

Addressing Minimalist Design for FLNG Projects

FLNG Global 2018

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Our Track Record – To Date

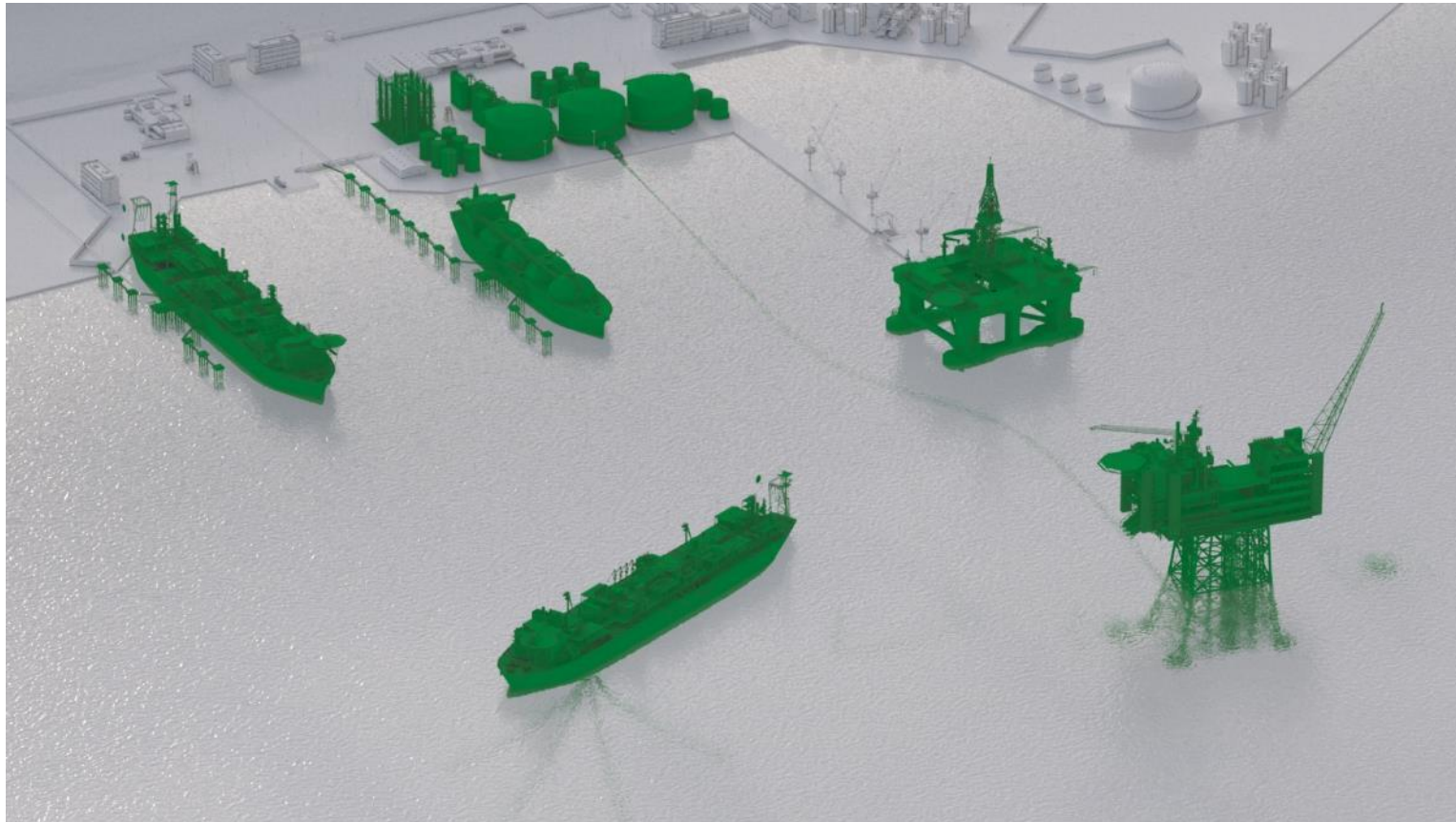
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Floating LNG

22 Developments – Floating & Gravity Based
Offshore, Nearshore & At-shore

Onshore LNG

Owners Engineers for ~26MTPA planned capacity



Offshore Oil & Gas

23 Projects
FPSO (conversion, newbuild & redployment) & Fixed Platform

FSRU & Regasification

6 Developments
Gravity based, FSRU & FRV/FRU

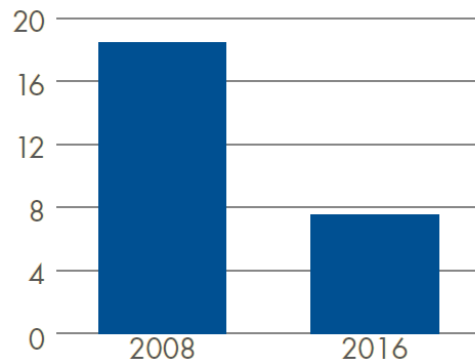
KEY TOPICS

- Why is “minimalist” design relevant?
- What are the important factors to consider
- Standardized solutions suitability
- Is “low cost” FLNG achievable?

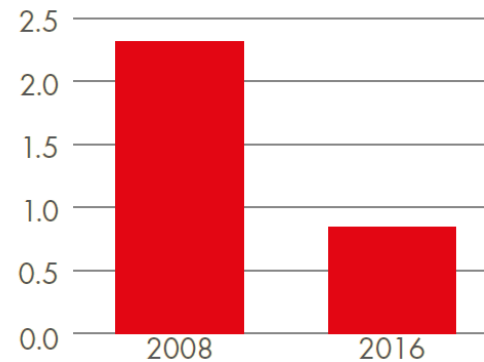
WHAT IS THE REAL DRIVER?

- Lean & Competitive Design rather than “minimalist”

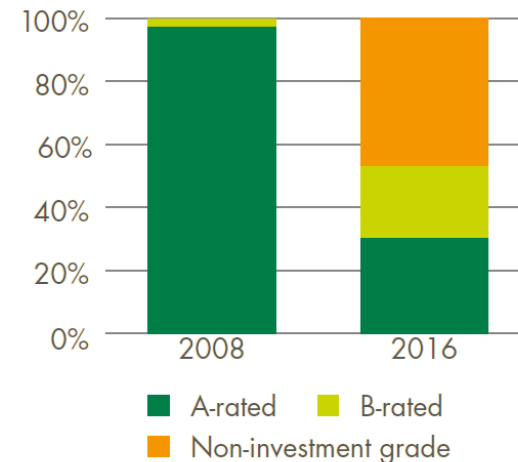
Average contract length, years



Average contract volume, MTPA



LNG buyer credit ratings



Source: Shell interpretation of IHS (Energy LNG Sales Contracts Database), Moody's and Fitch data

Shorter Contracts

Lower Volumes

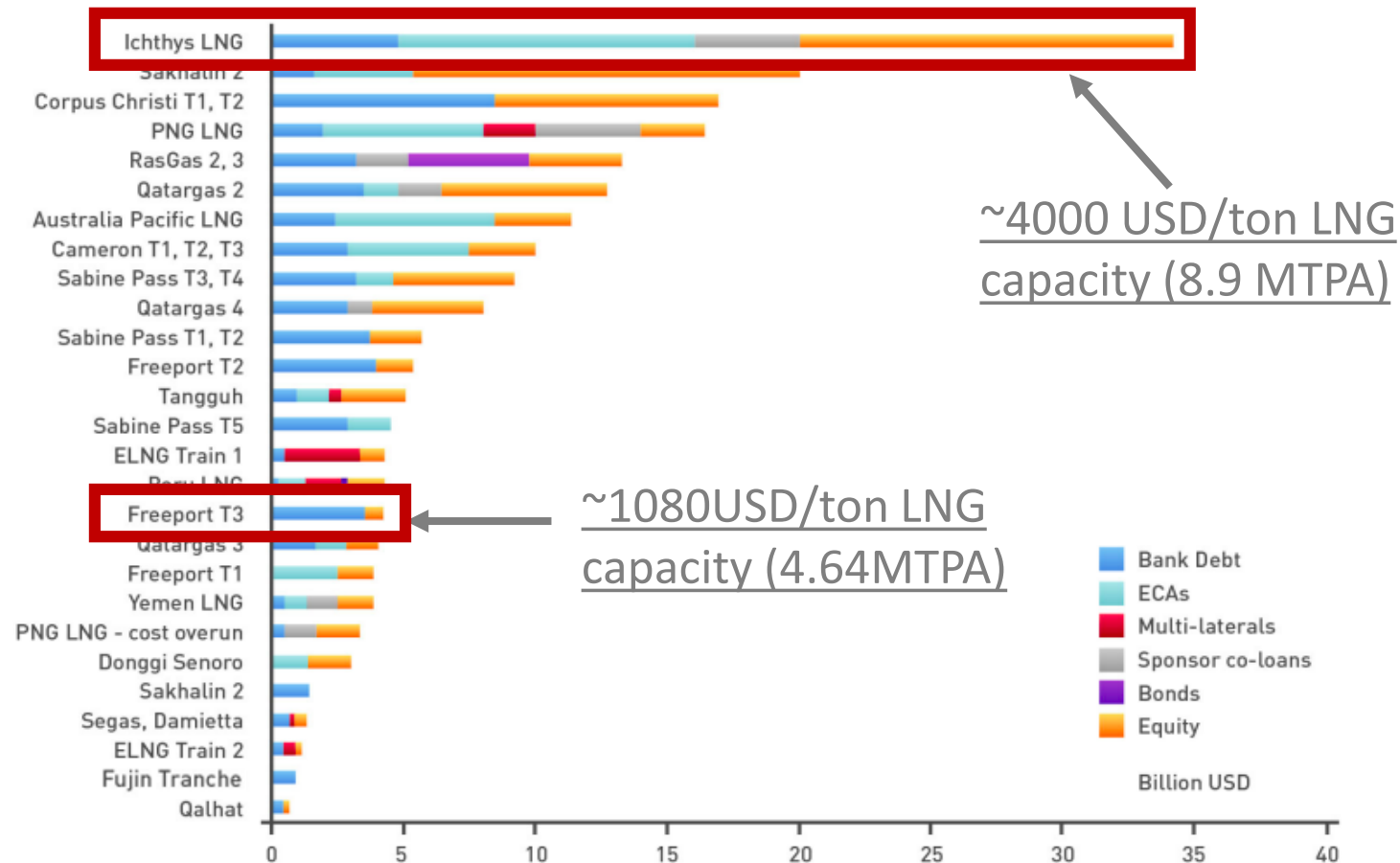
Buyers with poorer credit ratings
(and not least)...

Low LNG prices

Challenging Environment for achieving
Finance = Only Cost Effective Solutions
will be commercially attractive

Current Targets

HISTORICAL VS. CURRENT TARGETS



- Many new projects are targeting levels of 550 USD/ton LNG to 650 USD/ton LNG

FLNG Challenging Onshore LNG?

A DIFFERENT APPROACH



Image courtesy of Freeport LNG Development L.P.

VS.



Image Courtesy of Sembcorp Marine

- Under the right conditions LNG production can achieve CAPEX cost in the range of 550 USD/Ton LNG Capacity.
- Using FLNG can be an approach for bringing costs down.
- For FLNG project cost profile is dependent on;
 - Set Parameters – e.g. Location, Metocean Conditions, Gas Composition
 - Parameters that can be determined e.g. type of development, approach and design of the facility

PROJECT CHARACTERISTICS WHICH IMPACT FLNG COMPLEXITY & COST

Offshore vs. Nearshore/At-Shore

- Metocean conditions
- Feed gas source
- Interface – mooring & incoming gas

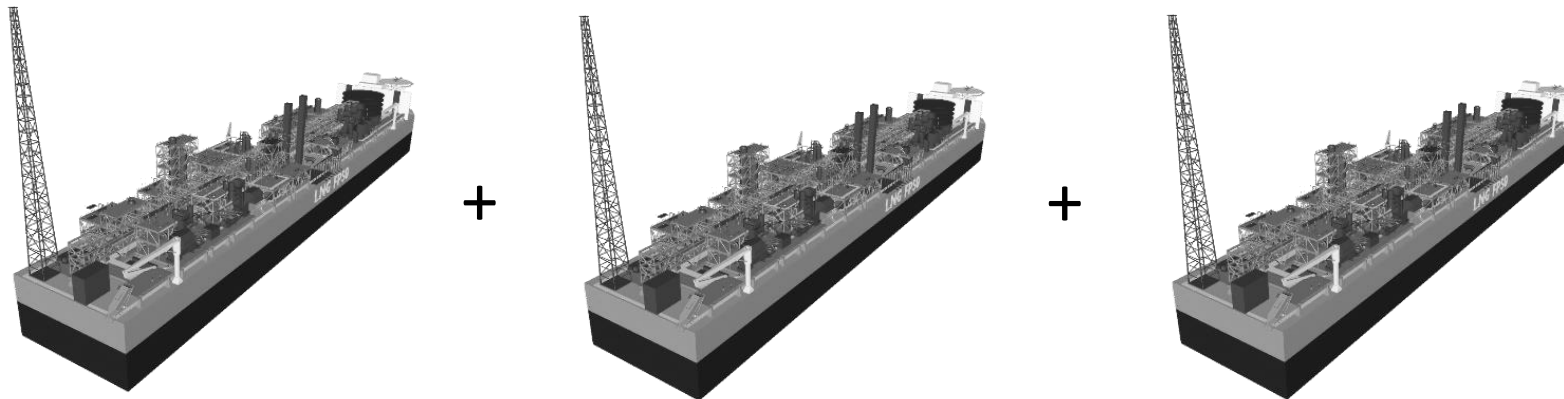
GAS CHARACTERISTICS

- High CO₂
 - Challenges with available heat
 - Threshold between 10% to 20%
- High nitrogen content
 - Special considerations above 3%
 - Above ~5% may require an NRU
- H₂S and mercaptans
 - High H₂S
 - COS and Mercaptans removal
- LPG Production
 - Impacts to safe design
 - Added complexity

PROJECT CHARACTERISTICS WHICH IMPACT COMPLEXITY & COST

Target Production

- Production Per Facility – Can be tailored to meet total required
 - Staying within finance limits
 - Staying within practical limits for construction
 - Develop in stages – enables design one, build many.



PROJECT CHARACTERISTICS WHICH IMPACT COMPLEXITY & COST

Liquefaction Technology Type

Technology	Onshore Projects (Operating >0.5MTPA LNG)	Nearshore/Offshore (Post-FID/In Execution)	Nearshore/Offshore (Operating)
Cascade Cycle	11	0	0
C3-MR	23	0	0
SMR	10	0	2*
DMR / MFC	2	2	0
N2 Cycles	0	1	1
Methane Expander Cycles	0	0	0

References based on publicly available data

- To date most FLNG developments are Mid-Scale projects (~0.5 to 3.5 MTPA LNG Production).
- Large Scale Technologies have not been applied

PROJECT CHARACTERISTICS WHICH IMPACT COMPLEXITY & COST

Selecting Liquefaction Technology Type

- Step 1 - Technology Selection Study
- Key Influence – Importance of Efficiency/Fuel Consumption
- Key Influence – floating or fixed facility

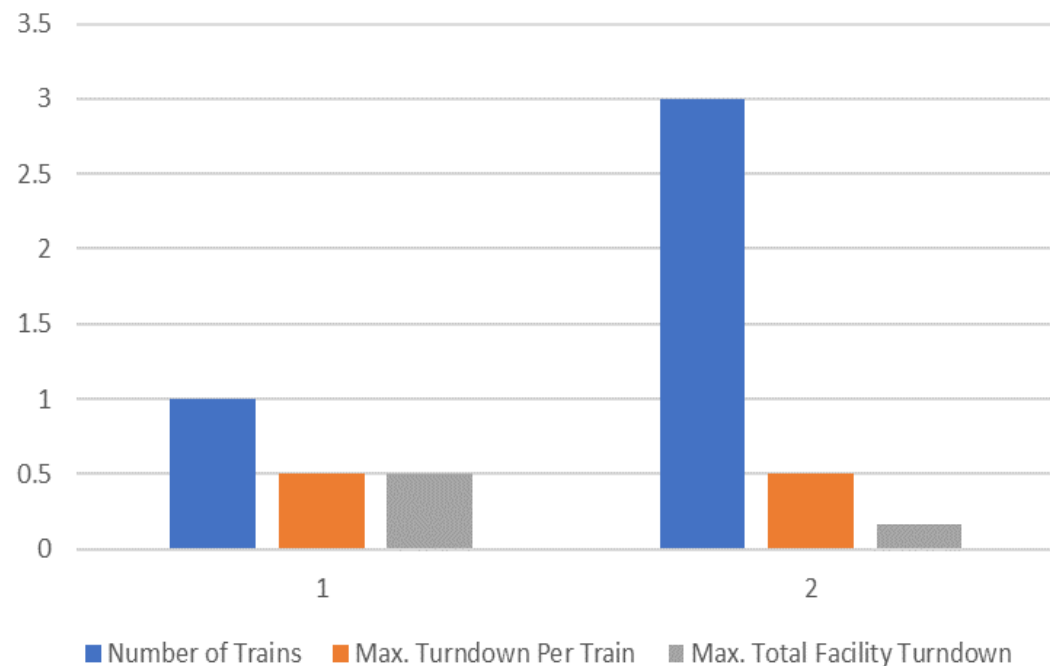
Shortlisted Technologies
DMR
SMR
N ₂ Cycles

- 
- ✓ References
 - ✓ Suitable for target production

PROJECT CHARACTERISTICS WHICH IMPACT COMPLEXITY & COST

Number of Trains & Configuration

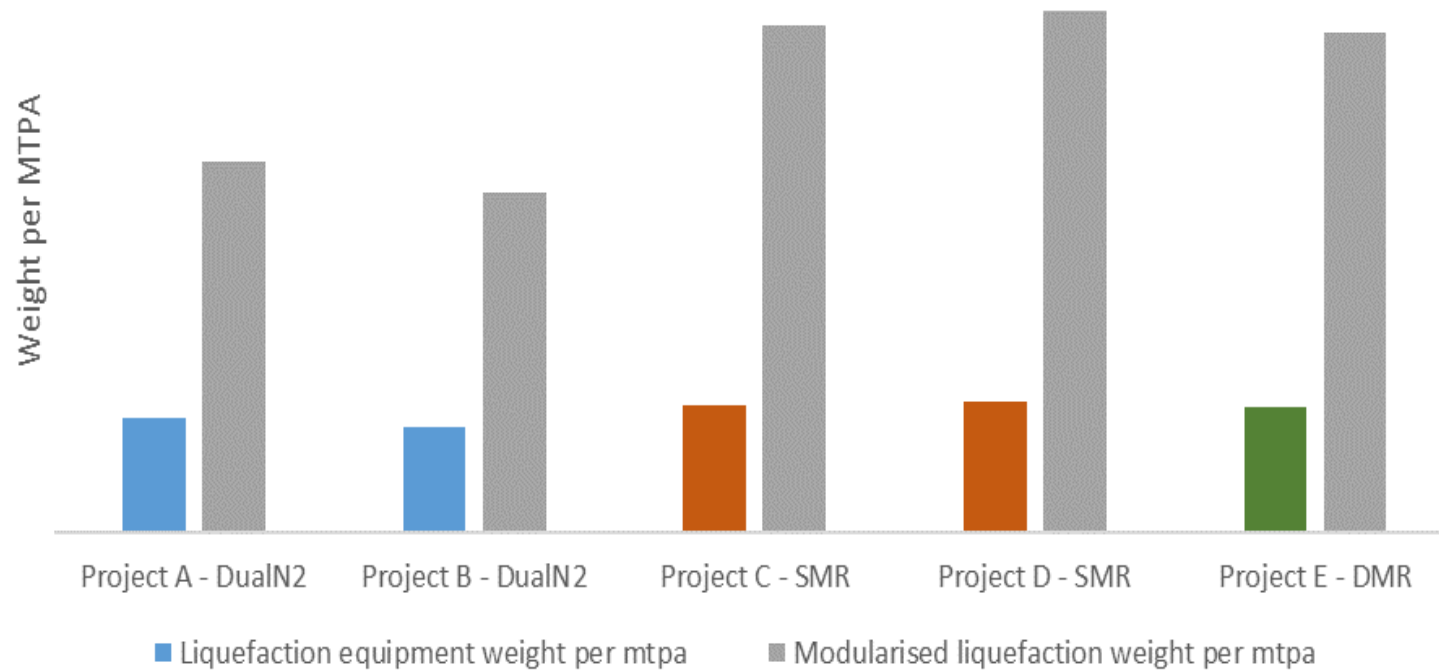
- Production Availability
 - Multiple Trains will give more production per year
 - Reduced impact of trips
- Turndown
 - Start Up
 - Flexible & stable operation
- Safety Design



PROJECT CHARACTERISTICS WHICH IMPACT COMPLEXITY & COST

Number of Trains & Configuration

- Equipment Count
 - 3 trains of SMR/N2 Cycle = 1 train DMR
- Weight & CAPEX Impacts

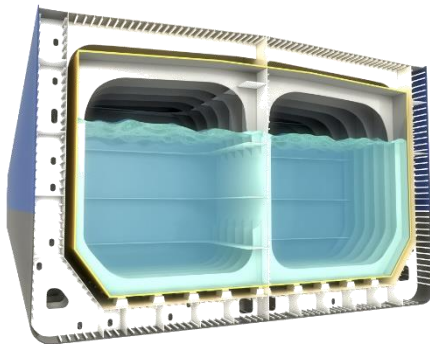


Parameters that can be Influenced

PROJECT CHARACTERISTICS WHICH IMPACT COMPLEXITY & COST

- LNG Storage

- Internal?



OR

- External?



- Floating or Gravity Based Solutions

- Vessel motions
 - Mooring Benefit
 - Avoid a breakwater
 - Shielding of LNGC by the facility
 - Jetty function in built



LIQUEFACTION ONLY?

- Liquefaction Pre-Designed Solutions are available
 - Typically Mid-Scale Solutions (1MTPA +/-0.5 MTPA)
- Technology & Equipment pre-selected
- Achievable Production is verified based on project specifics
- Design one – build many
- Pre-Treatment solutions can be possible but are not common



Example Standardised Liquefaction Solution – Aragon's Optimised ODEC Design

SUMMARY

From Aragon's Experience, the following considerations influence "low cost FLNG":

- ~3.5 MTPA or less LNG production per FLNG vessel
 - Multiple vessels are more cost effective and manageable than one single large facility
- Multiple trains of SMR or N₂ Cycle
 - When feed stock has a cost SMR cycles typically offer the best balance of improved cycle efficiency together with acceptable overall design, cost and production availability.
 - N₂ Cycles give highest LNG per m² and benefits in almost every aspect with the exception of cycle efficiency/feed shrinkage.
- Hull sizes should be defined by the required LNG storage rather than the topsides requirements and kept within standard/known sizes for shipyards.
- Nearshore / At-shore more cost effective than Offshore FLNG
- Feed gas considerations, notably LPG production, high N₂ content, and mercaptans can result in significant impacts on project economics.
 - Avoid LPG co-production if possible

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