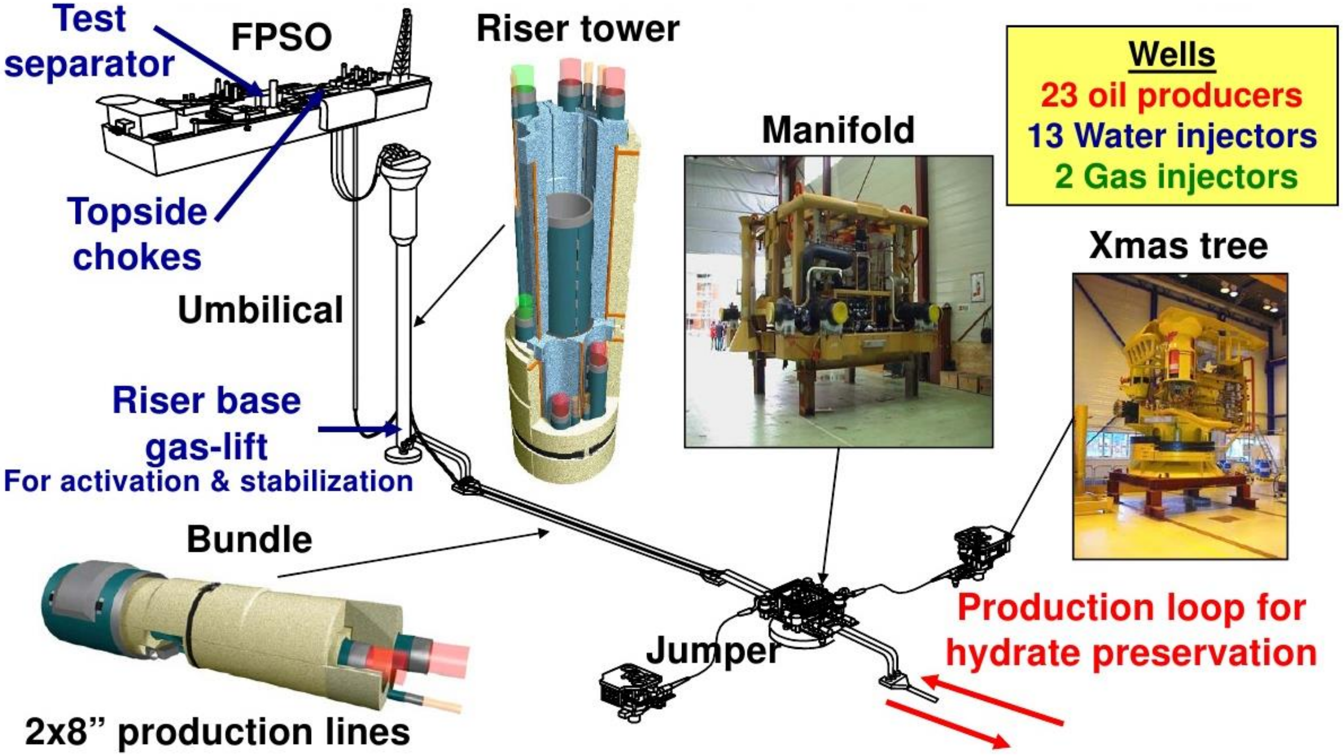


Oil FPSO topside facilities



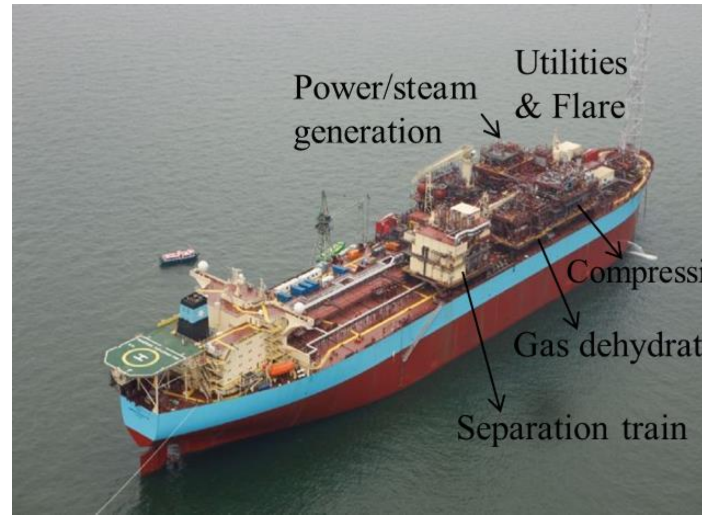
FPSO in West Africa

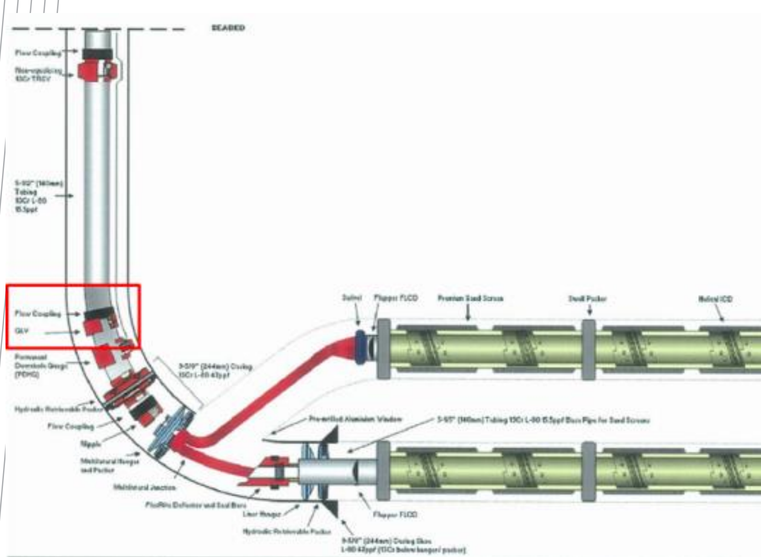
- Girassol (TotalFinaElf)
  - : Located of NNW Luanda, Angola - 1350m of water
  - : Producing 32^{o} API crude oil from 23 wells
  - : Total storage capacity 2 million bbl of crude oil
  - : Liquid processing 180,000 bpd
  - : 3 million m^{3}/d gas lift with 8 million m^{3}/d gas compression and dehydration

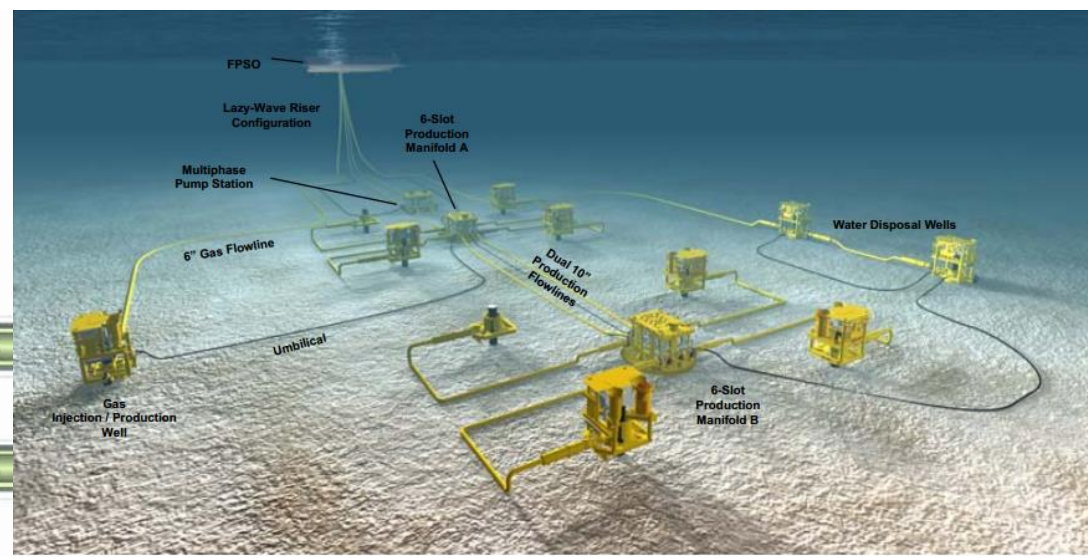


FPSO in Western Australia

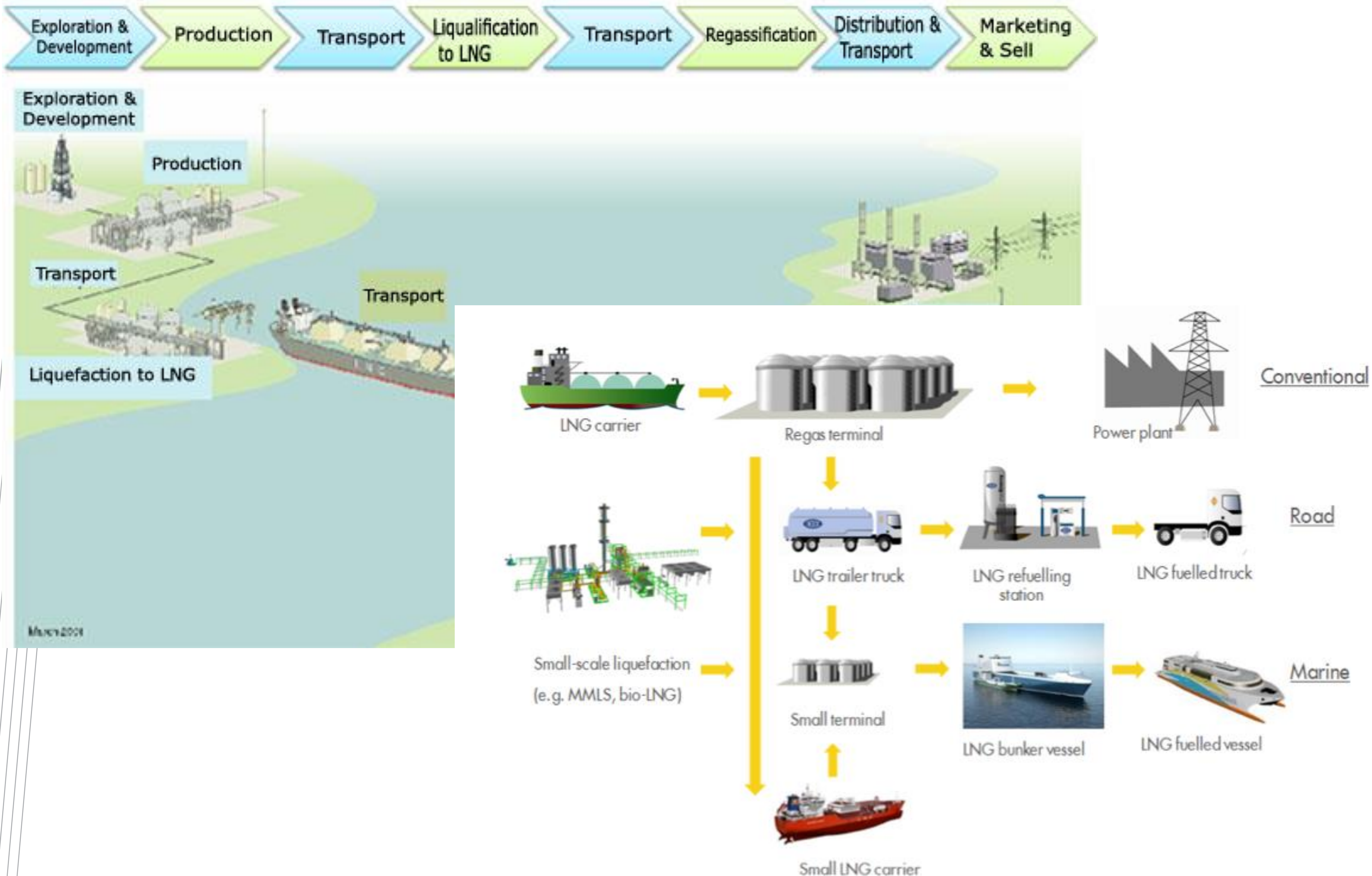
- **Vincent oil field**
  : Located offshore Exmouth in Western Australia
  : Water depth 350m, 17^o API crude from 8 wells
  : Oil column thickness 8.5 ~ 19.0 m
  : Total Liquid processing capacity 120,000 b/d with total storage capacity of 1.2 million barrels of oil
  : Water (150,000 b/d) & Gas (80 MMscf/d) Injection
  : Dual sided hull and disconnectable mooring





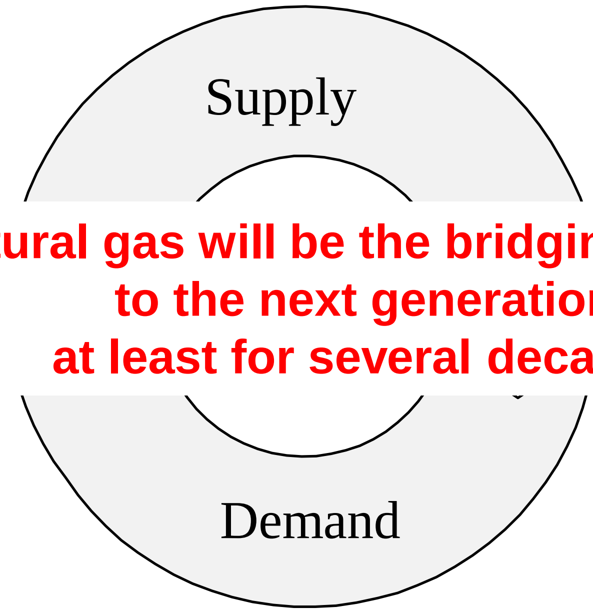


LNG value chain



Why natural gas?

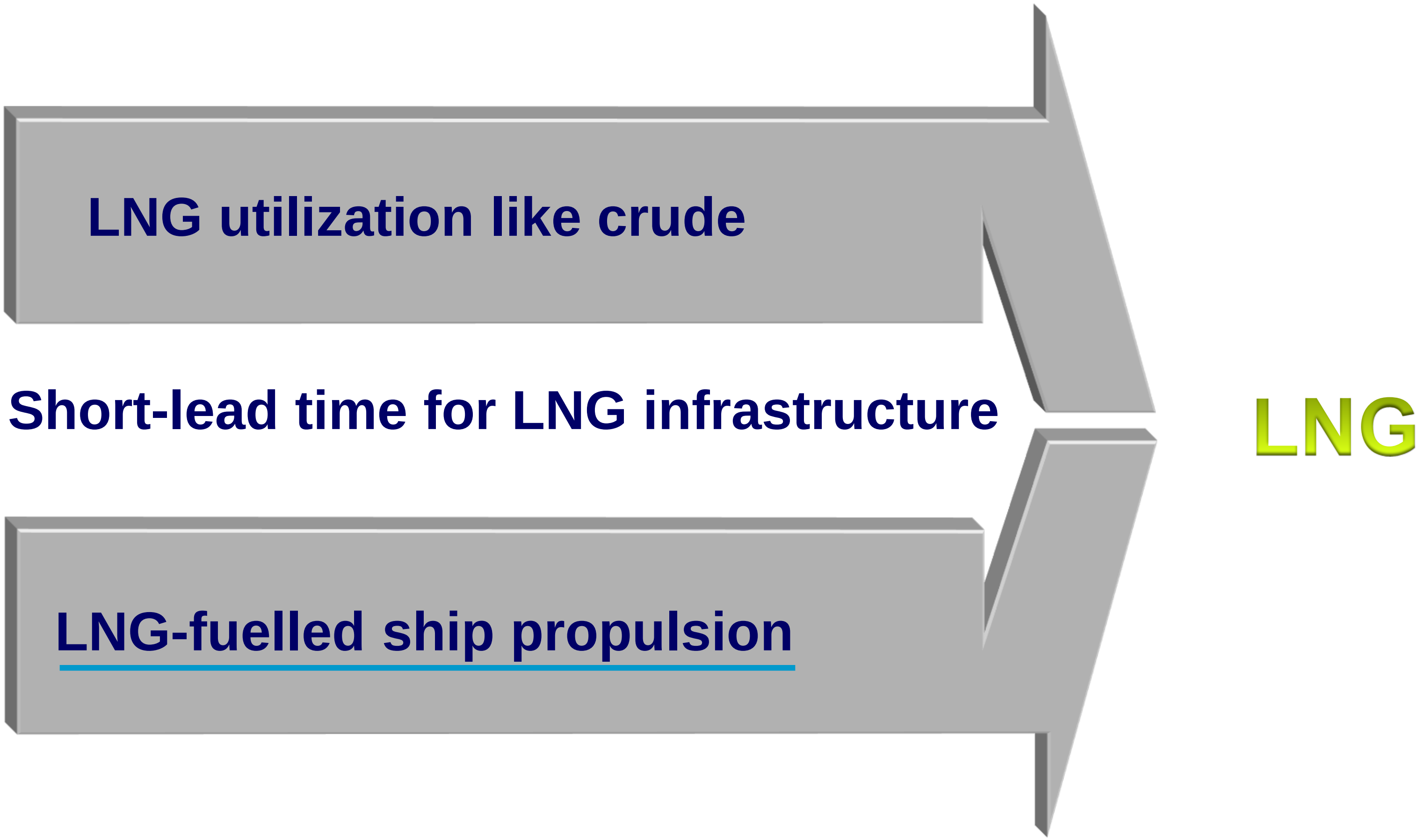
- Sufficient reserves: onshore and offshore
- New solutions to non-conventional gas development (FPSO, Shale gas production)



Natural gas will be the bridging energy to the next generation at least for several decades

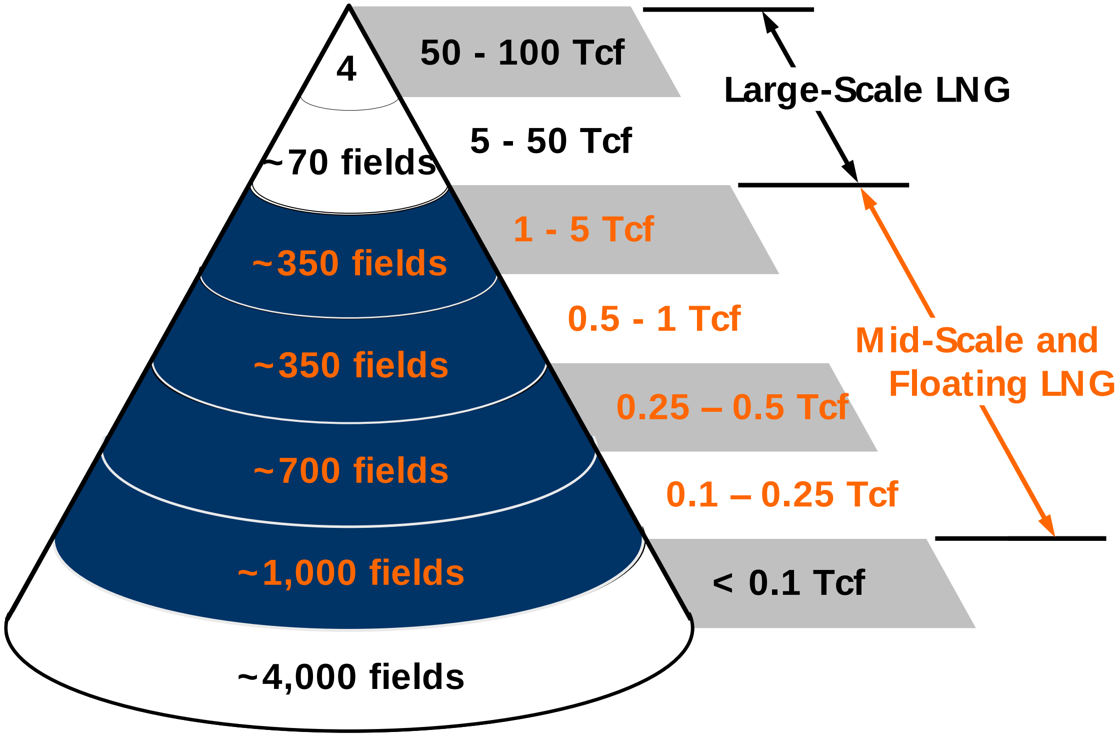
- Greener: Less CO_2
- Less polluting: Negligible NOx, No SOx, No PM
- More economical: Cheaper than crude-driven fuels

Why LNG?


LNG utilization like crude
Short-lead time for LNG infrastructure
LNG-fuelled ship propulsion
LNG

FLNG opening more gas to development

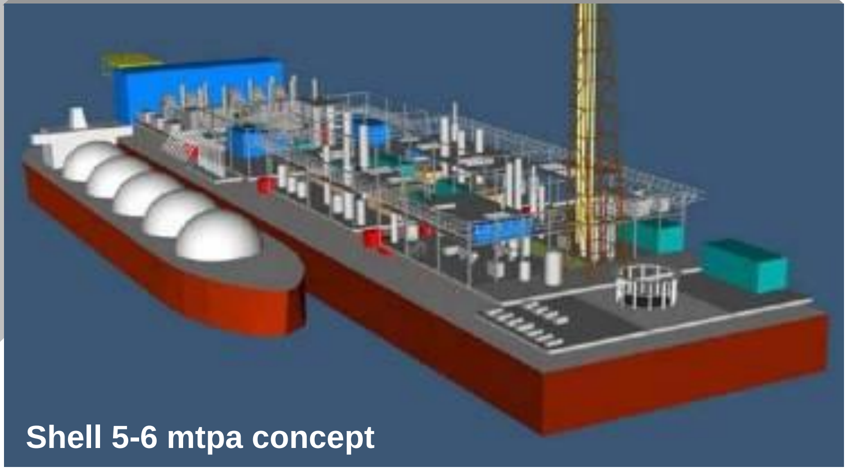
- Accesses gas unsuitable for baseload development
- Eliminates pipeline & loading infrastructure costs
- Reduces security and political risks
- Constructed in controlled shipyard environment
- Can relocate facility upon field depletion



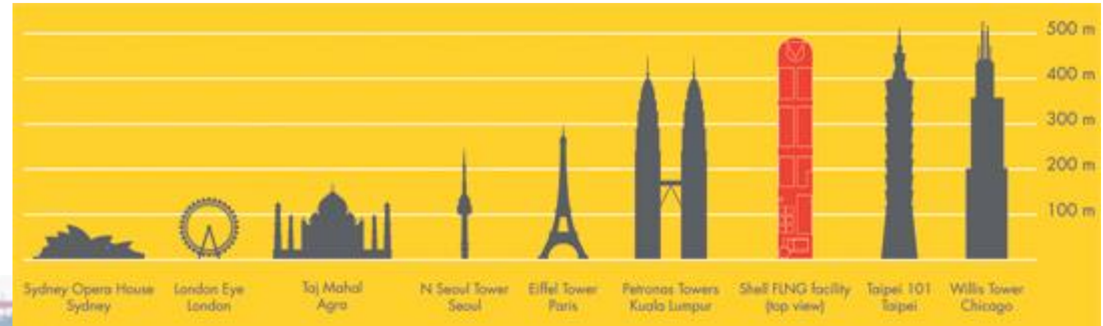
Two distinct development paths emerging

Characteristic	Small-scale Floating LNG	Large-scale Floating LNG
Liquefaction capacity:	less than 3.0 mtpa	3.5 to 6.0 mtpa
Required reserves:	0.5 to 3.0 Tcf	more than 3.0 Tcf
Hull:	Ship-like	Barge-like
Storage capacity:	up to 220,000 m^3	more than 250,000 m^3
Liquefaction processes:	Simpler processes (e.g., Single Mixed Refrigerant processes, dual expander processes)	Baseload-type processes (e.g., Dual MR, Mixed Fluid Cascade)

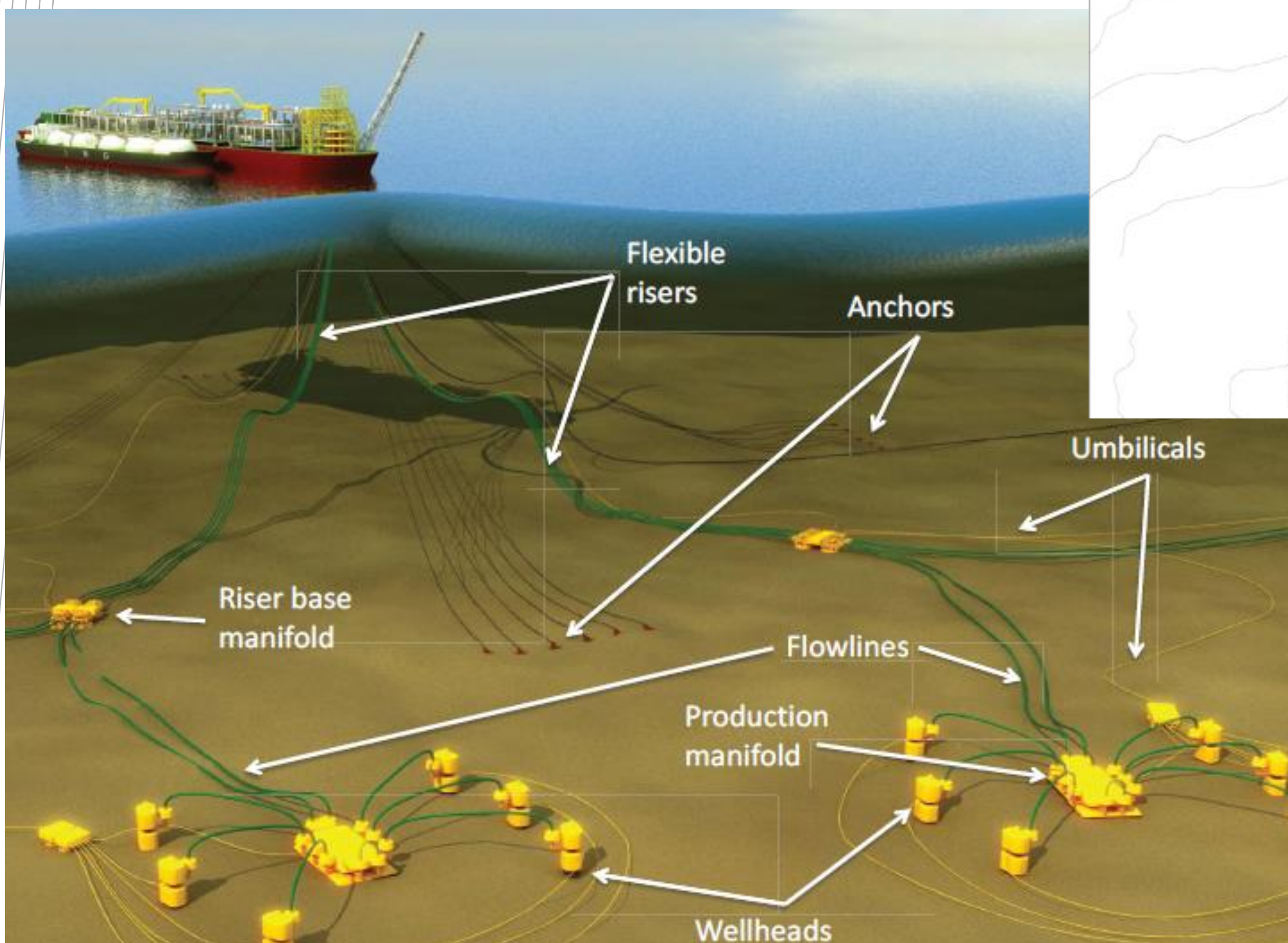
SBM Offshore 2.5 mtpa

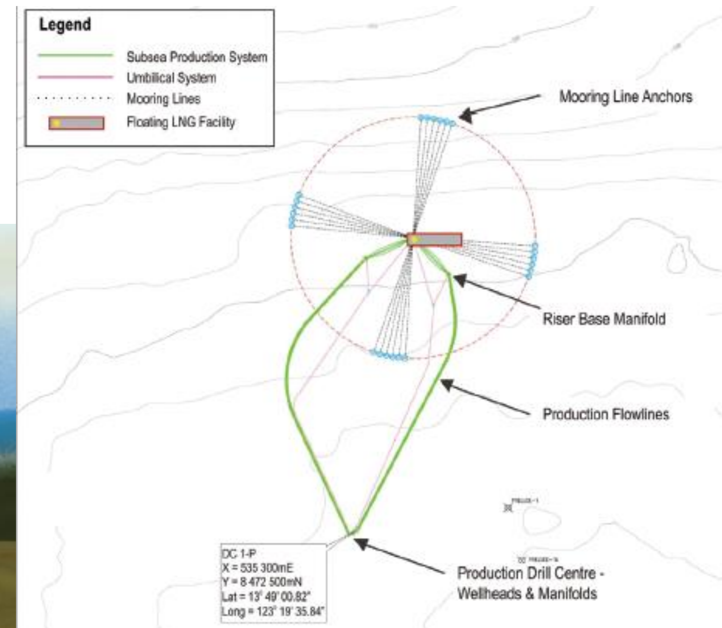

Shell 5-6 mtpa concept

Prelude FLNG

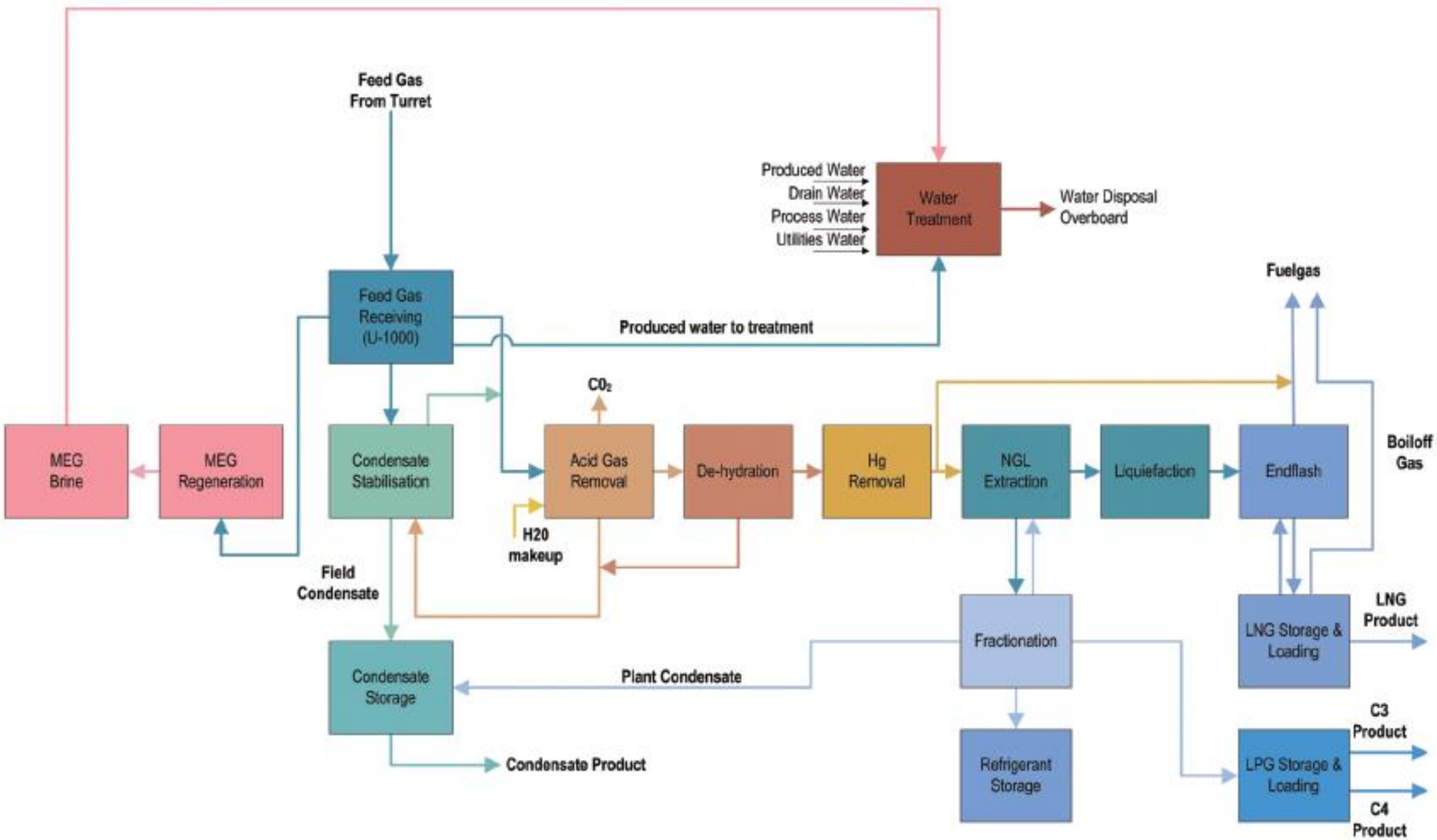


Prelude FLNG in operation

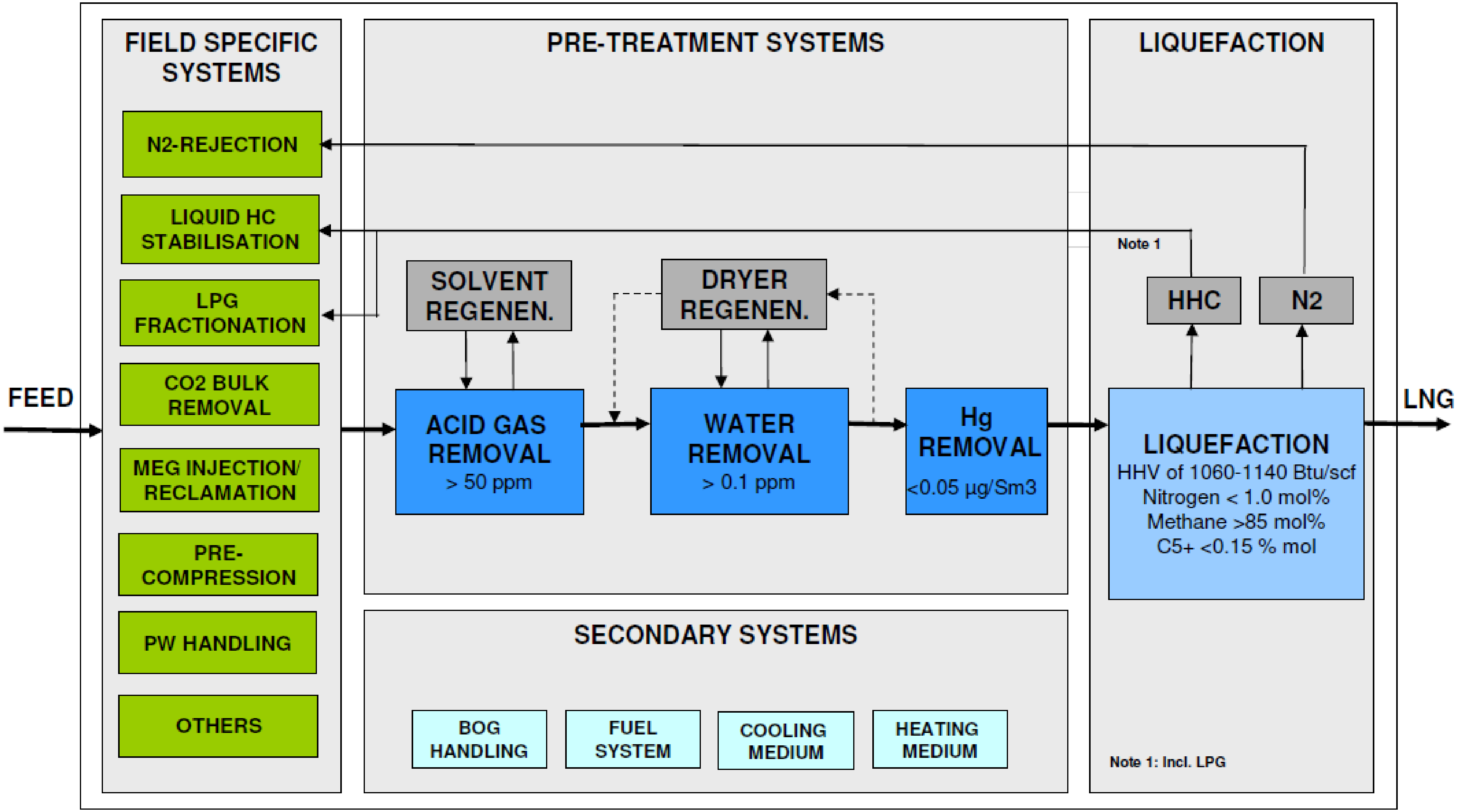




FLNG process overview



Field specific and pre-treatment systems



Field specific and pre-treatment systems

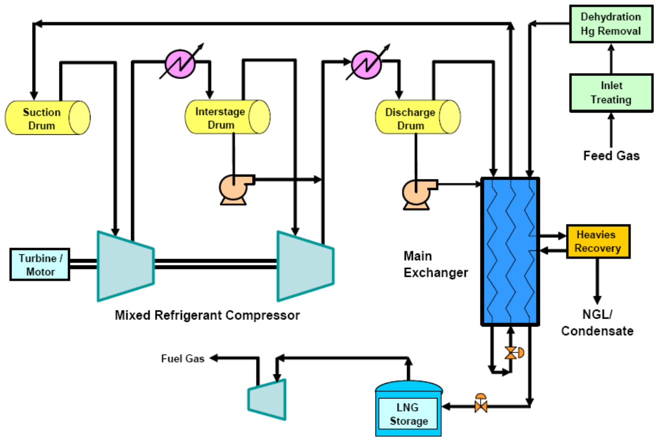
- Field specific and pre-treatment systems are conventional and not new to the offshore environment.
- Energy optimization is required to integrate the heat- and energy demanding systems in the overall topside.
- Optimize and include the pre-treatment and field specific systems in the fuel gas balance.
- Tall columns with internals must be carefully designed in order to minimize flow maldistribution.
- Avoiding stabilization issues of the condensate or recycle of middle components like propane and butane through the process system.

SYSTEMS	FPSO	LNG FPSO
Liquid separation and stabilisation	X	X
MEG injection and reclamation	X	X
Bulk acid gas removal system	X	X
Acid gas polishing system	√	X
Molsieve dehydration system	Limited	X
Mercury removal system	X	X
LPG fractionation and stabilisation system	Limited	X
Produced water treatment	X	X
N2-Rejection	√	X
BOG handling	X	X

Liquefaction choices far from mature

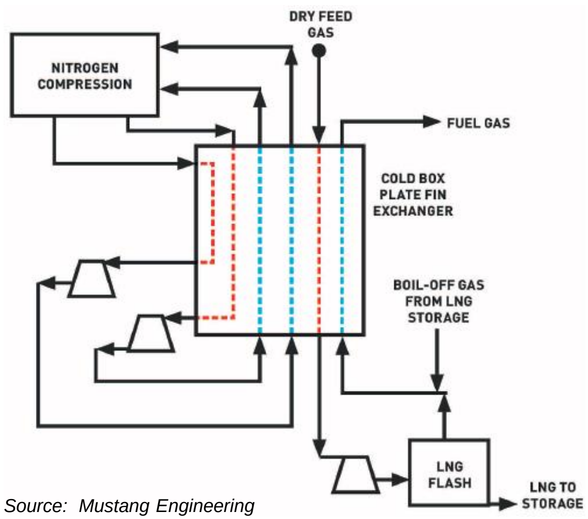
- Need simple, robust and compact liquefaction solutions
  - Single mixed refrigerant cycles
  - Gas expander-based cycles
- Concerns
  - Process efficiencies
  - Scale-up performance
  - LPG refrigerant storage
  - Marine performance and reliability

Black & Veatch PRICO SMR Process



Source: Black & Veatch

Mustang NDX-1 Process (patent pending)



Source: Mustang Engineering

LNG Properties

- LNG는 천연가스를 저장과 수송이 용이하도록 액체로 전환시킨 것
- LNG와 천연가스 부피비는 1/600 (- 162°C, 상압 조건에서 액화)
- LNG의 매우 낮은 온도로 인해 cryogenic liquid로 취급되며, 취급을 위해 특수한 기술과 설비가 요구됨.
- Cryogenic 상태의 LNG에 접촉되는 모든 물질은 빠르게 냉동되면서 강도와 기능을 잃어버리기 때문에, LNG 보관을 위해서는 container 매체 선정에 주의를 기울여야 함.
- LNG는 무색, 무취하며, 부식성이 없고, 불연성이고, 무독성.
- LNG 물성은 다음의 사항들로 구분된다.
  - ➢조성
  - ➢끓는점
  - ➢밀도 및 specific gravity
  - ➢가연성
  - ➢발화 온도

LNG composition

- 천연가스의 조성은 가스전의 특성과 처리 공정의 종류에 따라 달라짐.
- 일반적으로 LNG 생산에 사용되는 천연가스는 메탄과 에탄, 프로판, 부탄 그리고 소량의 heavy 탄화수소로 이루어지는 혼합가스.
- 불순물로는 질소와 이산화탄소, 황화수소 및 물 등이 포함될 수 있지만, 액화 공정 전에 모두 제거됨. 메탄이 주요 성분으로 보통 85 vol% 이상.

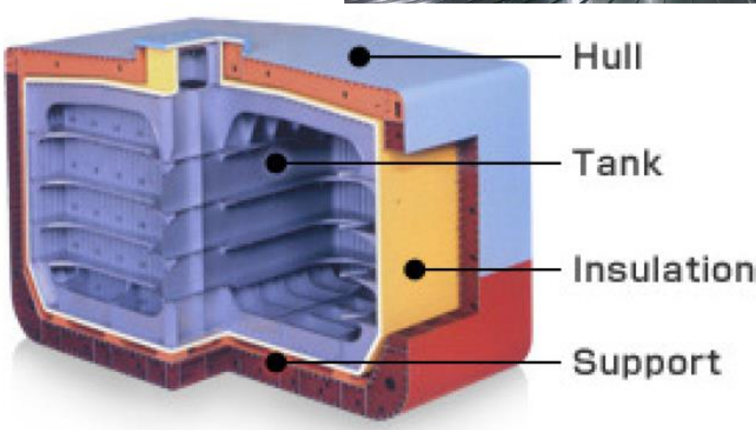
Chemical	Chemical Formula	Low	High
Methane	CH_4	87%	99%
Ethane	C_2H_6	<1%	10%
Propane	C_2H_8	>1%	5%
Butane	C_4H_{10}	>1%	>1%
Nitrogen	N_2	0.1%	1%
Other Hydro-carbons	Various	Trace	Trace

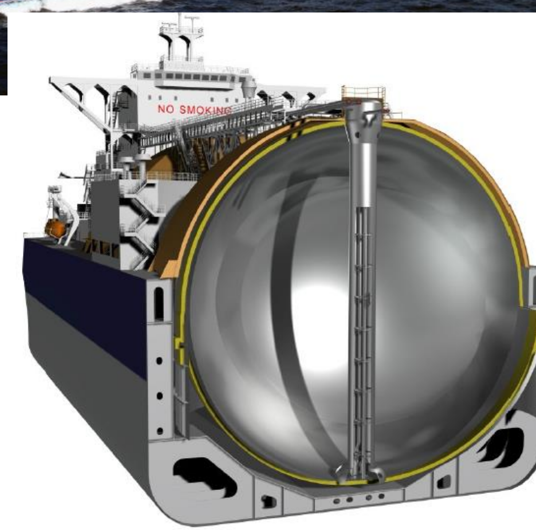
LNG boiling point, density & specific gravity

- LNG의 끓는점은 조성에 따라 변할 수 있지만, 일반적으로 -162°C (-259°F).
- 저온의 LNG가 따뜻한 공기 또는 물에 노출되는 경우, 주변 온도가 LNG의 끓는점보다 높기 때문에 LNG 표면에서 기화가 시작됨.

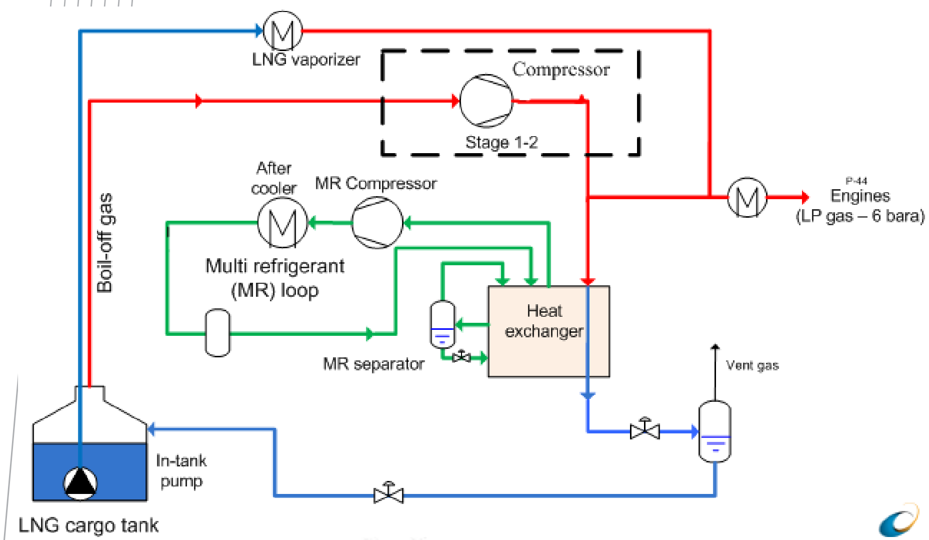
LNG Carrier

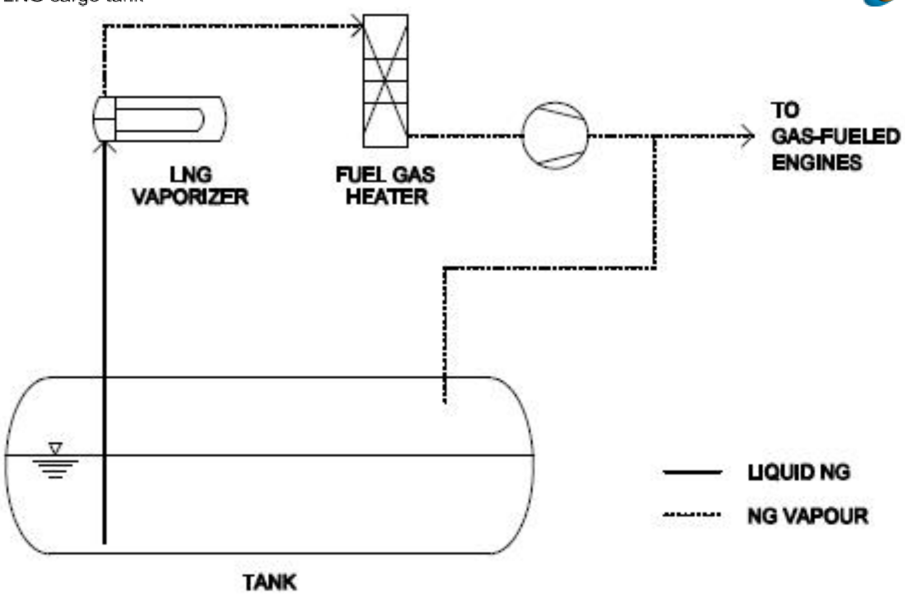
- Which type of tanks in it?

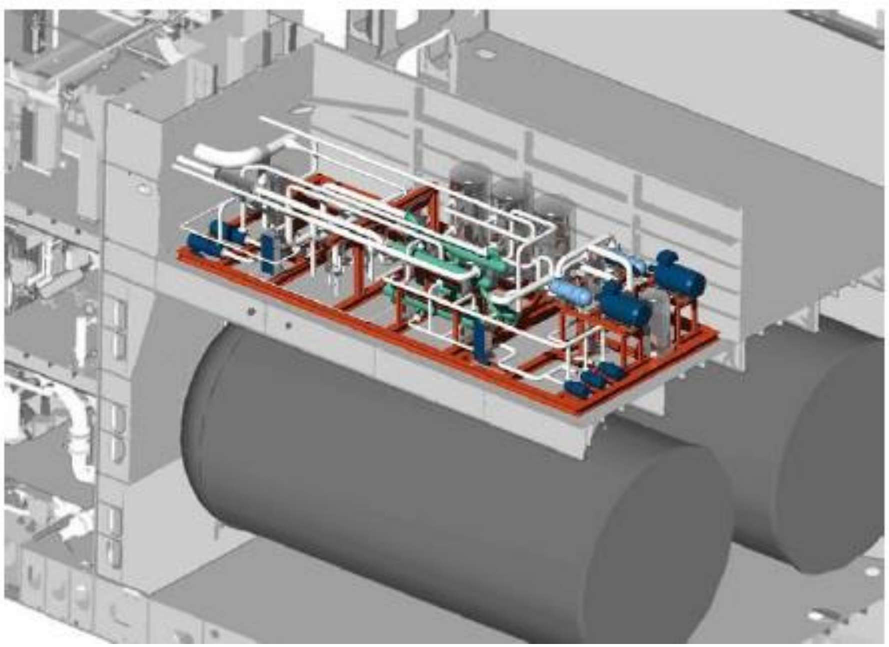




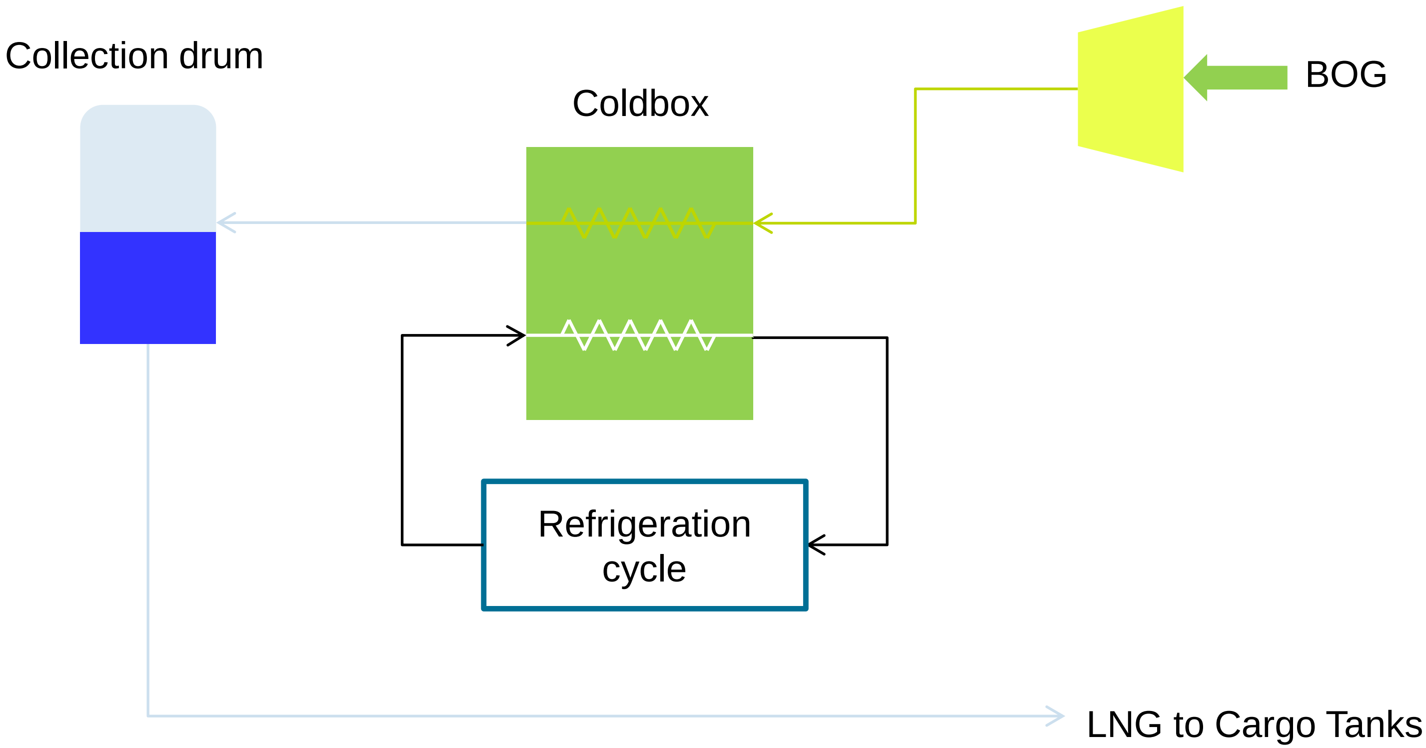
Cargo handling and fuel gas system







BOG liquefaction technology

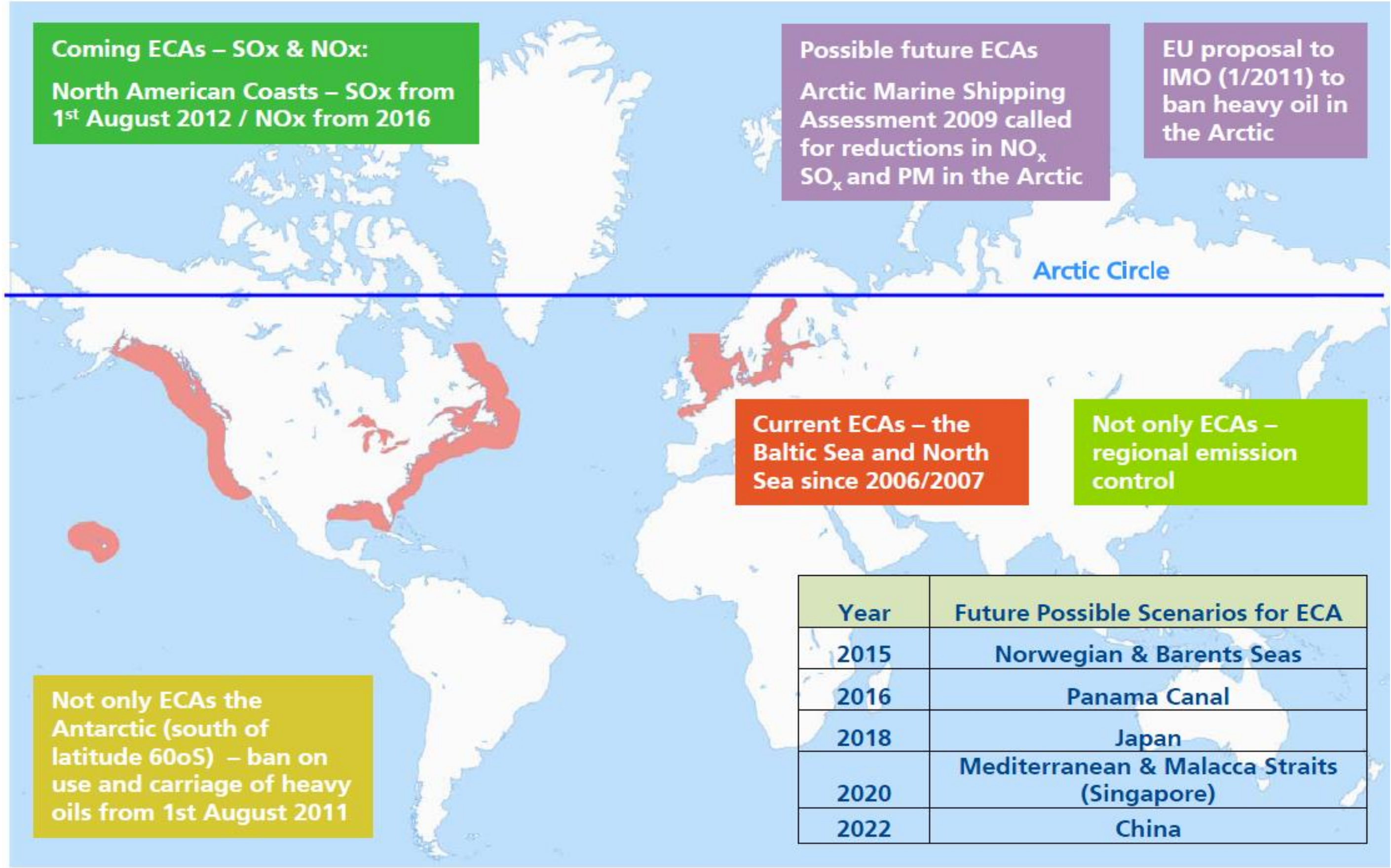


- Effective to treat continuous BOG
- To treat the BOG during LNG bunkering
  - Considerable capacity: 40 ton/hr to treat 40 ton BOG for 1 hr
  - Intermittent operation: 1 hr operation + 9 hr stop

LNG-fuelled ship propulsion

Regulation on fuel quality within emission control area (ECA)

- Currently, the seas around Europe and the North America are ECAs.
- ECAs are expanding, ultimately all over the world.

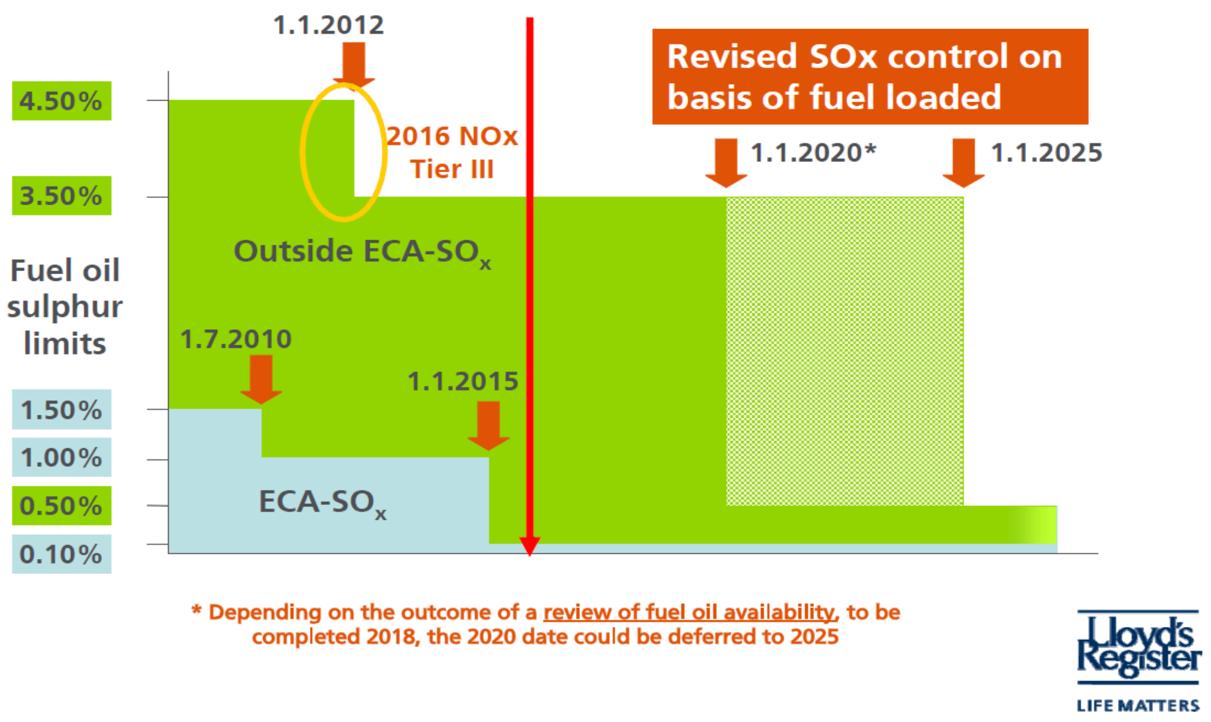


Year	Future Possible Scenarios for ECA
2015	Norwegian & Barents Seas
2016	Panama Canal
2018	Japan
2020	Mediterranean & Malacca Straits (Singapore)
2022	China

Regulation on fuel quality within emission control area (ECA)

- Regulations on emissions from ships, especially for SOx
  - Stringent regulation on fuel quality
  - Effective from 2015 for ECAs (emission control areas)

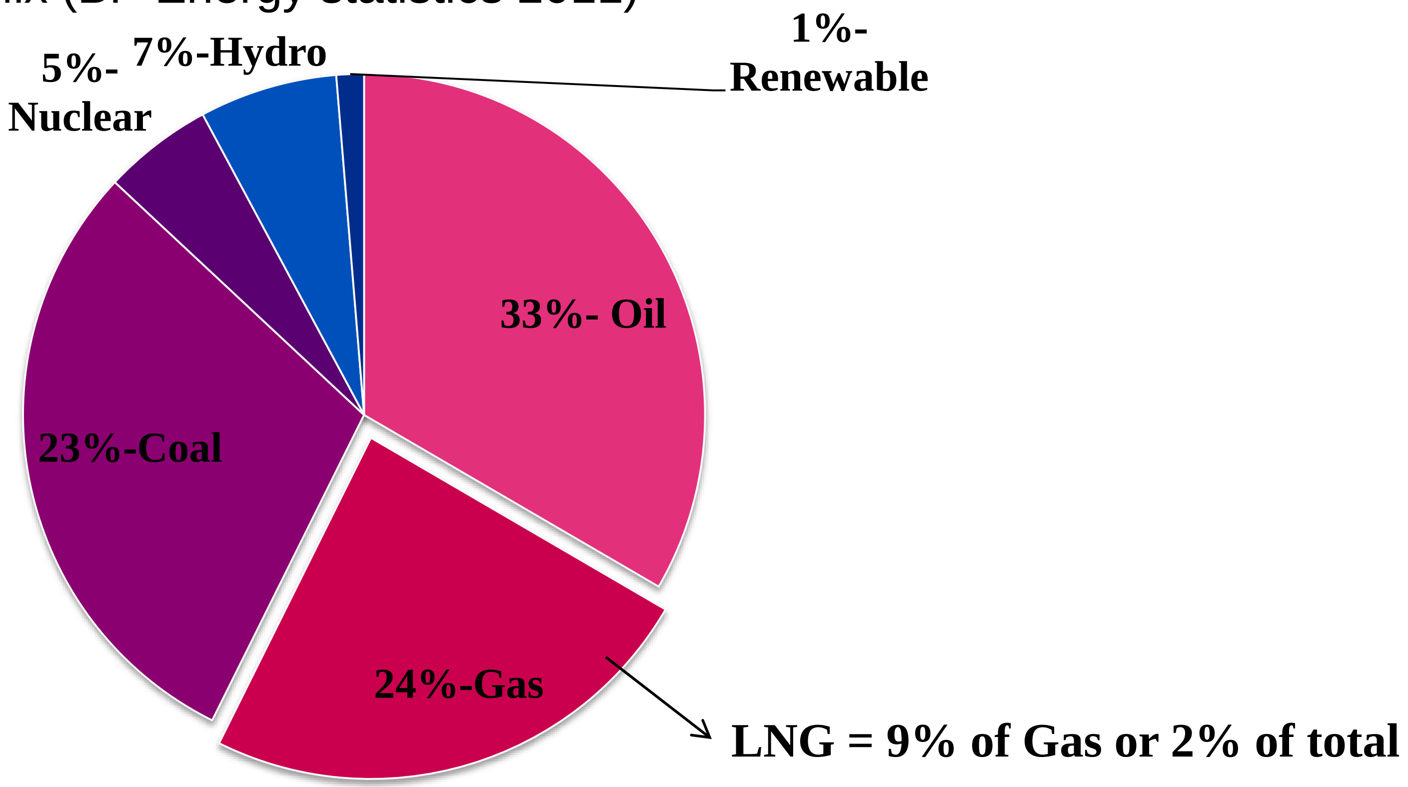
    from 2020 or 2025 globally



MARPOL Annex VI Requirements - SOx

Impact of LNG fuelled propulsion

- World Energy Mix (BP Energy statistics 2011)



Shipping is consuming 3% of total world energy.
➔ 300-375 million tonnes, 250 billion US$/yr
➔ LNG-fuelled shipping will consume 1.5 times the current world LNG trade.
➔ The world LNG consumption will increases to 250%.

LNG fuelled propulsion growing

- LNG fuelled propulsion: in service




Year	Ship Name	Ship Type	Ship Owner	Location	Tank	Engine	Fuel Type	Ships	Note
2000	Glutra	Car/pass. Ferry	Fjord1	Norway	**2 x 32 m3**	Mitsubish	**LNG**	1	In use
2003	Viking Energy	Offshore Supply	Eidesvik	Norway sea	**1 x 234 m3**	Wartsila	**LNG (DF)**	1	
2003	Stril Pioneer	Offshore Supply	Simon Mokster	Norway sea	**1 x 234 m3**	Wartsila	**LNG (DF)**	1	
2006	Bergens fjord	Car/pass. Ferry	Fjord1	Norway	**2 x 123 m3**	Rolls-Royce	**LNG**	1	
2007	Fana fjord	Car/pass. Ferry	Fjord1	Norway	**2 x 123 m3**	Rolls-Royce	**LNG**	1	
2007	Raune fjord	Car/pass. Ferry	Fjord1	Norway	**2 x 123 m3**	Rolls-Royce	**LNG**	1	
2007	Stavanger fjord	Car/pass. Ferry	Fjord1	Norway	**2 x 123 m3**	Rolls-Royce	**LNG**	1	
2007	Mastra fjord	Car/pass. Ferry	Fjord1	Norway	**2 x 123 m3**	Rolls-Royce	**LNG**	1	
2008	Viking Queen	Offshore Supply	Eidesvik	Norway sea	**2 x 234 m3**	Wartsila	**LNG (DF)**	1	
2008	Viking Lady	Offshore Supply	Eidesvik	Norway sea	**2 x 234 m3**	Wartsila	**LNG (DF)**	1	
2009	Tidekongen	Pass. Ferry	Tide	France	**1 x 29 m3**	Mitsubish	**LNG**	2	
2009	Barentshav	Military Vessel	Norwegian Coast Guard	Norway	**1 x 234 m3**	Mitsubish	**LNG**	2	Under Building
2009	-	RO-RO	Sea Cargo AS	Norway	**2 x 216 m3**	Rolls-Royce	**LNG**	2	
2010	Molde fjord	Car/pass. Ferry	Fjord1	Poland	**1 x 125 m3**	Mitsubish	**LNG**	4	
-	-	Offshore Supply	-	Norway	**1 x 210 m3**	Mitsubish	**LNG**	1	

Thank you!