KUALA LUMPUR 2012 WORLD GAS CONFERENCE

25th world gas conference

"Gas: Sustaining Future Global Growth"

PGCD: ENHANCE EFFICIENCY IN THE LNG VALUE CHAIN

PROGRAMME COMMITTEE CS 9.3

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Patron

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INTERNATIONAL GAS UNION
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Scope of the Study Group

- Review the efficiency along the value chain, signal trends and come up with ideas for further improvement.

- Definition of the LNG value chain: gas production, liquefaction, transport and re-gasification.

- Wide scope, which required to draw in expertise from many parties.

Members List

Mr. Rob Klein Nagelvoort	Shell Retiree, Chair
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Mr. Calogero Migliore	Repsol, Co-Chair
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Mr. Wouter Pastoor	Flex LNG
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*List of PGC D3 active members

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Approach and Challenges

The Approach

- Pursue efficiency enhancement opportunities along the value chain
- New onshore and offshore technologies
- Emerging alternative value chains

The Challenges

- Meet profitability and public acceptability.
- More remote and hostile locations, high construction costs, higher gas production costs and lower LNG prices.
- Growing Domgas demand in producing countries

Efficiency along the LNG Value Chain

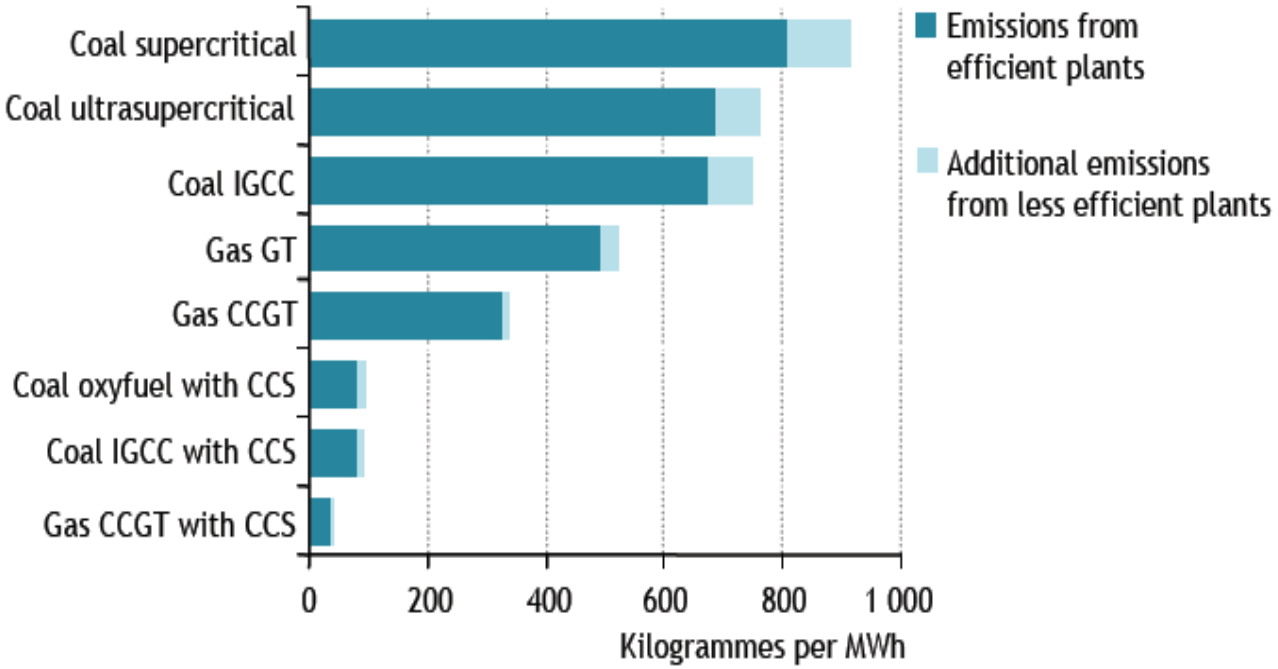
Typical efficiency ranges in the LNG chain *

	Liquefaction	Transport (**)	Regas	Overall
Thermal efficiency (%) * **	90 - 93	92 - 97	98 - 99	81 - 89
GHG emissions (kg CO_2 eq./MWh) ** **	20 - 28	8 - 23	3 - 6	32 - 55

(*) Excluding Gas production
(**) Considering a 138,000-m3 LNG tanker and 10 to 30-day round trip
(***) Heating Value "Product Out / Feed In"
(****) kg CO2 emitted per MWh of product energy

Benchmarking of LNG

CO_2 emissions produced by new power plants in the IEA GAS Scenario, 2020



Gas production, trends and consequences

Growing demand for LNG is leading to more gas sourced from difficult reservoirs, difficult locations

http://www.energyandcapital.com/articles/haynesville-natural-gas/695

Examples:

- Coal Bed Methane, Tight Gas
- Deep Sea, long transmission lines
- Tropical swamps, Arctic

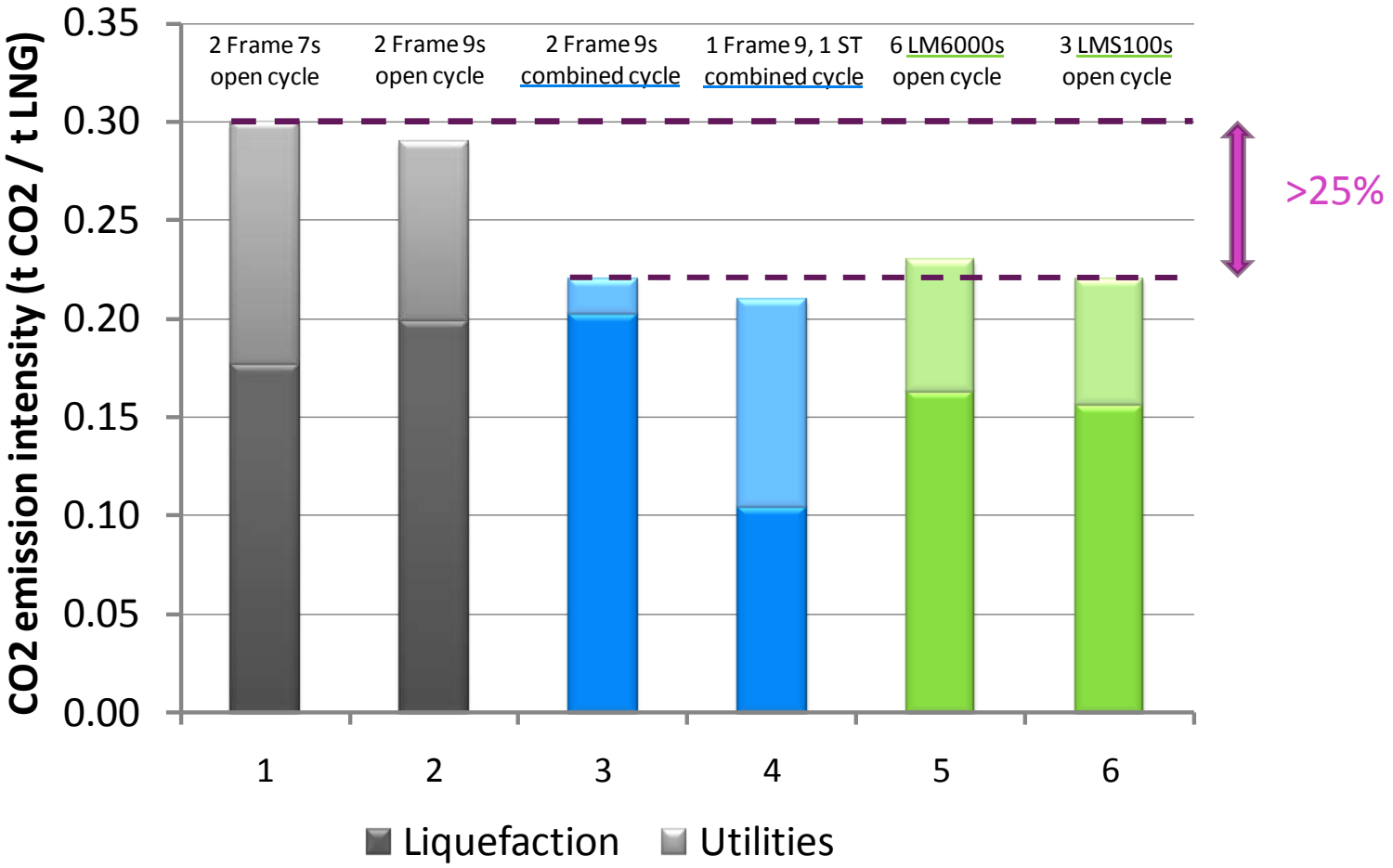
Context:

- Development of required technology
- Higher development and production costs
- Complex logistics and facilities

Trends in LNG production

- New plants use existing technologies (e.g. C3/MR, Optimised Cascade Process, DMR) in the range of 4.5-6 Mtpa
- For smaller capacities (1 – 3 mtpa) SMR and Gas Expansion processes are favoured
- High overall efficiencies can be achieved, either with industrial gasturbine drivers and maximum waste heat recovery, or via efficient aero-derivative gasturbines
- A strong drive towards higher efficiency is given by stricter emission regulations (i.e. max CO2/LNG limits in Australia, US)
- Floating LNG production is becoming reality

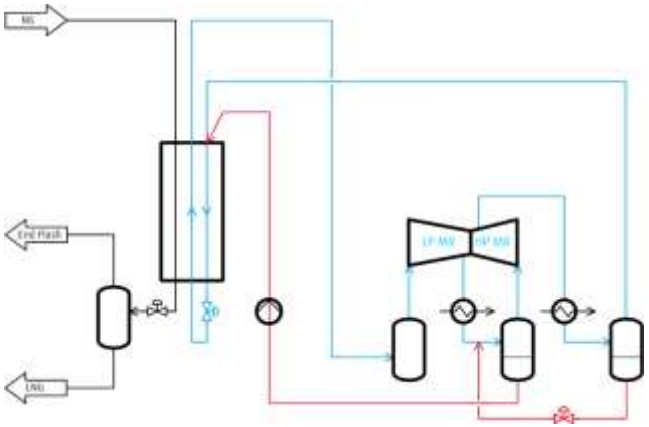
Reduced Specific CO_2 Emissions* from Fuel via Optimised Design



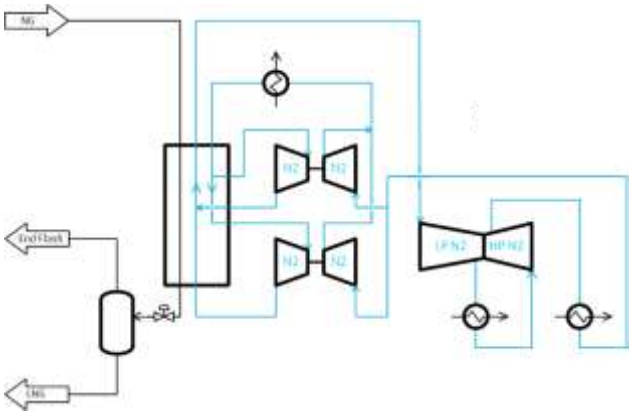
* CO2/LNG balance has been made per train

Efficiency of LNG processes in the 1 – 3 Mtpa range

MR Based Process



Double N_2 Expander Process



- The SMR process, with plate fins or spiral wounds, has a specific power of some 360 kWh/t, 10 % above world standard LNG.
- The N_2 expansion process has a specific power of some 560 kWh/t. Compact process for smaller scale, offshore operation.
- New processes with cascaded expansion cycles (N_2, C_1) have specific powers closer to SMR.

Comparison of processes on the same basis (feed gas quality, pressure, ambient temperature, equipment constraints etc.)

Enhancing efficiency in existing LNG Facilities

The need to improve efficiency in case of slack of gas supply or of lesser off-takes stimulated innovative solutions

Oman LNG

- Minimising Flaring Losses
- Optimising Production Planning
- Advanced Process Control (APC)

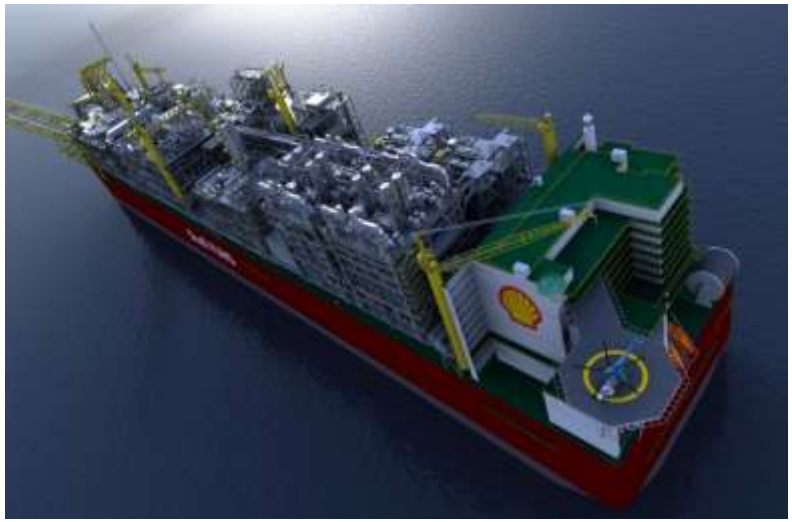
Nigeria LNG

- Turning off and balancing LNG trains
- Optimising power generation
- Optimising fractionation of NGL's

Offshore LNG production

FLNG is increasingly considered a realistic opportunity for the monetisation of offshore resources

Shell's Prelude FLNG



Höegh LNG FPSO solution

FLNG allows to efficiently develop difficult reservoirs by combining gas production and liquefaction

LNG shipping, trends and consequences

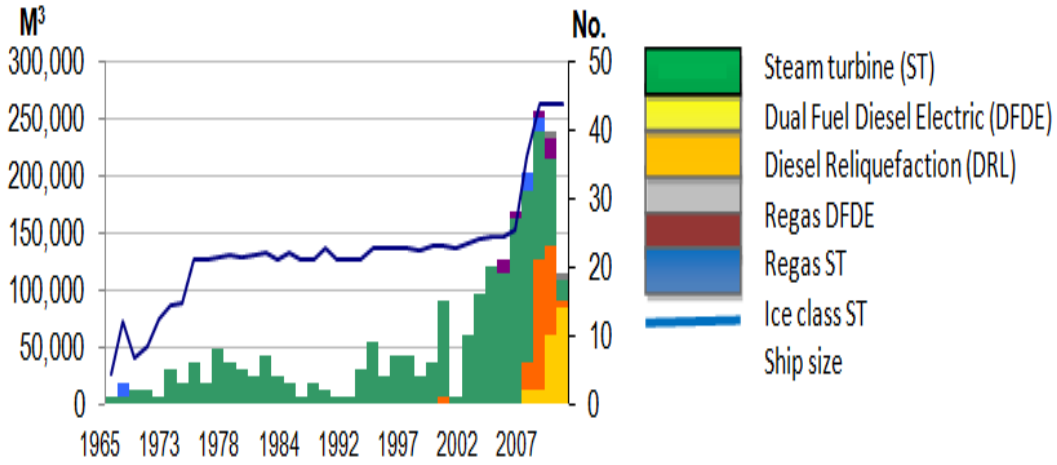
Engine Efficiency

Diesel engines have a 40% higher efficiency compared to steam turbines

1. Diesel re-liquefaction (DRL)
2. Dual Fuel Diesel Electric (DFDE).

Large Dielectric driven LNG carrier with dual fuel capability.

Larger Ship size

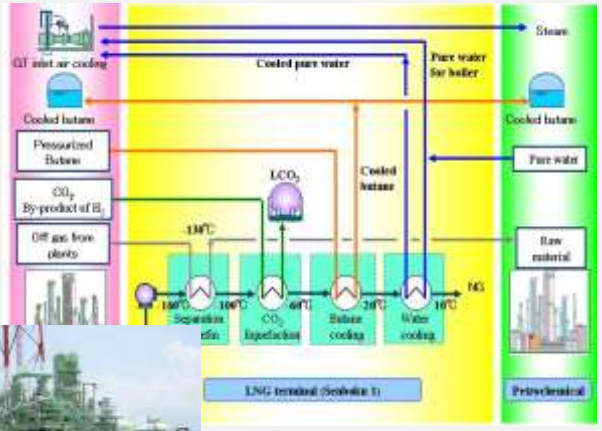


Onshore LNG terminals

Efficiency Enhancement via Cold Utilisation – Integration at the Senboku terminal of Osaka Gas

Air Separation

Cascade process of LNG cold utilisation



Cryogenic Power Generation

Liquefied Carbon Dioxide

Floating Regasification Terminals - FSRU


Höegh FSRU - Buoy Mooring

- Lower cost, faster schedule and lesser environmental impact; new builds and converted carriers
- Operational in North and South America, Europe and the Middle East
- Main Players: Excelerate Energy, Golar LNG and Höegh LNG.

Efficiency and Costs strongly depend on vaporisation system

Fuel consumption ranges from 0.5% (open loop vaporisation) to 2.5% of send out (closed loop vaporisation).

BUT Regulations/environmental impact limit application of open loop


Dubai Regas Terminal

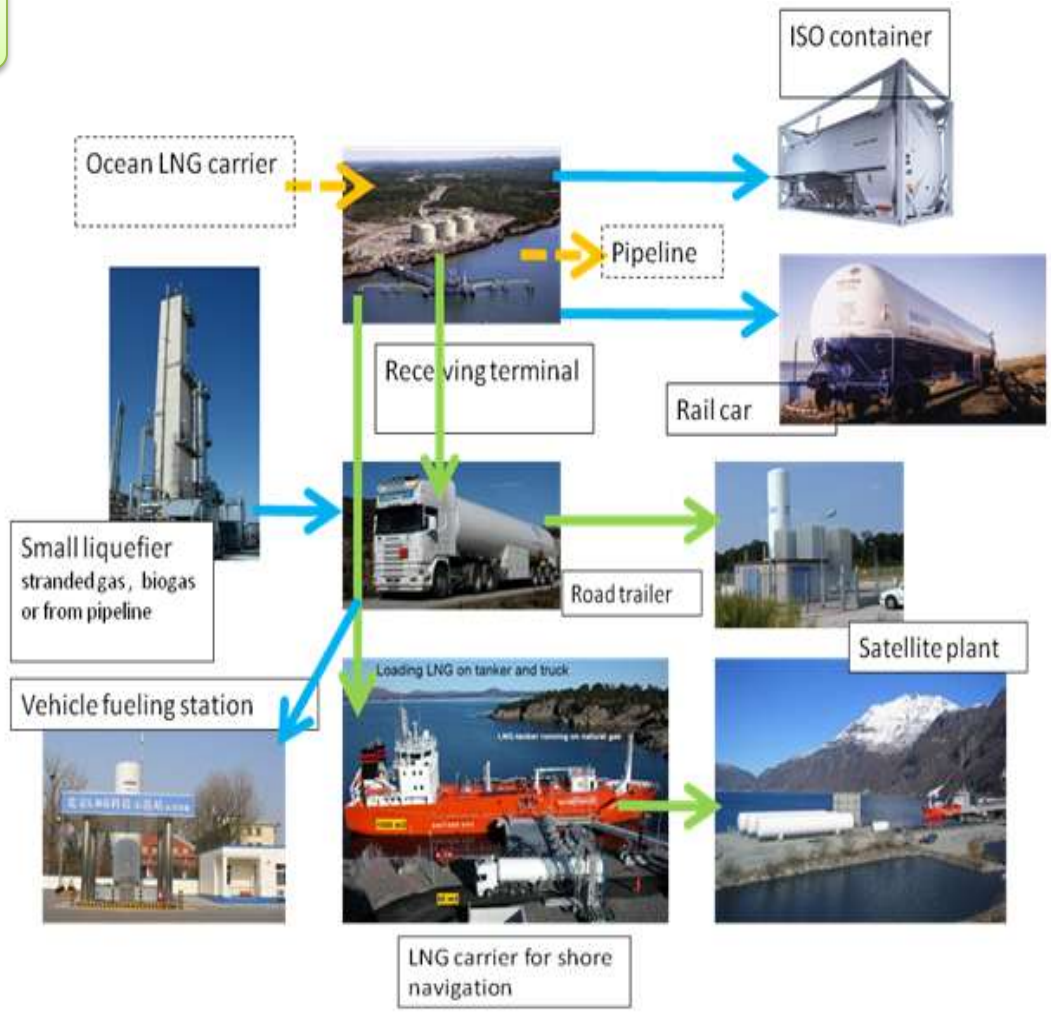
LNG as Transport Fuel

Applications

- Heavy-duty road transport
- Marine
  - offshore supply vessels
  - Inland waterway vessels
- Locomotives
- Mining trucks
- Stationary customers
  - local power stations
  - drilling rig power generators

Challenges

- Infrastructure Investments
- Safety and Sustainability
- Supportive Policy and Regulatory Environment
- Energy Efficiency



Conclusions

The LNG business has become booming again during the last three years

- LNG is a clear winner against coal for the “well to electron” efficiency.
- LNG can compete with pipeline gas in many cases
- Increasing use of LNG as replacement fuel for diesel and fuel oils.

Great technical advancements and improvements of efficiency across the value chain

- Gas production has become more complex
- Liquefaction and transport have become much more efficient
- Start of Floating LNG production
- Increase in re-gasification terminals many of them of the floating type.

Looking ahead

The IGU study groups in the next triennium will further deepen the main subjects of this efficiency report, viz. remote production/liquefaction, Life Cycle Analysis across the value chain and small scale LNG.