Floating LNG:
New Challenges, New Opportunities

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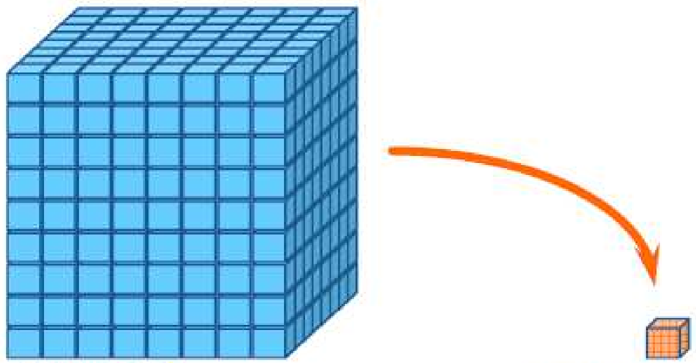
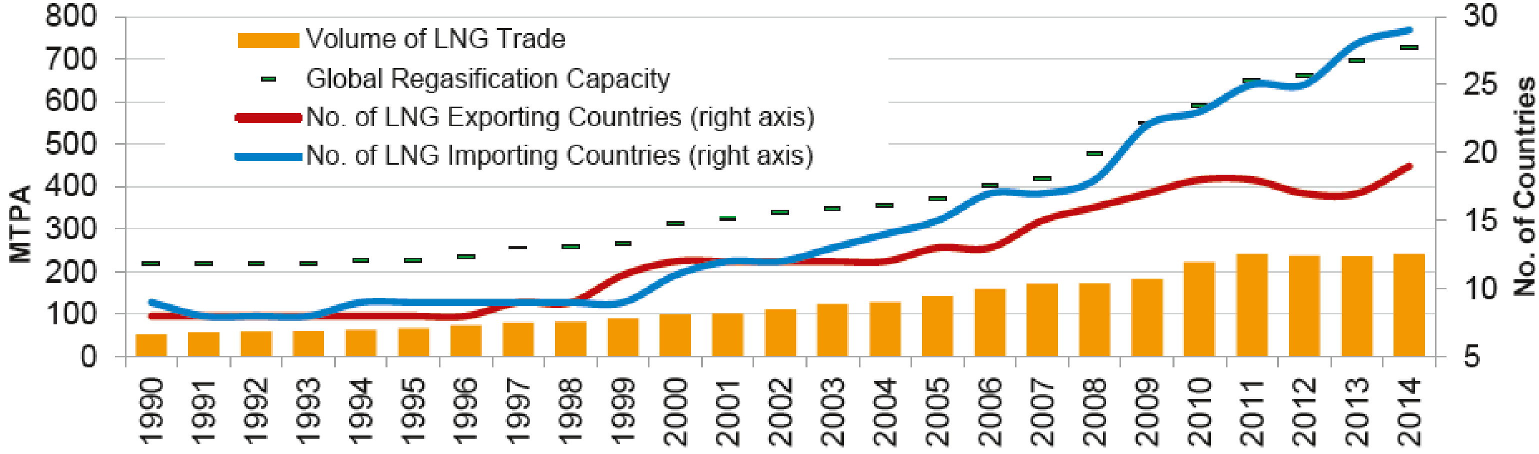
1. Introduction to LNG

- Methane (> 75%), ethane, propane, butane, …
- Boiling Point: -163 to -152 ºC (at 1 atm)
- Odorless, colorless, transparent
- Density: 0.43 to 0.47 ton/m3
- Ratio Gas/Liquid: 580

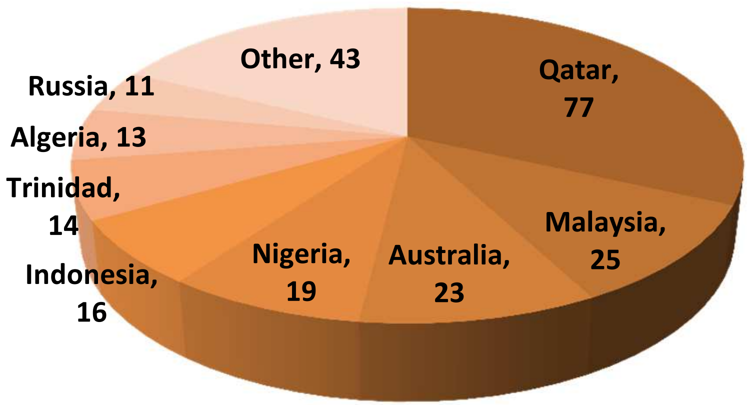


2. LNG Market Overview

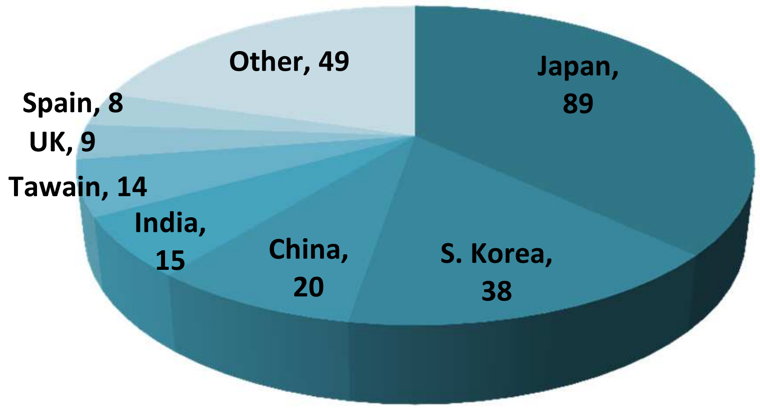
Source: IGU - World LNG Report - 2015 Edition



LNG Producers (2014) in MTPA



LNG Consumers (2014) in MTPA

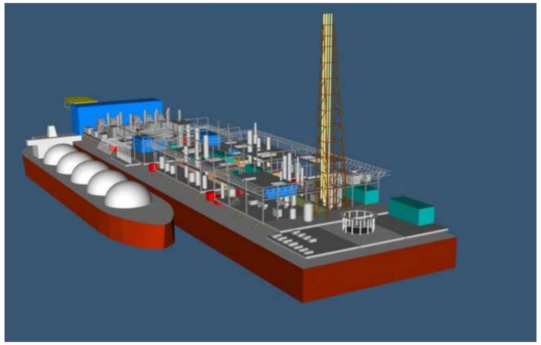


Growing Demand, Increasing Production, Developing Liquidity

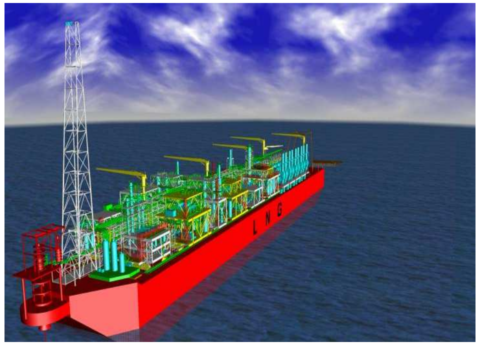
3. FLNG Concept Journey

Mobil, 1997

Chevron, 1999



Shell, 2004



1970s — Research beginning

1990s — O&G Companies Concepts

2005 — Concept development

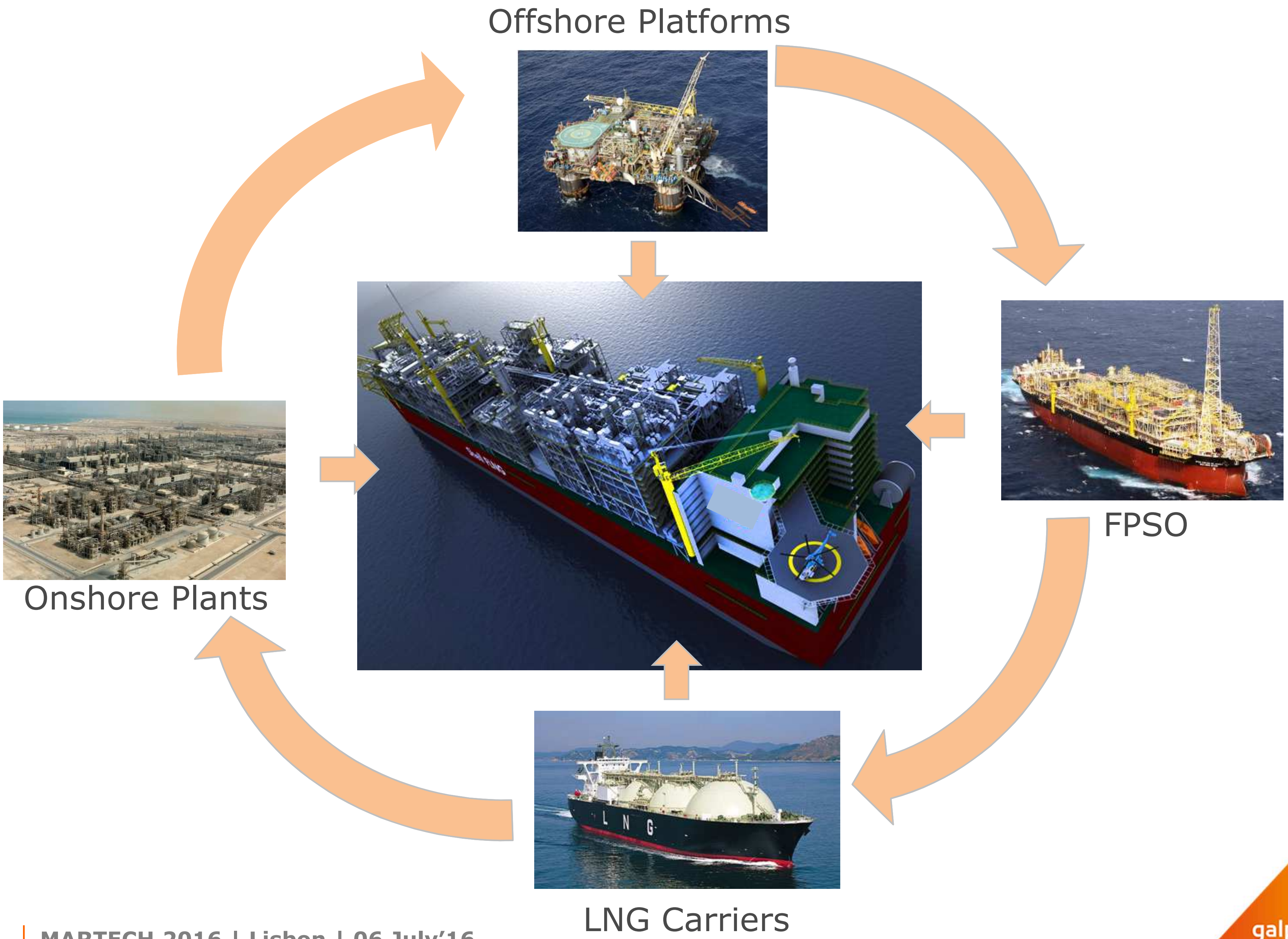
2015 — 20 projects under development

Projects under Execution

Prelude FLNG, 3.6 MTPA, Onshore Commissioning
(Shell, Australia, FID 2011, Start Up 2017)

Satu FLNG, 1.2 MTPA, Offshore Commissioning
(Petronas, Malaysia, FID 2012, Start Up 2016)

3. FLNG Concept Journey



4. Why Choose FLNG?

A. Monetize stranded reserves

B. Comply with no-flaring policies

C. Reduce environmental footprint

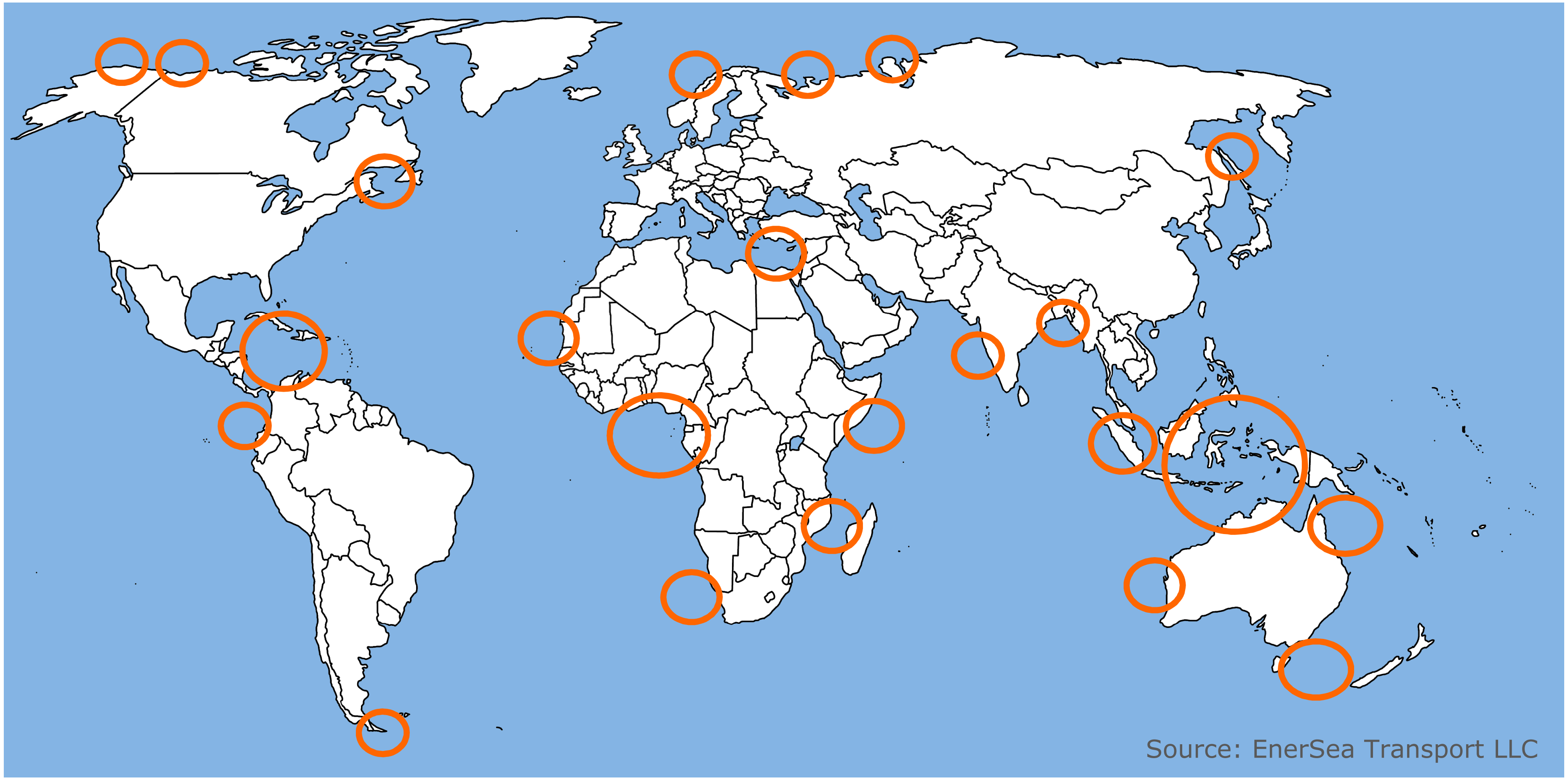
D. Avoid onshore sensitive zones (tourism and security)

E. Be closer to main consumers

F. Deliver projects cheaper and faster (potentially)

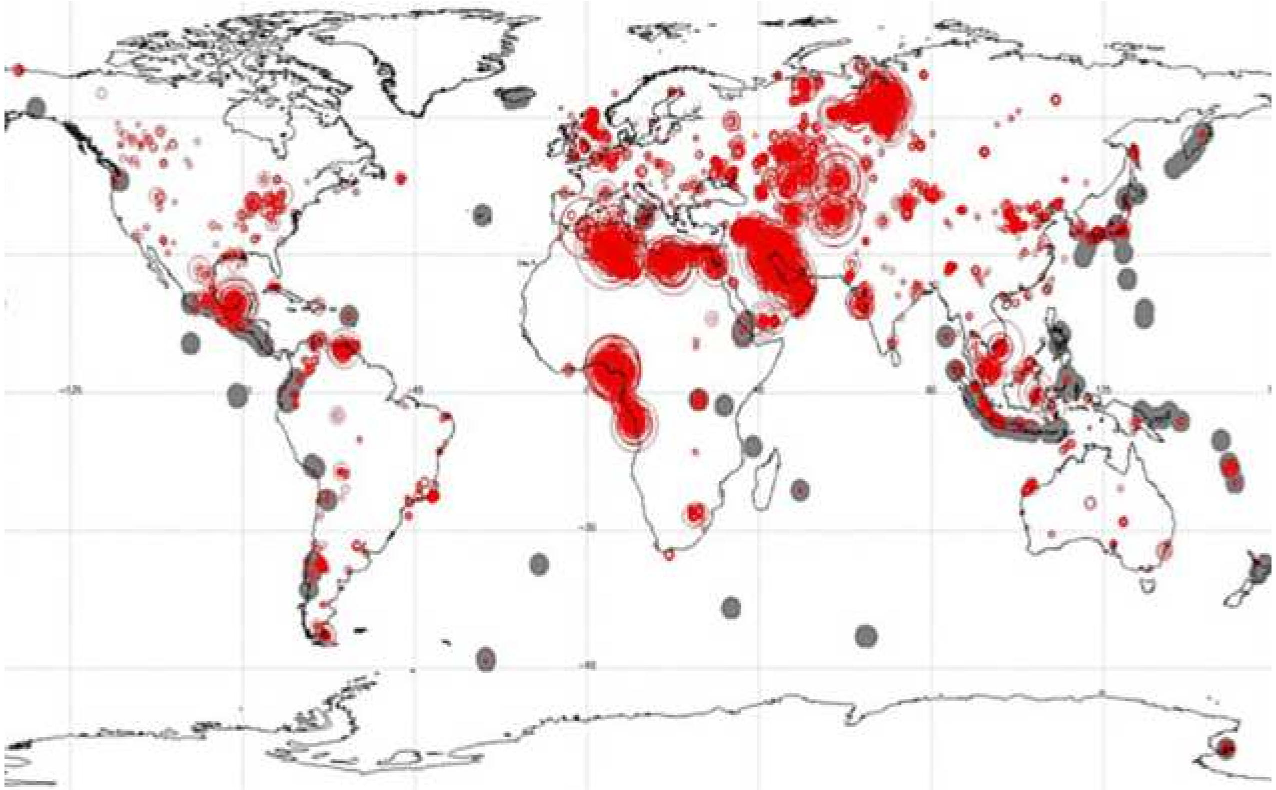
4. Why Choose FLNG? | Monetize stranded reserves

Too far offshore for pipeline construction and too small for onshore LNG Development



- Over 6.000 Tcf stranded gas reserves worldwide
- 900 Tcf (40 years US consumption) in offshore gas fields

4. Why Choose FLNG? | Comply with no-flaring policies



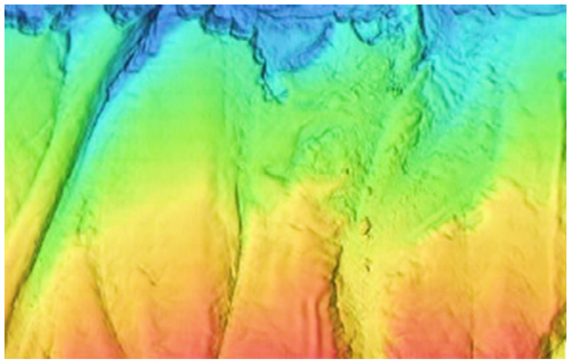
Source: World Bank Group, 2013

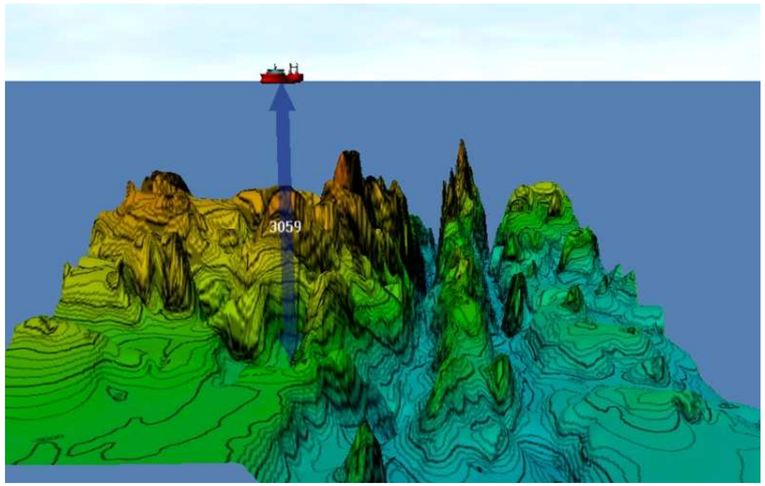
- 5.3 Tcf of natural gas are being flared and vented annually (25% US or 30% EU gas consumption)

- 1.4 Tcf of gas flared in Africa, equivalent to 50% of continent's power consumption

4. Why Choose FLNG? | Reduce environmental footprint

- Does not require long seabed pipelines and dredging for jetties
- Avoids fuel for compression to send gas to shore
- After decommissioning, potential to be easily removed (and re-deployed)





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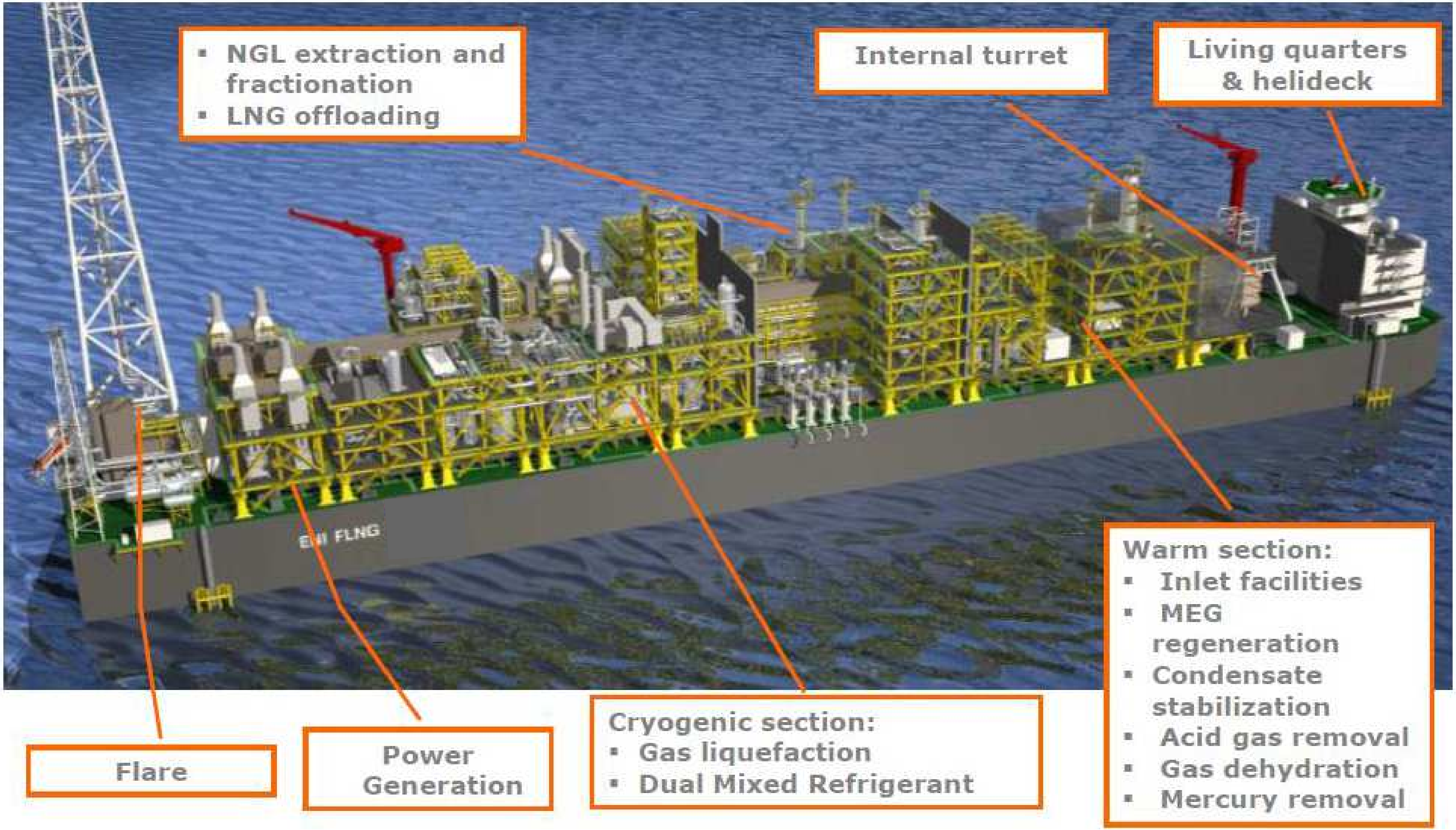
5. FLNG Overall Presentation



Source: ENI, 2014

6. Main Technical Challenges

A. Vessel motion impact on equipment performance

B. Sloshing phenomena inside LNG tanks

C. LNG offloading system

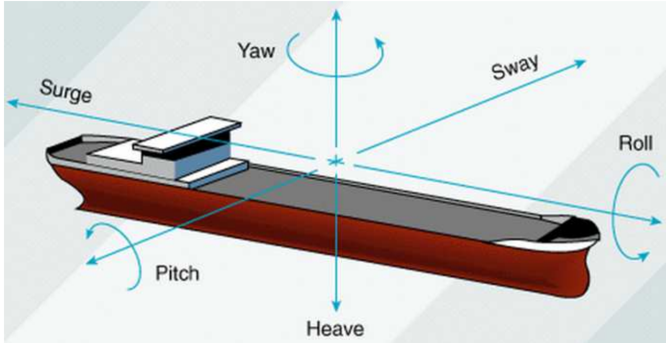
D. Compatibility with LNG Carriers

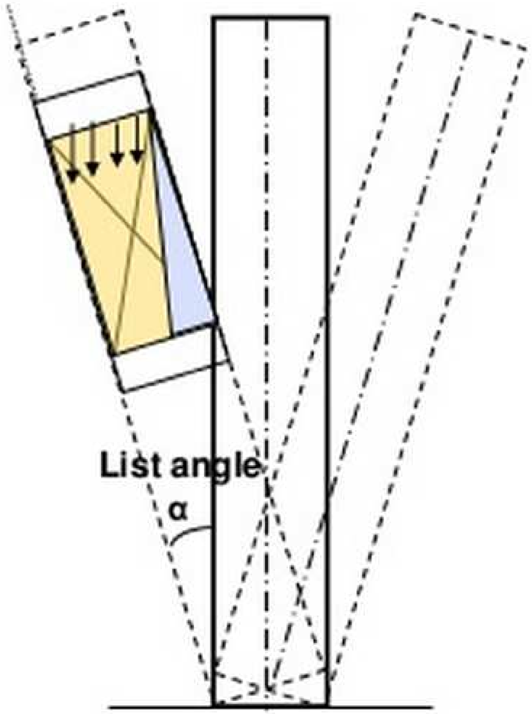
E. Marine operations

F. Design for offshore conditions

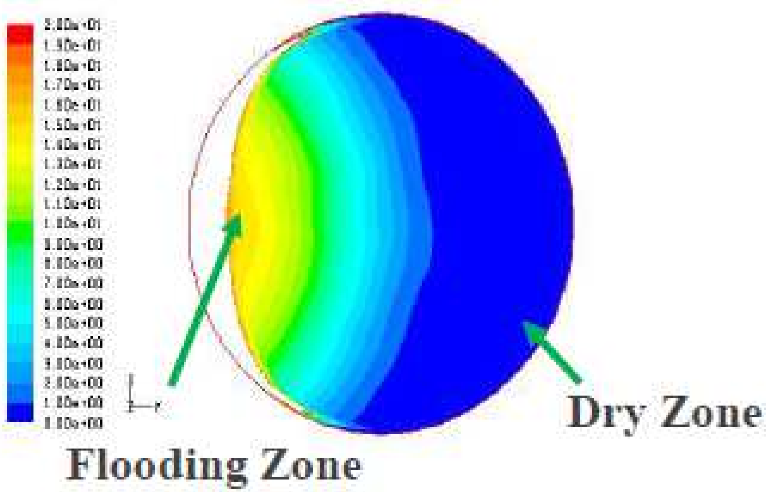
6. Main Technical Challenges | Vessel motion impact

- Ship movements can impact on critical equipment performance
- Pre-treatment columns are the most susceptible ones
- Critical items designed and located to minimize impact on LNG production





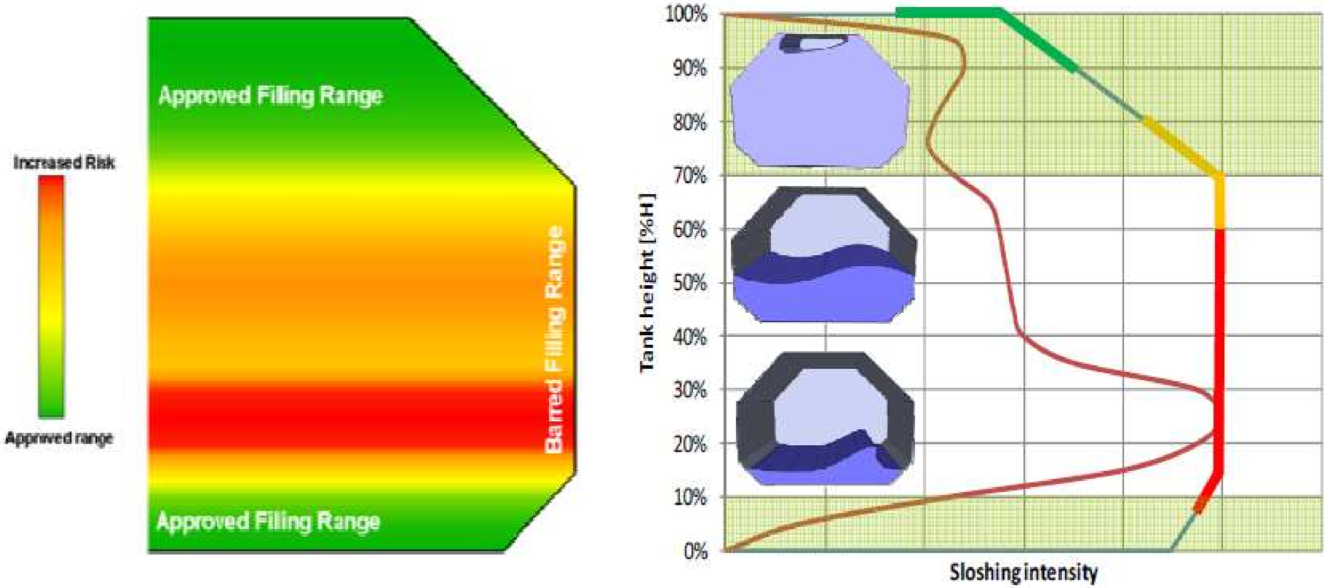
Source: UOP / Raschig Marinization Study, 2015



6. Main Technical Challenges | Sloshing phenomena

- Occur when the ship motions coincide with the natural frequency of the liquid motion inside the LNG tanks (when partially filled).

- May result in collapse of the tanks wall due to an overpressure, hull vibration effects, etc.



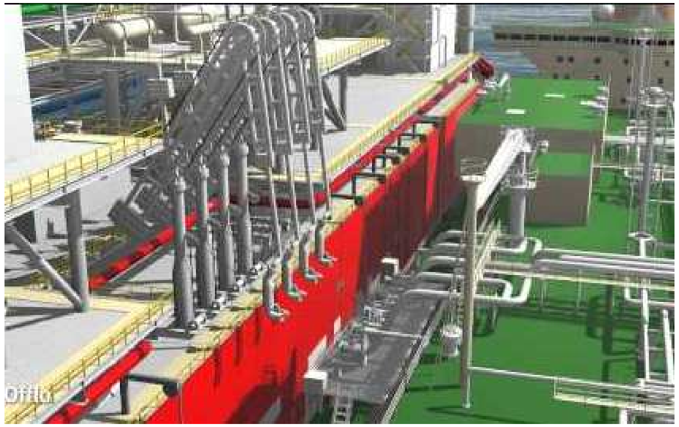
Source: FLNG 2014, GTT, June 2014

- Small-scale tests, double row arrangement to minimize sloshing, etc

6. Main Technical Challenges | LNG offloading system

- Technologies are not field proven for LNG services and offshore environment (ship to ship transfer)
- Difficulty to find flexible materials at -160ºC
- Uncertainties related to system performance under harsher conditions (reliability and availability)
- One of the main showstoppers to higher capacity FLNGs

Side-by-side rigid arms



Tandem aerial hoses

7. Future Developments | Higher capacity FLNG

Shell's Lean Gas Concept

- Solution for dry gas fields
- Lower unit technical cost

Standard FLNG Design

(3.6 MTPA)

Lean Gas FLNG Design

(6 – 8 MTPA)

7. Future Developments | Alternative Designs

LNG Carriers Conversion

Source: Golar LNG, 2015

- Lower capital cost, quicker delivery
- Liquefaction of pipeline quality gas, requiring minimal processing
- Small-scale FLNG (up to 1.5 MTPA)

Cylindrical FLNG

Source: Sevan Marine, 2013

- Reduce stresses due to global loads on the hull
- Favourable motions compared to ship-shaped units
- Suitable for harsher metoceam conditions

Thank You!

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E&P Projects
Engineering and Project Management Office

FLNG in Numbers




	FLNG	**Kizomba A (largest FPSO)**	**Harmony of Seas (largest cruise ship)**	**USS Nimitz (largest warship)**
Length (m)	400 – 450	285	362	333
Wide (m)	65 – 70	63	66	77
Height (m)	40 – 50	32	70	50
Weight (k ton)	200 – 250 (dry)	81	227	100

FLNG: 2.5 – 3.5 MTPA

- Inlet Gas: ~600 MMSCFD
- LNG Production: ~450 ton/h
- LNG Storage: 200k – 240k m3
- Installed Power: 250 - 300 MW
- Fuel Gas Consumption: ~50 ton/h
- PoB (under operation): 150 - 170