



OIL & GAS

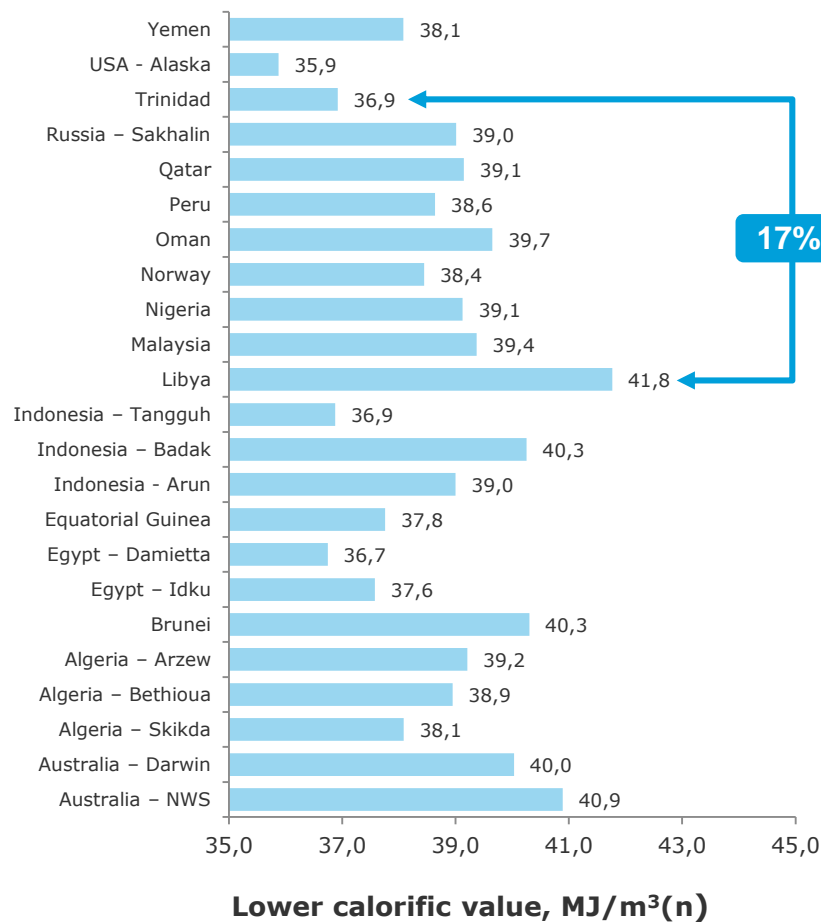
LNG testing facility

Testing facility for LNG vaporizers, LNG composition measurement equipment and engine control systems in small-scale LNG operations.

25 April 2018

1. Challenges in small-scale LNG

LNG is not just LNG: LNG has significant composition variations across the globe



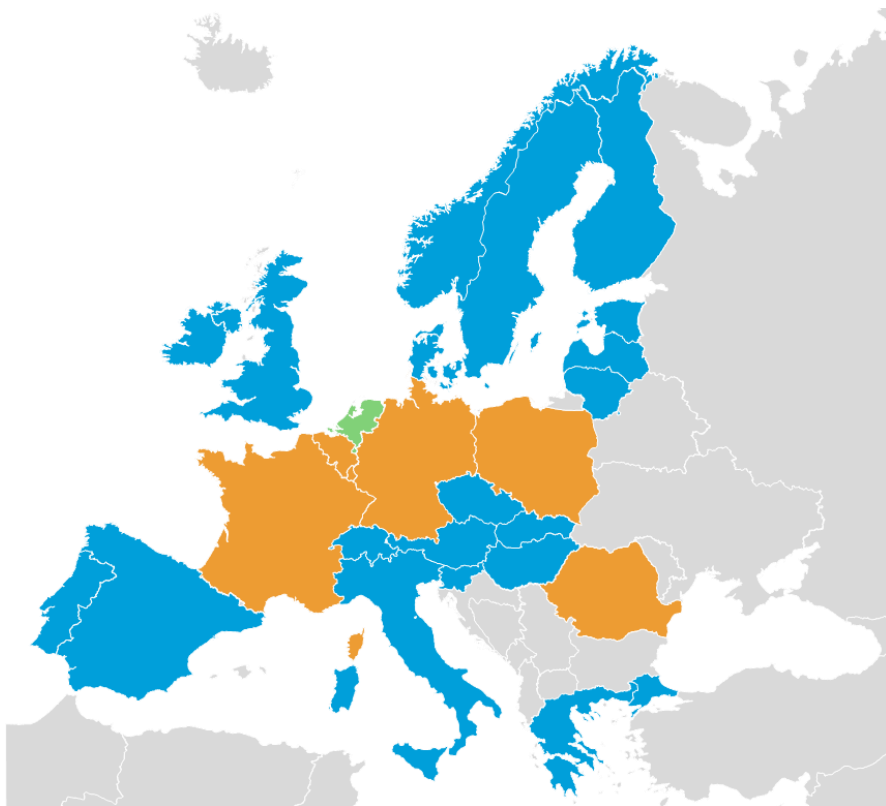
■ Sourcing

- LNG is produced at different locations around the world.
- Due to differences in natural gas sources, production technologies and the target markets for the LNG, the composition may vary substantially

■ Weathering

- The boil-off of volatile components in the LNG leads to a change in composition of LNG along the distribution chain

LNG is not just LNG: gas end-use requires specific compositions based on historical local gas market conditions



Different calorific values based on domestic appliances

- There is a variety of LNG-fueled engines used in ships and trucks. To safeguard the performance of LNG-fueled engines the right match ensures the fitness for purpose of the LNG supplied.
- Specifically, the knock resistance of the fuel must be determined unambiguously. The occurrence of knock can severely compromise engine performance, varying from increased pollutant emissions and reduced fuel efficiency to engine failure.
- The knock resistance of LNG is characterized by a methane number.
- The knock characteristics of LNG fuels is crucial for suppliers and traders to provide reliable and efficient products and for the end user to secure optimal engine operations.

Risks for composition variations of LNG

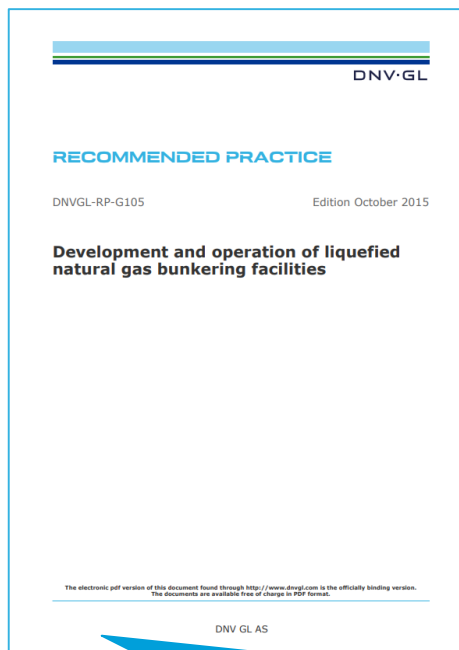
1. Quality control and correct billing

Issue	Effect / Risk
Weathering of LNG due to boil-off in the LNG distribution chain	Composition change over time, devaluation of the product
Substantial variations in density (up to 12%) and heating value (up to 17%) due to differences in natural gas sources	Incorrect billing and risk for unaccounted for product value

2. Engine performance with changing LNG composition

Issue	Effect / Risk
Mismatch between fuel composition and engine fuel requirements	Different combustion performance; loss of power and efficiency, higher emissions
	Different behaviour regarding engine knock can lead to loss of performance, engine shutdown and damage

DNV GL's LNG bunkering Recommended Practice describes the essence of composition determination of LNG

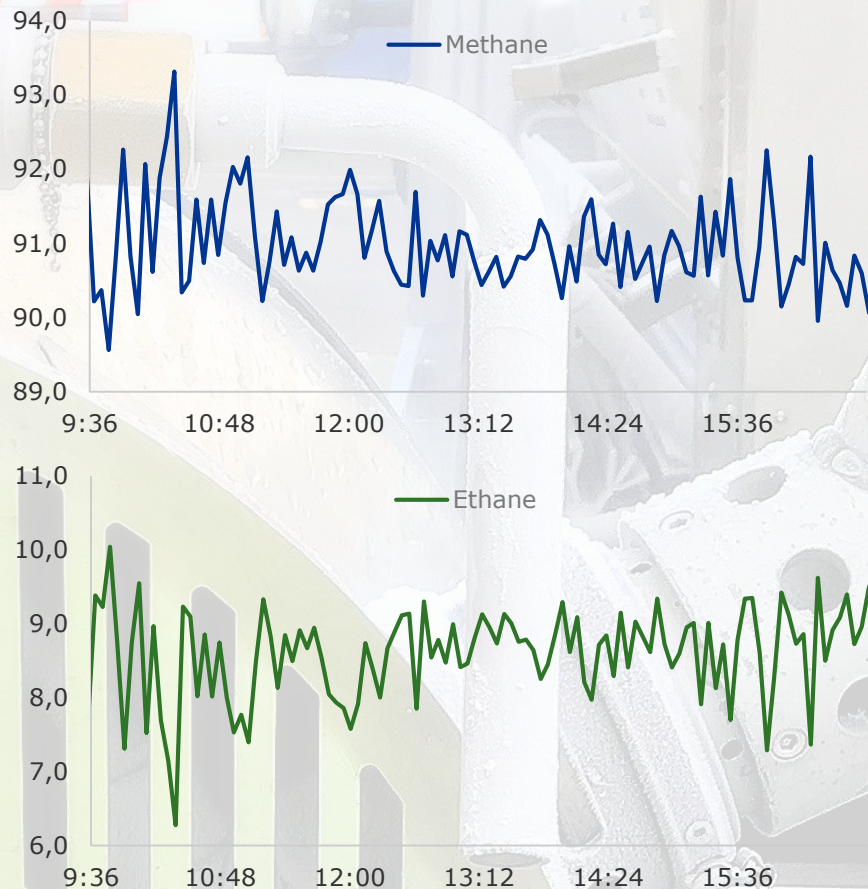


DNV GL provides first guidance on fiscal and quality measurements for LNG bunkering in its Recommended Practice (DNVGL-RP-G105) describing how to perform quality measurements and quantity metering of LNG as a fuel

*To ensure transparency in billing and that the use of LNG as a fuel is safe and fit for purpose...during bunkering, **the energy content and essential properties of the transferred LNG shall be determined.** More specifically, the LNG energy content shall be the basis for the billing (custody transfer), while the properties determine the LNG's fitness for purpose.¹*

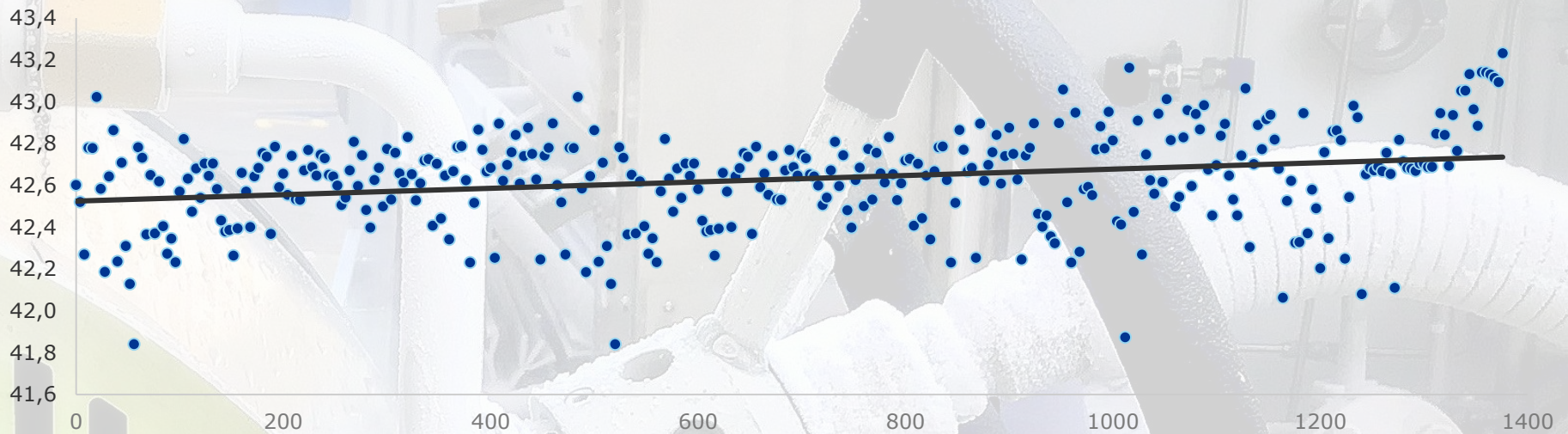
2. Operational LNG issues

I. Measured variations in gaseous LNG composition



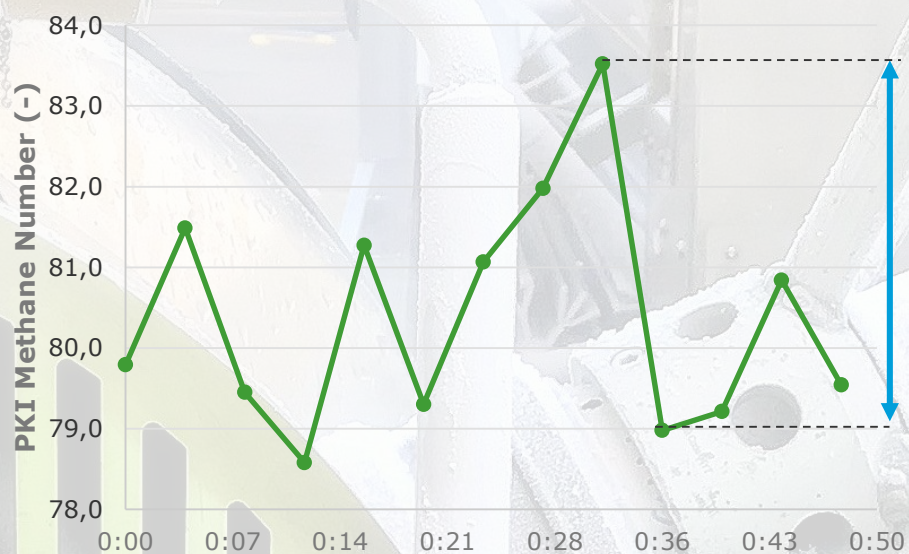
- With current common LNG vaporizers used significant changes in the composition of LNG occurs:
- I.e. methane content and ethane content variations are measured up $>1\text{mol\%/minute}$

II. Boil-off effect leads to increase of caloric value



- With current common LNG vaporizers used;
 - Caloric value of gaseous LNG increases over-time due to boil-off
 - Variations up to 0,3 MJ/minute are measured

III. Fast changing variations of the methane numbers



- With current common LNG vaporizers used and due to the occurring significant changes in the composition of LNG;
 - Variations up to 4,5 methane number points/minute are measured
- Gas engine allows variations of max ~4-5 MN points/minute

3. DNV GL LNG test facility

LNG testing facility - Groningen



More than 45 years experience in gas analytics and flow measurement

Test of LNG in gaseous phase and ability to connect sampling probes for liquid sampling

Testing of LNG under real-life operations and circumstances

Successfully executed JIP's to provide industry solutions and technology empowerment

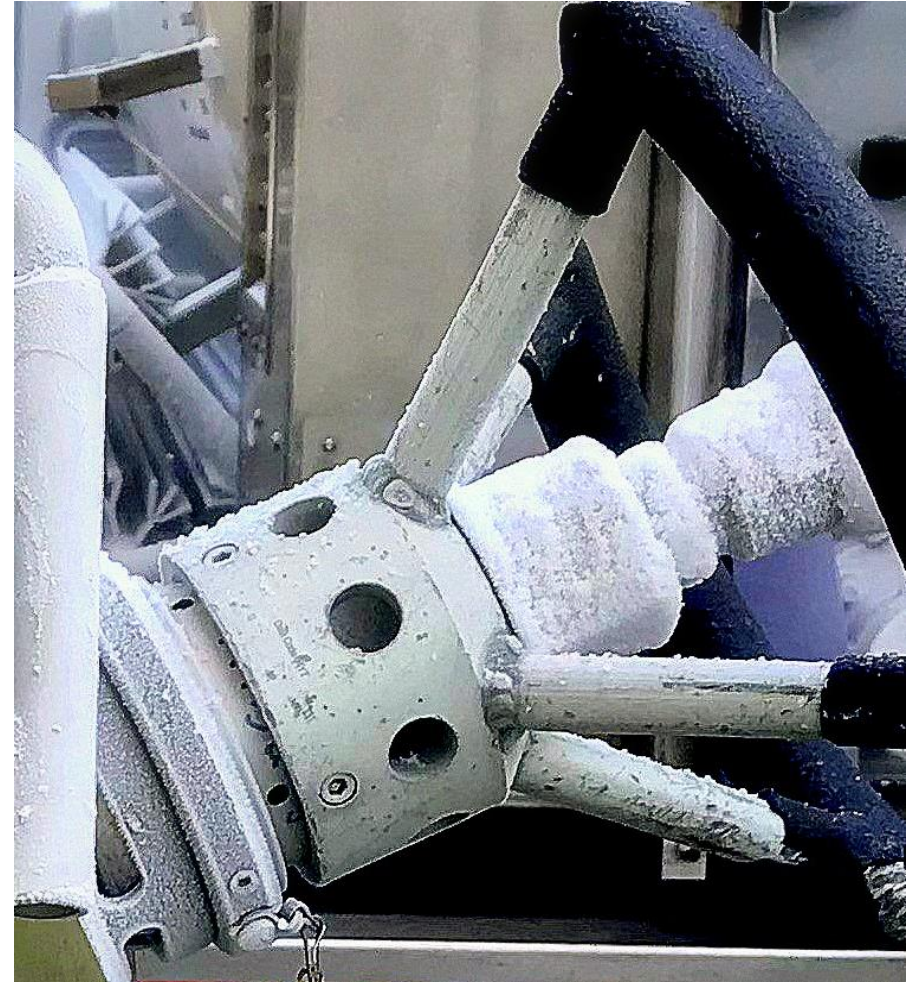
General information LNG test facility

- **LNG test facility**

- Maximum working pressure 16 bar
- Maximum working temperature -195 °C
- Internal volume 567 litre
- Maximum load 242 kg methane

- **Heat Exchanger:**

- Capacity 300 HP (approx. 225 kW)
- Maximum gas flow 70 – 75 m³(n)/h
- Maximum working pressure 23 bar



Unique testing capabilities

- The LNG test facility provides to the customers access to a state-of-the-art LNG research and test facility. The LNG lab facility can cross the bridge between the different LNG operators and the manufacturers by providing independent research, advisory, qualification and verification services.
- The LNG test facility aims to enable:

1. Performance testing for ssLNG equipment

E.g. heat exchangers, sampling probes, measurement systems and flow meters.

2. Investigate the effects of additives

i.e. lubricants, odorants or knock inhibitors on weathering and ageing.

3. Investigate the effects of changing LNG composition on end-use appliances

i.e. truck engines, (Marine) Fuel engine, domestic appliances.

4. Testing of boil-off effects in the small scale LNG value chain and test mitigation techniques

- The LNG test facility is unique, with its focus on small-scale LNG, focus on fuel composition and custody transfer and focus on effects of various LNG composition on end-use appliances.

4. About DNV GL

**We are a global classification, certification, technical assurance
and advisory company**

OUR PURPOSE

**TO SAFEGUARD
LIFE, PROPERTY
AND THE ENVIRONMENT**

OUR VISION

**GLOBAL IMPACT FOR A SAFE
AND SUSTAINABLE FUTURE**

We help businesses manage their most critical risks



The broader view

DNV GL has **in-depth** understanding of the oil, gas and energy value chain and its various modalities, linking the **Oil & Gas** and **Energy** industry with the **Maritime** sector



DNV GL OIL & GAS

- DNV GL Oil & Gas enables **safe, reliable** and enhanced **performance** in oil and gas projects and operations
- We provide **integrated services** in technical and marine assurance and advisory, risk management advisory and offshore classification

THE LEADING TECHNICAL ADVISOR

- DNV GL is **impartial**
- Our **5,500 oil & gas** experts combine **industry expertise**, multi-disciplinary skills and innovation to solve complex **technical issues**
- We drive the industry forward by developing **best practice and standards** across the asset lifecycle.

DNV GL's Fuel Transition Center

In our fuel transition center, DNV GL supports its **clients** with **empowering technology** in the down and midstream gas market..

...with **custom made services** like R&D support, rules development, technology assessment and qualification...

...to **accelerate** the development and **ensure** safe and reliable technology and fit for purpose fuels with fair and well founded rules and standards..



...to ensure a safe and sustainable future



OIL & GAS

Thanks for your attention

DNV·GL

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