G I I G N L

LNG Quality and Compatibility

2012

Contents

ANNEXES

1. Background

During the GIIGNL Executive Committee meeting in Paris 1996, participants expressed an interest in providing a tool that would be useful for an LNG import company that is considering short-term purchases of LNG.

Since 2003, when the last report on LNG compatibility was issued, commercial operations have begun at several new LNG liquefaction facilities, including plants in Egypt, Russia and Indonesia. These developments provide an added incentive/justification for producing a new report on LNG Quality and Compatibility, containing up-to-date data for the global LNG market.

Following the General Assembly meeting in London in 2009, work began on the preparation of a new Report on LNG Quality and Compatibility, on behalf of GIIGNL TSG members.

This Report could not have been produced without a great deal of effort and support from members of the GIIGNL TSG, and in particular a lot of hard work by Yasushi Kuno of Tokyo Gas.

1.1 Long Term LNG Contracts

Although there is a trend in the LNG industry towards more short-term/spot trading of LNG cargos, currently the majority of LNG is bought by LNG import companies under long-term contracts with their suppliers. The ranges of acceptable quality/composition of the LNG supplied are specified in these contracts. It is then the responsibility of each LNG import company to supply its customers with gas that meets the required, or minimum, specification.

Each LNG Import Company has strict requirements on the composition of the natural gas it sends out of the receiving terminal, in order to ensure that the contractual specifications for pipeline gas quality are met (in terms of Wobbe, calorific value, quality of the combustion etc.)

LNG produced at a particular liquefaction facility can be significantly different in terms of composition/quality to the LNG from another facility. Hence for LNG import companies that receive LNG from more than one facility, the composition/quality of each cargo, and the scheduling of cargos, can be very important. In particular these factors are very significant for terminals that do not have facilities for adjusting LNG quality, such as nitrogen ballasting or enrichment by LPG injection.

1.2 Short Term LNG Contracts

Although it is a minority (currently approx 20%) of LNG cargos that are traded under short-term contracts, the proportion is increasing as the global LNG market develops.

For an LNG Import Company to purchase LNG under a short-term contract, the composition/quality of the cargo, and the impact that the cargo has on the ability of the facility to supply gas within the pipeline specification, are key factors. Hence before signing a short term contract, it is necessary for the importer to have the required data from the supplier and to be able to analyze the issue thoroughly.

Whereas long-term contracts generally specify LNG quality as DES (delivered ex ship), for short-term contracts, the LNG quality/properties specified in the contract may be FOB (free on board) i.e. title to the LNG cargo is transferred at the point of loading. The distinction between DES and FOB is important because of the phenomenon of 'ageing' or 'weathering', whereby the composition of LNG stored in a tank changes with time. Hence the LNG quality/composition at the loading port can be significantly different to that at the receiving terminal. Although commercial software is available that can predict the unloaded LNG quality (using loaded quality, voyage distance etc.), there is no recognized industry standard.

Ageing arises because LNG is a mixture of components with different vapour pressures, and because the majority of LNG carriers burn the boil off gas produced during a voyage, rather than re-condensing it back into the cargo. Ageing results in a decrease of the nitrogen content of the LNG and to a lesser extent a decrease in the methane content, thereby raising the proportions of other components in the LNG and making it richer. But if an LNG tanker (and on-shore LNG tankage) has facilities for recondensing the boil off gas, then the effect of ageing can be eliminated.

1.3 Objective of this Report

The objective of this Report is to gather LNG cargo/terminal data from import companies, to collate the data/information and produce a Report that contains information useful for GIIGNL members that are contemplating, or are interested in, importing LNG from a different source.

The LNG terminal data includes pipeline gas send out quality requirements/constraints.

The LNG cargo data includes the quality of the loaded LNG at the supplier's facility.

"Ageing" of an LNG cargo is presented as a function of unloaded LNG quality and as a function of voyage duration.

2. Collection and processing of information

The GIIGNL members that worked together on this LNG quality and compatibility study are Tokyo Gas, Enagas, Sempra, Shell and BP, with Tokyo Gas taking a lead role. A questionnaire was sent to each GIIGNL member, the questionnaire containing two parts:

- Pipeline gas send out quality requirements/constraints
- Quality of LNG imported by a terminal, by cargo

For both pipeline gas send out quality and LNG import quality, the data presented include molar compositions, Gross Calorific Value (GCV), Wobbe index and concentrations of impurities (sulphur components and carbon monoxide).

The LNG cargo data has been reported on the following basis:

- the quality data for the most recent cargo, if it is regular cargo with a quality that is within a relatively narrow band
- for unloaded cargos, maximum and minimum values over the previous two years.

The members were also asked to identify the route for the LNG ship, the transit distance and the duration of each voyage.

A copy of the questionnaire is provided in Annex 1.

A list of contributing GIIGNL members is provided in Annex 2.

3. Presentation of results

The results are presented in four tables, as Annexes 3, 4, 5 and 6:

Annex	Title
3	Limit requirements for send out
4	LNG composition at loading terminal
5	LNG composition and quality at receiving terminal
6	Extreme values noted in the cargos unloaded

Annex 3: Limit requirements for send out gas

This table lists the maximum and minimum allowable limits for the send out gas at that location, in terms of:

- molar composition of the gas
- GCV and the Wobbe index
- Impurities (H_2S, RSH(S), total Sulfur, CO)

Annex 4: LNG composition and quality at the loading terminal

For each loading plant, this table lists:

- Average, minimum and maximum molar fractions of the loaded LNG
- GCV and the Wobbe index - adjusted to normal conditions in accordance with ISO standard 6976:1995(E)
- Impurities (H_2S, RSH(S), total Sulfur, CO) - very little data available

Annex 5: LNG composition at the receiving terminal

This table includes the following data:

- the distance and duration of the ship's voyage between the supply loading plant and the receiving terminal
- the molar fraction of the LNG at the time of unloading as indicated by the receiving terminal (adjusted to 100% as required)
- the GCV and the Wobbe index - adjusted to normal conditions in accordance with ISO standard 6976:1995(E)
- Impurities (H_2S, RSH(S), and total Sulfur) - very little data available

Annex 6: Extreme values noted in the cargos unloaded.

- minimum and maximum values for molar composition and impurities of the LNG unloaded, by LNG source.

Information from contributors, if necessary, has been converted to International System of units (SI).

The calculations of the GCV and the Wobbe Index have been carried out at the normal conditions of 0°C/0°C (combustion/metering) and 101.325 kPa. LNG temperature and density have been calculated at a pressure of 10kPaG, considering the fact that it is stored in a tank.

To facilitate the exploitation of data, a table is provided (Annex 7) listing the conversion factors between the conventional units and SI units, plus the factors for GCV conversion to different combustion/metering reference conditions. The most commonly used reference conditions for LNG are as follows:

Country	Combustion Reference Temp	Metering Reference Temp
Japan	0°C	0°C
UK, Italy	15°C	15°C
France, Spain	25°C	0°C
USA	60°F	60°F

Values indicated by the unloading terminals are average values. They result in slight inconsistencies due to different methods in determining the data by the contributing members.

Figures in italics in the tables indicate values that have been calculated.

4. Exploitation of results to estimate the new route feasibility

The results/data presented in this Report will facilitate the assessment of the technical feasibility, in terms of LNG quality, for an LNG Receiving Terminal to take an LNG cargo from an LNG source that it has not previously used.

An example using the collected information can be found in the Annex 8.

5. Interpretation of results of inquiry

Limit requirements imposed for send out are similar no matter what the geographical zone is. Note that:

- the maximum content of nitrogen is limited to 1% in Asia but can reach as high as 5% in Europe and in the USA.
- the allowable gas GCV range is generally larger in Europe than in Asia.
- requirements relative to impurities are, at first glance, more numerous in Europe and America than in Asia (limited essentially to the total sulfur).
- There are few problems due to the presence of impurities in LNG.

Some characteristics of different LNG are seen. Note that:

Figure 1 and figure 2 show the average GCV and Wobbe Index of LNG at each Loading Terminal. For each new LNG project commissioned in the last few years, the average GCV at the loading point is in the range of GCVs for existing LNG plants. Based on average GCVs, LNG from Kenai, Alaska has the lowest GCV and LNG from Marsa El Brega, Libya has the highest GCV.

Figure 1: Average GCV at Loading Terminal

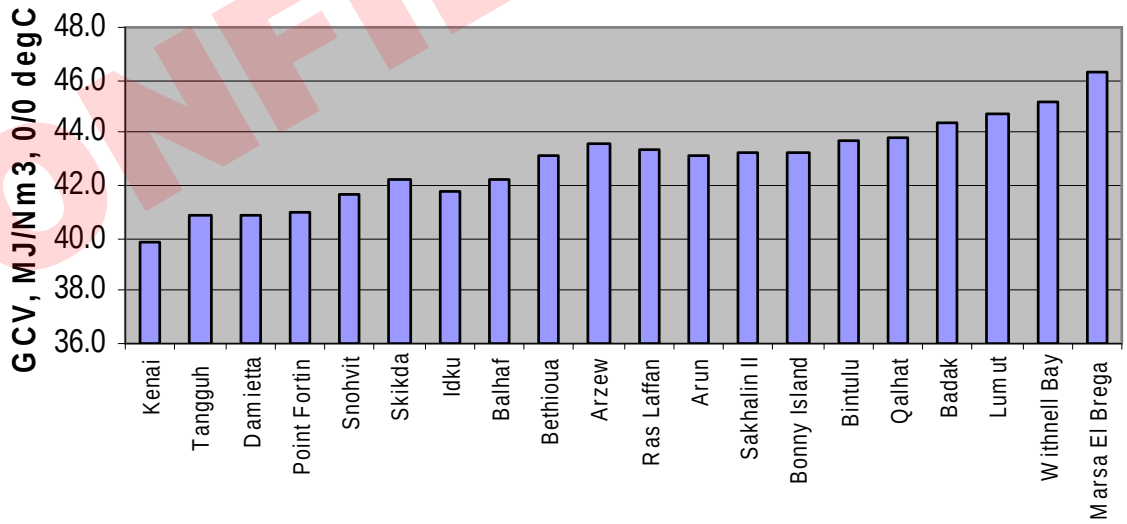


Figure 2: Average WI at Loading Terminal

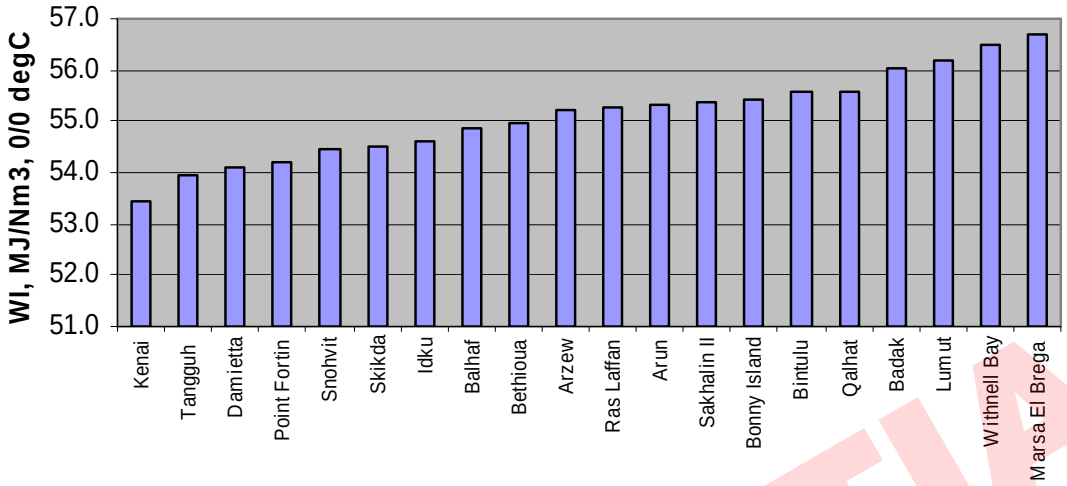


Figure 3 shows the correlation/spread between Wobbe Index and GCV for different sources of LNG.

Figure 3: WI vs GCV at Loading Terminal

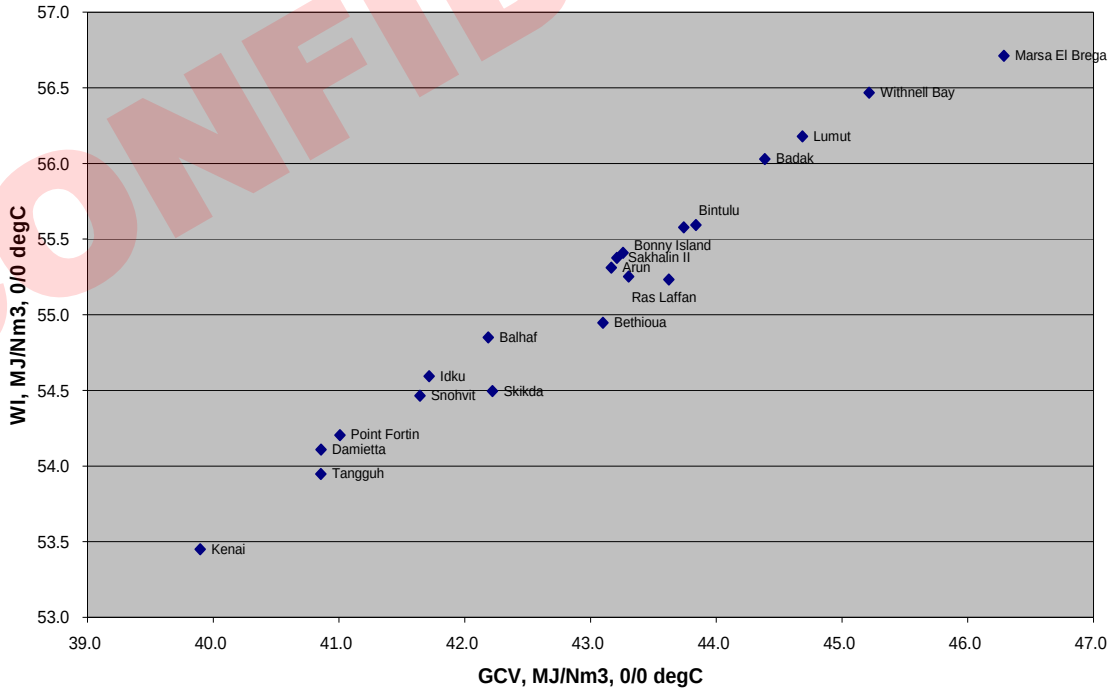


Figure 4 shows GCV against nitrogen content at the loading terminal. The difference between Libya (Marsa El Brega) and Algeria (Skikda, Bethioua, Arzew) arises from the high C2 content of Marsa El Brega raising its GCV. LNG from USA (Kenai) has been continuously even lower GCV than LNG from Egypt (Damietta) or Indonesia (Tangguh). LNG from Australia, Brunei, and Indonesia (Badak) all have a relatively low nitrogen content and a high GCV. Please refer to Annex 4 for the detailed Loading Terminal data.

Figure 5 also shows GCV against nitrogen content, but at the receiving terminal. As would be expected, Figure 5 (the receiving terminal) resembles Figure 4 (the loading terminal). The points in Figure 5 representing Qatar LNG cargos are spread over a relatively wide range. The fact that this range is relatively wide (min 0.09%, average 0.27%, max 0.59%) could be due to the wide range of distances over which the Qatar LNG is transported, in addition to other factors such as the range of nitrogen contents in the loaded Qatar cargos.

From Figures 4 and 5 is can be seen that the difference in GCVs for each LNG between loading terminal and receiving terminal is not very great. But it is necessary to pay attention to the difference/change in LNG density in a real operation. The GCV increases due to the phenomenon of “ageing”. The amount by which the GCV increases depends principally on the distance or the duration of the voyage. However it also depends on the LNG composition, the insulation capacity of the cargo tank, and BOG handling/management during the voyage. Please refer to Annex 5 for the detailed Receiving Terminal data.

Many companies have, or are developing, software to model the LNG aging process, thereby enabling the properties of an LNG cargo bound for a particular receiving terminal to be predicted, based on the LNG cargo composition/properties at the loading terminal, the length/route of the voyage and the design/operation of the LNG carrier. An example of such software is MOLAS, being developed by GERG with support from several companies - see Annex 9.

Figure 4: GCV vs N2 at Loading Terminal

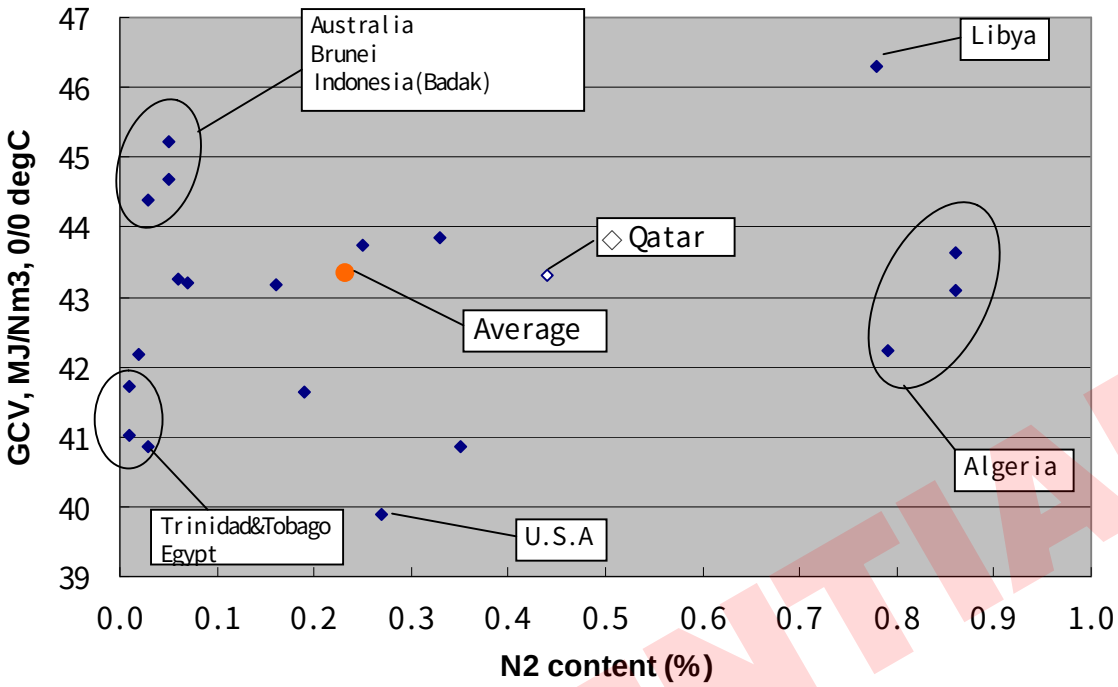
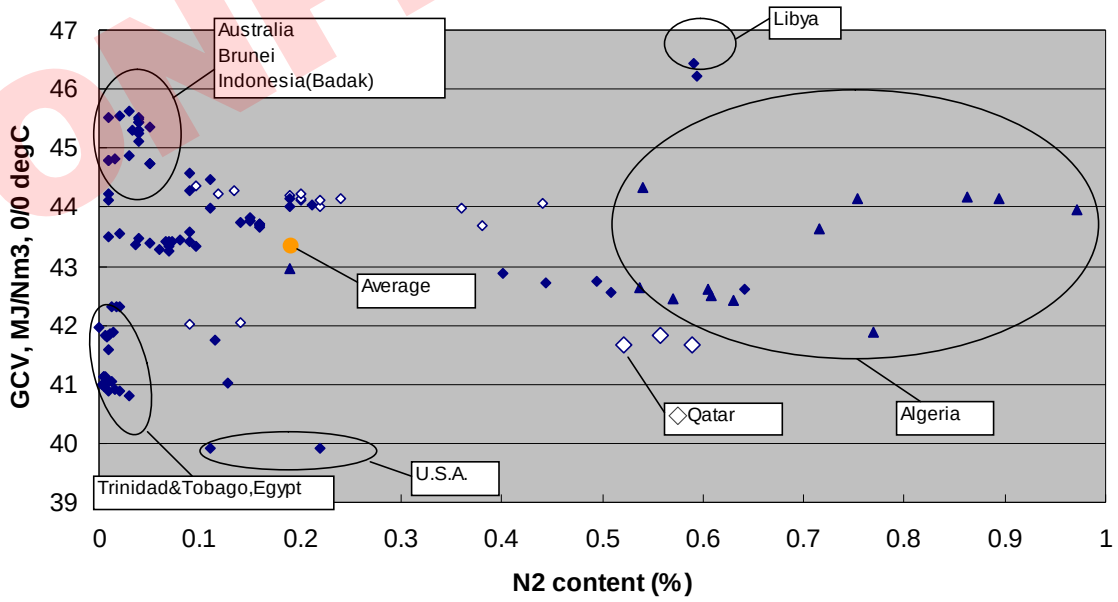


Figure 5: GCV vs N2 at Receiving Terminal



Figures 6 and 7 show GCV and Wobbe Index at Receiving Terminals, with indications of the max/average/min spread at each terminal. It is interesting to note that several of the LNG sources which generally have high nitrogen contents (including Algeria - Skikda, Bethioua, Arzew - and some Qatar cargos) are also those that show wider ranges between max/min GCV/WI at the receiving terminal.

Figure 6: GCV at Receiving Terminal

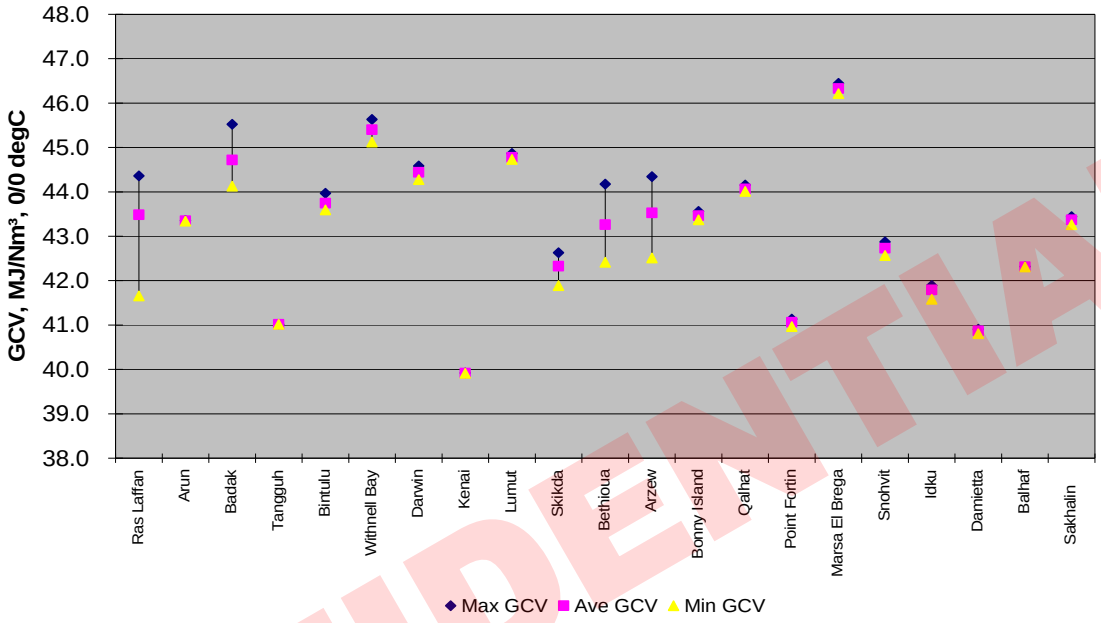
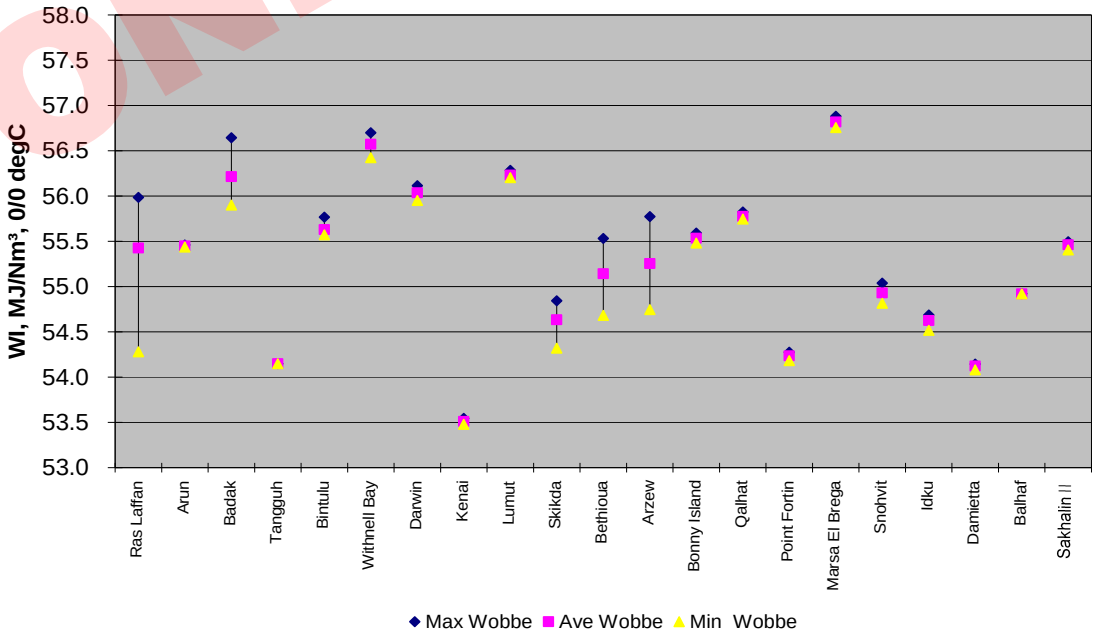


Figure 7: WI at Receiving Terminal



6. Conclusions

The gathering of this data and the production of this Report shows what can be achieved by the collaboration of the GIIGNL members. In total 30 companies were contacted, and of these 25 responded, covering 33 terminals. This participation allows us to provide all members with a useful and significant database/source of information about LNG quality and compatibility.

In this report the database is updated and the data for new LNG projects, such as Egypt and Russia, are added.

This study work/report has enabled GIIGNL to collate/tabulate limit requirements for send out gas at each receiving terminal.

It appears that according to send out requirements and to information on characteristics of unloaded LNG, there exists not only many new possible routes but also the possibility of exchanging cargoes between members.

Annex 1

Receiving Terminal	
LNG source(Project)	
Lording plant	

Distance between loading plant and receiving terminal*		nautical miles
Duration of the trip between loading plant and receiving terminal		days
Particular point(for ex. Suez)		

* refer to GIIGNL *"The LNG industry 2001"*

LNG Components and quality

Component	ISO unit	Last cargo characteristics if representative of the average cargo		Extreme values noted in the cargoes unloaded during the last two years	
		at loading plant	at receiving plant	Minimum	Maximum
Nitrogen - N2	%				
Oxygen -O2	%				
Carbon Dioxide -CO2	%				
Methane - C1	%				
Ethane - C2	%				
Propane - C3	%				
i-Butane - i-C4	%				
n-Butane - n-C4	%				
i-Pentane - i-C5	%				
n-Pentane - n-C5	%				
C6+	%				
Total					

Impurities

Hydrogen sulfide - H2S	mg/m3N				
Sulfur from mercaptans - RSH(S)	mg/m3N				
Carbonyl sulfide(COS)	mg/m3N				
Total Sulfur	mg/m3N				
Carbon Dioxide - CO2	mg/m3N				

m3N at normal conditions:101.325kPa and 0℃

Receiving Terminal	

NG Components and quality

Characteristic	ISO unit	Limit requirements		Comments
		Maximum	Minmum	
Nitrogen - N2	%			
Oxygen -O2	%			
Carbon Dioxide -CO2	%			
Methane - C1	%			
Ethane - C2	%			
Propane - C3	%			
i-Butane - i-C4	%			
n-Butane - n-C4	%			
i-Pentane - i-C5	%			
n-Pentane - n-C5	%			
C6+	%			
Calorific Value - Gas*	MJ/m3N			
Wobbe index - Gas*	MJ/m3N			
Others(to define)				

*m3N at normal conditions:101.325kPa and 0℃

Impurities

Characteristics	ISO unit	Limit requirements		Comments
		Maximum	Minmum	
Hydrogen sulfide - H2S	mg/m3N			
Sulfur from mercaptans - RSH(S)	mg/m3N			
Carbonyl sulfide(COS)	mg/m3N			
Total Sulfur	mg/m3N			
Carbon Dioxide - CO2	mg/m3N			
Carbon Monoxide - CO	mg/m3N			
Others (to define)				

m3N at normal conditions:101.325kPa and 0℃

Annex 2

List of GIIGNL members who replied to Questionnaire:

Company/Operator	Country
BG	UK
Dragon LNG	UK
National Grid	UK
Botas	Turkey
Enagas	Spain
Fluxys	Belgium
GNL Itaila	Italy
Cameron LNG	U.S.A.
Distrigas of Massachusetts	U.S.A.
GDF-Suez NA	U.S.A.
Sempra	U.S.A.
Southern LNG	U.S.A.
Energia Costa Azul	Mexico
GNLQ - Chile	Chile
Korea Gas Corporation	Korea
Petronet	India
Guangdong Dapeng LNG	China
Chubu Electric Power Company, Inc.	Japan
The Chugoku Electric Power Co., Inc.	Japan
Hiroshima Gas Co., Ltd.	Japan
Kyushu Electric Power Company, Inc.	Japan
Saibu Gas Co., Ltd.	Japan
Shizuoka Gas Co., Ltd.	Japan
Toho Gas Co., Ltd.	Japan
Tohoku Electric Power Company, Inc.	Japan
Tokyo Gas Company, Ltd.	Japan

Annex 3

Limit Requirements for send out gas

Country	Europe Spain	Europe Italy	Europe UK	Europe UK	Europe BELGIUM	Europe Turkey
Receiving Terminal	Barcelona, Huelva, Cartagena	Panigaglia	Dragon LNG	Grain LNG	Zeebrugge	Marmara Ereglisi
Operator	Enagas	GNL	Dragon LNG	Grain LNG	Zeebrugge	Botas

NG Components and quality

Characteristic	ISO unit	Limit requirements		Limit requirements		Limit requirements		Limit requirements		Limit requirements		Limit requirements	
		Maximum	Minmum	Maximum	Minmum	Maximum	Minmum	Maximum	Minimum	Maximum	Minmum	Maximum	Minmum
Nitrogen - N2	%					5.00		n/a	0			5.8	
Oxygen -O2	%	0.01		0.60		0.001		0.001	0	0.5		0.5	
Carbon Dioxyde -CO2	%	2.5		3.00		2.50		2	0	2		3	
Methane - C1	%					98.00	78.00	100	78				82
Ethane - C2	%					12.00	0.00	12	0			12	
Propane - C3	%					7.00	0.00	7	0			4	
i-Butane - i-C4	%					1.00	0.00	1	0			2.5	
n-Butane - n-C4	%					1.00	0.00	1	0				
i-Pentane - i-C5	%					0.35	0.00	0.35	0			1	
n-Pentane - n-C5	%					0.35	0.00	0.35	0				
GCV - Gas*	MJ/m3N	47.63	36.83	47.84	36.93	42.3 *3	36.9 *3	42.3	36.9	46.044	38.988	10427	8100
Wobbe index - Gas*	MJ/m3N	57.66	48.12	55.29	49.99	51.41 *3	47.2 *3	51.41	47.2	56.016	51.012	13000	10465
Relative Density	m3/m3	0.7	0.555										
Incomplete Combustion Factor - Gas*								0.48	-2				
Sooting Index - Gas*								0.60	0				

*m3N at normal conditions:101.325kPa and 0℃

*3: MJ/Sm3

*m3S at standard conditions:101.325kPa and 15℃

Impurities

Characteristics	ISO unit	Limit requirements		Limit requirements		Limit requirements		Limit requirements		Limit requirements		Limit requirements	
		Maximum	Minmum	Maximum	Minmum	Maximum	Minmum	Maximum	Minimum	Maximum	Minmum	Maximum	Minmum
Hydrogen sulfide - H2S	mg/m3N	15 *1		6.97		5.0mg/m3 *3		5	n/a	5 (*)		5.35	
Sulfur from mercaptans - RSH(S)	mg/m3N	17		16.37		NA	NA	n/a	n/a	6		16.07	
Carbonyl sulfide(COS)	mg/m3N							n/a	n/a	5 (*)			
Total Sulfer	mg/m3N	50		158.40		50mg/m3 *3		50	n/a	22.4		115.5	
Carbon Dioxyde - CO2	mg/m3N					NA	NA	2	n/a			3	
Carbon Monoxyde - CO	mg/m3N					NA	NA	n/a	n/a				
Others(to define)				Water dwe point: -5C° *2 Hydrocarbon dew point: 0C° *2									

m3N at normal conditions:101.325kPa and 0℃

*1: H2S+COS

*2: at 7000 kPa relative

*3: MJ/Sm3

*m3S at standard conditions:101.325kPa and 15℃

(*) Sum of H2S + COS should be lower than 5 mg/m³N

Limit Requirements for send out gas

Country	America U.S.A	America Mexco	America U.S.A	America U.S.A	America Chile
Receiving Terminal	Elba Island	Energia Costa Azul	Cameron LNG Co, LLC	Distrigas of Massachusetts	GNLQ - Quintero
Operator	Elpaso-Southern LNG	Energia Costa Azul	Cameron LNG Co, LLC	Distrigas of Massachusetts	GNLQ - Quintero

NG Components and quality

Characteristic	ISO unit	Limit requirements		Limit requirements *3		Limit requirements		Limit requirements		Limit requirements	
		Maximum	Minmum	Maximum	Minmum	Maximum	Minmum	Maximum	Minmum	Maximum	Minmum
Nitrogen - N2	%			5	-	3 *3		2.75	N/A	4.0	
Oxygen -O2	%			0.2	-	0.2		0.2	N/A	0.2	
Carbon Dioxyde -CO2	%			3	-	3 *3		2.0	N/A	2.0	
Methane - C1	%			-	-			N/A	N/A		
Ethane - C2	%			-	-			12*6	N/A		
Propane - C3	%			-	-			12*7	N/A		
i-Butane - i-C4	%			0.045	-			1.5*8	N/A		
n-Butane - n-C4	%			0.045	-			1.5*9	N/A		
i-Pentane - i-C5	%			0.045	-			1.5*10	N/A		
n-Pentane - n-C5	%			0.045	-			1.5	N/A		
GCV - Gas*	MJ/m3N	1075 BTU	1000 BTU	41.53	35.42	1100Btu/scf	980Btu/scf	44.5	38.8	42.635	36.995
Wobbe index - Gas*	MJ/m3N			50.6	45.8			56.2	52.7	52.125	47.235
Relative Density	m3/m3			112*4	-						
Incomplete Combustion Factor - Gas*											
Sooting Index - Gas*											

Combine non-hydrocarbon gasese cannot exceed 4%

*m3N at normal conditions:101.325kPa and 0℃

*3: NOM-001-SECRE-2003
*4: Humidity (H^2O)

*1:C2 + C3 not to exceed
*2:12% total
*3:i-C4 + n-C4 + i-C5 + n-C5
*4:not to exceed
*5:1.5 % total

Impurities

Characteristics	ISO unit	Limit requirements		Limit requirements *5		Limit requirements		Limit requirements		Limit requirements	
		Maximum	Minmum	Maximum	Minmum	Maximum	Minmum	Maximum	Minmum	Maximum	Minmum
Hydrogen sulfide - H2S	mg/m3N	Less than 10 grains		6.1	-	0.25 grains per 100 scf		5.75	N/A	5.7	
Sulfur from mercaptans - RSH(S)	mg/m3N			-	-			2.3	N/A		
Carbonyl sulfide(COS)	mg/m3N							N/A	N/A		
Total Sulfer	mg/m3N	Less than 200 grains		150	-	20 grains per 100 scf		30	N/A	35 max before, 65 max after odor	
Carbon Dioxyde - CO2	mg/m3N	Less than 3% by Volume		3	-			SEE ABOVE	N/A	2.0	
Carbon Monoxyde - CO	mg/m3N			-	-			N/A	N/A		
Others(to define)		Less than 1% by Volume		-	-	7 This is lbs of water vapor per MMscf					

m3N at normal conditions:101.325kPa and 0℃

SLNG's tariff does not Have Min and Max defined for these components

*5: NOM-001-SECRE-2003

Limit Requirements for send out gas

Country	Asia Korea	Asia India	Asia China	Asia Japan	Asia Japan	Asia Japan	Asia Japan
Receiving Terminal	PYOUNG-TAEK, IN-CHEON, TONG-YOUNG	Dahej, Gujarat (India)	Guangdong	Tobata,Oita	Niigata	Yanai	Mizushima
Operator	KOGAS	Petronet	Guangdong Dapeng LNG	KYUSHU ELECTRIC POWER COMPANY	Nihonkai LNG Co.,LTD	THE CHUGOKU ELECTRIC POWER	THE CHUGOKU ELECTRIC POWER

NG Components and quality

Characteristic	ISO unit	Limit requirements		Limit requirements		Limit requirements		Limit requirements		Limit requirements		Limit requirements		Limit requirements	
		Maximum	Minmum	Maximum	Minmum	Maximum	Minmum	Maximum	Minmum	Maximum	Minmum	Maximum	Minmum	Maximum	Minmum
Nitrogen - N2	%	-	-					—	—	0.17	0.92	1.00		1.00	
Oxygen -O2	%	-	-					—	—	0.00	0.00				
Carbon Dioxyde -CO2	%	-	-					—	—	0.00	0.00				
Methane - C1	%	-	85				84	—	—	91.07	95.79		84.00		84.00
Ethane - C2	%	-	-					—	—	5.91	2.45	8.00		8.00	
Propane - C3	%	-	-					—	—	2.17	0.60	3.00		3.00	
i-Butane - i-C4	%	-	-					—	—	0.32	0.12	2.5 *7		2.5 *7	
n-Butane - n-C4	%	-	-					—	—	0.35	0.12				
i-Pentane - i-C5	%	-	-					—	—	0.01	0.00	0.1 *8		0.1 *8	
n-Pentane - n-C5	%	-	-					—	—	0.00	0.00				
GCV - Gas*	MJ/m3N	-	42.28			46.61 *6	40.38 *6			43.63	40.89	46.38	42.05	46.38	42.05
Wobbe index - Gas*	MJ/m3N	57.78	52.75			57	53.3								
Relative Density	m3/m3														
Incomplete Combustion Factor - Gas*															
Sooting Index - Gas*															

*m3N at normal conditions:101.325kPa and 0℃

*6: Superior heating value

*6: Butane & heavier
*7: Pentane & heavier

Impurities

Characteristics	ISO unit	Limit requirements		Limit requirements		Limit requirements		Limit requirements		Limit requirements		Limit requirements		Limit requirements	
		Maximum	Minmum	Maximum	Minmum	Maximum	Minmum	Maximum	Minmum	Maximum	Minmum	Maximum	Minmum	Maximum	Minmum
Hydrogen sulfide - H2S	mg/m3N	6	-			5.28	N/A	—	—	—	—	5.00		5.00	
Sulfur from mercaptans - RSH(S)	mg/m3N	-	-			N/A		—	—						
Carbonyl sulfide(COS)	mg/m3N	-	-			N/A		—	—						
Total Sulfer	mg/m3N	40	-			31.66	N/A	—	—	N.D	N.D	30.00		30.00	
Carbon Dioxyde - CO2	mg/m3N	-	-			N/A		—	—						
Carbon Monoxyde - CO	mg/m3N	-	-			N/A		—	—						
Others(to define)		-				Particulates		—	—						

m3N at normal conditions:101.325kPa and 0℃

KOREA' Standard Heating Value system (present)
-Standard Heating Value: 43.54 MJ/mN
* Monthly Average Heating Value of gas should be sustained more than 10,400 kcal/Nm3.
-KOGAS take responsibility for Standard Heating

Limit Requirements for send out gas

Country	Asia Japan	Asia Japan	Asia Japan	Asia Japan	Asia Japan	Asia Japan	Asia Japan
Receiving Terminal	Chita, Kawagoe, Yokkaichi	Nagasaki	Fukuoka	Hatsukaichi	Sodeshi	Chita, Yokkaichi	Negishi Sodegaura Ohgishima
Operator	CHUBU ELECTRIC POWER COMPANY	SAIBU GAS	SAIBU GAS	HIROSHIMA GAS	SHIZUOKA GAS	TOHO GAS	TOKYO GAS

NG Components and quality

Characteristic	ISO unit	Limit requirements		Limit requirements		Limit requirements		Limit requirements		Limit requirements		Limit requirements		Limit requirements	
		Maximum	Minmum	Maximum	Minmum	Maximum	Minmum	Maximum	Minmum	Maximum	Minimum	Maximum	Minmum	Maximum	Minmum
Nitrogen - N2	%			1.00	0.00	1.00	0.00								
Oxygen -O2	%			—	—	—	—								
Carbon Dioxyde -CO2	%			—	—	—	—								
Methane - C1	%			92.00	86.00	92.00	86.00								
Ethane - C2	%														
Propane - C3	%														
i-Butane - i-C4	%			15.00	8.00	15.00	8.00								
n-Butane - n-C4	%														
i-Pentane - i-C5	%														
n-Pentane - n-C5	%														
GCV - Gas*	MJ/m3N			46.47	45.63	46.47	45.63		44.4		44	46.16	45.96	46	44.2
Wobbe index - Gas*	MJ/m3N			57.7	55.7	57.7	55.7	57.8	52.7	57.8	52.7	56.97	56.82	56.97	56.82
Relative Density	m3/m3			38	36	38	36								
Incomplete Combustion Factor - Gas*															
Sooting Index - Gas*															

*m3N at normal conditions:101.325kPa and 0℃

Impurities

Characteristics	ISO unit	Limit requirements		Limit requirements		Limit requirements		Limit requirements		Limit requirements		Limit requirements		Limit requirements	
		Maximum	Minmum	Maximum	Minmum	Maximum	Minmum	Maximum	Minmum	Maximum	Minmum	Maximum	Minmum	Maximum	Minmum
Hydrogen sulfide - H2S	mg/m3N			—	—	—	—								
Sulfur from mercaptans - RSH(S)	mg/m3N			—	—	—	—							1	
Carbonyl sulfide(COS)	mg/m3N			—	—	—	—								
Total Sulfer	mg/m3N			9	—	9	—							10	
Carbon Dioxyde - CO2	mg/m3N			—	—	—	—								
Carbon Monoxyde - CO	mg/m3N			—	—	—	—								
Others(to define)															

m3N at normal conditions:101.325kPa and 0℃

Annex 4

The average composition is chosen as being representative among composition provided by GIIGNL Members
Figures in shaded cells are calculated

Loading plant country		Qatar			Indonesia			Indonesia			Indonesia		
Loading plant		Ras Laffan			Arun			Badak			Tangguh		
Characteristic	ISO unit	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.
Nitrogen - N2	%	0.44	0.27	0.88	0.16	0.14	0.18	0.03	0.01	0.18	0.35	0.35	0.35
Oxygen -O2	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carbon Dioxyde -CO2	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methane - C1	%	91.04	90.05	93.27	92.13	92.09	92.16	90.64	89.00	92.16	96.88	96.88	96.88
Ethane - C2	%	6.16	5.91	6.55	5.44	5.42	5.46	5.33	5.10	5.51	2.21	2.21	2.21
Propane - C3	%	1.64	0.05	2.21	1.52	1.50	1.55	2.76	1.50	3.88	0.42	0.42	0.42
i-Butane - i-C4	%	0.28	0.00	0.39	0.35	0.35	0.36	0.63	0.35	0.83	0.07	0.07	0.07
n-Butane - n-C4	%	0.42	0.00	0.59	0.37	0.37	0.37	0.61	0.37	0.87	0.07	0.07	0.07
i-Pentane - i-C5	%	0.01	0.00	0.03	0.03	0.02	0.03	0.00	0.00	0.02	0.00	0.00	0.00
n-Pentane - n-C5	%	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C6+	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	%	99.99			100.00			100.00			100.00		
GCV on a mass basis	kJ/kg	*54.528*			*54.817*			*54.702*			*55.096*		
GCV on a volumetric basis	MJ/m3N	*43.302*			*43.165*			*44.386*			*40.856*		
Wobbe index - Gas*	MJ/m3N	*55.252*			*55.311*			*56.029*			*53.947*		

*m3N at normal conditions:101.325kPa and 0℃
** satarated temperature and density at 10kPaG

Impurities

Hydrogen sulfide - H2S	mg/m3N	0.00			0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00
Sulfur from mercaptans-RSH(S)	mg/m3N	0.00			0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00
Carbonyl sulfide(COS)	mg/m3N	0.00			0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00
Total Sulfer	mg/m3N	0.00			0.00	0.00	0.00	0.01	0.00	0.02		0.00	0.00
Carbon Dioxide - CO2	mg/m3N	0.00			0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00

m3N at normal conditions:101.325kPa and 0℃

The average composition is chosen as being representative among composition provided by GIIGNL Members
Figures in shaded cells are calculated

Loading plant country		Malaysia			Australia			U.S.A.			Brunei		
Loading plant		Bintulu			Withnell Bay			Kenai			Lumut		
Characteristic	ISO unit	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.
Nitrogen - N2	%	0.25	0.21	0.27	0.05	0.05	0.06	0.27	0.18	0.36	0.05	0.05	0.05
Oxygen -O2	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carbon Dioxyde -CO2	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methane - C1	%	91.54	90.24	92.44	87.76	87.40	88.34	99.58	99.46	99.73	90.28	90.27	90.29
Ethane - C2	%	4.62	4.18	5.25	8.01	7.72	8.17	0.10	0.08	0.12	5.27	5.24	5.29
Propane - C3	%	2.64	2.31	3.12	3.24	3.00	3.42	0.03	0.01	0.04	2.95	2.94	2.96
i-Butane - i-C4	%	0.52	0.43	0.65	0.40	0.37	0.41	0.01	0.00	0.01	0.61	0.61	0.62
n-Butane - n-C4	%	0.42	0.36	0.51	0.52	0.49	0.54	0.01	0.00	0.01	0.80	0.79	0.81
i-Pentane - i-C5	%	0.01	0.00	0.02	0.02	0.02	0.04	0.00	0.00	0.00	0.03	0.03	0.03
n-Pentane - n-C5	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
C6+	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	%	100.00			100.00			100.00			100.00		
GCV on a mass basis	kJ/kg	*54.617*			*54.544*			*55.385*			*54.627*		
GCV on a volumetric basis	MJ/m3N	*43.742*			*45.215*			*39.895*			*44.686*		
Wobbe index - Gas*	MJ/m3N	*55.577*			*56.468*			*53.449*			*56.179*		

*m3N at normal conditions:101.325kPa and 0°C
** satarated temperature and density at 10kPaG

Impurities

Hydrogen sulfide - H2S	mg/m3N	0.00			0.00			0.00			0.00		
Sulfur from mercaptans-RSH(S)	mg/m3N	0.00			0.00						0.00		
Carbonyl sulfide(COS)	mg/m3N	0.00			0.00						0.00		
Total Sulfer	mg/m3N	0.00			0.00			0.09			0.00		
Carbon Dioxide - CO2	mg/m3N	0.00			0.00						0.00		

m3N at normal conditions:101.325kPa and 0°C

The average composition is chosen as being representative among composition provided by GIIGNL Members
Figures in shaded cells are calculated

Loading plant country		Algeria			Algeria			Algeria			Nigeria		
Loading plant		Skikda			Bethioua			Arzew			Bonny Island		
Characteristic	ISO unit	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.
Nitrogen - N2	%	0.79	0.65	0.88	0.86	0.74	1.02	0.86	0.84	1.06	0.06	0.06	0.07
Oxygen -O2	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carbon Dioxyde -CO2	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methane - C1	%	91.32	90.39	92.45	89.53	87.73	90.84	88.54	87.75	90.53	92.10	91.94	92.35
Ethane - C2	%	7.29	6.03	8.30	8.04	7.75	8.52	8.41	7.75	8.36	5.26	5.02	5.41
Propane - C3	%	0.56	0.52	0.60	1.26	0.54	2.13	1.75	0.87	2.11	2.05	2.03	2.05
i-Butane - i-C4	%	0.02	0.00	0.03	0.13	0.00	0.31	0.19	0.01	0.30	0.29	0.28	0.29
n-Butane - n-C4	%	0.02	0.00	0.04	0.18	0.00	0.45	0.24	0.00	0.43	0.24	0.24	0.25
i-Pentane - i-C5	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
n-Pentane - n-C5	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C6+	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
Total	%	100.00			100.00			99.99			100.00		
GCV on a mass basis	kJ/kg	*54.406*			*54.181*			*54.090*			*54.895*		
GCV on a volumetric basis	MJ/m3N	*42.220*			*43.099*			*43.623*			*43.259*		
Wobbe index - Gas*	MJ/m3N	*54.496*			*54.946*			*55.233*			*55.410*		

*m3N at normal conditions:101.325kPa and 0°C
** satarated temperature and density at 10kPaG

Impurities

Hydrogen sulfide - H2S	mg/m3N				0.00			0.00			0.00		
Sulfur from mercaptans-RSH(S)	mg/m3N							0.00			0.00		
Carbonyl sulfide(COS)	mg/m3N							0.00			0.00		
Total Sulfer	mg/m3N				0.00			0.00			0.00		
Carbon Dioxide - CO2	mg/m3N							0.00			0.00		

m3N at normal conditions:101.325kPa and 0°C

The average composition is chosen as being representative among composition provided by GIIGNL Members
Figures in shaded cells are calculated

Loading plant country		Oman			Trinidad & Tobago			Libya			Norway		
Loading plant		Qalhat			Point Fortin			MARSA EL BREGA			SNOHVIT		
Characteristic	ISO unit	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.
Nitrogen - N2	%	0.33	0.31	0.35	0.01	0.01	0.02	0.78	0.75	0.81	0.19	0.01	0.55
Oxygen -O2	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carbon Dioxyde -CO2	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methane - C1	%	90.91	90.82	91.02	96.93	96.70	97.27	82.39	82.19	82.59	95.09	91.43	96.97
Ethane - C2	%	5.56	5.52	5.60	2.64	2.31	2.83	12.56	12.34	12.77	3.81	2.62	6.09
Propane - C3	%	2.01	1.96	2.06	0.37	0.34	0.42	3.56	3.55	3.56	0.70	0.34	1.41
i-Butane - i-C4	%	0.64	0.64	0.64	0.03	0.03	0.03	0.32	0.31	0.33	0.06	0.03	0.11
n-Butane - n-C4	%	0.53	0.53	0.54	0.02	0.02	0.02	0.38	0.36	0.41	0.15	0.02	0.42
i-Pentane - i-C5	%	0.02	0.02	0.03	0.00	0.00	0.01	0.01	0.01	0.02	0.00	0.00	0.01
n-Pentane - n-C5	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
C6+	%							0.00	0.00	0.00	0.00	0.00	0.00
Total	%	100.00			100.00			100.00			100.00		
GCV on a mass basis	kJ/kg	*54.526*			*55.413*			*53.742*			*55.095*		
GCV on a volumetric basis	MJ/m3N	*43.839*			*41.008*			*46.287*			*41.643*		
Wobbe index - Gas*	MJ/m3N	*55.592*			*54.203*			*56.712*			*54.465*		

*m3N at normal conditions:101.325kPa and 0°C
** satarated temperature and density at 10kPaG

Impurities

Hydrogen sulfide - H2S	mg/m3N	0.00			0.00								
Sulfur from mercaptans-RSH(S)	mg/m3N	0.00			0.00								
Carbonyl sulfide(COS)	mg/m3N	0.00			0.00								
Total Sulfer	mg/m3N	0.00			0.39								
Carbon Dioxide - CO2	mg/m3N	0.00			0.00								

m3N at normal conditions:101.325kPa and 0°C

The average composition is chosen as being representative among composition provided by GIIGNL Members
Figures in shaded cells are calculated

Loading plant country		Egypt			Egypt			YEMAN			Rossiya		
Loading plant		IDKU			Damietta			Balhaf			Sakhalin II		
Characteristic	ISO unit	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.
Nitrogen - N2	%	0.01	0.01	0.02	0.03	0.03	0.03	0.02	0.01	0.04	0.07	0.07	0.08
Oxygen -O2	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carbon Dioxyde -CO2	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methane - C1	%	95.49	94.29	96.68	97.34	97.27	97.41	93.45	93.17	93.73	92.77	92.50	93.18
Ethane - C2	%	3.49	2.31	5.44	2.38	2.28	2.50	5.72	5.50	5.95	4.42	4.28	4.51
Propane - C3	%	0.69	0.19	0.84	0.12	0.08	0.19	0.71	0.66	0.76	1.88	1.68	2.00
i-Butane - i-C4	%	0.17	0.04	0.21	0.06	0.05	0.07	0.04	0.04	0.05	0.39	0.35	0.43
n-Butane - n-C4	%	0.14	0.03	0.18	0.03	0.02	0.04	0.05	0.04	0.07	0.45	0.41	0.50
i-Pentane - i-C5	%	0.01	0.00	0.03	0.01	0.00	0.04	0.00	0.00	0.00	0.02	0.00	0.04
n-Pentane - n-C5	%	0.00	0.00	0.01	0.03	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.01
C6+	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	%	100.00			100.00			99.99			100.00		
GCV on a mass basis	kJ/kg	*55.258*			*55.424*			*55.158*			*54.890*		
GCV on a volumetric basis	MJ/m3N	*41.717*			*40.857*			*42.187*			*43.209*		
Wobbe index - Gas*	MJ/m3N	*54.593*			*54.109*			*54.850*			*55.376*		

*m3N at normal conditions:101.325kPa and 0℃
** satarated temperature and density at 10kPaG

Impurities

Hydrogen sulfide - H2S	mg/m3N	0.00			0.00			0.00			0.1ppm		
Sulfur from mercaptans-RSH(S)	mg/m3N	0.00			0.00			0.00			0.15ppm		
Carbonyl sulfide(COS)	mg/m3N	0.00			0.00			0.00			0.00		
Total Sulfer	mg/m3N	0.00			0.00			0.00			0.05ppm		
Carbon Dioxide - CO2	mg/m3N	0.00			0.00			0.00			0.00		

m3N at normal conditions:101.325kPa and 0℃

Annex 5

Loading plant country		Qatar	Qatar	Qatar	Qatar	Qatar	Qatar	Qatar	Qatar	Qatar	Qatar	Qatar
Loading plant		Ras Laffan	Ras Laffan	Ras Laffan	Ras Laffan	Ras Laffan	Ras Laffan	Ras Laffan	Ras Laffan	Ras Laffan	Ras Laffan	Ras Laffan
Distance between loading plant and receiving plant (Km)		1,210	6,548	6,576	6,568	6,259	6,428	6,446	6,446	6,594	6,304	6277
Duration of the trip between loading plant and receiving terminal (days)		3	15	15	15	15	15	14	14	13	15	16
Receiving terminal region		Asia	Asia	Asia	Asia	Asia	Asia	Asia	Asia	Asia	Asia	Europe
Characteristic	ISO unit											
Nitrogen - N2	%	0.440	0.220	0.220	0.200	0.240	0.200	0.360	0.140	0.200	0.381	0.558
Oxygen -O2	%	0.000	0.000	0.000	0.010	0.000	0.100	0.000	0.000	0.010	0.000	0.000
Carbon Dioxyde -CO2	%	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Methane - C1	%	89.820	90.140	90.390	90.130	90.110	90.100	90.170	92.890	90.250	90.540	92.777
Ethane - C2	%	6.480	6.370	6.200	6.380	6.300	6.380	6.310	6.830	6.270	6.319	6.435
Propane - C3	%	2.240	2.260	2.170	2.250	2.330	2.290	2.150	0.120	2.210	1.882	0.226
i-Butane - i-C4	%	0.400	0.400	0.400	0.410	0.400	0.410	0.380	0.010	0.410	0.337	0.002
n-Butane - n-C4	%	0.590	0.600	0.600	0.610	0.600	0.600	0.600	0.010	0.620	0.513	0.002
i-Pentane - i-C5	%	0.030	0.010	0.020	0.010	0.020	0.100	0.020	0.000	0.020	0.022	0.001
n-Pentane - n-C5	%	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.000	0.010	0.008	0.000
C6+	%	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	%	100.00	100.00	100.00	100.00	100.00	100.18	100.00	100.00	100.00	100.00	100.00

GCV on a mass basis	kJ/kg	*54.389*	*54.583*	*54.600*	*54.587*	*54.559*	*54.477*	*54.478*	*55.072*	*54.591*	*54.513*	*54.706*
GCV on a volumetric basis	MJ/m3N	*44.061*	*44.112*	*44.018*	*44.132*	*44.138*	*44.217*	*43.978*	*42.052*	*44.109*	*43.686*	*41.815*
Wobbe index - Gas*	MJ/m3N	*55.663*	*55.794*	*55.743*	*55.809*	*55.799*	*55.806*	*55.656*	*54.720*	*55.796*	*55.488*	*54.384*

*m3N at normal conditions:101.325kPa and 0℃
** saturated temperature and density at 10kPaG

Impurities

Hydrogen sulfide - H2S	mg/m3N	0.00	N/d	0.00	N/d	0.00	0.00	0.00	0.00	–	0.00	0.00
Sulfur from mercaptans - RSH(S)	mg/m3N	0.00	0.00	0.00	–	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carbonyl sulfide(COS)	mg/m3N	0.00	0.00	0.00	–	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Sulfur	mg/m3N	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	N.D	0.00	0.00
Carbon Dioxide - CO2	mg/m3N	0.00	0.00	0.00	–	0.00	0.00	0.00	0.00	0.00	0.00	0.00

m3N at normal conditions:101.325kPa and 0℃

Loading plant country		Qatar	Qatar	Qatar	Qatar	Qatar	Qatar	Qatar	Indonesia	Indonesia	Indonesia	Indonesia
Loading plant		Ras Laffan	Ras Laffan	Ras Laffan	Ras Laffan	Ras Laffan	Ras Laffan	Ras Laffan	Arun	Arun	Badak	Badak
Distance between loading plant and receiving plant (Km)		8,301	8,673	8,866	9,687	9,527		10,931	3129	3,582	2,560	2,200
Duration of the trip between loading plant and receiving terminal (days)		15	15	15	25	15		29	8	8	6	7
Receiving terminal region		Europe	Europe	Europe	America	Europe	Europe	America	Asia	Asia	Asia	Asia
Characteristic	ISO unit											
Nitrogen - N2	%	0.119	0.134	0.189	0.522	0.096	0.590	0.090	0.097	0.070	0.010	0.010
Oxygen -O2	%	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Carbon Dioxyde -CO2	%	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Methane - C1	%	90.051	89.972	89.904	93.202	89.800	93.118	93.031	91.896	91.830	89.000	90.720
Ethane - C2	%	6.484	6.514	6.600	6.165	6.657	6.178	6.819	5.598	5.730	5.420	5.510
Propane - C3	%	2.324	2.328	2.332	0.109	2.439	0.094	0.057	1.611	1.580	3.880	2.730
i-Butane - i-C4	%	0.406	0.415	0.389	0.001	0.399	0.007	0.001	0.373	0.370	0.820	0.550
n-Butane - n-C4	%	0.603	0.616	0.578	0.002	0.588	0.011	0.001	0.388	0.400	0.870	0.480
i-Pentane - i-C5	%	0.012	0.017	0.008	0.000	0.019	0.000	0.000	0.032	0.020	0.000	0.000
n-Pentane - n-C5	%	0.001	0.004	0.000	0.000	0.001	0.000	0.000	0.004	0.000	0.000	0.000
C6+	%	0.000	0.000	0.000	0.000	0.001	0.002	0.000	0.000	0.000	0.000	0.000
Total	%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

GCV on a mass basis	kJ/kg	*54.654*	*54.633*	*54.596*	*54.769*	*54.653*	*54.706*	*55.130*	*54.843*	*54.866*	*54.511*	*54.751*
GCV on a volumetric basis	MJ/m3N	*44.238*	*44.275*	*44.205*	*41.674*	*44.359*	*41.657*	*42.013*	*43.341*	*43.360*	*45.524*	*44.235*
Wobbe index - Gas*	MJ/m3N	*55.910*	*55.923*	*55.860*	*54.323*	*55.986*	*54.281*	*54.723*	*55.436*	*55.460*	*56.643*	*55.958*

*m3N at normal conditions:101.325kPa and 0℃
** saturated temperature and density at 10kPaG

Impurities

Hydrogen sulfide - H2S	mg/m3N	<1	0.00	0.00	0.00	0.00	n/a	0.00	0.00	–	N/d	0.00
Sulfur from mercaptans - RSH(S)	mg/m3N	0.00	0.00	0.00	0.00	0.00	n/a	0.00	0.00	0.00	–	0.00
Carbonyl sulfide(COS)	mg/m3N	0.00	0.00	0.00	0.00	0.00	n/a	0.00	0.00	0.00	–	0.00
Total Sulfur	mg/m3N	<5	0.00	0.00	0.00	0.00	n/a	0.00	0.00	2.70	0.00	0.00
Carbon Dioxide - CO2	mg/m3N	0.00	0.00	0.00	0.00	0.00	n/a	0.00	0.00	0.00	–	0.00

m3N at normal conditions:101.325kPa and 0℃

Loading plant country		Indonesia	Indonesia	Indonesia	Indonesia	Indonesia	Malaysia	Malaysia	Malaysia	Malaysia	Malaysia	Malaysia
Loading plant		Badak	Badak	Badak	Badak	Tangguh	Bintulu	Bintulu	Bintulu	Bintulu	Bintulu	Bintulu
Distance between loading plant and receiving plant (Km)		2,510	2,370	2,413	2,506	6,921	2,513	2,515	2,530	2,366	2,378	2,160
Duration of the trip between loading plant and receiving terminal (days)		6	6	6	6	14	6	6	6	5	6	6
Receiving terminal region		Asia	Asia	Asia	Asia	America	Asia	Asia	Asia	Asia	Asia	Asia
Characteristic	ISO unit											
Nitrogen - N2	%	0.010	0.010	0.010	0.016	0.128	0.160	0.160	0.150	0.150	0.160	0.140
Oxygen -O2	%	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Carbon Dioxyde -CO2	%	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Methane - C1	%	90.130	90.150	90.900	89.969	96.913	91.830	91.730	91.510	91.630	91.730	91.810
Ethane - C2	%	5.500	5.480	5.450	5.418	2.367	4.570	4.610	4.810	4.640	4.610	4.540
Propane - C3	%	2.710	2.680	2.660	3.240	0.439	2.540	2.630	2.670	2.670	2.580	2.470
i-Butane - i-C4	%	0.820	0.830	0.530	0.683	0.080	0.480	0.480	0.490	0.490	0.490	0.540
n-Butane - n-C4	%	0.830	0.840	0.450	0.673	0.070	0.410	0.380	0.360	0.410	0.410	0.490
i-Pentane - i-C5	%	0.000	0.010	0.000	0.001	0.002	0.010	0.010	0.010	0.010	0.020	0.010
n-Pentane - n-C5	%	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
C6+	%	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Total	%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

GCV on a mass basis	kJ/kg	*54.642*	*54.641*	*54.772*	*54.634*	*55.288*	*54.718*	*54.711*	*54.706*	*54.706*	*54.707*	*54.719*
GCV on a volumetric basis	MJ/m3N	*44.798*	*44.804*	*44.128*	*44.821*	*41.017*	*43.655*	*43.695*	*43.774*	*43.769*	*43.714*	*43.742*
Wobbe index - Gas*	MJ/m3N	*56.257*	*56.260*	*55.901*	*56.267*	*54.148*	*55.573*	*55.595*	*55.643*	*55.640*	*55.605*	*55.629*

*m3N at normal conditions:101.325kPa and 0℃
** saturated temperature and density at 10kPaG

Impurities

Hydrogen sulfide - H2S	mg/m3N	0.00	—	—	0.00	-	—	—	N/d	0.00	0.00	N/d
Sulfur from mercaptans - RSH(S)	mg/m3N	0.00	—	—	0.00	-	0.00	0.00	—	0.00	0.00	N D
Carbonyl sulfide(COS)	mg/m3N	0.00	—	—	0.00	0.00	0.00	0.00	—	0.00	0.00	N D
Total Sulfur	mg/m3N	0.00	—	—	0.00	-	—	—	—	0.00	0.00	N D
Carbon Dioxide - CO2	mg/m3N	0.00	—	—	0.00	-	0.00	0.00	—	0.00	0.00	N D

m3N at normal conditions:101.325kPa and 0℃

Loading plant country		Malaysia	Malaysia	Malaysia	Malaysia	Australia	Australia	Australia	Australia	Australia	Australia	Australia
Loading plant		Bintulu	Bintulu	Bintulu	Bintulu	Withnell Bay	Withnell Bay	Withnell Bay	Withnell Bay	Withnell Bay	Withnell Bay	Withnell Bay
Distance between loading plant and receiving plant (Km)		2,151	2,342	2,511	2,280	3,664	3,692	3,683	3,622	3,632	3,491	3,596
Duration of the trip between loading plant and receiving terminal (days)		6	6	6	6	10	10	10	8	10	10	11
Receiving terminal region		Asia	Asia	Asia	Asia	Asia	Asia	Asia	Asia	Asia	Asia	Asia
Characteristic	ISO unit											
Nitrogen - N2	%	0.110	0.090	0.150	0.160	0.050	0.040	0.040	0.040	0.040	0.040	0.040
Oxygen -O2	%	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Carbon Dioxyde -CO2	%	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Methane - C1	%	91.360	92.090	91.520	91.699	87.420	87.280	87.680	87.210	87.920	87.140	87.500
Ethane - C2	%	4.790	4.480	4.720	4.674	8.250	8.340	8.120	8.420	8.020	8.440	8.250
Propane - C3	%	2.700	2.460	2.670	2.575	3.340	3.340	3.200	3.360	3.080	3.400	3.280
i-Butane - i-C4	%	0.550	0.460	0.500	0.489	0.400	0.410	0.400	0.410	0.390	0.420	0.400
n-Butane - n-C4	%	0.480	0.400	0.420	0.392	0.520	0.560	0.530	0.540	0.530	0.540	0.510
i-Pentane - i-C5	%	0.010	0.020	0.020	0.011	0.020	0.020	0.030	0.020	0.020	0.020	0.020
n-Pentane - n-C5	%	0.000	0.000	0.000	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.000
C6+	%	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

GCV on a mass basis	kJ/kg	*54.705*	*54.796*	*54.695*	*54.709*	*54.521*	*54.514*	*54.547*	*54.514*	*54.570*	*54.507*	*54.538*
GCV on a volumetric basis	MJ/m3N	*43.970*	*43.592*	*43.825*	*43.702*	*45.350*	*45.441*	*45.251*	*45.446*	*45.125*	*45.485*	*45.308*
Wobbe index - Gas*	MJ/m3N	*55.767*	*55.573*	*55.670*	*55.599*	*56.540*	*56.593*	*56.491*	*56.595*	*56.424*	*56.617*	*56.522*

*m3N at normal conditions:101.325kPa and 0℃
** saturated temperature and density at 10kPaG

Impurities

Hydrogen sulfide - H2S	mg/m3N	N/d	0.00	–	0.00	0.00	–	N/d	0.00	0.00	0.00	0.00
Sulfur from mercaptans - RSH(S)	mg/m3N	N D	0.00	0.00	0.00	0.00	0.00	–	0.00	0.00	0.00	0.00
Carbonyl sulfide(COS)	mg/m3N	N D	0.00	0.00	0.00	0.00	0.00	–	0.00	0.00	0.00	0.00
Total Sulfur	mg/m3N	N D	0.00	N.D	0.00	–	–	0.00	0.00	0.00	0.00	0.00
Carbon Dioxide - CO2	mg/m3N	N D	0.00	0.00	0.00	0.00	0.00	–	0.00	0.00	0.00	0.00

m3N at normal conditions:101.325kPa and 0℃

Loading plant country		Australia	Australia	Australia	Australia	Australia	Australia	Australia	U.S.A.	U.S.A.	Brunei	Brunei
Loading plant		Withnell Bay	Withnell Bay	Withnell Bay	Withnell Bay	Darwin	Darwin	Darwin	Kenai	Kenai	Lumut	Lumut
Distance between loading plant and receiving plant (Km)		3,997	3,460	3,633		3,078	3,078	3,078	3,290	3,300	2,416	2,430
Duration of the trip between loading plant and receiving terminal (days)		9	10	8					8-9	8～9	6	6
Receiving terminal region		Asia	Asia	Asia	Europe	Asia	Asia	Asia	Asia	Asia	Europe	America
Characteristic	ISO unit											
Nitrogen - N2	%	0.030	0.040	0.032	0.020	0.090	0.110	0.090	0.220	0.110	0.030	0.050
Oxygen -O2	%	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.010	0.000	0.000	0.000
Carbon Dioxyde -CO2	%	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Methane - C1	%	86.860	87.070	87.520	87.042	88.250	87.530	87.150	99.610	99.810	89.990	90.210
Ethane - C2	%	8.570	8.460	8.251	8.509	9.350	10.100	10.460	0.110	0.070	5.400	5.270
Propane - C3	%	3.540	3.450	3.237	3.452	1.950	1.940	1.980	0.040	0.010	3.060	3.010
i-Butane - i-C4	%	0.430	0.420	0.402	0.412	0.170	0.160	0.160	0.010	0.000	0.650	0.620
n-Butane - n-C4	%	0.550	0.540	0.531	0.543	0.150	0.130	0.130	0.000	0.000	0.830	0.800
i-Pentane - i-C5	%	0.020	0.020	0.022	0.014	0.020	0.020	0.020	0.000	0.000	0.030	0.030
n-Pentane - n-C5	%	0.000	0.000	0.005	0.003	0.010	0.010	0.000	0.000	0.000	0.010	0.010
C6+	%	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	%	100.00	100.00	100.00	100.00	99.99	100.00	100.00	100.00	100.00	100.00	100.00

GCV on a mass basis	kJ/kg	*54.490*	*54.500*	*54.543*	*54.516*	*54.688*	*54.638*	*54.624*	*55.423*	*55.549*	*54.613*	*54.619*
GCV on a volumetric basis	MJ/m3N	*45.633*	*45.522*	*45.315*	*45.538*	*44.275*	*44.461*	*44.586*	*39.911*	*39.919*	*44.866*	*44.732*
Wobbe index - Gas*	MJ/m3N	*56.700*	*56.636*	*56.529*	*56.654*	*55.951*	*56.043*	*56.115*	*53.478*	*53.545*	*56.284*	*56.203*

*m3N at normal conditions:101.325kPa and 0℃
** saturated temperature and density at 10kPaG

Impurities

Hydrogen sulfide - H2S	mg/m3N	—	—	0.00	n/a	—	0.00	N/d	0.00	—	—	—
Sulfur from mercaptans - RSH(S)	mg/m3N	0.00	—	0.00	n/a	0.00	0.00	—	0.00	0.00	0.00	0.00
Carbonyl sulfide(COS)	mg/m3N	0.00	—	0.00	n/a	0.00	0.00	—	0.00	0.00	0.00	0.00
Total Sulfur	mg/m3N	N.D	—	0.00	n/a	—	0.03	0.05	0.16	—	—	—
Carbon Dioxide - CO2	mg/m3N	0.00	—	0.00	n/a	0.00	0.00	—	0.00	0.00	0.00	0.00

m3N at normal conditions:101.325kPa and 0℃

Loading plant country		Brunei	Algeria	Algeria	Algeria	Algeria	Algeria	Algeria	Algeria	Algeria	Algeria	Algeria
Loading plant		Lumut	Skikda	Skikda	Skikda	Bethioua	Bethioua	Bethioua	Bethioua	Bethioua	Arzew	Arzew
Distance between loading plant and receiving plant (Km)		2,026	456	349	349	8,982	113	113	113	113	9,245	690
Duration of the trip between loading plant and receiving terminal (days)		6	1.2	3	3	25	2.5	2	2.5	2	21	2
Receiving terminal region		Asia	Europe	Europe	Europe	Asia	Europe	Europe	Europe	Europe	Asia	Europe
Characteristic	ISO unit											
Nitrogen - N2	%	0.050	0.770	0.571	0.537	0.190	0.862	0.894	0.630	0.605	0.540	0.641
Oxygen -O2	%	0.000	0.000	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000
Carbon Dioxyde -CO2	%	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Methane - C1	%	90.169	92.527	90.992	90.670	90.550	87.764	87.822	90.940	90.669	87.970	90.663
Ethane - C2	%	5.336	6.069	7.857	8.124	8.360	8.489	8.369	7.892	7.896	8.590	7.813
Propane - C3	%	2.994	0.560	0.563	0.598	0.860	2.146	2.153	0.538	0.819	2.160	0.865
i-Butane - i-C4	%	0.614	0.033	0.008	0.033	0.020	0.311	0.310	0.000	0.007	0.310	0.011
n-Butane - n-C4	%	0.801	0.036	0.009	0.035	0.010	0.428	0.445	0.000	0.004	0.430	0.007
i-Pentane - i-C5	%	0.028	0.003	0.000	0.002	0.000	0.000	0.007	0.000	0.000	0.000	0.000
n-Pentane - n-C5	%	0.008	0.002	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C6+	%	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

GCV on a mass basis	kJ/kg	*54.619*	*54.483*	*54.574*	*54.575*	*54.835*	*53.993*	*53.967*	*54.525*	*54.513*	*54.257*	*54.479*
GCV on a volumetric basis	MJ/m3N	*44.732*	*41.889*	*42.460*	*42.628*	*42.955*	*44.175*	*44.154*	*42.416*	*42.609*	*44.344*	*42.604*
Wobbe index - Gas*	MJ/m3N	*56.204*	*54.321*	*54.735*	*54.844*	*55.185*	*55.532*	*55.505*	*54.683*	*54.801*	*55.774*	*54.780*

*m3N at normal conditions:101.325kPa and 0℃
** saturated temperature and density at 10kPaG

Impurities

Hydrogen sulfide - H2S	mg/m3N	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sulfur from mercaptans - RSH(S)	mg/m3N	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carbonyl sulfide(COS)	mg/m3N	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Sulfur	mg/m3N	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carbon Dioxide - CO2	mg/m3N	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

m3N at normal conditions:101.325kPa and 0℃

Loading plant country		Algeria	Algeria	Algeria	Algeria	Nigeria	Nigeria	Nigeria	Nigeria	Nigeria	Oman	Oman
Loading plant		Arzew	Arzew	Arzew	Arzew	Bonny Island	Bonny Island	Bonny Island	Bonny Island	Bonny Island	Qalhat	Qalhat
Distance between loading plant and receiving plant (Km)		690	113	691		3,359	3,359	3,533	10,643	10,406	5,688	5,619
Duration of the trip between loading plant and receiving terminal (days)		2	2	2		11	11	11	23	24	14	14
Receiving terminal region		Europe	Europe	Europe	Europe	Europe	Europe	Europe	Asia	Asia	Asia	Asia
Characteristic	ISO unit											
Nitrogen - N2	%	0.971	0.716	0.754	0.608	0.039	0.067	0.037	0.020	0.010	0.190	0.212
Oxygen -O2	%	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.000
Carbon Dioxyde -CO2	%	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Methane - C1	%	87.942	88.528	87.625	90.823	91.553	91.836	91.926	91.430	91.767	90.490	90.738
Ethane - C2	%	8.411	8.743	9.056	7.885	5.731	5.287	5.366	5.780	5.430	5.860	5.710
Propane - C3	%	2.031	1.755	2.033	0.678	2.115	2.205	2.099	2.210	2.197	2.200	2.096
i-Butane - i-C4	%	0.271	0.138	0.227	0.003	0.305	0.333	0.301	0.310	0.313	0.670	0.670
n-Butane - n-C4	%	0.374	0.119	0.280	0.000	0.257	0.269	0.270	0.250	0.273	0.560	0.544
i-Pentane - i-C5	%	0.000	0.001	0.013	0.000	0.000	0.003	0.001	0.000	0.007	0.020	0.027
n-Pentane - n-C5	%	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.003
C6+	%	0.000	0.000	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

GCV on a mass basis	kJ/kg	*53.932*	*54.225*	*54.101*	*54.528*	*54.873*	*54.854*	*54.895*	*54.876*	*54.898*	*54.588*	*54.599*
GCV on a volumetric basis	MJ/m3N	*43.950*	*43.624*	*44.136*	*42.512*	*43.480*	*43.430*	*43.370*	*43.559*	*43.485*	*44.154*	*44.037*
Wobbe index - Gas*	MJ/m3N	*55.359*	*55.303*	*55.562*	*54.746*	*55.540*	*55.499*	*55.481*	*55.592*	*55.557*	*55.824*	*55.755*

*m3N at normal conditions:101.325kPa and 0℃
** saturated temperature and density at 10kPaG

Impurities

Hydrogen sulfide - H2S	mg/m3N	0.00	0.00	0.00	n/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sulfur from mercaptans - RSH(S)	mg/m3N	0.00	0.00	0.00	n/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carbonyl sulfide(COS)	mg/m3N	0.00	0.00	0.00	n/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Sulfur	mg/m3N	0.00	0.00	0.00	n/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carbon Dioxide - CO2	mg/m3N	0.00	0.00	0.00	n/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00

m3N at normal conditions:101.325kPa and 0℃

Loading plant country		Oman	Trinidad-Tobago	Trinidad-Tobago	Trinidad-Tobago	Trinidad-Tobago	Trinidad-Tobago	Trinidad-Tobago	Trinidad-Tobago	Libya	Libya	Norway
Loading plant		Qalhat	Point Fortin	Point Fortin	Point Fortin	Point Fortin	Point Fortin	Point Fortin	Point Fortin	MARSA EL BREGA	MARSA EL BREGA	Snohvit
Distance between loading plant and receiving plant (Km)		5,771	2,200	3,976	3,701	3,417		3,985	12,890	1,074	1,169	2,573
Duration of the trip between loading plant and receiving terminal (days)		14	5	11	11	11		10	29	4	4	10
Receiving terminal region		Asia	America	Europe	Europe	Europe	Europe	Europe	Asia	Europe	Europe	Europe
Characteristic	ISO unit											
Nitrogen - N2	%	0.190	0.005	0.012	0.010	0.004	0.003	0.004	0.006	0.591	0.594	0.495
Oxygen -O2	%	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Carbon Dioxyde -CO2	%	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Methane - C1	%	90.810	96.601	96.793	96.807	97.116	96.972	96.598	96.597	82.266	82.880	91.961
Ethane - C2	%	5.680	2.950	2.775	2.745	2.456	2.657	2.923	2.937	12.870	12.375	5.696
Propane - C3	%	2.070	0.383	0.364	0.386	0.358	0.301	0.425	0.403	3.607	3.514	1.421
i-Butane - i-C4	%	0.670	0.034	0.031	0.029	0.033	0.034	0.028	0.033	0.310	0.283	0.102
n-Butane - n-C4	%	0.550	0.023	0.021	0.020	0.027	0.025	0.019	0.024	0.350	0.336	0.286
i-Pentane - i-C5	%	0.020	0.003	0.003	0.003	0.004	0.003	0.002	0.001	0.006	0.015	0.034
n-Pentane - n-C5	%	0.000	0.001	0.001	0.000	0.002	0.002	0.001	0.000	0.000	0.003	0.005
C6+	%	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000
Total	%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

GCV on a mass basis	kJ/kg	*54.614*	*55.393*	*55.401*	*55.403*	*55.428*	*55.424*	*55.392*	*55.391*	*53.881*	*53.914*	*54.580*
GCV on a volumetric basis	MJ/m3N	*44.010*	*41.125*	*41.052*	*41.053*	*40.964*	*40.988*	*41.132*	*41.128*	*46.444*	*46.212*	*42.752*
Wobbe index - Gas*	MJ/m3N	*55.746*	*54.271*	*54.227*	*54.228*	*54.182*	*54.196*	*54.275*	*54.272*	*56.881*	*56.756*	*54.926*

*m3N at normal conditions:101.325kPa and 0℃
** saturated temperature and density at 10kPaG

Impurities

Hydrogen sulfide - H2S	mg/m3N	0.00	0.00	0.00	0.00	0.00	n/a	0.00	0.00			
Sulfur from mercaptans - RSH(S)	mg/m3N	0.00	0.00	0.00	0.00	0.00	n/a	0.00	0.00			
Carbonyl sulfide(COS)	mg/m3N	0.00	0.00	0.00	0.00	0.00	n/a	0.00	0.00			
Total Sulfur	mg/m3N	0.00	0.00	0.00	0.00	0.00	n/a	0.00	0.00			
Carbon Dioxide - CO2	mg/m3N	0.00	0.00	0.00	0.00	0.00	n/a	0.00	0.00			

m3N at normal conditions:101.325kPa and 0℃

Loading plant country		Norway	Norway	Norway	Egypt	Egypt	Egypt	Egypt	Egypt	Egypt	Egypt	Egypt
Loading plant		Snohvit	Snohvit	Snohvit	Idaku	Idaku	Idaku	Idaku	Idaku	Idaku	Idaku	Damietta
Distance between loading plant and receiving plant (Km)		3,170		1455	1,491	1,595	1,920	3184	5,150	5,495	7,830	1,554
Duration of the trip between loading plant and receiving terminal (days)		15		6	6	5	6	9	15	15	18	6
Receiving terminal region		Europe	Europe	Europe	Europe	Europe	Europe	Europe	America	America	Asia	Europe
Characteristic	ISO unit											
Nitrogen - N2	%	0.402	0.509	0.444	0.014	0.011	0.008	0.009	0.116	0.009	0.007	0.030
Oxygen -O2	%	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Carbon Dioxyde -CO2	%	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Methane - C1	%	91.797	92.271	92.088	95.235	95.360	95.460	95.430	95.391	96.170	94.107	97.406
Ethane - C2	%	5.965	5.655	5.666	3.477	3.387	3.310	3.354	3.260	2.677	5.614	2.315
Propane - C3	%	1.348	1.098	1.384	0.889	0.856	0.842	0.827	0.822	0.743	0.201	0.132
i-Butane - i-C4	%	0.130	0.110	0.098	0.214	0.213	0.211	0.207	0.206	0.185	0.040	0.050
n-Butane - n-C4	%	0.346	0.327	0.287	0.166	0.168	0.161	0.163	0.169	0.166	0.027	0.023
i-Pentane - i-C5	%	0.011	0.022	0.026	0.005	0.005	0.007	0.006	0.016	0.038	0.004	0.016
n-Pentane - n-C5	%	0.001	0.003	0.008	0.000	0.000	0.001	0.004	0.002	0.004	0.000	0.007
C6+	%	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.021
Total	%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98	99.99	100.00	100.00

GCV on a mass basis	kJ/kg	*54.647*	*54.602*	*54.633*	*55.215*	*55.228*	*55.238*	*55.236*	*55.141*	*55.285*	*55.246*	*55.436*
GCV on a volumetric basis	MJ/m3N	*42.874*	*42.565*	*42.730*	*41.892*	*41.847*	*41.811*	*41.816*	*41.757*	*41.580*	*41.833*	*40.807*
Wobbe index - Gas*	MJ/m3N	*55.038*	*54.817*	*54.939*	*54.686*	*54.663*	*54.645*	*54.647*	*54.561*	*54.517*	*54.663*	*54.081*

*m3N at normal conditions:101.325kPa and 0℃
** saturated temperature and density at 10kPaG

Impurities

Hydrogen sulfide - H2S	mg/m3N		n/a	0.00								
Sulfur from mercaptans - RSH(S)	mg/m3N		n/a	0.00								
Carbonyl sulfide(COS)	mg/m3N		n/a	0.00								
Total Sulfur	mg/m3N		n/a	0.00								
Carbon Dioxide - CO2	mg/m3N		n/a	0.00								

m3N at normal conditions:101.325kPa and 0℃

Loading plant country		Egypt	Egypt	Egypt	Yeman	Yeman	Yeman	Rossiya	Rossiya	Rossiya	Rossiya	Rossiya
Loading plant		Damietta	Damietta	Damietta	Balhaf	Balhaf	Balhaf	Sakhalin Ⅱ - Prigorodnoye	Sakhalin Ⅱ - Prigorodnoye	Sakhalin Ⅱ - Prigorodnoye	Sakhalin Ⅱ - Prigorodnoye	Sakhalin Ⅱ - Prigorodnoye
Distance between loading plant and receiving plant (Km)		1,662	1,984	7,879	6,025		6,400	894	911	900	1,034	1,400
Duration of the trip between loading plant and receiving terminal (days)		5	6	17	14		22				2	5
Receiving terminal region		Europe	Europe	Asia	Asia	Europe	America	Asia	Asia	Asia	Asia	Asia
Characteristic	ISO unit											
Nitrogen - N2	%	0.021	0.016	0.010	0.020	0.018	0.013	0.070	0.080	0.070	0.070	0.050
Oxygen -O2	%	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Carbon Dioxyde -CO2	%	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Methane - C1	%	97.107	97.310	97.180	93.155	93.185	93.169	92.620	92.390	92.440	92.670	92.510
Ethane - C2	%	2.682	2.341	2.610	5.925	5.907	5.948	4.410	4.520	4.490	4.470	4.520
Propane - C3	%	0.077	0.171	0.110	0.790	0.757	0.755	1.950	2.010	2.030	1.910	1.970
i-Butane - i-C4	%	0.076	0.073	0.070	0.050	0.054	0.046	0.410	0.450	0.450	0.390	0.420
n-Butane - n-C4	%	0.010	0.045	0.010	0.060	0.074	0.066	0.480	0.540	0.520	0.470	0.500
i-Pentane - i-C5	%	0.008	0.029	0.010	0.000	0.002	0.000	0.050	0.010	0.000	0.020	0.020
n-Pentane - n-C5	%	0.003	0.012	0.000	0.000	0.001	0.000	0.010	0.000	0.000	0.000	0.010
C6+	%	0.016	0.005	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000
Total	%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

GCV on a mass basis	kJ/kg	*55.429*	*55.427*	*55.441*	*55.131*	*55.134*	*55.140*	*54.862*	*54.834*	*54.849*	*54.880*	*54.873*
GCV on a volumetric basis	MJ/m3N	*40.885*	*40.908*	*40.881*	*42.317*	*42.313*	*42.308*	*43.347*	*43.442*	*43.418*	*43.262*	*43.390*
Wobbe index - Gas*	MJ/m3N	*54.130*	*54.144*	*54.133*	*54.921*	*54.920*	*54.920*	*55.449*	*55.497*	*55.488*	*55.404*	*55.483*

*m3N at normal conditions:101.325kPa and 0℃
** saturated temperature and density at 10kPaG

Impurities

Hydrogen sulfide - H2S	mg/m3N			0.00	0.00	n/a	0.00	N/d	–	N/d	0.00	0.00
Sulfur from mercaptans - RSH(S)	mg/m3N			0.00	0.00	n/a	0.00	0.00	0.00	–	0.00	0.00
Carbonyl sulfide(COS)	mg/m3N			0.00	0.00	n/a	0.00	0.00	0.00	–	0.00	0.00
Total Sulfur	mg/m3N			0.00	0.00	n/a	0.00	0.00	–	0.00	0.00	0.00
Carbon Dioxide - CO2	mg/m3N			0.00	0.00	n/a	0.00	0.00	0.00	–	0.00	0.00

m3N at normal conditions:101.325kPa and 0℃

Loading plant country		Rossiya	Rossiya	Rossiya	Equatorial Guinea
Loading plant		Sakhalin Ⅱ - Prigorodnoye	Sakhalin Ⅱ - Prigorodnoye	Sakhalin Ⅱ	Bioko Island
Distance between loading plant and receiving plant (Km)		1,776	1,943	1,363	
Duration of the trip between loading plant and receiving terminal (days)		4	4	4	
Receiving terminal region		Asia	Asia	Asia	Asia
Characteristic	ISO unit				
Nitrogen - N2	%	0.060	0.090	0.073	0.000
Oxygen -O2	%	0.000	0.000	0.000	0.000
Carbon Dioxyde -CO2	%	0.000	0.000	0.000	0.000
Methane - C1	%	92.710	92.480	92.454	93.407
Ethane - C2	%	4.420	4.410	4.497	6.524
Propane - C3	%	1.890	2.030	2.008	0.067
i-Butane - i-C4	%	0.400	0.450	0.439	0.001
n-Butane - n-C4	%	0.470	0.520	0.511	0.001
i-Pentane - i-C5	%	0.040	0.020	0.017	0.000
n-Pentane - n-C5	%	0.010	0.000	0.001	0.000
C6+	%	0.000	0.000	0.000	0.000
Total	%	100.00	100.00	100.00	100.00

GCV on a mass basis	kJ/kg	*54.884*	*54.830*	*54.847*	*55.229*
GCV on a volumetric basis	MJ/m3N	*43.286*	*43.411*	*43.409*	*41.965*
Wobbe index - Gas*	MJ/m3N	*55.422*	*55.475*	*55.482*	*54.741*

*m3N at normal conditions:101.325kPa and 0℃
** saturated temperature and density at 10kPaG

Impurities

Hydrogen sulfide - H2S	mg/m3N	—	—	0.00	
Sulfur from mercaptans - RSH(S)	mg/m3N	—	—	0.00	
Carbonyl sulfide(COS)	mg/m3N	—	—	0.00	
Total Sulfur	mg/m3N	—	—	0.00	
Carbon Dioxide - CO2	mg/m3N	—	—	0.00	

m3N at normal conditions:101.325kPa and 0℃

Annex 6

LNG Source	Qatar		Indonesia		Indonesia		Indonesia		Malaysia	
Lording plant	Ras Laffan		Arun		Badak		Tangguh		Bintulu	
Component	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Nitrogen - N2	0	0.71	0.03	0.11	0	0.04	0.0099	0.128	0.07	0.23
Oxygen -O2	0	0.1	0	0	0	0.01	0	0	0	0
Carbon Dioxyde -CO2	0	0	0	0	0	0	0	0	0	0
Methane - C1	88.831	96.74	90.9	92.18	88.1	91.15	96.715	96.91309	90.55	92.61
Ethane - C2	2.777	7.464	5.44	5.84	5.17	5.94	2.367	2.8727	4.18	5.46
Propane - C3	0.038	2.67	1.44	2.77	2.59	4.16	0.349	0.465251	2.2	3.05
i-Butane - i-C4	0	0.69	0.35	0.47	0.48	0.92	0.0285	0.085137	0.37	0.59
n-Butane - n-C4	0	0.717	0.36	0.42	0.39	0.97	0.0205	0.071874	0.23	0.58
i-Pentane - i-C5	0	0.1	0	0.06	0	0.01	0.001493	0.0028	0	0.03
n-Pentane - n-C5	0	0.021	0	0.02	0	0	0.00076	0.0013	0	0.01
C6+	0	0.0023	0	0	0	0	0.000033	0.00053	0	0
Impurities	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Hydrogen sulfide - H2S	0	0	0	0	0	0	0	0	0	0
Sulfur from mercaptans - RSH(S)	0	0	0	0	0	0	0	0	0	0
Carbonyl sulfide(COS)	0	0	0	0	0	0	0	0	0	0
Total Sulfur	0	0.91	0	0	0	0.08	0	0	0	0.05
Carbon Dioxide - CO2	0	0	0	0	0	0	0	0	0	0

LNG Source	Austraria		Austraria		USA		Brunei		Algeria	
Lording plant	Withnell Bey		Darwin		Kenai		Lumut		Skikda	
Component	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Nitrogen - N2	0.019912	0.07	0.08	0.13	0.08	0.13	0.03	0.07	0.38	0.827
Oxygen -O2	0	0	0	0.01	0	0	0	0	0	0
Carbon Dioxyde -CO2	0	0.01	0	0	0	0.01	0	0	0	0
Methane - C1	86.82	88.47	86.83	88.25	99.73	99.81	89.77	91.22	87.438	91.802
Ethane - C2	7.76	8.63	9.34	10.69	0.06	0.11	4.87	5.59	6.898	9.018
Propane - C3	2.78	3.54	1.94	2.33	0	0.04	2.57	3.2	0.563	2.253
i-Butane - i-C4	0.35	0.44	0.16	0.22	0	0.01	0.53	0.65	0.004	0.331
n-Butane - n-C4	0.46	0.6	0.13	0.2	0	0.01	0.69	0.86	0.001	0.479
i-Pentane - i-C5	0.01	0.04	0.02	0.03	0	0	0.02	0.05	0	0.018
n-Pentane - n-C5	0	0.02	0	0.01	0	0	0	0.02	0	0.016
C6+	0.002496	0.002496	0	0	0	0	0	0	0	0.002
Impurities	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Hydrogen sulfide - H2S	0	0	0	0	0	0	0	0	0	0
Sulfur from mercaptans - RSH(S)	0	0	0	0	0	0	0	0	0	0
Carbonyl sulfide(COS)	0	0	0	0	0	0	0	0	0	0
Total Sulfur	0	0.32	0	0.15	0.09	0.46	0	0.09	0	0
Carbon Dioxide - CO2	0	0	0	0	0	0	0	0	0	0

LNG Source	Algeria		Algeria		Nigeria		Oman		Trinidad	
Lording plant	Bethioua		Arzew		Bonny Island		Qalhat		Point Fortin	
Component	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Nitrogen - N2	0.19	1.082	0.415	0.993	0	0.074	0.14	0.36	0	0.327
Oxygen -O2	0	0.01	0	0	0	0	0	0.01	0	0
Carbon Dioxyde -CO2	0	0	0	0.015	0	0	0	0.01	0	0
Methane - C1	87.292	91.492	85.499	91.1245	90.463	92.9934	89.94	91.56	95.936	97.214
Ethane - C2	7.393	8.929	7.6986	10.803	4.4536	6.552	5.29	6.19	2.282	3.111
Propane - C3	0.532	2.195	0.501	2.539	1.854	2.519	1.77	2.41	0.3011	0.761
i-Butane - i-C4	0	0.312	0	0.31	0.207	0.3916	0.64	0.71	0.024	0.168
n-Butane - n-C4	0	0.453	0	0.43	0.129	0.37	0.47	0.62	0.016	0.16
i-Pentane - i-C5	0	0.009	0	0.027	0	0.02	0.01	0.04	0	0.007
n-Pentane - n-C5	0	0.004	0	0.023	0	0.01	0	0.01	0	0.005
C6+	0	0.0002	0	0.008	0	0.0012	0	0	0	0.0047
Impurities	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Hydrogen sulfide - H2S	0	0	0	0	0	0	0	0	0	0
Sulfur from mercaptans - RSH(S)	0	0	0	0	0	0	0	0	0	0
Carbonyl sulfide(COS)	0	0	0	0	0	0	0	0	0	0
Total Sulfur	0	0	0	0	0	0	0	0	0	0
Carbon Dioxide - CO2	0	0	0	0	0	0	0	0	0	0

LNG Source	Libya		Norway		Egypt		Egypt		Yemen	
Lording plant	MARSA EL BREGA		SNOHVIT		Idku		Damietta		Balhaf	
Component	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Nitrogen - N2	0.38	0.663	0.281	0.798	0	0.053	0.017	0.056	0.01	0.03
Oxygen -O2	0	0	0	0	0	0	0	0	0	0
Carbon Dioxyde -CO2	0	0	0	0	0	0	0	0	0	0
Methane - C1	80.392	82.894	91.514	92.297	91.7989	97.1897	97.022	97.753	93.09	93.22
Ethane - C2	12.375	14.102	5.62	6.115	2.5069	6.587	2.085	2.694	5.90748636	5.94
Propane - C3	3.36	4.276	1.0742	1.423	0.052	2.1656	0.041	0.174	0.72	0.86
i-Butane - i-C4	0.246	0.356	0.095	0.147	0	0.2909	0.045	0.087	0.05	0.05394091
n-Butane - n-C4	0.263	0.384	0.286	0.401	0	0.197	0.009	0.03	0.06	0.07446818
i-Pentane - i-C5	0	0.019	0.0048	0.035	0	0.046	0.008	0.016	0	0.001675
n-Pentane - n-C5	0	0.006	0	0.0077	0	0.011	0.003	0.008	0	0.00066477
C6+	0	0	0	0.002	0	0.001	0.002	0.024	0.00222614	0.00222614
Impurities	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Hydrogen sulfide - H2S	0	0	0	0	0	0	0	0	0	0
Sulfur from mercaptans - RSH(S)	0	0	0	0	0	0	0	0	0	0
Carbonyl sulfide(COS)	0	0	0	0	0	0	0	0	0	0
Total Sulfur	0	0	0	0	0	0	0	0	0	0
Carbon Dioxide - CO2	0	0	0	0	0	0	0	0	0	0

LNG Source	Rossia		Equatorial Guinea	
Lording plant	Sakhalin		Bioko Island	
Component	Minimum	Maximum	Minimum	Maximum
Nitrogen - N2	0.03	0.1	0	0
Oxygen -O2	0	0	0	0
Carbon Dioxyde -CO2	0	0	0	0
Methane - C1	88.72	93.19	92.951	93.554
Ethane - C2	4.28	6.6	6.383	6.988
Propane - C3	1.66	3.17	0.057	0.101
i-Butane - i-C4	0.34	0.67	0	0.008
n-Butane - n-C4	0.4	0.74	0	0.008
i-Pentane - i-C5	0	0.06	0	0
n-Pentane - n-C5	0	0.02	0	0
C6+	0	0	0	0
Impurities	Minimum	Maximum	Minimum	Maximum
Hydrogen sulfide - H2S	0	0	0	0
Sulfur from mercaptans - RSH(S)	0	0	0	0
Carbonyl sulfide(COS)	0	0	0	0
Total Sulfur	0	0.1	0	0
Carbon Dioxide - CO2	0	0	0	0

Annex 7

1. CONVERSION FACTORS ACCORDING TO THE REFERENCE CONDITIONS GROSS CALORIFIC VALUES CONVERSION

Gross Calorific Value (GCV) : the GCV is the quantity of heat produced by the combustion in air under constant pressure of one cubic meter of anhydrous gas, the air being at the same temperature and the same pressure as the gas, after the cooling of the products of combustion to the initial temperature of the gas and the air and after condensation of the water created by the combustion. Appropriate corrections will be made if the initial conditions of the air and the gas do not equal 0℃ and 101.325kPa.

The volumetric GCV depends also on the reference conditions of volume.

Gross Calorific Value to weight (or molecular) GCV_W

From GCV_W (0℃)	divide by 1.0026	to obtain GCV_W (25℃)
From GCV_W (0℃)	divide by 1.0016	to obtain GCV_W (15℃)
From GCV_W (15℃)	divide by 1.0010	to obtain GCV_W (25℃)

Gross Calorific Value to volume (GCV_V)

From GCV_V (0℃)/m^3 (n)	divide by 1.0026	to obtain GCV_V (25℃))/m^3 (n)
From GCV_V (0℃)/m^3 (n)	divide by 1.0566	to obtain GCV_V (15℃))/m^3 (st)
From GCV_V (25℃)/m^3 (n)	divide by 0.9489	to obtain GCV_V (15℃))/m^3 (st)

Conversion factors for calorific values and Wobbe index are given in table J.3 of ISO 6976:1995 (e) - Natural Gas, Calculation of calorific values, density, relative density, and Wobbe index from composition(noting the Technical Corrigendum 3 for this ISO which states that in the last column of the row designated 'a)', '15 + 15' should be replaced by '15 + 0'.). This table gives conversion factors for a range of combustion reference temperatures and metering reference temperatures.

2. CONVERSION FACTORS ACCORDING TO DIFFERENT UNITS

Note: reference temperature of combustion : 0℃ except for Btu IT. Convert to 15℃ or 25℃ before or after.

2.1 Gross Calorific Value to weight (or molecular) GCV_W

FROM→ TO ↓ x by	kJ/kg 0℃
kcal/kg 0℃	0.239
Btu IT /lb	0.430

FROM→ TO ↓ x by	kcal/kg 0℃
kJ/kg 0℃	4.186
Btu IT/lb 0℃	1.800

FROM→ TO ↓ x by	Btu IT /lb
kJ/kg 0℃	2.326
kcal/kg 0℃	0.556

2.2 Gross Calorific Value to volume GCV_V

FROM→ TO ↓ x by	kJ/m^3 (n)
kJ/m^3 (st)	0.947
kcal/m^3 (n)	0.239
kcal/m^3 (st)	0.226
Btu IT / scf	0.025

FROM→ TO ↓ x by	kcal/m^3 (n)
kJ/m^3 (n)	4.186
kJ/m^3 (st)	3.963
kcal/m^3 (st)	0.947
Btu IT / scf	0.107

FROM→ TO ↓ x by	kcal/m^3 (st)
kJ/m^3 (n)	4.416
kJ/m^3 (st)	4.186
kcal/m^3 (n)	1.056
Btu IT / scf	0.112

FROM→ TO ↓ x by	Btu IT / scf
kJ/m^3 (n)	39.265
kJ/m^3 (st)	37.681
kcal/m^3 (n)	9.378
kcal/m^3 (st)	9.000

USEFUL CONSTANTS

1 Btu IT = 1.055 kJ = 0.2521 kcal

Note: value of Btu IT (international) and Btu at 60ºF are very close (at 10^{-4})

1 Btu IT =1.055056 kJ

1 Btu 60 ºF = 1.05468 kJ

1 thermie =10^3 kcal = 4.8 MJ

1 lb av (avoir du poids) =0.4536 kg

1 gal = 3.785 dm^3

1 lb / gal = 119 kg/m^3

1 kcal = 4.1855 kJ

VOLUME REFERENCES

m^3 (n) : (0℃ at 101.325 kPa)

m^3 (st) : (15℃ at 101.325 kPa)

scf (US) : (60ºF)

VOLUME CONVERSION:

1 m^3 (st) = 0.9476 m^3 (n)

1 m^3 (n) = 1056m^3 (st)

1 scf (US) = 0.02687 m^3 (n)

Annex 8

Exploitation of results to estimate the new route feasibility

The information collected in this inquiry allow us to estimate in many cases what would be the quality of the LNG at loading in case of creation of a new route between an existing loading plant and receiving terminals.
It would be possible according to this quality at unloading and to send out requirements to identify possible difficulties linked to the quality and/or to the ageing of the LNG.
We present hereafter the method.

1. Firstly, it is necessary to know or calculate the distance between the loading plant and the receiving terminal. The notion of duration of the trip is more relevant if the route includes the passage from a singular point as Suez canal.

   Distances can be calculated by using, for example the "BP shipping marine distance tables".

2. Secondly, according to the duration of the trip, it is necessary to estimate the ageing of the LNG and its quality at unloading. There are two possibilities:

   - To estimate the quality at unloading taking into account the information collected for a terminal located at approximately the same distance from the loading plants. This piece of information is listed in the table titled "composition and quality at receiving terminal". This method allows us to use full information provided by the inquiry. This approach can nearly always be used when the receiving terminal is located in the natural geographical zone of sale of the loading plant(for example: Asian terminals and Indonesian or Malaysian plants, European terminals and Northern Africa loading plants).

   - To estimate the ageing of the cargo by the calculation if the distance or duration between the loading plant and the receiving terminal cannot be available. According to the molar fraction and characteristics of the ship such as boil-off-rate per day, the composition and the quality of the LNG at unloading terminal can be estimated depending on the distance.

3. Thirdly, to verify that estimated characteristics of the LNG at the point of unloading terminal are compatible with send out requirements of the terminal provided in the table "requirements for send out".

   It is important in this comparison to take into account the ageing of the LNG in onshore storage tanks of the terminal before send out. This ageing can equally be estimated by similar calculations. Regarding the ageing of LNG in the receiving terminal, the composition and quality of the LNG can be estimated depending on the boil-off-rate and storage duration. Without this estimation, it is necessary that

characteristics at unloading terminal are appreciably far from limit values required for send out.

For example, we will verify that the LNG from Oman(Qalhat) can be unloaded and send out by Ohgishima terminal(Japan) by using the data collectd.
The distance calculated from BP tables is approximately 5980 nautical miles.
The terminal of Futtsu(Japan) is located near the Ohgishima terminal and has already received the LNG of this loading plant. The difference of the distance is very little and the ageing of the LNG will evolve very slightly after a so long travel. We will therefore think of the characteristics of LNG at unloading in Futtsu as those foreseeable at unloading in Ohgishima.
The unloaded LNG appears to be compatible with the limit requirements fixed by the terminal, considering the calorific value adjustment operation by mixing LPG at Ohgishima terminal(45.416MJ/m3N lower than 46.05MJ/m3N(send out standard GCV)).

Characteristics		Unloading in Ohgishima	Limits requirements	
			min.	max
Nitrogen – N2	%	0.25		
Oxygen - O2	%	0		
Carbon Dioxyde - CO2	%	0		
Methane - CH4	%	87.79		
Ethane - C2H6	%	7.39		
Propane - C3H8	%	2.95		
i-Butane- i-C4H10	%	0.79		
n-Butane- n-C4H10	%	0.77		
i-Pentane- i-C5H12	%	0.05		
n-Pentane- n-C5H12		0.01		
GCV Gas	MJ/m3N	**45.416**	45.63	**46.47**
			the standard GCV for send out is **46.05**MJ/m3N	
Wobbe Index	MJ/m3N	56.478	52.7	57.8
Hydrogen Sulfide	mg/m3N			1.0
Sulfur from Mercaptans	mg/m3N			
Total sulfur	mg/m3N			10.0

But after unloading, GCV of LNG will continue to increase and may exceed the standard GCV. So regarding the introduction of the new LNG, not only the ageing during the voyage but also that in the receiving terminal must be considered.

Conclusion

The data collected help to forecast the quality of unloaded LNG.
For a detailed check of compatibility, the precise calculation must be carried out on actual values for a given LNG.

Annex 9

MOLAS SOFTWARE, AN ALTERNATIVE (SUBSTITUTE) METHOD FOR LNG DENSITY PREDICTION AND ESTIMATION UPON ARRIVAL AT THE UNLOADING TERMINAL.

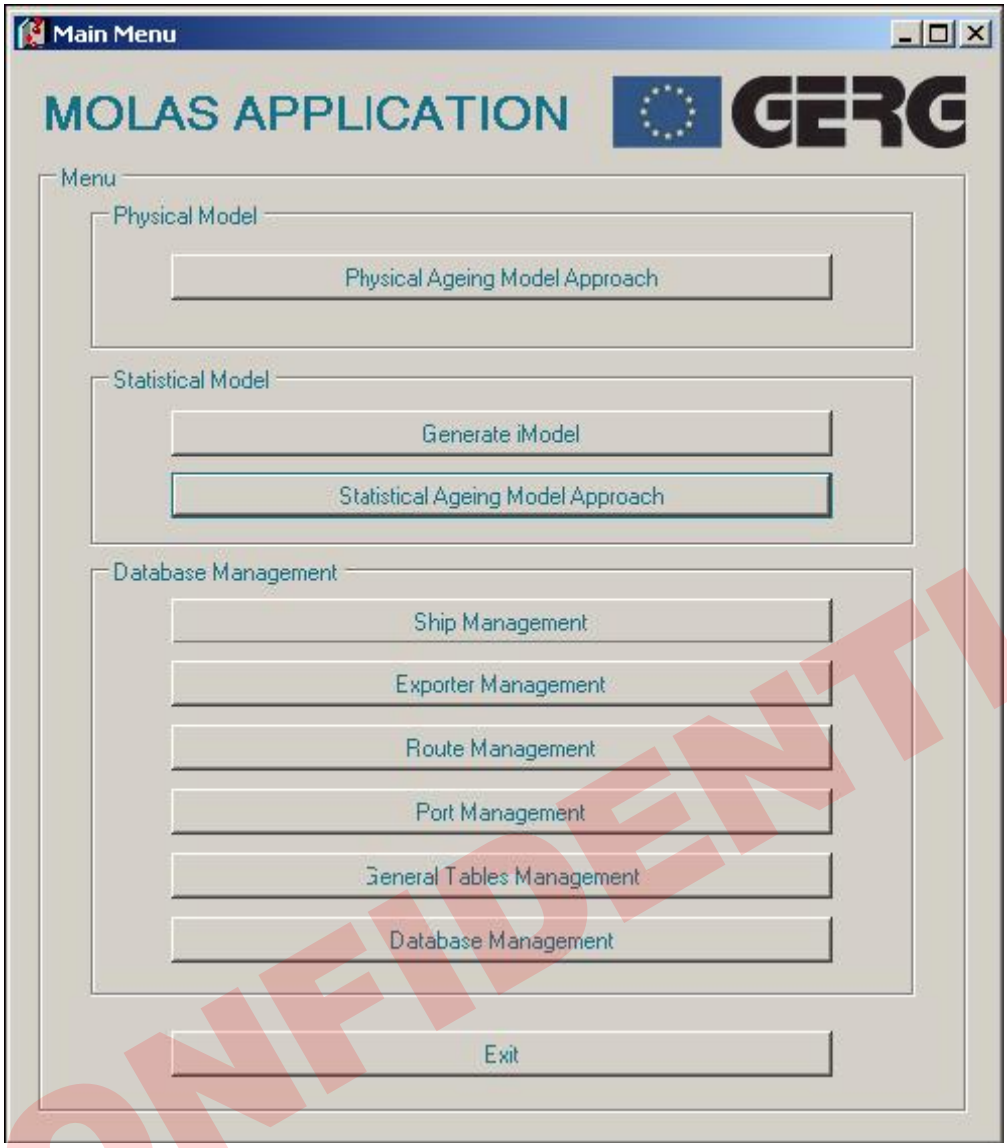
For information only

Liquefied Natural Gas is transported by ship at near atmospheric pressure, close to its boiling point which is around –160 ºC. During the voyage a small fraction of the LNG is vaporized into boil-off gas (BOG) by heat ingress from the surroundings through the cryogenic insulation into the cargo containment system (unless complete BOG reliquefaction is implemented all along the voyage). Due to the different boiling points of LNG components (varying from -196 ºC to +36 ºC), this vaporization is not homogenous. In particular there is preferential boil-off of the two most volatile components in LNG: nitrogen (atmospheric boiling point -196°C), followed by methane (atmospheric boiling point -161.5°C). Other components have substantially higher atmospheric boiling points than nitrogen and methane: ethane , propane, butanes, and C5+ have even higher atmospheric boiling points. This phenomenon of preferential boil-off of these most volatile components nitrogen and methane, is called ageing and its main consequence is the modification of the initial LNG composition and properties over time. So during the transportation in the LNG carrier the composition of LNG between the port of origin and the destination port is slightly different. Consequently, relevant properties of the LNG at the destination point are also different.

In this context, a group of European gas companies[1] led by Enagas have carried out the GERG Project "Calculation MOdel(s) of LNG Ageing during Ship transportation (called the MOLAS Project)" to develop a software application for predicting changes in LNG composition during ship transportation from the port of loading (origin) to the port of unloading (destination). The MOLAS software application is a user friendly, powerful and reliable tool that runs on a desktop and allows a reasonably good prognosis and estimation of the LNG molar composition to be unloaded at the destination point and, therefore, the most essential LNG properties. The predictive results provided by this MOLAS application can help terminal operators and technicians to manage regasification plants in a safer and more efficient manner, and to take necessary proactive actions on the natural gas sendout section so that it can continuously comply with the sendout quality specifications.

Although this MOLAS application is not intended for billing purposes, it may also be used to estimate the amount of energy transferred from ship to shore tank. Pending prior agreement between all parties involved, its predicition and estimation of LNG composition upon arrival may for instance be considered as a back-up or substitute in the event of a failure of the on-shore LNG molar analysis as outlined in sections 6 (LNG sampling) and 7 (gas analysis) of this handbook.

1 The following European companies have participated in the GERG Project: Enagás (Project Leader), E.ON Ruhrgas AG; GLNoble Denton; GDF SUEZ; Naturgas Energía Transporte, S.A.U.; REPSOL YPF; StatoilHydro ASA



The MOLAS Application contains two different modelling options: A Physical Model based on mass balances and equilibrium state between liquid and vapour phases, and a Statistical Model, based on artificial neural networks to take into account non linearities due to the specific characteristics of each ship, LNG quality, ports of origin and destination, etc. The Statistical Model is based on a database with historical data provided by GIIGNL members.

A database is provided with the information about ships, countries, routes, trips, ports, exporters, etc. The aim of this database is to collect the most widely used data regarding the LNG shipping and terminalling business.

Parties who are interested to have access to this MOLAS software tool can contact the GERG project leader for further details on the access conditions:

Mr. Angel Benito, Enagas, e-mail address: ambenito@enagas.es .