IENE International Workshop

Athens, 4-5 July 2017

"Energy Security in SE Europe and the role of LNG"

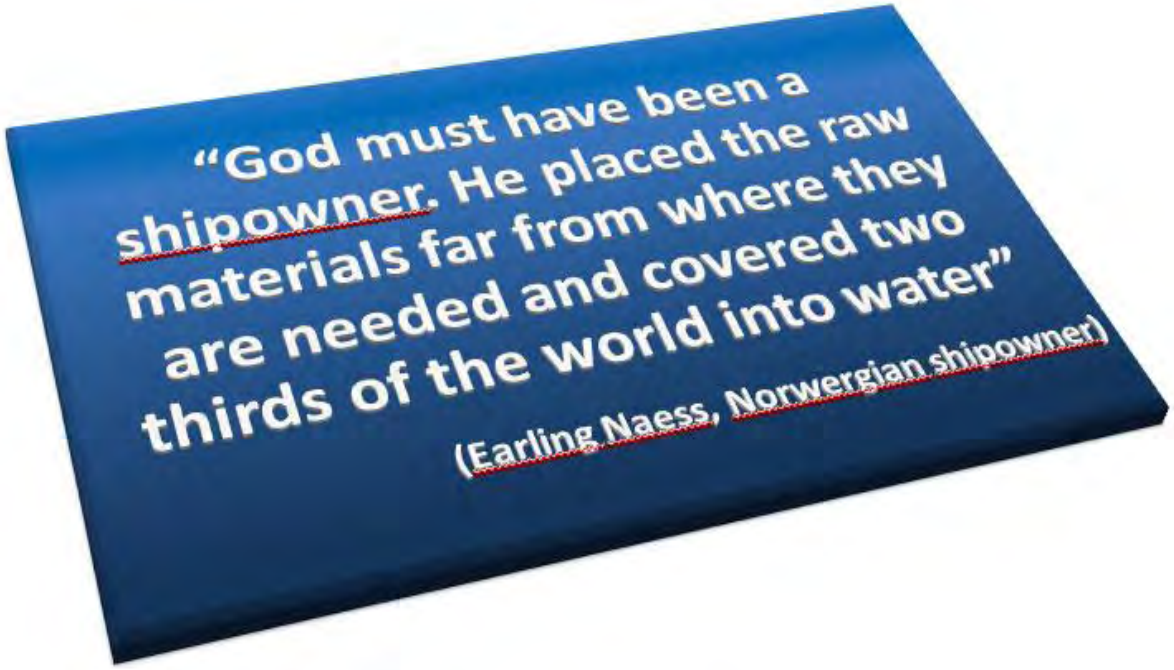
LNG
PRODUCTION & TRANSPORTATION TECHNOLOGIES

Panos Yannoulis, President, Oceanking Technical & Trading S.A.

OCEANKING TECHNICAL & TRADING SA

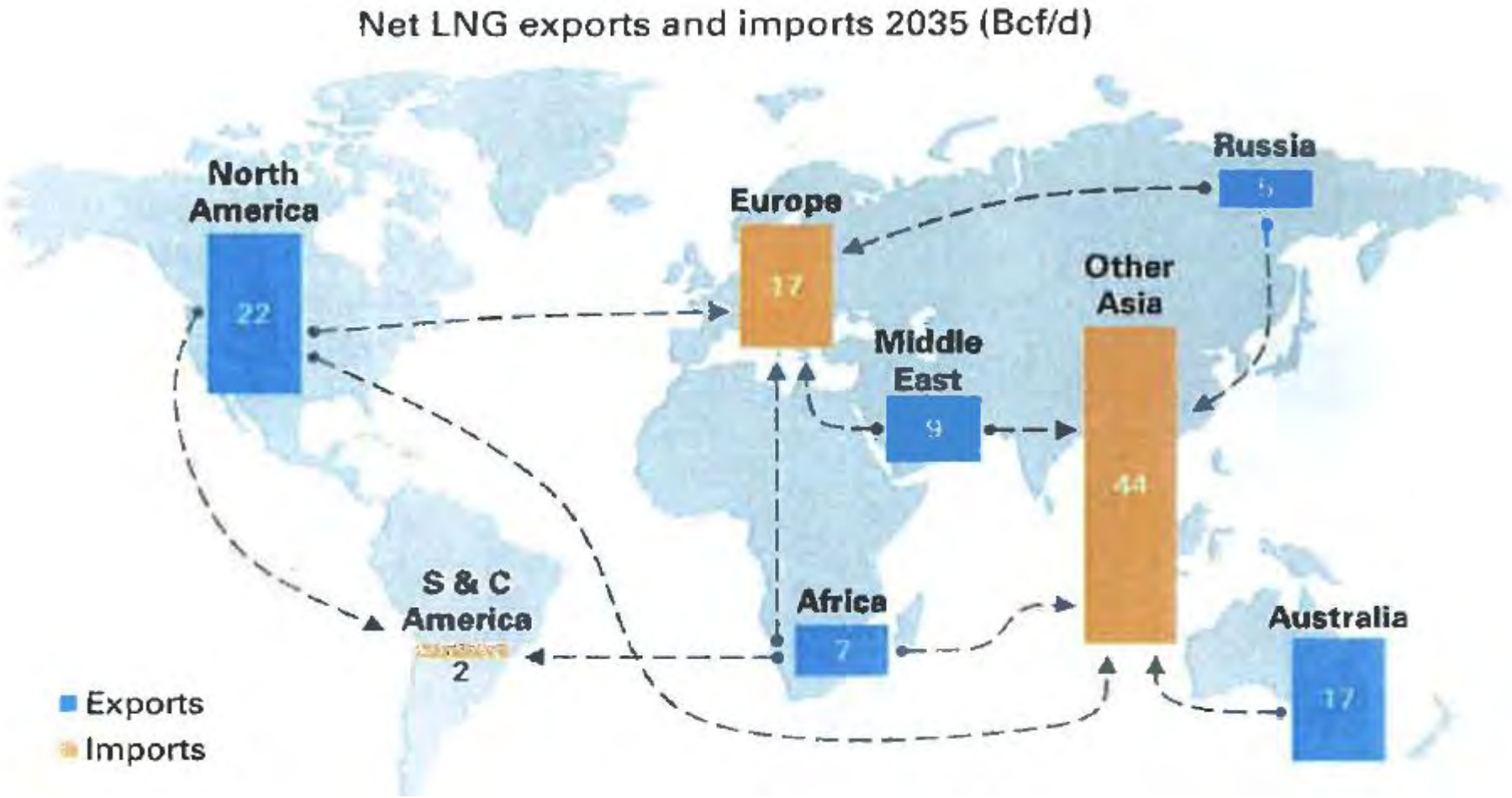
Main technology strategic options for natural gas transportation from well to land utilities:

LIQUEFACTION vs GAS PIPING



Main factors making LNG attractive compared to long land or underwater piping:

- **Distance between production & customers**
- **Most of Natural Gas reserves are offshore Approach of specialized vessels effective**
- **Shipping is the most competitive transportation mean, in terms of cost per ton-mile.**


Net LNG exports and imports 2035 (Bcf/d)
North America
22
Europe
17
Russia
5
Other Asia
44
Middle East
9
S & C America
2
Africa
7
Australia
17
Exports
Imports

BP p.l.c. 2017

Technologies for:

- **Offshore floating LNG Terminals,**
- **LNG Production / Liquefaction / FLNGs,**
- **LNG Regasification Units / FSRUs**

are mature

WHY OFFSHORE TERMINALS?

Advantages compared to land based:

- Access to larger ships / deeper draft
- No traffic concerns / port authority restrictions
- Offshore within territorial waters
- Security implementation easier due to isolation
- Governmental & Local community approval easier
- Comparable cost
- Easy access by the trading LNG ships – no jetties required
- Facilitates changing location as & when necessary/desirable

OFFSHORE LNG **TERMINALS' CATEGORIES**

STRUCTURAL

- Fixed (laying on sea bed)
- Floating, normally anchored through a single point mooring buoy

OPERATIONAL

- Case I – LNG FPSO (FLNG)

Gas treatment, liquefaction, storage and offloading

- Case II – STORAGE REGAS UNIT

Loading LNG, storage, regasification & discharge ashore

- Case III – TRANSHIPPING

Loading LNG, storage & offloading LNG

Technologies for:

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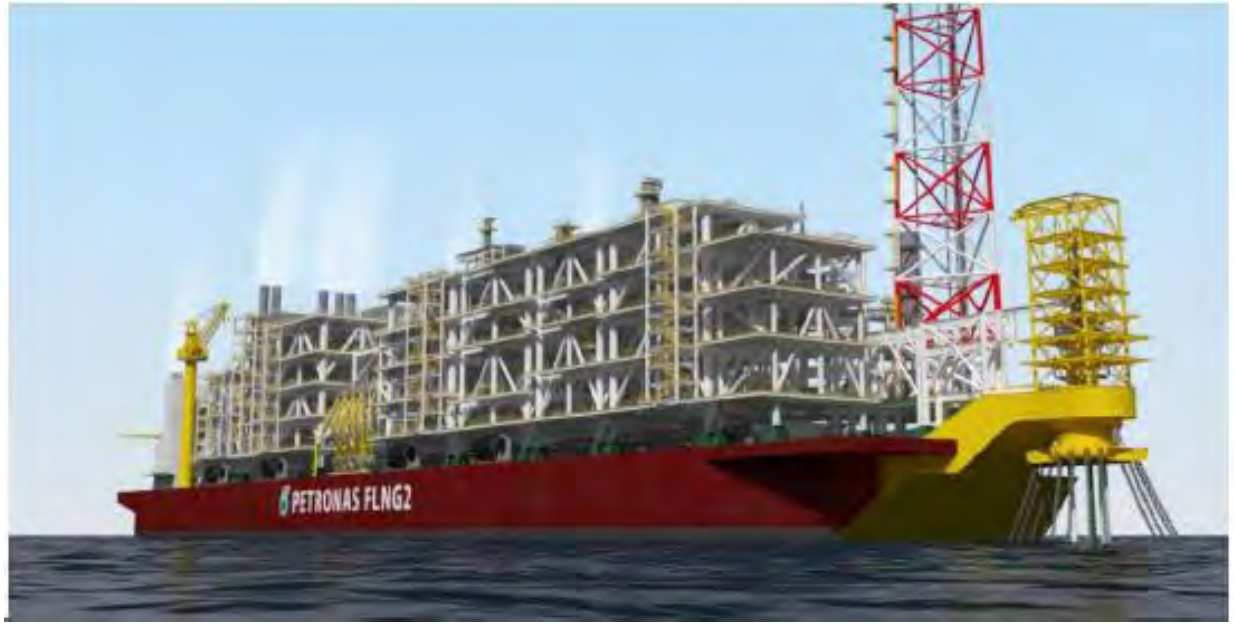
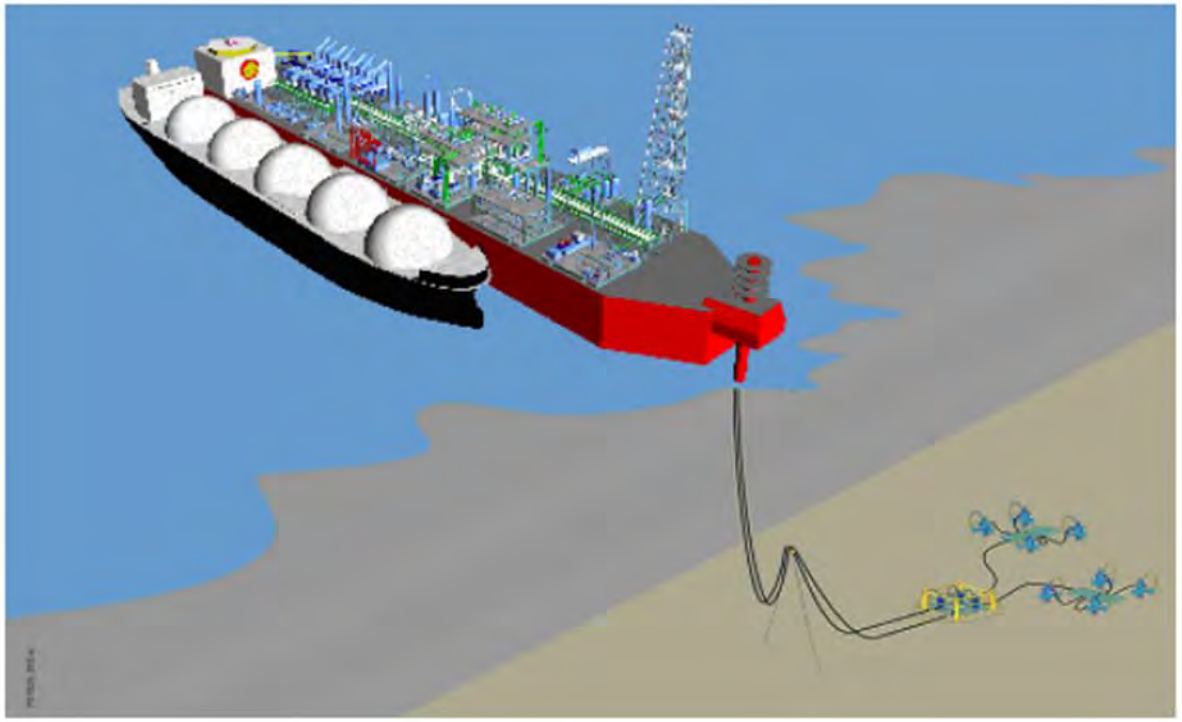
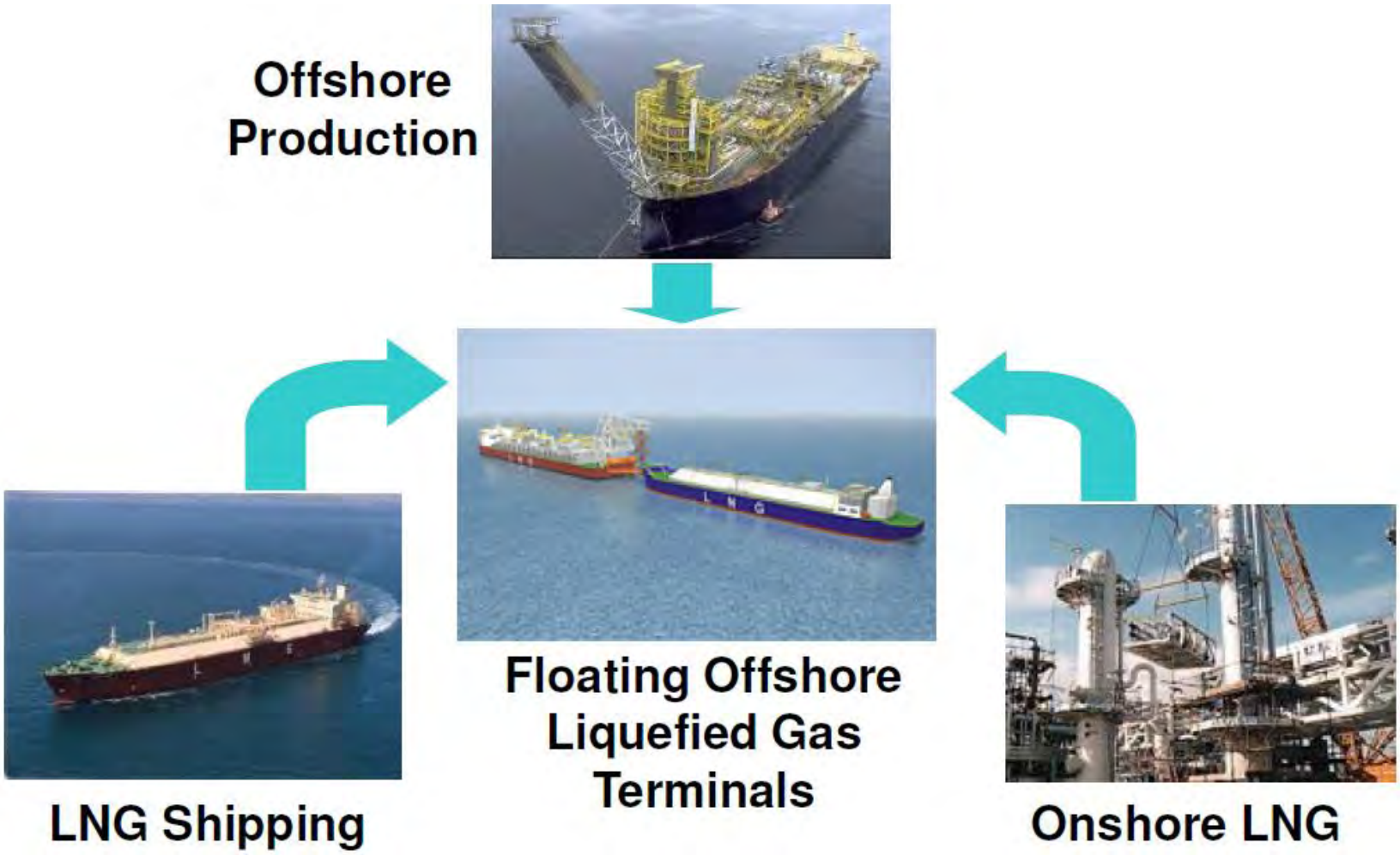
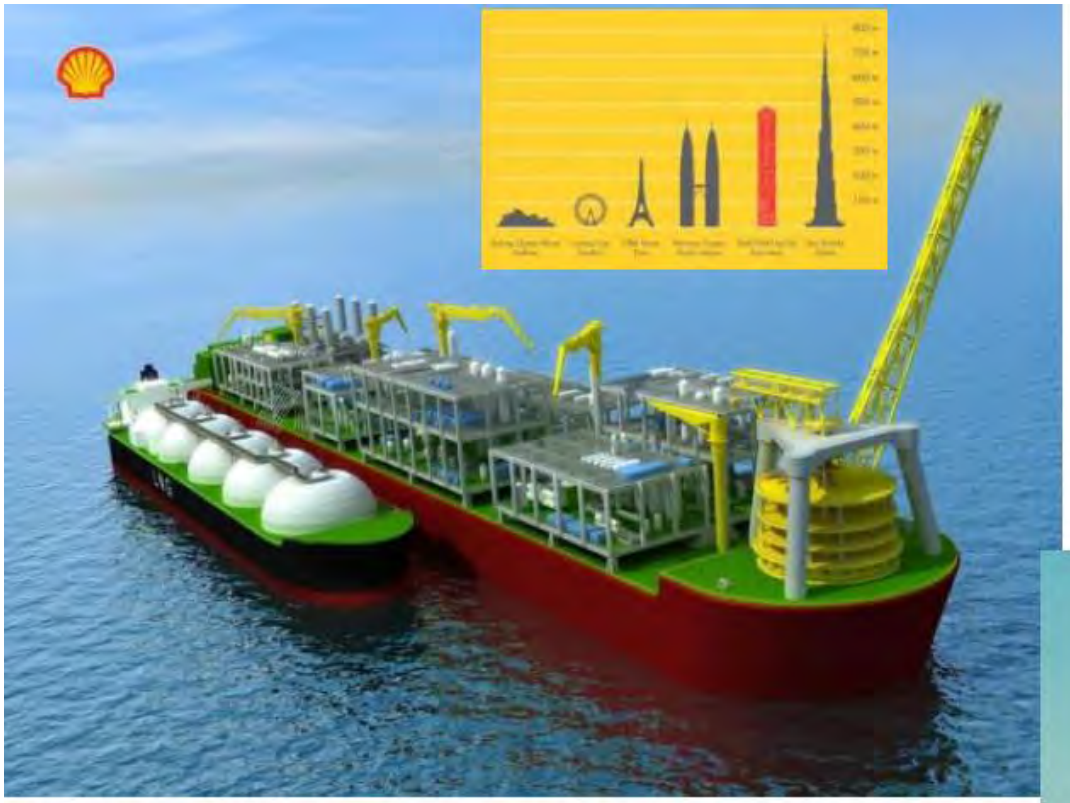

PETRONAS FLNG2



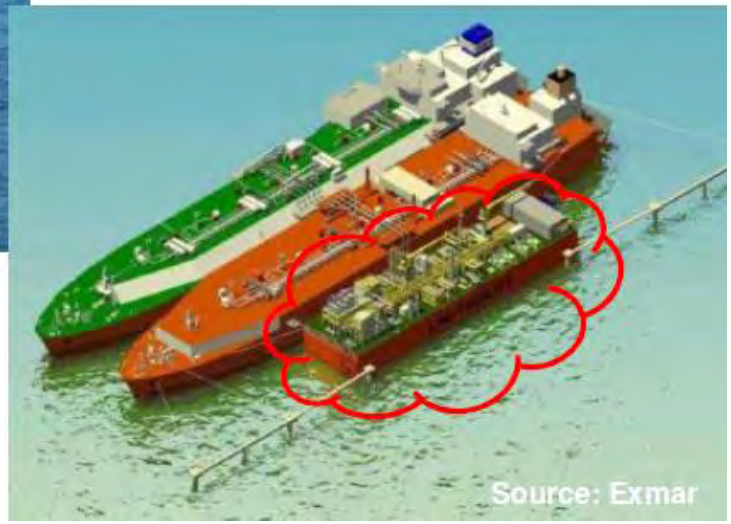
FLNG: COMBINATION OF 3 INDUSTRIES



WIDE RANGE OF FLNGs



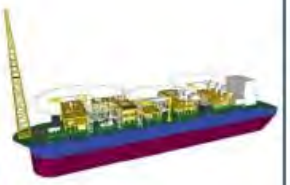
From XXL
(Shell Prelude)
3.6 mtpa LNG
0.4 mtpa LPG
1.3 mtpa Condensates



To XS
(Exmar – Columbia)
0.5 mtpa LNG

Floating LNG

aragon

KOGAS	FLEX LNG SAMSUNG	SEVAN marine	FLEX LNG SAMSUNG	海油发展采油服务公司 CNOOC EnerTech-Oil Production Services Co.
Project: KOGAS FLNG	**Project: PNGT2**	**Project: Sevan FLNG**	**Project: LNGP1**	**Project: LS FLNG**
Details: 2.5MTPA production	Details: 2.1MTPA production	Details: up to 2.4 MTPA production	Details: 1.7MTPA production	Details: 1.1MTPA production
Technology Evaluation (DMR, SMR, KSMR) & Engineering by KANFA Aragon	Engineering, Procurement & Technology by KANFA Aragon	Engineering & Technology by KANFA Aragon	Engineering, Procurement & Technology by KANFA Aragon	Engineering & Technology by KANFA Aragon
Technology: KSMR	Technology: N_2 Cycle	Technology: N_2 Cycle	Technology: N_2 Cycle	Technology: N_2 Cycle
				

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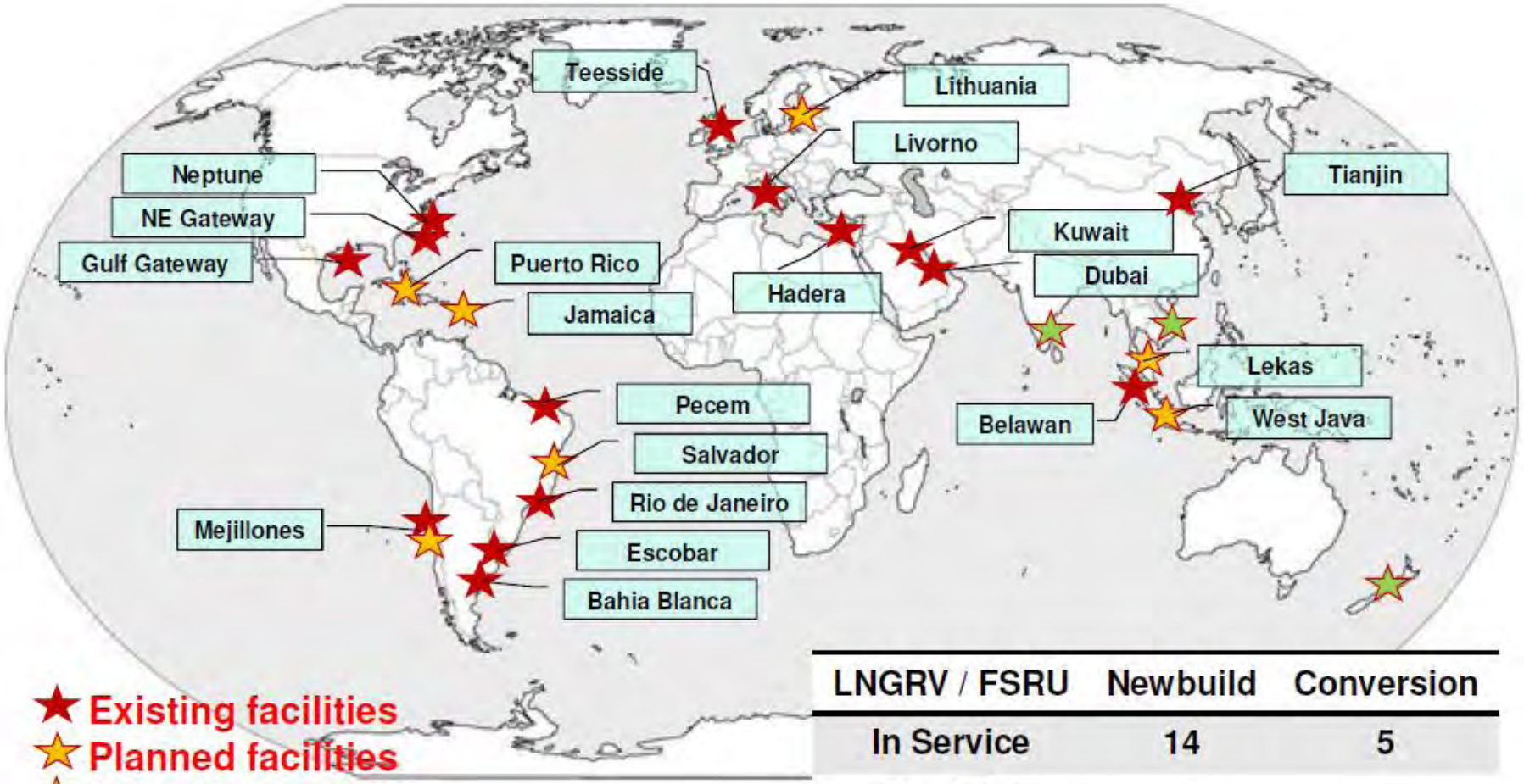
PROVEN CONCEPT



LNGRV / FSRU	Newbuild	Conversion
In Service	14	5
On order	7	-

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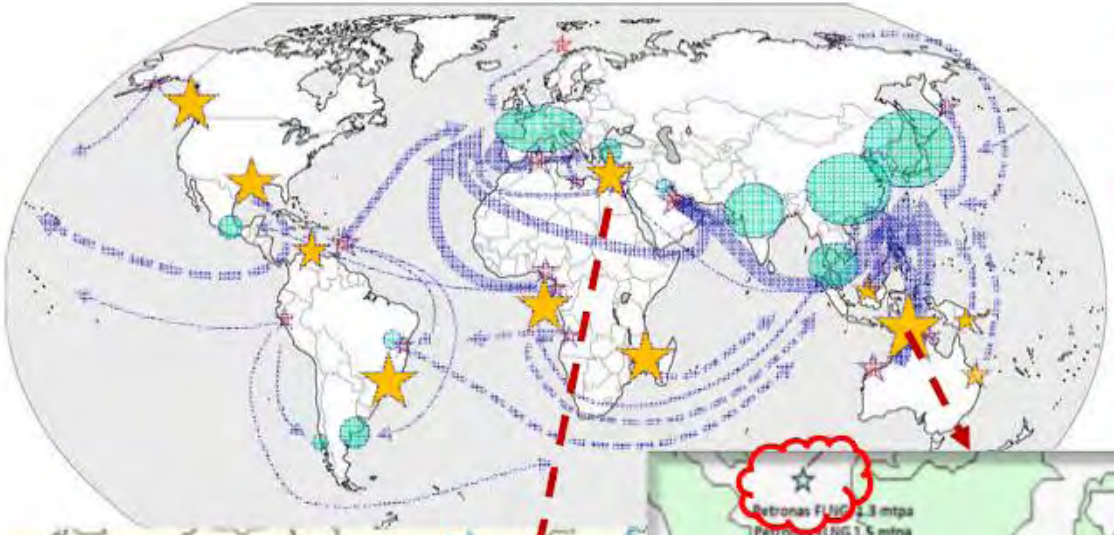
FLOATING LNG PRODUCTION: OPPORTUNITIES?



- Southeast Asia
- Papua New Guinea (PNG)
- Mediterranean (Tamar, Leviathan)
- South America (Brazil)
- US/Canada
- Colombia
- West Africa (Nigeria)
- East Africa (Mozambique)

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Technologies for:

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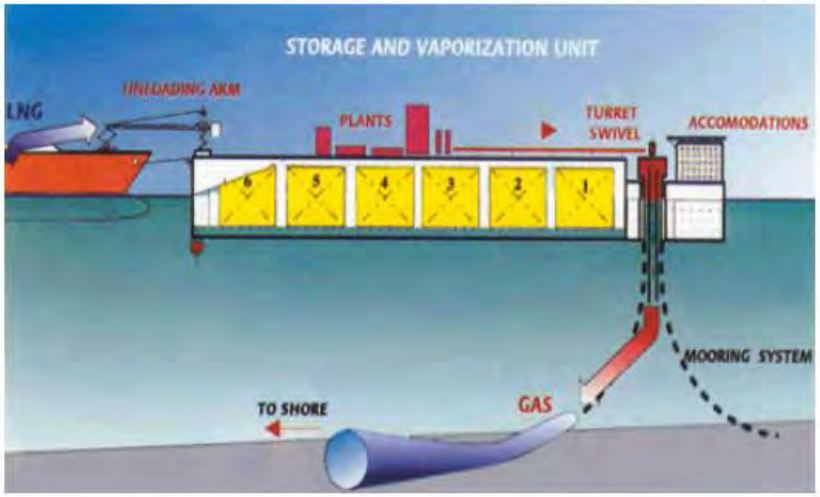
FLOATING REGASIFICATION

- **Main objectives**
  - Deliver degasified LNG to the market
    - Tie into existing networks that need increased capacity
    - Develop new markets with minimum local infrastructure
    - Provide seasonable supply

- **Main advantages**
  - Time to market
  - Can be located away from the shore line in the populated areas
  - Reduces political risks

- **Main challenges**
  - Sloshing & motions (offshore)
  - LNG transfer (offshore and at the jetty)
  - Safety
  - Environmental requirements (use of sea water, air emissions,…)
  - NG heating value adjustment / odorizing



Floating Regasification Units (FSRUs)

FSRU

aragon

GRAVIFLOAT	VGS GROUP	Refinería del Pacífico Eloy Alfaro RDP-CEM
Project: Gravifloat Regas	**Project: Kakinada FSRU**	**Project: RDP FSRU**
Details: Gravity-based Barge Regas Rate: 1 MM Nm3/day	Details: Jetty-based Regas Rate: 20 MM Nm3/day	Details: Jetty-based Regas Rate: 5.75 MM Nm3/day
Storage: 30 K m3	Storage: 40+174 K m3 FSU	Storage: 130-175 K m3
Evaluation: Vendors concept evaluation (technical: simulations, equipment selection; economic evaluation)	Evaluation: Topside design and layout. Hull design. Concept evaluation (barge-based).	Evaluation: Vendors concept (new-built vs. conversion). Site evaluation (land vs floating). LNG transfer evaluation.
		

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FSRU

aragon

H-ENERGY power to the people	GASATACAMA	Colbún
Project: H-FSRU	**Project: Mejillones FSRU**	**Project: Quintero Bay FSRU**
Details: Jetty-based Regas Rate: MM 15.6 Nm3/day	Details: Offshore Regas Rate: 3.4 MM Nm3/day	Details: Jetty-based Regas Rate: 10 MM Nm3/day
Storage: 125-173 K m3	Storage: 125-145 K m3	Storage: 130-150 K m3
Evaluation: Vendors concept (new-built vs. conversion). Site evaluation (land vs floating). LNG transfer evaluation.	Evaluation: Topside design. Concept evaluation (new-built vs. conversion). Budgetary cost estimate.	Evaluation: Project description. Safety evaluation for selected site. LNG transfer evaluation.
		

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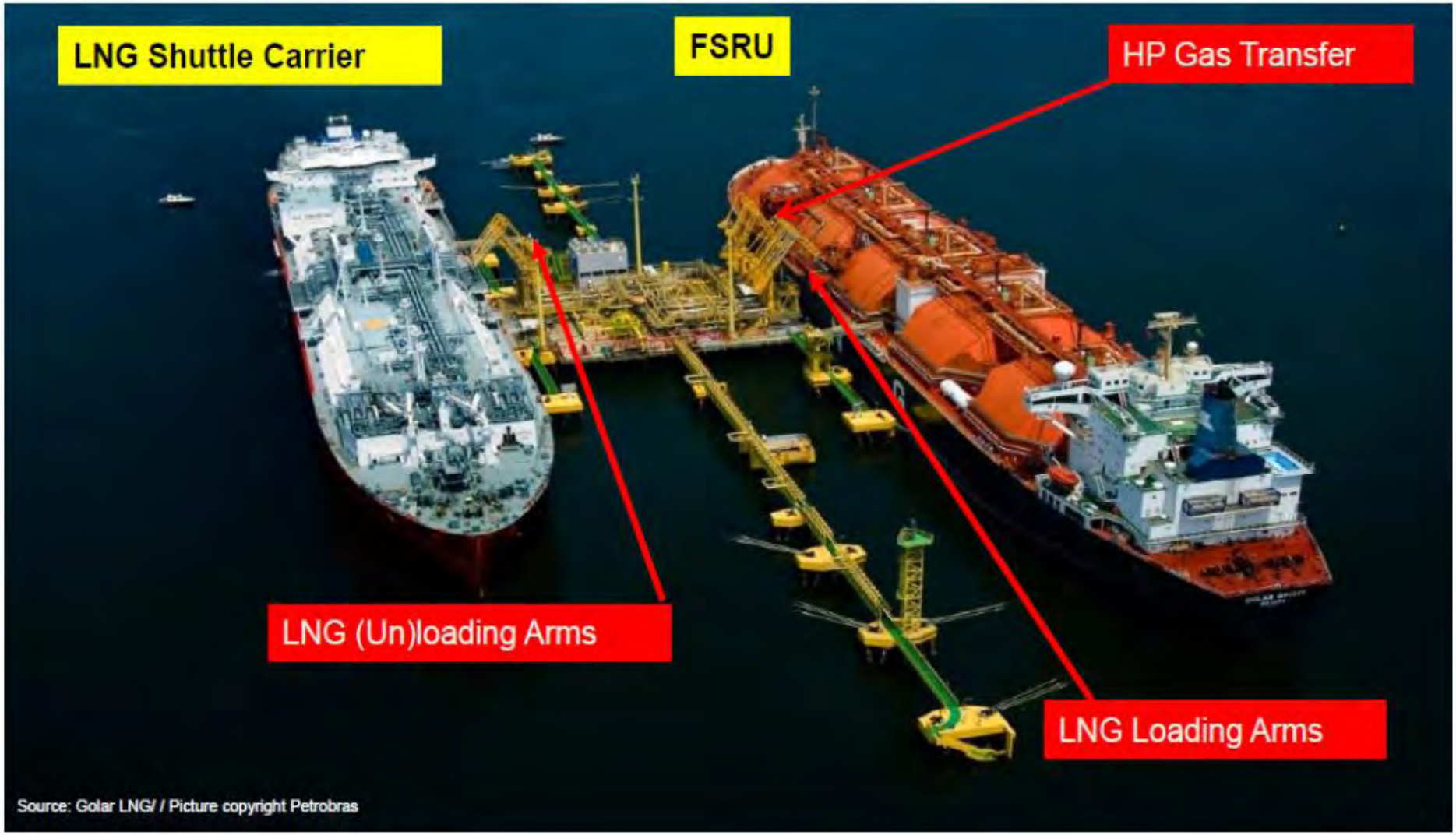

LNG Shuttle Carrier
FSRU
HP Gas Transfer
LNG (Un)loading Arms
LNG Loading Arms
Source: Golar LNG/ / Picture copyright Petrobras

CARGO TRANSFER: CRYOGENIC HOSES

Photos Source: Gutteling / Exmar

LNG CARRIERS

IMO Classification of LNG Containment systems

Independent Tanks

Type A
p < 700 mbar
Full Secondary barrier

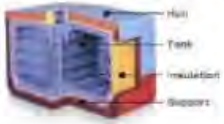
None in operation
New systems under development:
- Aker ADBT
- LNG New Technology
- Torgy

Based on classical ship structure design rules

Type B
p < 700 mbar
Partial Secondary barrier

Spherical (Moss)

Prismatic (IHI SPB)



Based on first-principle analysis and model tests

"Leak Before Failure"

Type C
p > 2000 mbar
No Secondary barrier

Cylindrical

Bilobe

Pressure vesels, based on pressure vessel code

Integrated tanks

Membrane Tanks
p < 700 mbar
Full Secondary barrier

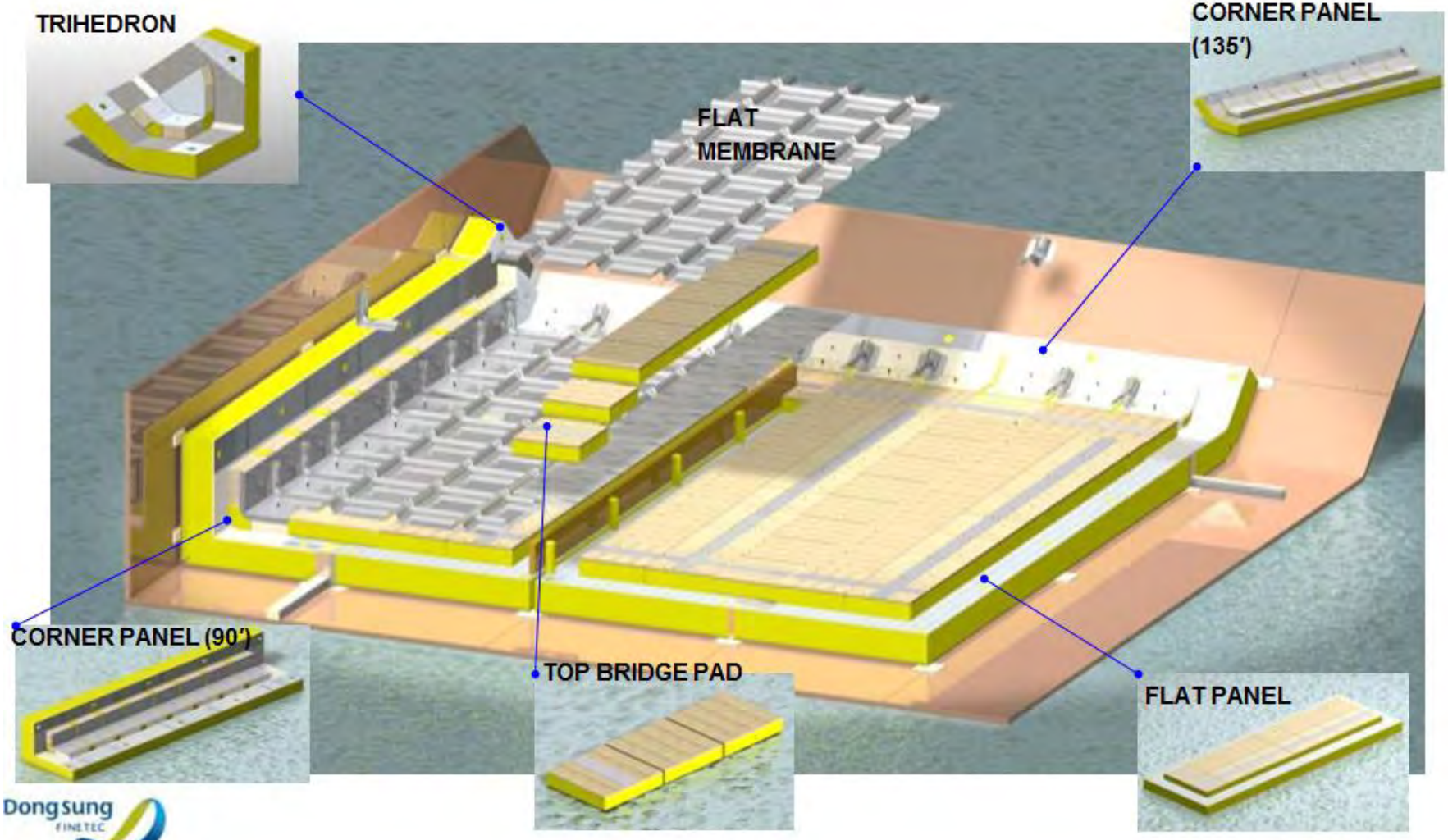
GTT No 96

GTT Mark III

Other Systems:
- GTT MARK V
- KOGAS KC-1
- SHI SCA-WS
- HHI LNG Membrane
- DSME Membrane

Sources: Moss Maritime, IHI, TGE, GTT

LNG CARRIERS CONTAINMENT SYSTEMS MARK-III



Dongsung FINETEC

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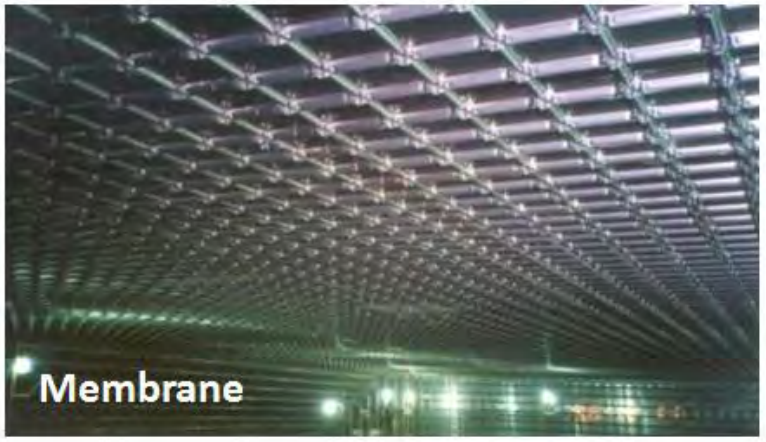
LNG CARRIERS CONTAINMENT SYSTEMS MARK-III



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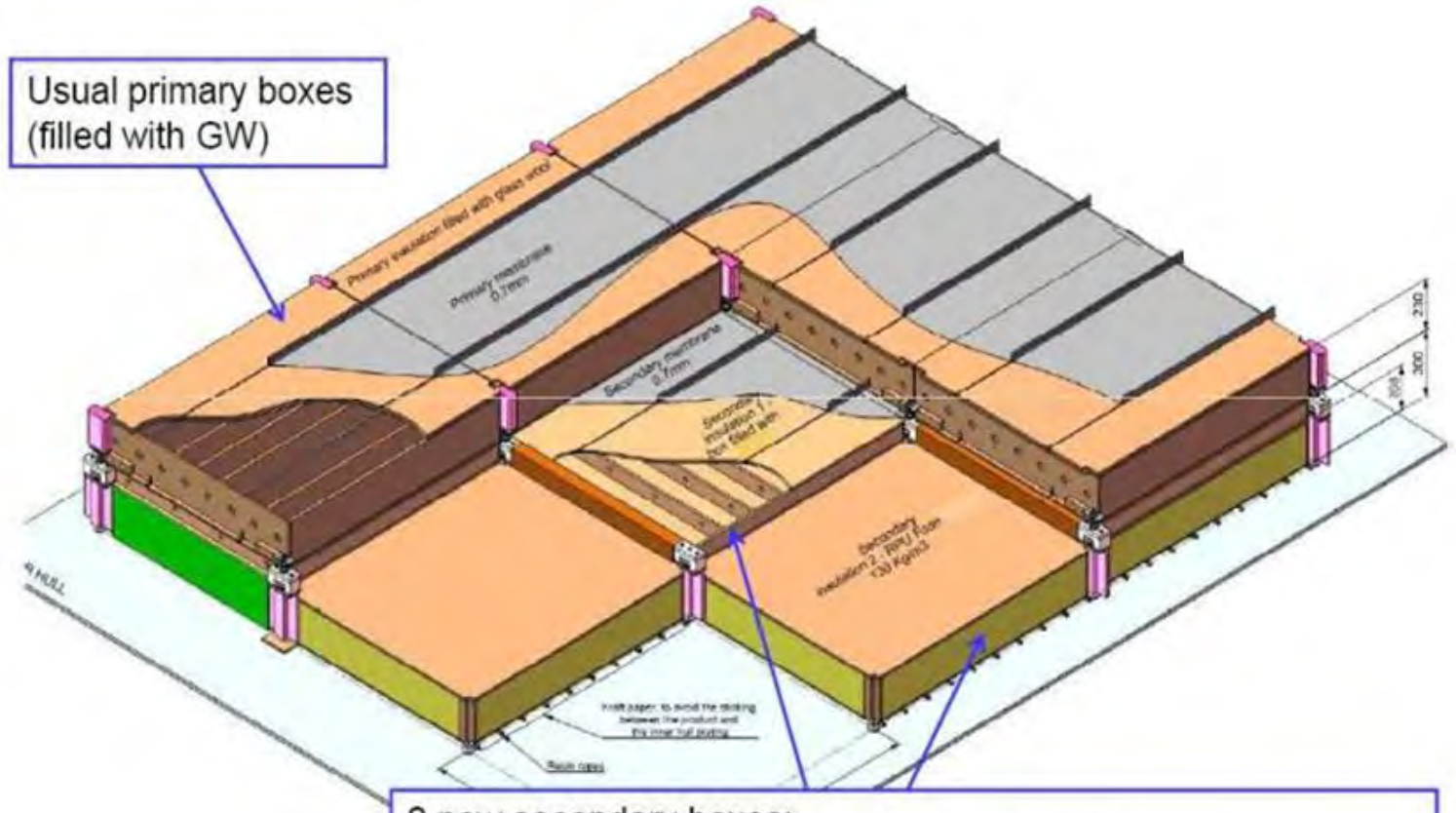
LNG CARRIERS CONTAINMENT SYSTEMS NO96-L-O3



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LNG CARRIERS CONTAINMENT SYSTEMS NO96-L-O3

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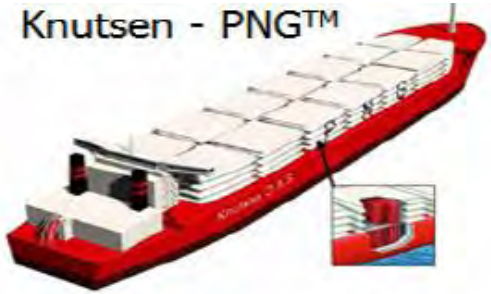
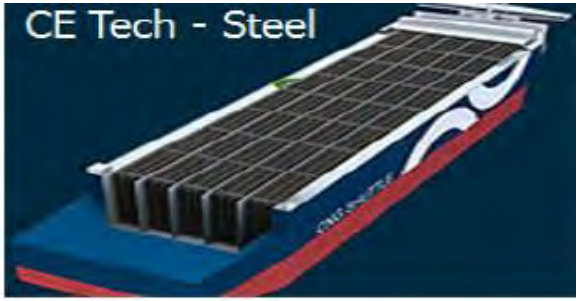
CNG CARRIERS

Knutsen - PNG™



EnerSea – VOTRANS™ Steel

CE Tech - Steel



Floating Pipeline Co. –
FRP Wrapped Steel Cylinder

Lincoln Composite – Carbon Composite

Trans Ocean Gas –
Glass Fiber

Trans Canada – GTM™ FRP
Wrapped Steel Cylinder

SeaNG – Coselle™ Pipe

GRAVIFLOAT TECHNOLOGY STRATEGIC PARTNERSHIP

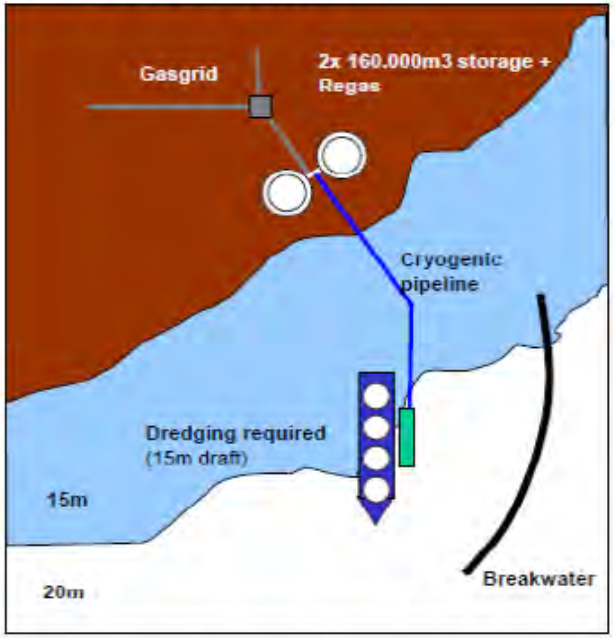
GRAVIFLOAT

sembcorp marine

LMG MARIN

GRAVIFLOAT ADVANTAGES

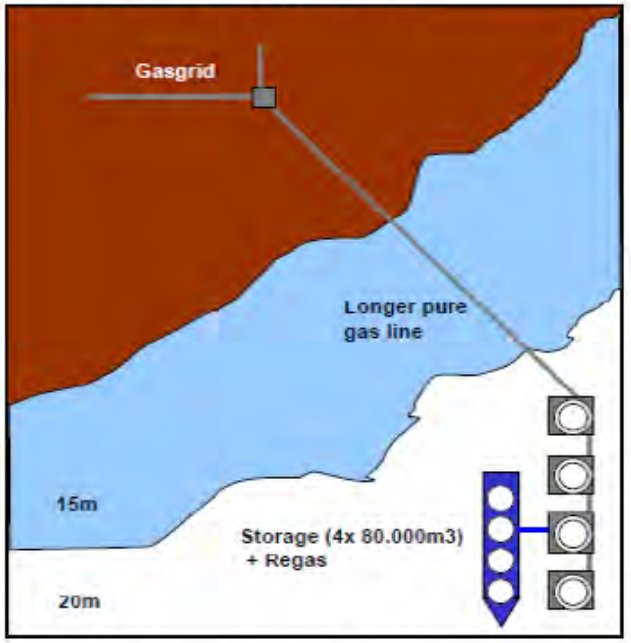
Land Based Terminal



- Significant use of land area
- Requires cryogenic pipes from jetty to storage tanks
- Jetty + Breakwater installation to protect jetty
- Dredging or harbour development required

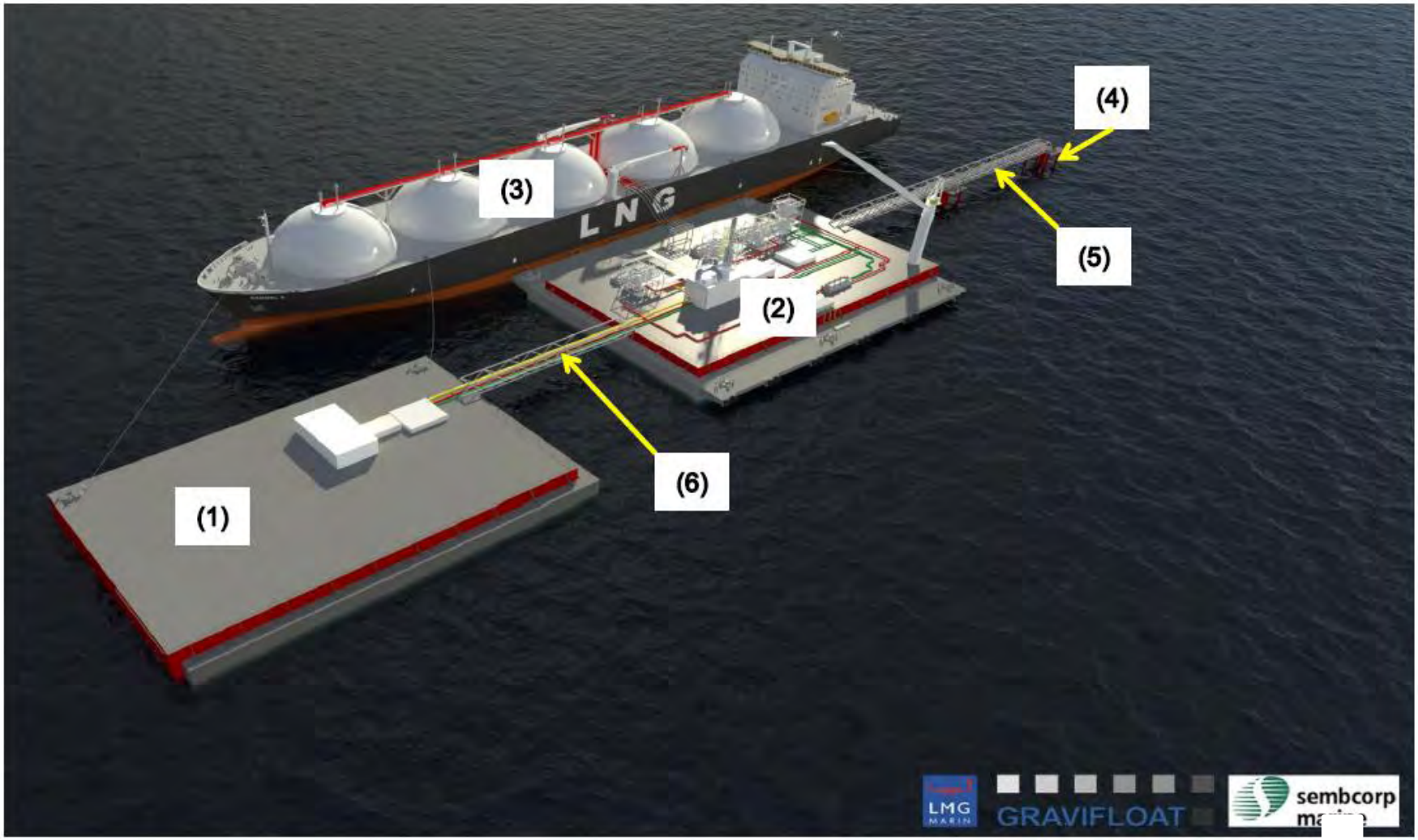
VS

GraviFloat Terminal

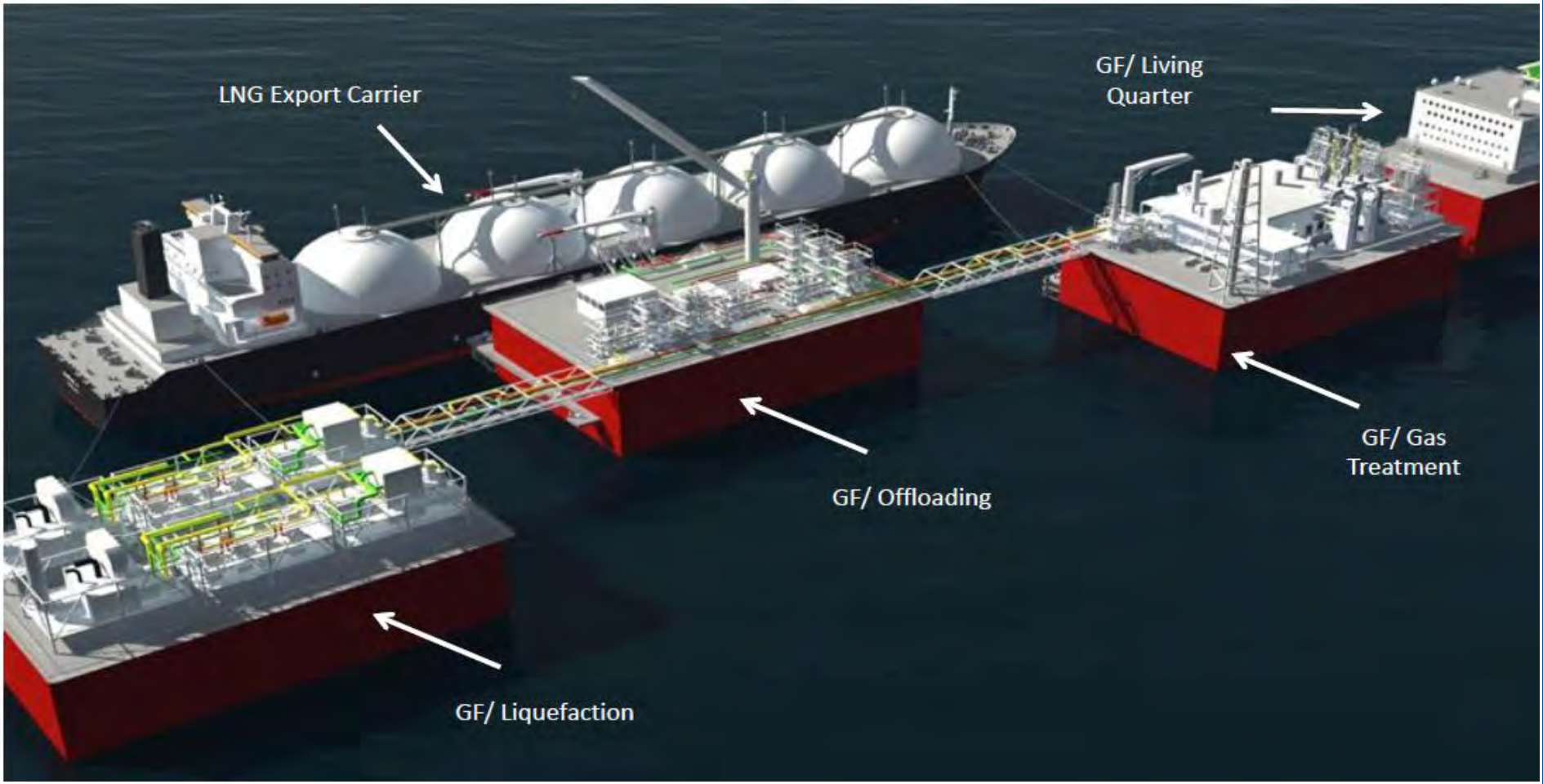


- Very limited use of land area
- Storage tanks located away from land
- Cost efficient and flexible expansion
- No dredging, terminal at sufficient depth

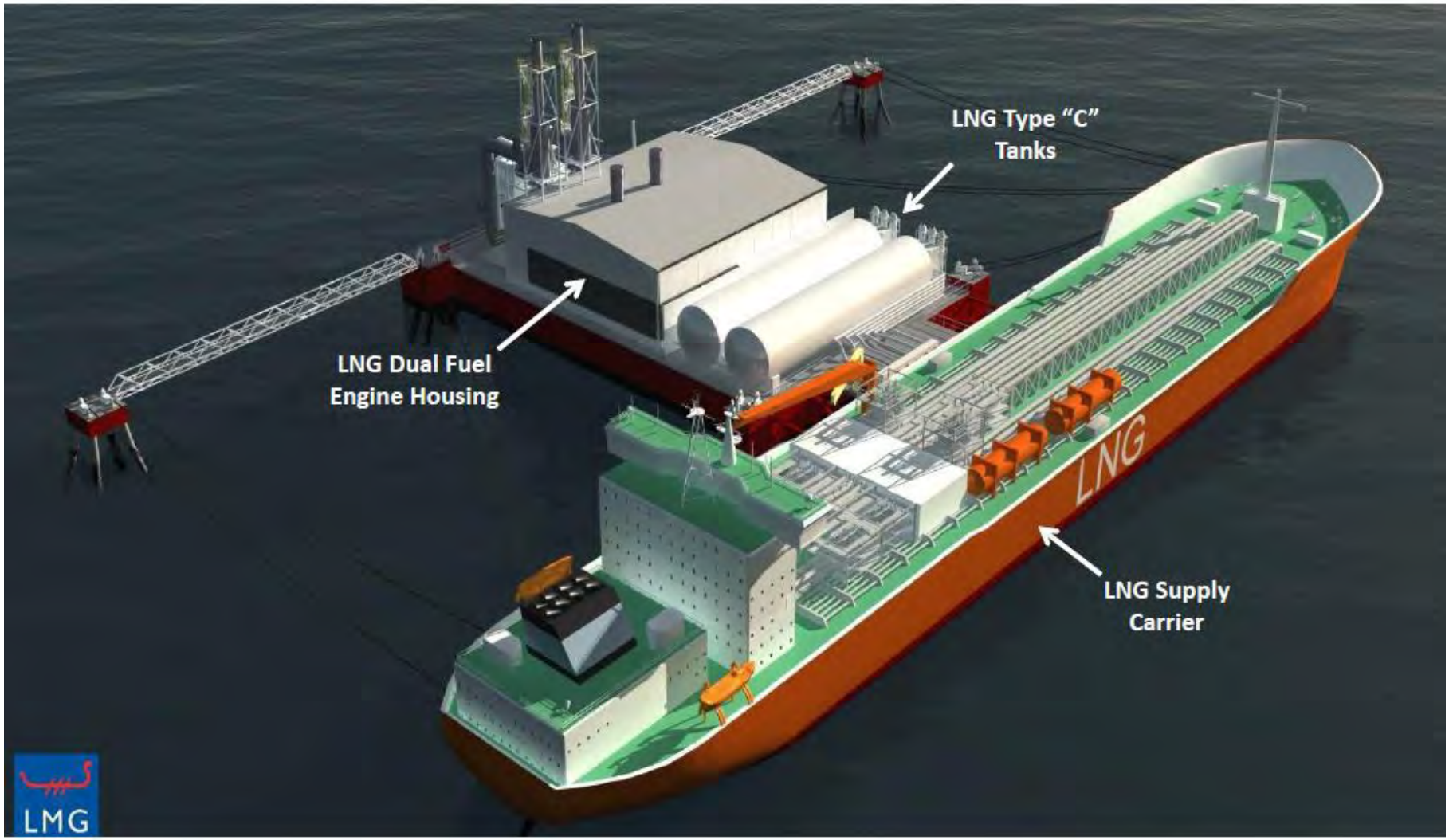
RECEIVING TERMINAL + RE-GASIFICATION



LNG EXPORT TERMINAL (LIQUEFACTION)

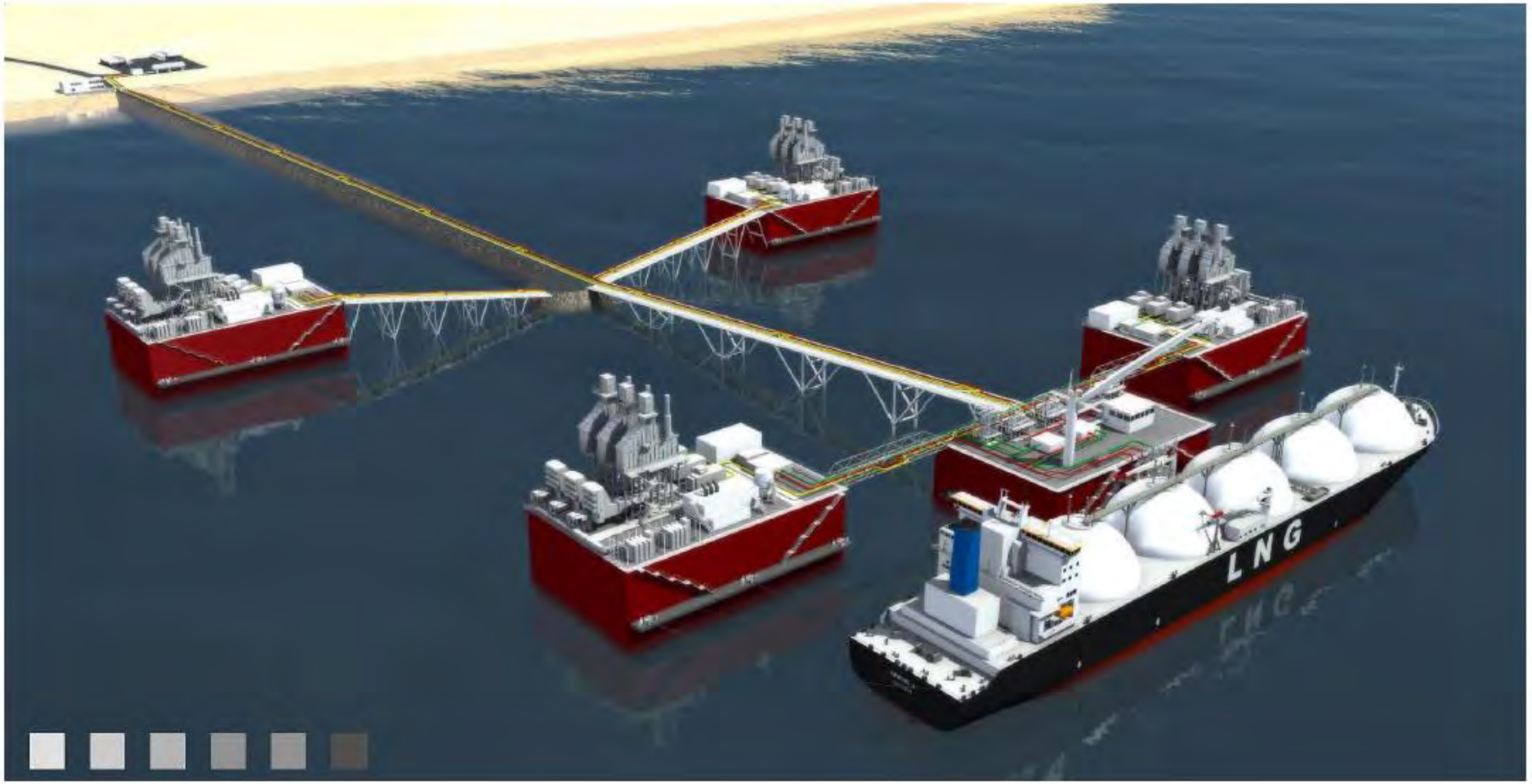


SMALL ISLAND POWER PLANT



MID - SCALE POWER PLANT

INTEGRATED RECEIVING TERMINAL WITH POWER



LNG
BUNKERING & DISTRIBUTION

STRATEGIC ADVANTAGES OF LNG vs LONG PIPELINES

- **Flexibility, under full control of exporting country**
- **Better commercial viability making risk management easier**
- **Risks minimized in geographical areas with volatile geopolitics**

NATURAL **GAS AS "TRANSITION" FUEL**

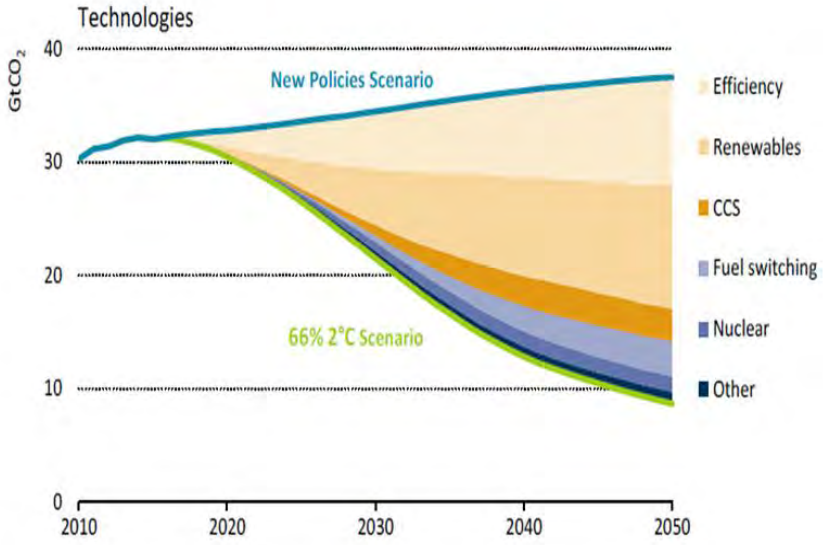
It is a "cleaner" fuel compared with coal and oil, as far as it concerns emissions of SOx, NOx, PM and, to a small extent, GHG. Nevertheless, it remains a fossil fuel.

All fossil fuels are or will be targeted in the near future towards a decarbonized, fossil fuels free future.

ROAD MAP TO DECARBONIZATION

- **COP21: temperature increase well below 2(1.5?) deg C by 2050, as compared to 2008.**

- **66% 2deg C Scenario:**
  - ✓**Electricity 95% low carbon**
  - ✓**Cars 70% electric**
  - ✓**Buildings 80% to be retrofitted**
  - ✓**Industry CO_2 decrease by 80%**



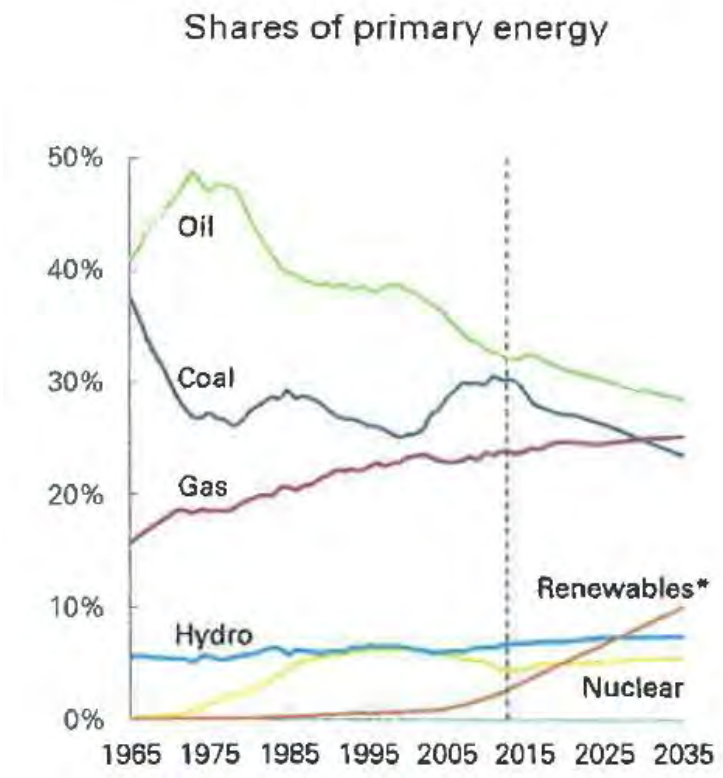
Source IEA

"SCENARIOs"

Energy demand breakdown by 2050 as compared to 2014:

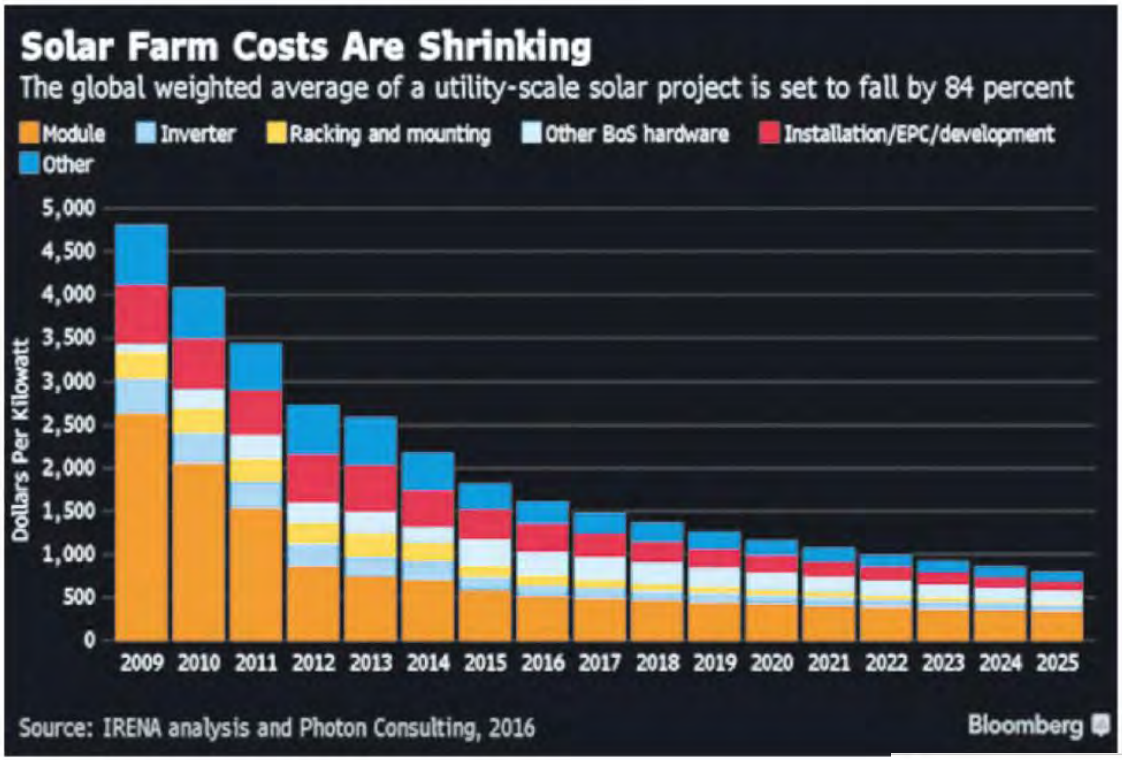
- **Renewables from 1% to 20%**
- **Oil from 31% to 23%**
- **Gas around 20%**

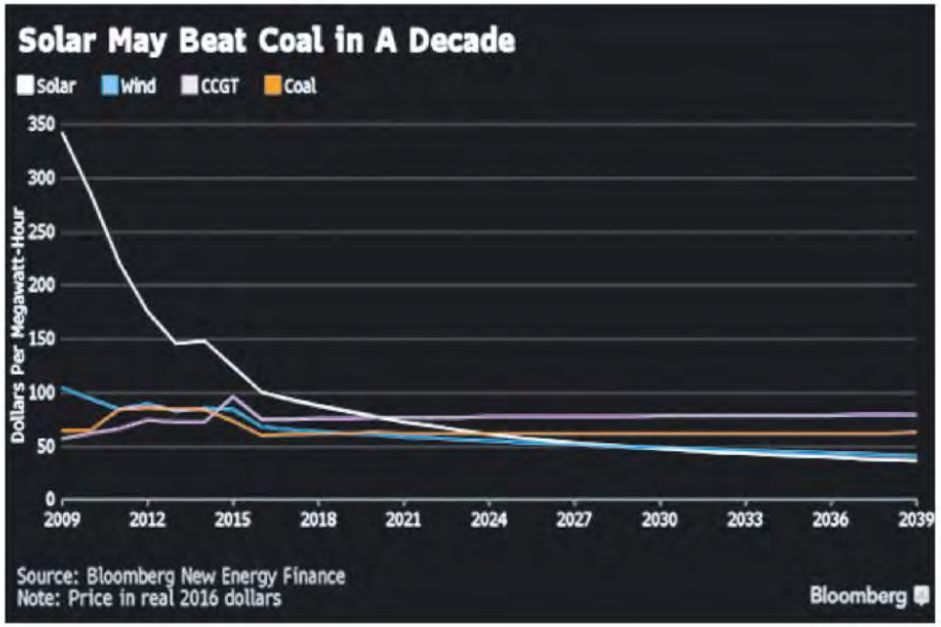
Source: STATOIL



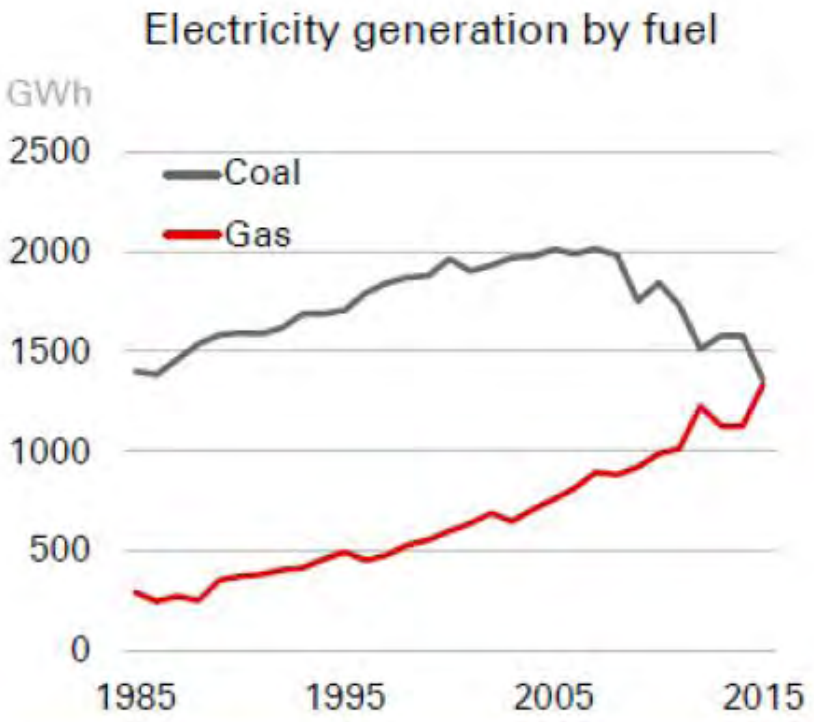
Source: BP

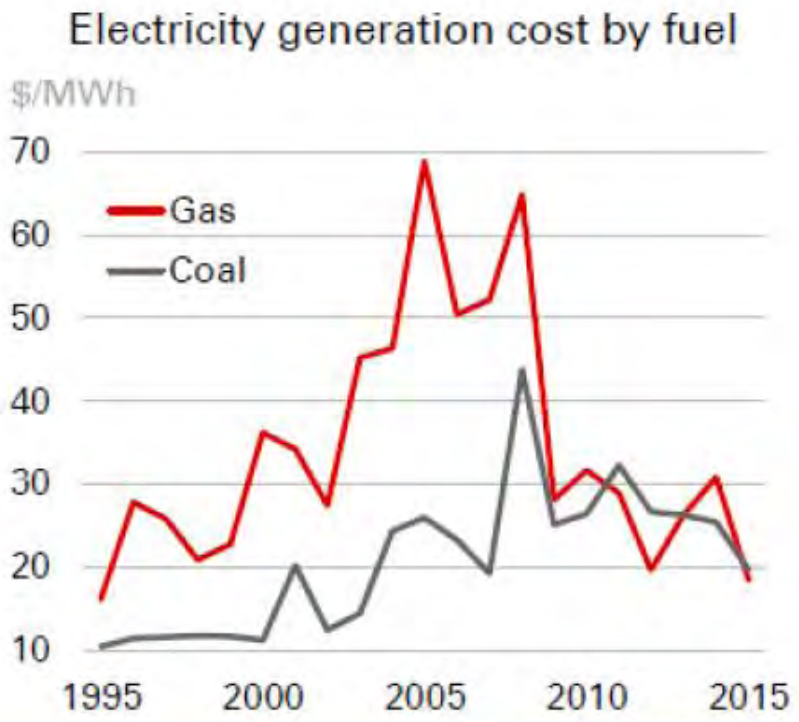
Major "risk": renewables


Solar Farm Costs Are Shrinking
The global weighted average of a utility-scale solar project is set to fall by 84 percent
Module
Inverter
Racking and mounting
Other BoS hardware
Installation/EPC/development
Other
Dollars Per Kilowatt
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025
Source: IRENA analysis and Photon Consulting, 2016
Bloomberg


Solar May Beat Coal in A Decade
Solar
Wind
CCGT
Coal
Dollars Per Megawatt-Hour
350
300
250
200
150
100
50
0
2009 2012 2015 2018 2021 2024 2027 2030 2033 2036 2039
Source: Bloomberg New Energy Finance
Note: Price in real 2016 dollars
Bloomberg

US ELECTRICITY SECTOR
COAL TO GAS SWITCHING





Source: includes data from EIA

BP Statistical Review of World Energy

FINAL REMARKS

Natural Gas offers flexibility of supply & existing proven technologies for FSRUs, LNG carriers, small scale LNG/CNG can offer this flexibility

Natural gas can provide back up to renewable energy sources for gas-fired generating stations / facilities

SHIPPING

- LNG valid option for meeting restrictions on emissions of SOx, NOx & PM
- Shipping was excluded from COP21
- It will have a higher share in GHG emissions in the future
- There will be a higher pressure on shipping from politics & societal forces, so it will be forced to follow general trends, helped by the improvement of technologies (hydrogen, fuel cells, nuclear etc.)
- IMO MEPC 70: Roadmap to decarbonization to be finalized in 2023. Decisions this week (MEPC 71)

SHIPPING CONT.

BIMCO, INTERCARGO, INTERTANKO, ICS, are taking steps, so IMO, at its next MEPC Session, this week, adopts two "aspirational" objectives:

- **To maintain international shipping's annual total CO_2 emissions below 2008 levels**
- **To reduce CO_2 emissions per ton of cargo transported one kilometer, as an average across international shipping, by at least 50% by 2050, compared to 2008**

This is definitely a break from "business as usual".


thank you
danke
謝謝
gracias
merci
obrigado
dziękuję
bedankt
go raibh maith agat
teşekkür ederim
спасибо
ngiyabonga
рахмат
Баярлалаа
mauruuru
hvala
sukriya
kop khun krap
terima kasih
arigatô
dakujem
grazie
taiku
takk
merci
ευχαριστώ
감사합니다
ধন্যবাদ
mochchakkeram
tapadh leat
dank je
vinaka
blagodaram
matondo
paldies
grazzi
mahalo
хвала
asante
manana
mesi
barka
welalin
tack
spas
kiitos
dankie
faafetai lava
köszönöm
gracias
dekuji
sobodi
sagolun
chnorakaloutioun
gratias ago
gracies
sulpay
djere dieut
tau
mamnun
murakoze
tenkiu
enkosi
ありがとう
najis luke
rahmat
tanemirt
rahmet
dioloh
dhanyavadagalu
shukriya
merce
мерси
trugarez
xiexie
akun
dankon
ačiū
nanmi
nandri
bayarlalaa
gràcie
dhanyavaad
kun sah hamnida
дякую


Thank You