

Compare LNG development options

FLAME Gas and LNG

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Introduction

- This presentation will contain
 - Description of the development options for stranded gas as LNG for export on a generic concept level,
 - Comparison on operational, development cost and time, and project execution aspects.
 - The location of this project could be West Africa, East Africa, Asia Pacific with similar development concept (Apart from offshore and seastate conditions)

Context of this presentation

- The project we talk about could be in a region either West Africa, East Africa or Asia Pacific. consisting of significant gas accumulations, with 2C resources of approx. 2500 to 3000 BCF located offshore.
- Purpose is to monetise the offshore gas through LNG production/ export of about 1.8 to 2.4 MTPA capacity,
- The field is about 250 to 300 km from shore.

Offshore part

- Subsea wells, subsea flowlines
- Control tower (Only in case of onshore LNG or Nearshore LNG)
- Pipeline (Only for Onshore LNG or Nearshore LNG)
- Compression platform (Optional for increased recovery)

Map of development



FLNG description of main considerations

- FLNG in fact means a “compact” offshore Gas Pre-treatment and Liquefaction facility on a floater, with LNG/ NGL storage. LNG is produced when gas would otherwise be stranded.
- FLNG is mostly considered when distance to shore is too large or when an onshore LNG plant would be not preferred due to site/ location aspects or due to complex pipeline routing or lengthy permit process,
- An FLNG based project endeavours to keep all functions offshore, this includes Wells , subsea system + Gas Pre-treatment, Liquefaction on floating facility, and offloading to LNG tankers , all in one location,
- However FLNG could be complex due to many functions combined on one large facility. The capacity is often limited to about 0.5 to 5.5 MTPA.



Source world press

Recent FLNG projects and how does the subject project fit

Project	Mtpa (nr of trains)	FID	Start-up/ first gas	Field/ Location	Operator	Contractor
Caribbean FLNG	0.5		2016	TBA	Exmar	Exmar/ Wison/B&V
PFLNG Satu	1.2 (Precooled-N2 Tech.)	End 2013	Nov 2016	Kanowit Field, Sarawak, Malaysia	Petronas	Technip/ DSME
PFLNG2, note 2)	1.5 (N2 TBC)		2020	Rotan Field, Sabah, Malaysia	Petronas	JGC/ Samsung
Fortuna, Gandria note 1)	2.2 (4 x 0.55), SMR Tech.	Half 2018	2021	Equatorial Guinea	Ophir Energy	Golar/ Keppel/B&V
FLNG Hilli Episeyo, note 3)	2.4 (4 x 0.6), but initial production 1.2MTA (SMR)	Nov 2015	April 2018	Sanaga & Ebomé Cameroon, near Kribi	SNH/ Perenco	Golar/ Keppel/B&V
Prelude	3.6 + Condensate + LPG; (DMR)	May 2011	Mid 2018	Timor Sea, Australia	Shell	Technip/ Samsung

- 1) Final Invest Decision expected in 2018, while construction started, start up estimated 2021 (Info from Offshore energy today paper)
- 2) Expected to be operational in 2020 (according publication March 2017 by Reuters)
- 3) Completion / Acceptance tests April 2018

Source: Various publications and FLNG report Oxford Institute for Energy st. Nov 2016, Paper OIES-NG107, by B.Songhurst

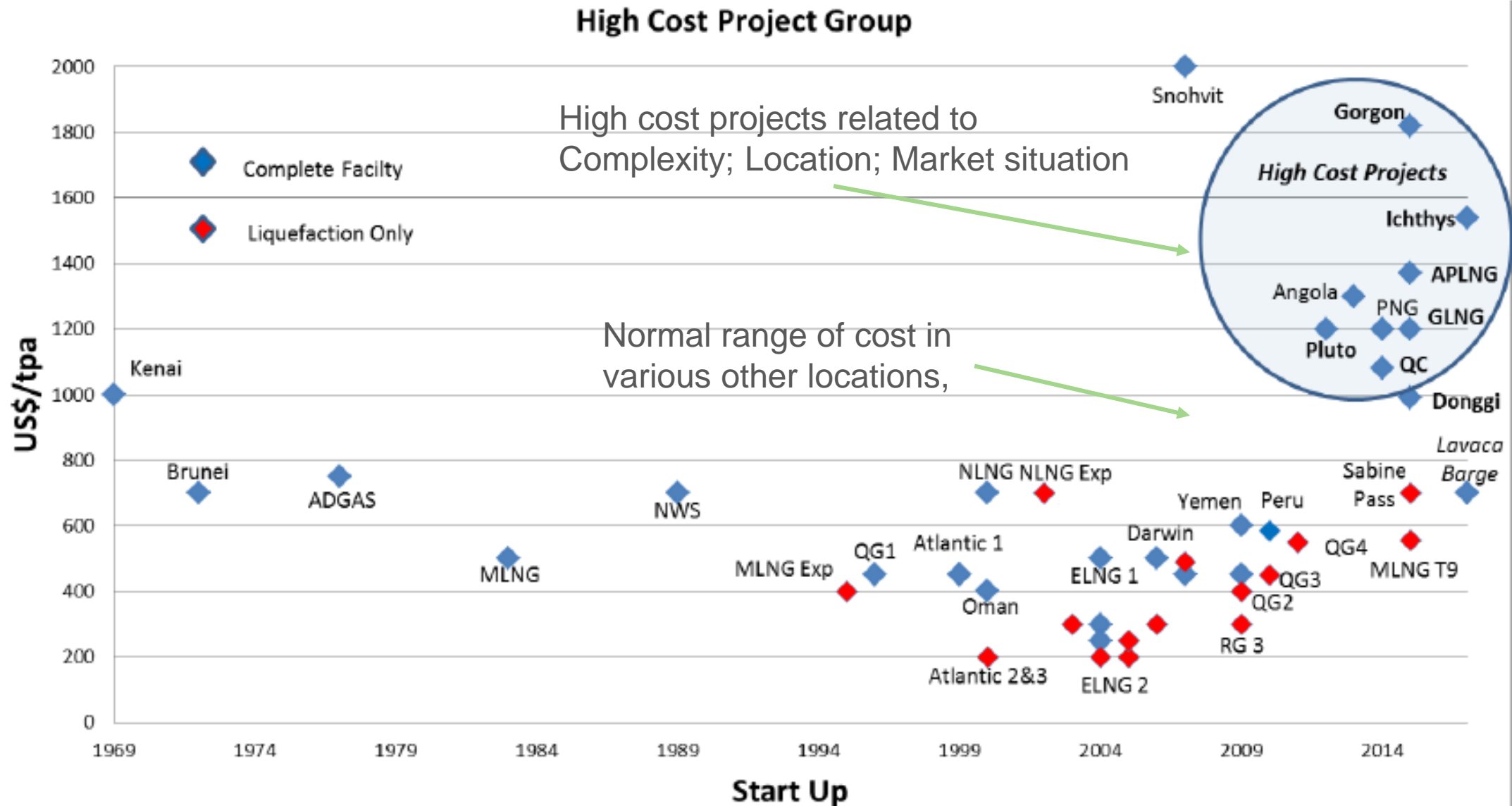


Onshore LNG Plant Description of Main Considerations

- The onshore LNG plant is less restricted in terms of space and capacity, however significant infrastructure is needed, Provided the land is stable and flat the civil works are manageable,
- If the gas field is offshore, need a pipeline route/ landing, and a sufficient deep route for LNG tankers to approach, which could require dredging depending on the type of coast, and inshore situation,
- Jetty to load LNG / LPG / Condensate on tankers,
- Onshore LNG could have 1, or more trains of each 2 to 8 MTPA, i.e. a wide range of capacities can be build-up,

Onshore LNG project Capex info

Figure 1: Metric cost for recent and ongoing LNG projects (Songhurst, 2015)



Few onshore LNG projects ongoing (Not exhaustive list)

Project	Mtpa (nr of trains)	FID/ EPC	Start-up/ first gas	Field/ Location	Operator/ Contrac-tor	Scope
PNG-LNG	2 trains in phase 1, 7.9 MTPA, Additional trains are planned in cooperation between Exxon/ Total.	End 2009,	April 2014	Field at South and Western Highlands. Of PNG,	Exxon	3 GasFields development at Highlands, pipeline , of 417km offshore and 265km onshore LNG plant near NapaNapa, Pt. Moresby.
IchtyS-LNG	2 trains, 8.9 MTPA + 1.6 MTA LPG + 100,000 bpd Cond.	Jan. 2012	Q2 2018	Browse Basin, West Australia	Inpex	CPF, Offshore FPSO for process and storage of condensate , 890 km pipeline, 2 LNG trains near Darwin.
Sabine Pass	upto 6 trains 27 MTPA (Operated on a Tolling basis)	Authori-sation April 2012	Train 4 complete Oct.2017	USA, Cameron Parish Louisiana	Cheniere	Construct upto 6 trains, of 4.5 MTPA each, to liquefy pipeline gas from unconventional resources
Darwin LNG	1 train 3.24 MTPA, Train 2 studies (DLNG2) started,	June 2003	Feb 2006	Bayu-Undan, NT Australia,	Conoco-Phillips/ Bechtel	LNG Plant at Wickham Point, Darwin Harbour, 502km Pipeline from Bayu-Undan. Philips optimised cascade LNG process liquefaction technology.
Yemen LNG	2 trains combined capacity = 6.7 MTPA (3.35 MTPA p train),	2005	Mid 2009	Yemen,	Total / By Technip JGC, KBR	LNG plant at Balhaf, on the coast of Shabwah. Gas from the Marib-Jawf gas fields northeast of Sanaa, Tech APCI C3/MCR
Sengkang LNG project in Sulawesi	Upto 4 trains of combined total 2.0 MMt/y, Indonesia.	In devel-opment	Mid 2018 TBC	SKK Migas Wasambo field, Sulawesi, Indonesia	EWC	1 train almost complete , 3 trains to be added depending on Market / Project status etc.
Yinchuan	2-train x 0.4 = 0.8 MMt/y facility using Air Products SMR liquefaction	EPC award 2009	March 2012 start up	Yinchuan, China	Ningxia Hanas Natural Gas C/ By Technip/ Air Pr.	2 Trains of 0.4 MTPA each, takes gas from nearby fields

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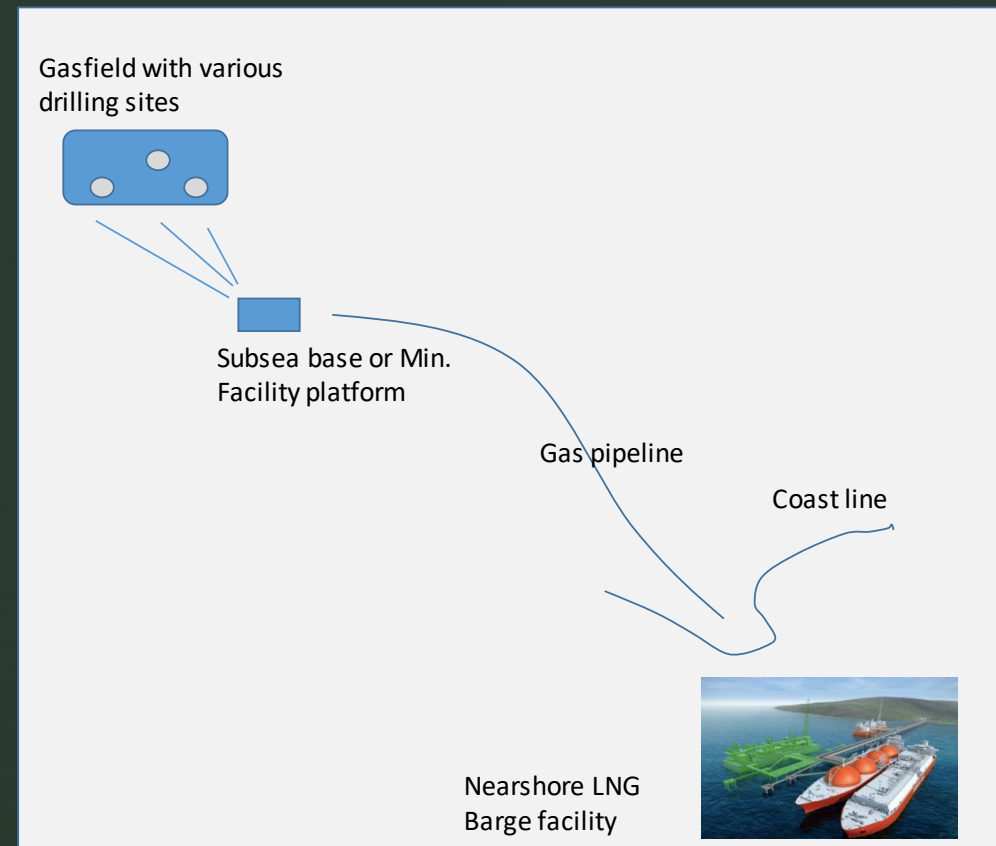
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Source: Various publications in Poten reports, Alaska Natural gas Tr. office, by LNG world news, Hydrocarbons tech. and info from the operators.

Nearshore LNG

Description of main considerations

- Nearshore is a floating LNG facility, located near shore , in sheltered area (protect from waves), with an access route for LNG tankers
- The produced fluids (gas/ liquids) still needs to be transferred from wells at the offshore field by a pipeline
- As the LNG facility is floating it could be constructed in a foreign yard (South Korea, China, Japan, Middle east) and could therefore be build very competitively,
- It can be relocated if the gas production terminates after few years for example after 5 to 10 years. This could mean to take the LNG facility on a lease,



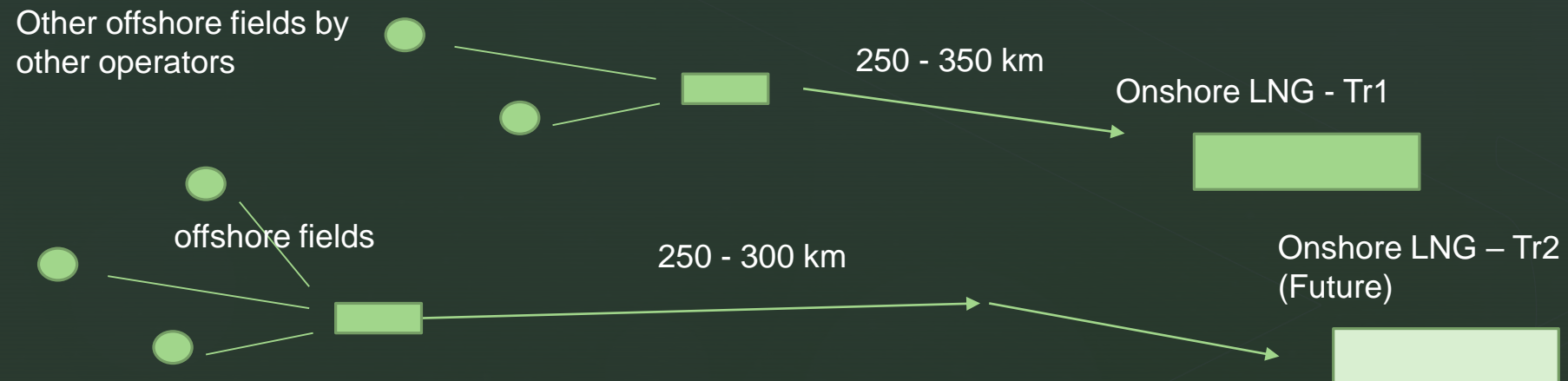
Nearshore project references

Project	Mtpa (nr of trains)	FID or EPC	Start-up/ first gas	Field/ Location	Operator/ Contractor	Scope
Pacific Rubiales, Colombia	0.5, Prico SMR		Start up postponed	Tolu, Colombia (Gas from shore)	Pacific Rubiales/ Contr. Exmar	Floating LNG, fed with gas from shore
Lavaca Bay FLNG by (LNG export from USA)	Cap. 4.4MTA , Capex: 2.4 BUSD, FLSO with 4 Prico B&V trains each 1.1 mtpa	Project cancelled in 2015.		Fed by Pipeline gas Texas Gulf coast	Excelerate Energy. / FEED complete	NA
Greater Tortue development	2.5 MTPA, nr of trains TBC.	Mid / end 2018	2021	On Maritime border of Mauretania and Senegal offshore; Yakaar and Teranga finds made by Kosmos in the Cayar Profond block	BP (Partner Kosmos) / Contr...	Offshore gas fields development feeding near shore floating LNG facility.
(Facility would be chosen dependent on manufacturer standard train sizes.)						

Source : Various publications , BP, Excelerate Pac. Rubiales, & Petroleum Economics Feb. 2018.

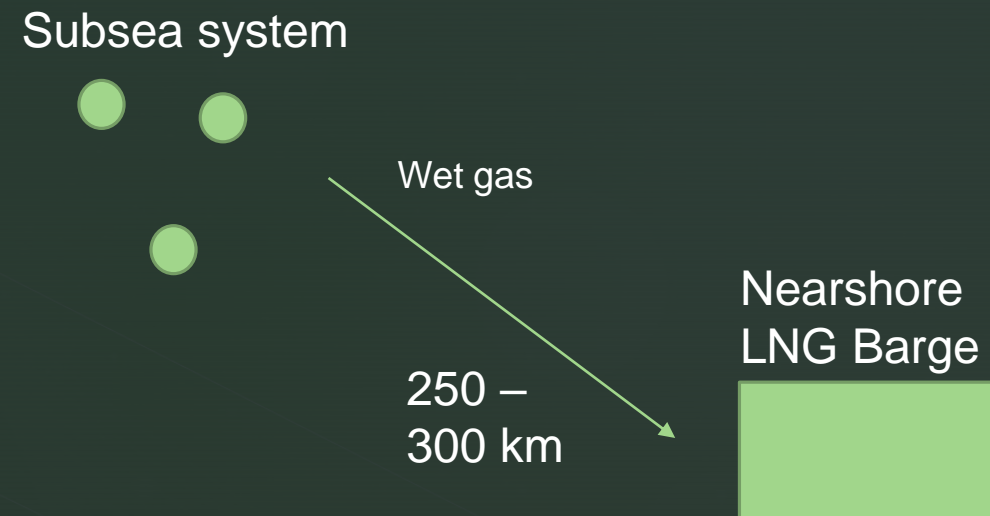
Onshore LNG – Options studied

- This project has studied several onshore options (for 1.8 to 2.4 MTA , for a resource 2500 – 3000bcf)
- Feed gas to an existing LNG system,
 - Is dependent also on other competitive gas projects in the region wanting to use the same LNG capacity (Example Darwin / Caldita Barossa, info from Santos/ LNG world news)
 - Could mean Production profile and timing has to be adapted to existing LNG train available capacity or other options (below)
- Built a new LNG train near onshore LNG plant site
 - New LNG train that would create some capacity, and would also require significant Capex to be shared with consortium, (Feasibility Study by partners + government started in April 2017)



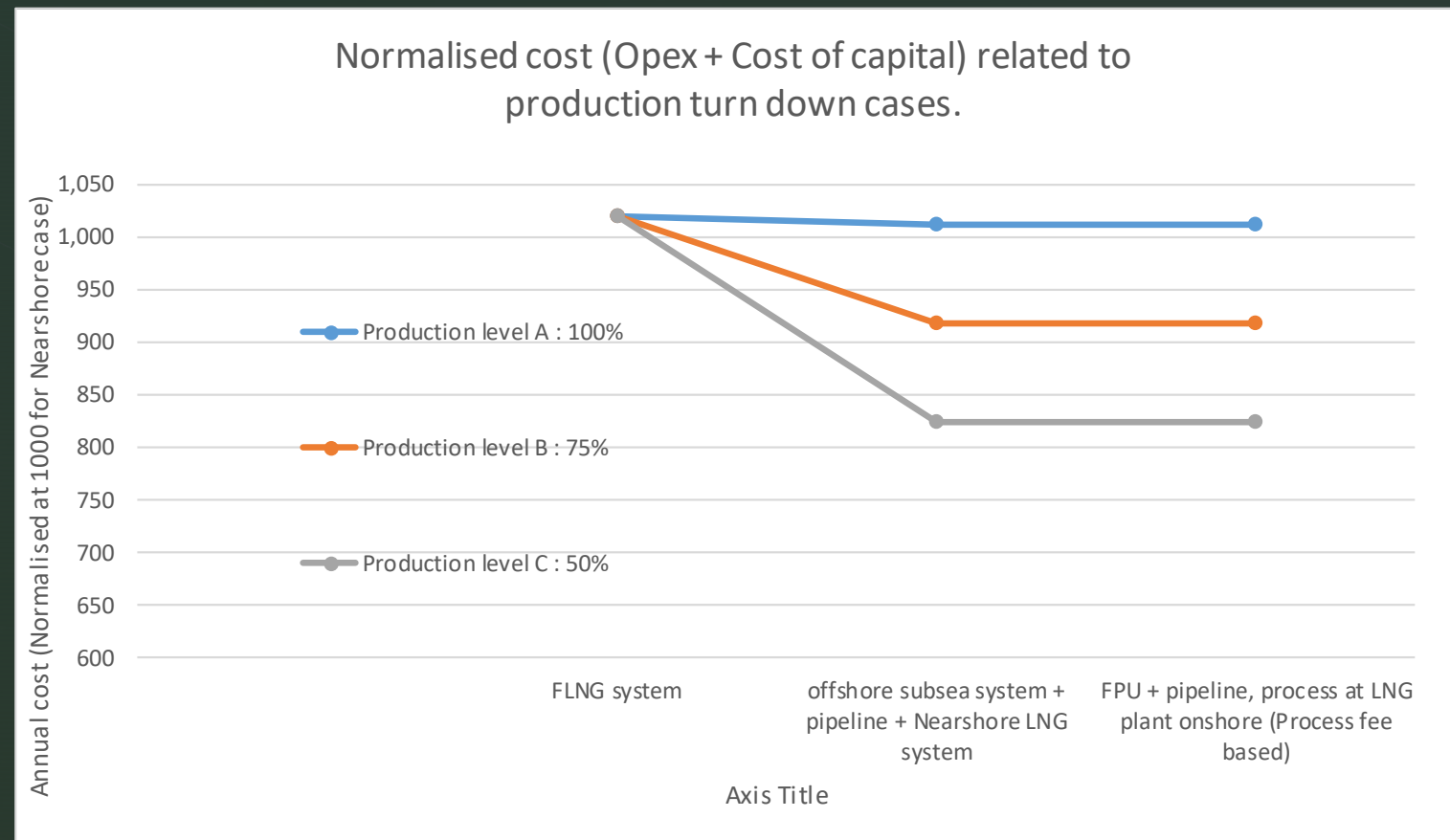
Nearshore LNG – Options studied

- Offshore wells + subsea system and wet pipe to shore, pre-treatment on Nearshore facility.
- At Nearshore Gas Pre-treatment, Liquefaction, handling of LPG and condensate , loading products to tankers LNG, LPG, Condensate
- Capacity needed 1.8 to 2.4 MTA for a resource of approx. 2500 to 3000 bcf



- Normalised cost related to production down turn,
- The liquefaction Tariff for onshore LNG has the advantage that at lower production rates, annualised cost are significantly lower,
- The nearshore case , could also contract out part of the Liquefaction capacity to other producers, which could lead to lower cost for the main producer when decline starts.

- Otherwise the annualised cost of the three options are in similar range
- Basis 2.4 MTPA annual production for all development concepts,



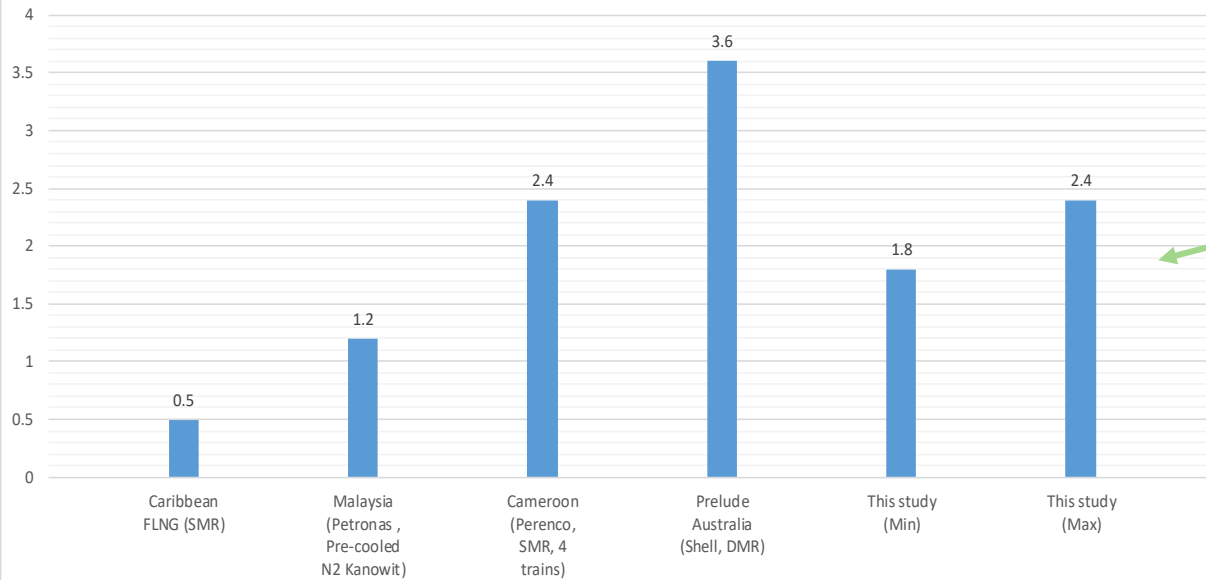
LNG production efficiency

This study in range of 1.8 to 2.4 MTPA
Likely process could be SMR or DMR

Liquefaction tech and its range

type	Capacity (per train)	Characteristics & Process cycle Eff. %	Track record	Technology provider
N2 expander	0.5 to 1.0 MTPA	Eff. approx 70% Large size equipment	Possible for FLNG	AP
SMR	0.5 to 1.0 MTPA	Approx. 80%	Possible for FLNG	Black & Veatch (Prico)
Dual SMR	0.5 – 1.0 MTPA	Approx 80%		
C3MR	> 1.0 MTPA	Approx (100%), Propane inventory is issue for FLNG	Significant nr of projects onshore, less attractive for FLNG	AP
DMR	> 1.0 MTPA	100% , very efficient and compact	Possible for FLNG	Shell & AP

Capacity (MTPA)



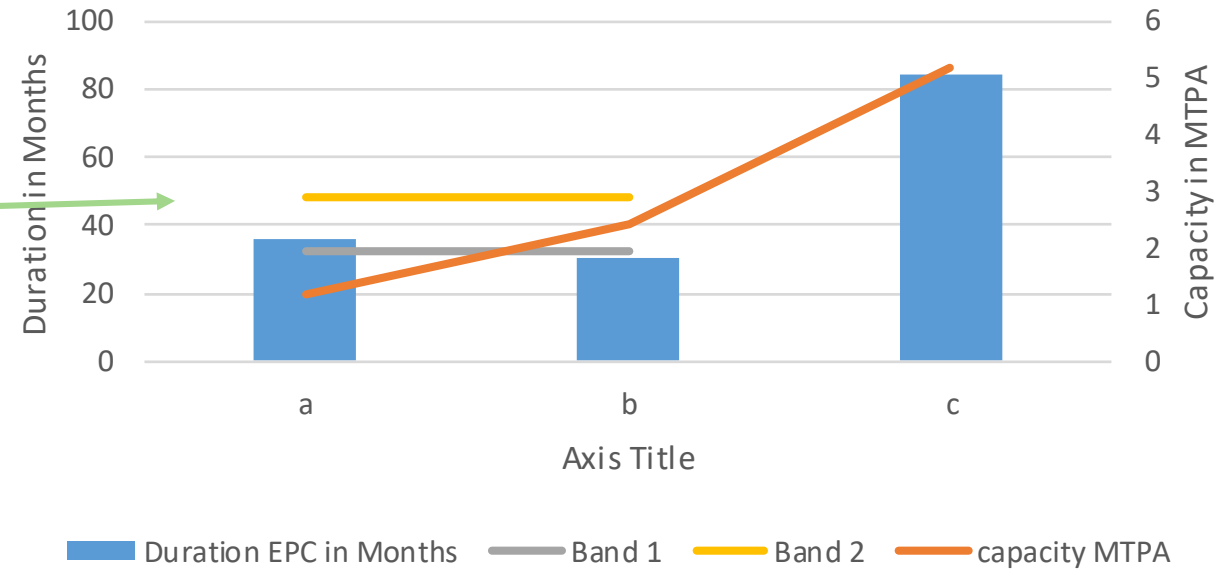
Various LNG technologies & efficiencies

- Some technologies are more compact and therefore easier to include on an offshore facility,
- There is a balance to make between technology efficiency and cost.

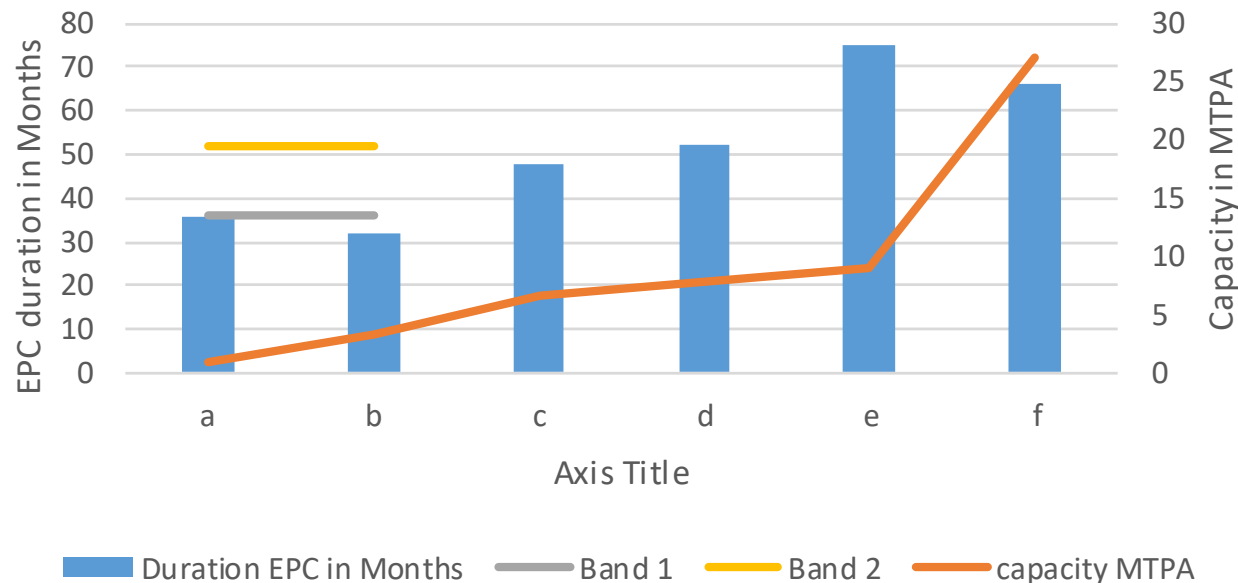
Schedule comparison FLNG and onshore LNG completed projects

Neptune nearshore project study would be in the range 36 to 48 months

EPC duration and Capacity various completed FLNG projects



EPC duration and capacity Various completed onshore LNG plants.



Schedule FLNG/ LNG Onshore

- Most medium sized (1 to 2.5 MTPA) FLNG projects complete EPC phase in 36 to 52 months,
- Most medium sized (3 to 8 MTPA) Onshore LNG complete EPC phase in some 36 to 52 months

Discussion for comparison of offshore options

Full subsea system

- Almost no travel and almost no interventions
- Wet gas transfer to shore, control slugging, other flow assurance issues

Subsea Minimum facilities platform/ Controls

- Minimum facilities platform allows control and chemicals injection to be managed,
- Minimal offshore trips/ intervention needed

(Subsea) wells + platform for Pre-treatment and compression

- Separation of liquids and water , such that slugging and other flow assurance is minimised,
- In case one gas, one liquid pipeline offshore cost would be significant.

Nearshore LNG

- Better uptime due to weather impact,
- Less technical complexity due to no turret, no risers,
- Less Barge cost due to less wave impact,
- Lower Opex due to “Walk on Board”
- Could be a Lease contract,
- Could be relocated after short production lifetime,

Discussion for comparison of development scenarios

Onshore LNG

- Known technology
- Site preparation work could be needed, permits could take time,
- Significant local content, less competitive
- Preparing tanker route could be necessary.
- Operational cost can be controlled onshore
- Uptime could be very good,
- In this case all liquefaction could possibly be done under a process fee/ tolling arrangement,

FLNG

- Advantage is that everything is together offshore, no pipeline needed, or onshore site works
- Disadvantage is the Complexity, uncertainty in development cost,
- Lower uptime, due to seastate, storms

Conclusions

FLNG option

- FLNG is complex & new/ or developing technology,
- high Capex, with some uncertainty on Cost & schedule due to technology
- It is not the preferred option for medium resource range.

Nearshore LNG

- Offers advantages in Competition/ Capex, Technical feasibility
- Opex and operations can be well managed
- The case has good potential in terms of constructability and lease opportunity/ mobility of the facility,

Onshore LNG

- Process fee or tolling basis would offer great capex advantage
- Depends on Consortium formation

appendix