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(Review Article)

Part-4: Concept development of 'LNG Abscissa' for REMARIS Island

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Abstract

This paper is brought by the fact that, 'LNG Abscissa' will be an LNG producer of End User Investor Agreement. This technology is still again an island operation, as with that of 'REMARIS Island'. A new Super giant reservoir iCloud with Gas Crude Networks is brought by Data loggers & SCADA controllers that will revisit LNG producers such as (i) Intelli LNG Max Booster and (ii) Intelli LNG Box Thunder. The LNG is further re-gasified to Natural Gas to feed Customers. However, as the World moves towards net zero carbon emissions and renewable energy sources, LNG may be the 'clean' fossil fuel that is best placed to help us transition to a carbon free future. The below sessions explain the importance and uses of LNG operation in 'REMARIS Island' as an adjacent source of initiative.

Keywords: LNG Island; Remaris Island; Gas Crude Networks; LNG Abscissa; Gas Carriers

1. Introduction

The Renewable marine island (REMARIS) is an artificial or naturally formed functional hybrid island that forms a Central processing Smart ocean fuel station where homes, marine vessels, carriers, ships like VLCC, FPSO, RFSU, LNG, LOHC etc and even airplanes capture energy in batches that docks to function island towards its marine and aviation journey R[1]

Liquefied natural gas or LNG, is the liquid form of natural gas. It is clear, colourless, odourless, clean burning fuel, taken out of the ground as natural gas and becomes a liquid when it is cooled to -162 Celsius (-260 F). The cooling process reduces the volume of natural gas by more than 600 times which makes it easier and safer to store and transport R [3].

In case of LNG import, the LNG arrives at Jetty terminal in specially designed double hulled ships. There are four unloading arms to transfer LNG from the ship. Two arms for offloading liquid, one arm for vapour and one dual purpose vapour or liquid arm. The arms provide a flexible connection to the LNG tankers to accommodate the wide range of tidal movements as each ship goes through at least one tide cycle during offloading.

After the unloading arms are securely connected, the ship begins pumping LNG through the arms into the piping system at the terminal, leading to LNG storage tanks. Depending the size of the ship, the entire unloading process may take approximately 24 to 36 hours. The LNG is stored in LNG storage tanks that are insulated to keep the LNG cold and contained until it is re-gasified.

In practical, the storage tank is capable of holding 3.3 billion cubic feet (BCF) of natural gas. The tank consists of an inner shell of 9% nickel steel, an inner layer of insulation and external outer shell of concrete. The roof is made of reinforced concrete with carbon steel liner.

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Through the process called re-gasification, the LNG is warmed in a highly controlled environment through vaporizers until it returns to its original gaseous state as natural gas. LNG is pumped from the storage tanks to the process area and is re-gasified and sent into the pipeline to be transported through underground pipelines and distributed to the customers who use it for cooking, home heating, generating electric power and many other everyday uses.

In case of LNG export, the LNG is transported in specially designed ships with double hulls protecting the cargo systems from damage or leaks. There are several special leak test methods available to test the integrity of an LNG vessel's membrane cargo tanks. The tankers cost around US$200 million each. The maximum transport pressure is set at around 25 kPa (4 psi) (gauge pressure), which is about 1.25 times atmospheric pressure at sea level.

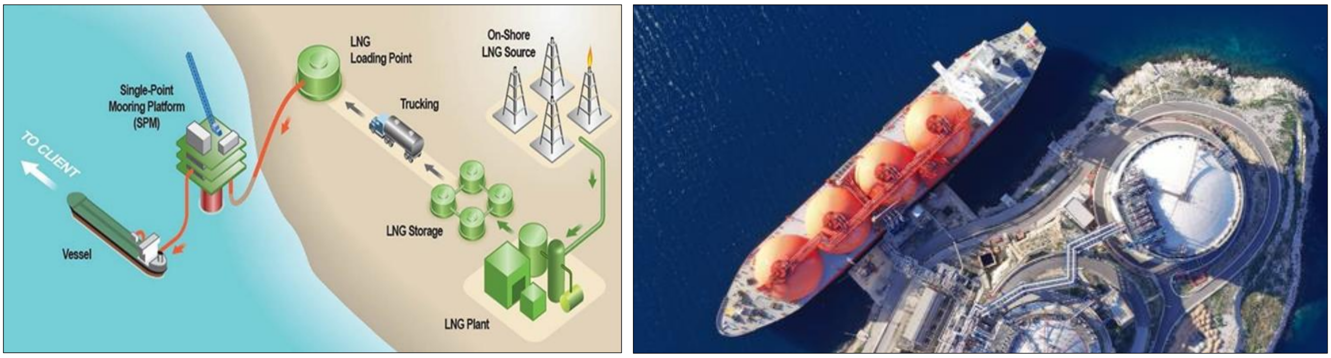


Figure 1 (Left) LNG Export, (Right) LNG Import at REMARIS Island

LNG has other uses in the race to net zero. It can act as the 'feedstock' for low-carbon hydrogen, a net zero process as it captures the carbon emissions during the manufacturing process. Meaning it has the potential to become part of a new hydrogen economy**.**

2. LNG Life Cycle

The process begins with the pre-treatment of a feedstock of natural gas entering the system to remove impurities such as H_2S, CO_2, H_2O, mercury and higher-chained hydrocarbons. Feedstock gas then enters the liquefaction unit where it is cooled to between -145 °C and -163 °C. Although the type or number of heating cycles and refrigerants used may vary based on the technology, the basic process involves circulating the gas through aluminum tube coils and exposure to a compressed refrigerant. As the refrigerant is vaporized, the heat transfer causes the gas in the coils to cool. The LNG is then stored in a specialized double-walled insulated tank at atmospheric pressure ready to be transported to its final destination.

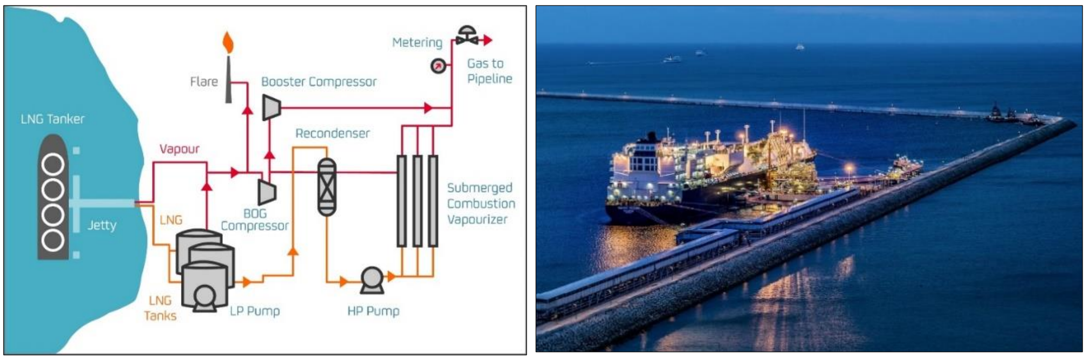


Figure 2 (Left)LNG Process (Right) LNG loading/unloading R [3]

2.1.1. Safety and accidents

Natural gas is a fuel and a combustible substance. To ensure safe and reliable operation, particular measures are taken in the design, construction and operation of LNG facilities. In maritime transport, the regulations for the use of LNG as a marine fuel are set out in the IGF Code.

In its liquid state, LNG is not explosive and cannot ignite. For LNG to burn, it must first vaporize, then mix with air in the proper proportions (the flammable range is 5 percent to 15 percent), and then be ignited. In the case of a leak, LNG vaporizes rapidly, turning into a gas (methane plus trace gases), and mixing with air. If this mixture is within the flammable range, there is risk of ignition, which would create fire and thermal radiation hazards.

3. LNG Quality

LNG quality is one of the most important issues in the LNG business. Any gas which does not conform to the agreed specifications in the sale and purchase agreement is regarded as "off-specification" (off-spec) or "off-quality" gas or LNG. Quality regulations serve three purposes:

- To ensure that the gas distributed is non-corrosive and non-toxic, below the upper limits for H_2S, total sulphur, CO_2 and Hg content
- To guard against the formation of liquids or hydrates in the networks, through maximum water and hydrocarbon dewpoints
- To allow interchangeability of the gases distributed, via limits on the variation range for parameters affecting combustion: content of inert gases, calorific value, wobbe index, Soot Index, Incomplete Combustion Factor, Yellow Tip Index, etc.

In the case of off-spec gas or LNG the buyer can refuse to accept the gas or LNG and the seller has to pay liquidated damages for the respective off-spec gas volumes.

Table 1 Upcoming emissions reduction measures (CCUS) in LNG projects (Source: Rystad Energy)

Market	Emissions Reduction Technology	Project	Project Capacity (MTPA)	CCUS Capacity (MTPA of CO_2)
Canada	Renewables-sourced electric drive	Woodfibre LNG	2.1	
Canada		Cedar FLNG	3.0	
Canada		Ksi Lisims FLNG	12.0	
Norway		Snohvit LNG	4.3	
UAE	Renewables/nuclear sourced electric drive	Ruwais LNG	9.6	
US	Electric drive	Freeport LNG Train 4	5.1	
US		Cameron Train 4	6.75	
Papua New Guinea		Papua LNG	4.0	
Australia	CCUS	Moomba	NA	1.7
Australia		Bonaparte (Ichthys)	8.9	2.0
Australia		Bayu Undan (Darwin)	3.7	10.0
Qatar		QatarEnergy LNG expansion	NA	7.0
Indonesia		Tangguh	11.4	2.7
Malaysia		Kasawari (MLNG)	29.3	3.7
Papua New Guinea		Elk-Antelope (Papua LNG)	4.0	1.0
US		Calcasieu Pass	10.0	0.5
US		Plaquemines	20.0	0.5
US		Calcasieu Pass 2	19.8	0.5
US		Rio Grande LNG	17.6	5.0
US		Cameron Train 4	6.75	2.0

The quality of gas or LNG is measured at delivery point by using an instrument such as a gas chromatograph. The most important gas quality concerns involve the sulphur and mercury content and the calorific value. Due to the sensitivity of liquefaction facilities to sulfur and mercury elements, the gas being sent to the liquefaction process shall be accurately refined and tested in order to assure the minimum possible concentration of these two elements before entering the liquefaction plant.

There are some methods to modify the heating value of produced LNG to the desired level. For the purpose of increasing the heating value, injecting propane and butane is a solution. For the purpose of decreasing heating value, nitrogen injecting and extracting butane and propane are proven solutions. Blending with gas or LNG can be a solution; however, all of these solutions while theoretically viable can be costly and logistically difficult to manage in large scale. Lean LNG price in terms of energy value is lower than the rich LNG price.

4. LNG Liquefaction Technology

There are several liquefaction processes available for large, baseload LNG plants (in order of prevalence).

- AP-C3MR – designed by Air Products & Chemicals, Inc. (APCI)
- Cascade – designed by ConocoPhillips
- AP-X – designed by Air Products & Chemicals, Inc. (APCI)
- AP-SMR (Single Mixed Refrigerant) – designed by Air Products & Chemicals, Inc. (APCI)
- AP-N (Nitrogen Refrigerant) – designed by Air Products & Chemicals, Inc. (APCI)
- MFC (mixed fluid cascade) – designed by Linde
- PRICO (SMR) – designed by Black & Veatch
- AP-DMR (Dual Mixed Refrigerant) – designed by Air Products & Chemicals, Inc. (APCI)
- Liquefin – designed by Air Liquide

As of January 2016, global nominal LNG liquefaction capacity was 301.5 MTPA (million tonnes per annum), with a further 142 MTPA under construction. A typical single train LNG plant may cost USD 1.5 billion and consume 6 to 8% of the inlet gas as fuel, R [3].

The majority of these trains use either APCI AP-C3MR or Cascade technology for the liquefaction process. The other processes used in a small minority of some liquefaction plants include Shell's DMR (double-mixed refrigerant) technology and the Linde technology.

5. LNG Pricing

5.1.1. There are three major pricing systems in the current LNG contracts:

- Oil indexed contract, used primarily in Japan, Korea, Taiwan and China
- Oil, oil products and other energy carriers indexed contracts, used primarily in Continental Europe and
- Market indexed contracts, used in the US and the UK.

5.1.2. The formula for an indexed price is as follows:

$$CP = BP + \beta X$$

BP: constant part or base price; β: gradient; X: Indexation

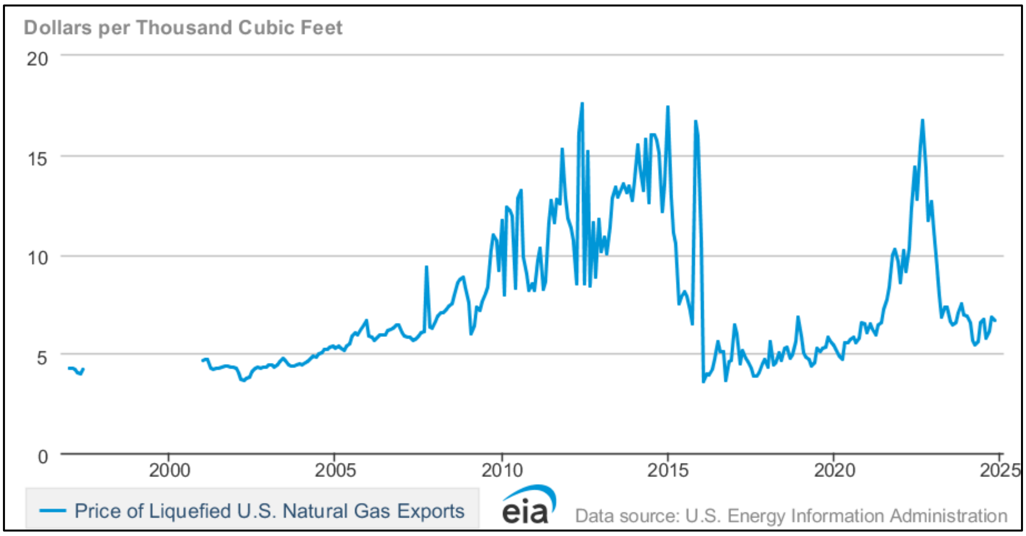


Figure 3 Price of LNG Exports

6. LNG Exports & Imports

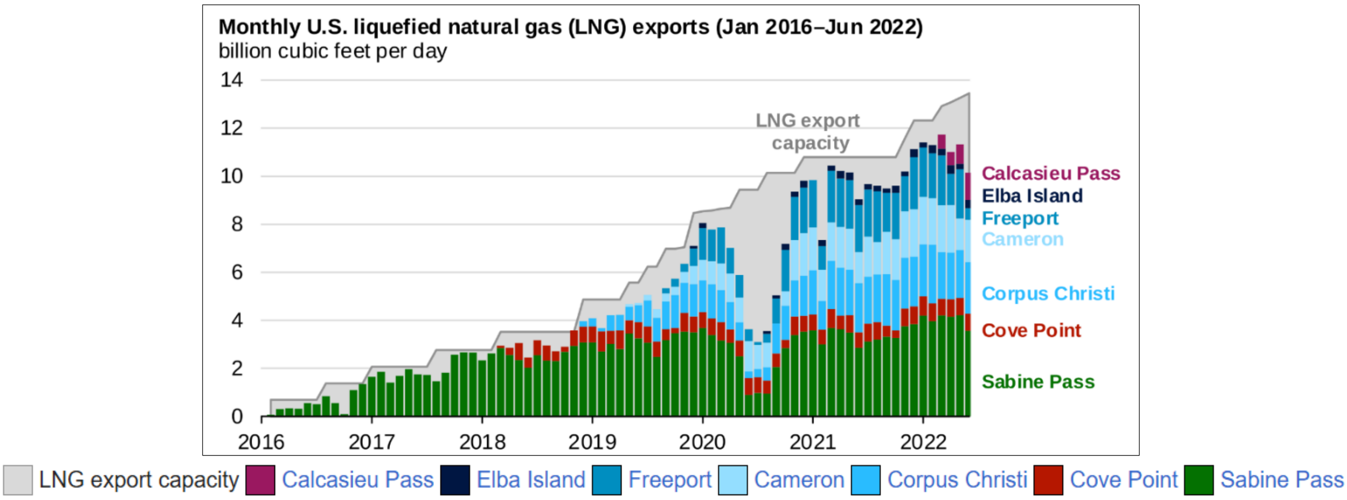


Figure 4 Natural gas capacity and exports R[3].

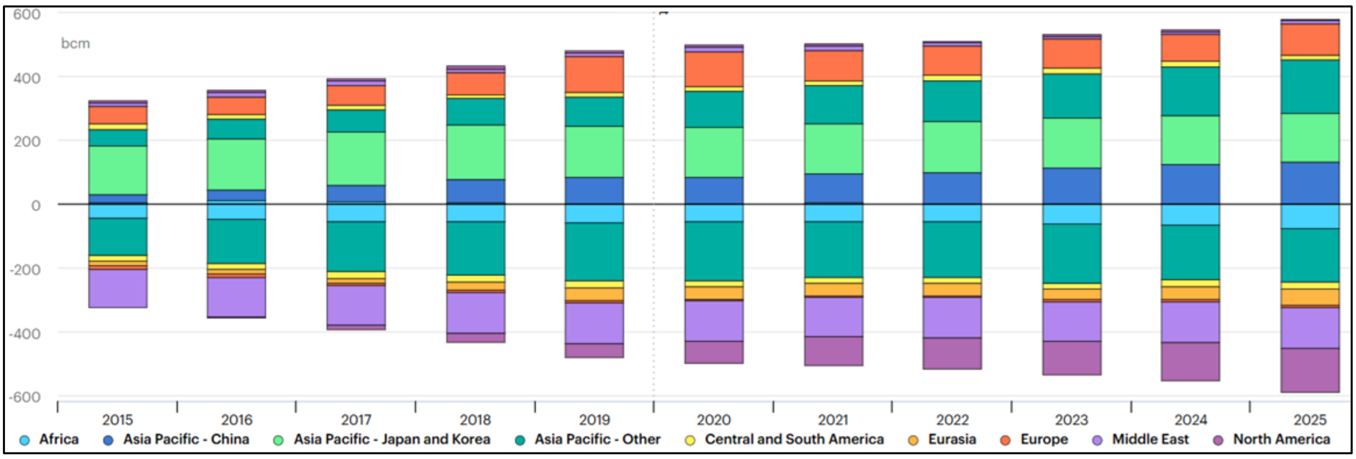


Figure 5 World LNG imports and exports by region 2015 – 2025 R[11].

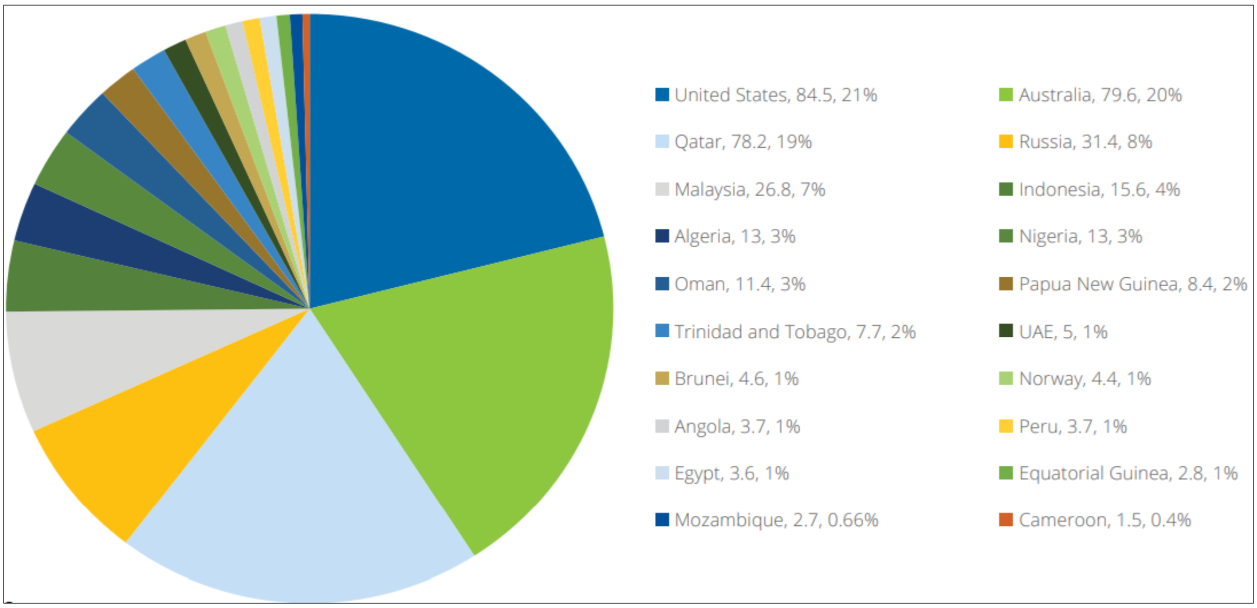


Figure 6 2023 LNG exports and market share by export market (MT) (Source: GIIGNL)

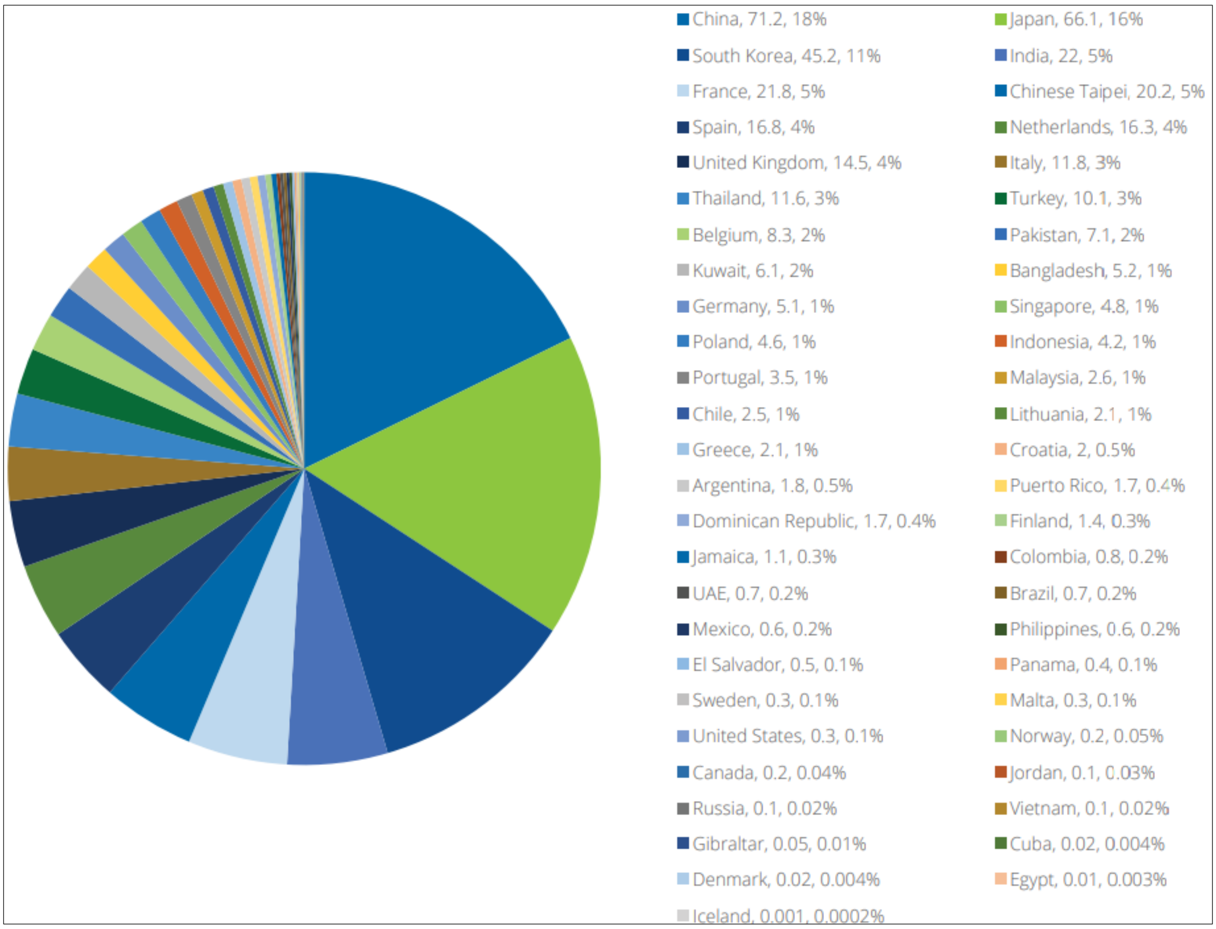


Figure 7 2023 LNG imports and market share by market (MT) (Source: GIIGNL).

7. LNG Trading

Global LNG trade hit a new record of 401.42 MT in 2023, connecting 20 exporting markets with 51 importing markets. 21 markets performed re-export re-loading in 2023. The 8.4 MT increase was influenced by a gradual decline in LNG prices, which incentivised spot market purchases particularly in Asia. The price reduction was influenced by Gas and LNG inventories remaining high following a warmer than expected 2022-2023 Winter. The annual growth rate of 2.1% in LNG trade for 2023 was lower than the 5.6% seen in 2022 *(www.wikipedia.org)*.

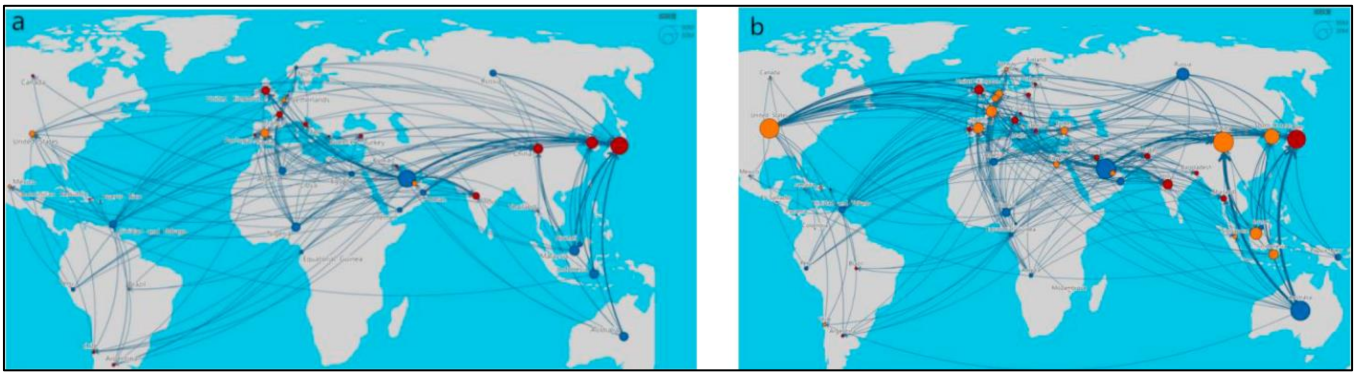
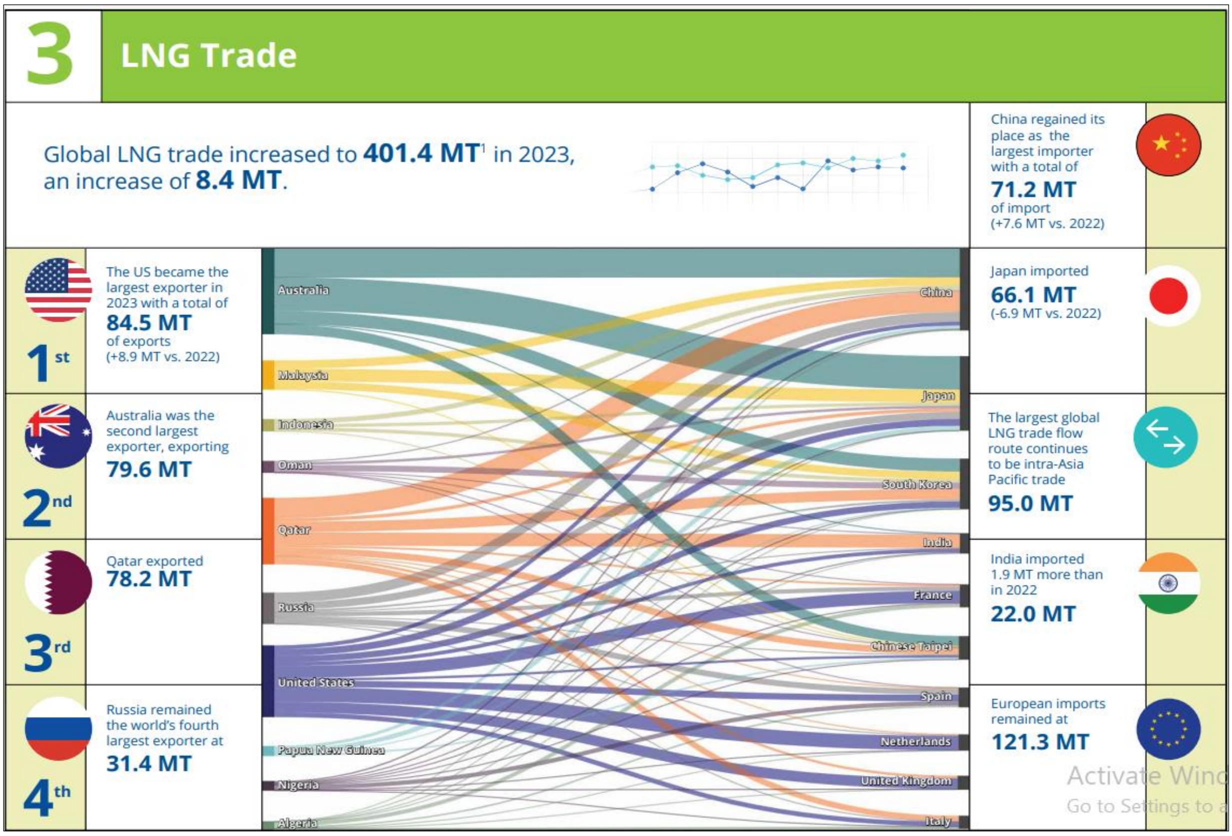


Figure 8 (a)Global LNG trade flows in 2011; (b)Global LNG trade flows in 2022 R [10]

Note: Blue: exporting countries, red: importing countries, orange: both importing and exporting; the larger the node, the larger the value of the degree



a)

Figure 9 Global LNG Trade R [7].

Table 2 Growth of LNG exports and imports

Global LNG trade	LNG exporters and importers	LNG re-exports
(+)8.40 MT Growth in global LNG trade	Growth in exports came from the US (+8.90 MT), Algeria (+2.88 MT) and Mozambique (+2.62 MT)	(+)0.71 MT Re-exported volumes increased by 10% year-on-year in 2023

Global LNG trade reached a new record of 401.42 MT in 2023, up 2.1% compared to 2022	There were 4 additional importing markets in 2023: Philippines, Vietnam, Iceland, and Cuba	Re-export activity increased to 7.97 MT in 2023 compared to 7.25 MT in 2022
Asia experienced the biggest change in net imports, increasing by 10.49 MT Europe net imports decreased by 0.02 MT	Europe decreased net imports by 0.02 MT. Utilisation rate of receiving terminals decreased to 54% due to addition of new terminals	Asia Pacific received the largest volume of re-exports (2.92 MT) while Europe loaded the largest volume of re-exports (-3.12 MT)
Asia Pacific remained the highest importing region, although there was a decrease in net imports of 3.47 MT		

8. Project 'LNG Abscissa'

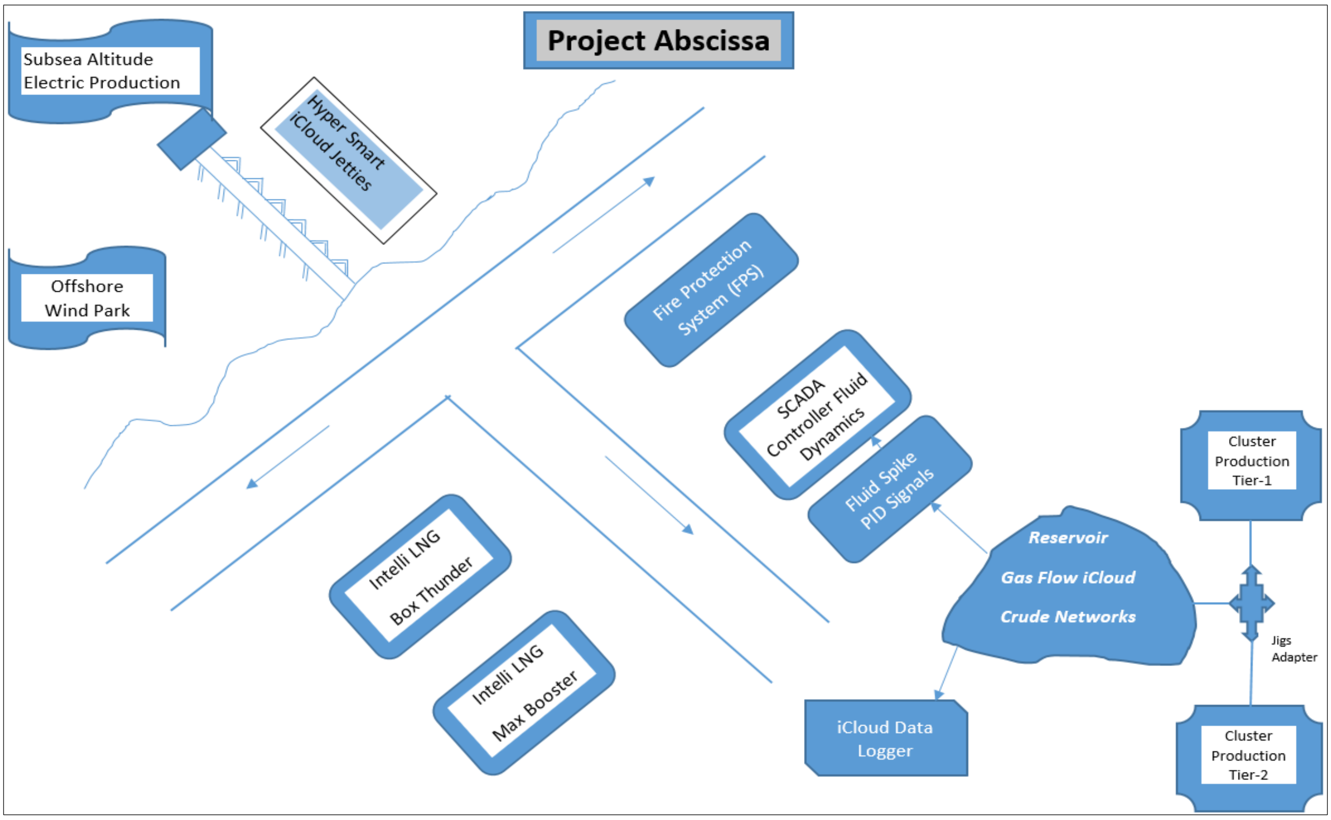


Figure 10 Concept Definition - LNG Abscissa

A new Super Giant Island reservoir – Gas flow iCloud Crude Networks is brought by Data loggers & SCADA controllers that will revisit LNG producers such as (i) Intelli LNG Max Booster and (ii) Intelli LNG Box Thunder. The LNG is further re-gasified to Natural Gas to feed Customers. However, as the World moves towards **net zero** carbon emissions and renewable energy sources, LNG may be the 'clean' fossil fuel that is best placed to help us transition to a carbon free future.

9. Conclusion

For 'LNG Abscissa' to become the energy source of REMARIS, the cost of the LNG chain has to be competitive with alternative fuel sources. The trend is towards large liquefaction trains and fit for purpose plants to reduce the capital cost of the liquefaction facilities. On the terminal side, there is a high level of interest in moving facilities offshore because of environmental and permitting issues. Several companies have proposed concepts for offshore storage and regasification terminals. Other areas of interest are integration of receiving terminals with facilities such as power plants or air separation units.

LNG is a mature industry and has established a niche for itself by matching remote gas supplies to markets that lack indigenous gas reserves. Currently, the majority of the LNG is not traded like a commodity. LNG trading requires coordination of principals in the production, export, shipping, and import segments of the trade. Hence as a result, long term contracts for LNG dominate the industry. The requirement for long-term (20 to 25 years) contracts is seen by some as a possible hurdle in the growth potential for LNG.

'LNG Abscissa' will come into existence once the proponent Investor debate for LNG sources of clean energy. Hence LNG Abscissa is discerned here to define the concept development and ready to go facility project. This author calls upon End User Investors to adopt the 'LNG Abscissa' license to premature the growing demand from transition to renewable and alternative fuels.

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