Flowcenter Danmark

Flow Metrology for Liquefied Natural Gas (LNG)

EMRP Project – Introduction and overview

October 2011

Lars Poder, FORCE Technology

Flow Metrology for LNG

Flowcenter Danmark

About LNG

- Liquefied Natural Gas is produced by cooling down natural gas below its dew point (-161 °C)
- A unique solution for transporting natural gas to areas far from a pipeline structure
- The volume occupied by LNG at atmospheric pressure is about 614 times smaller than its gaseous state – this reduces the space needed to freight an amount of energy
- LNG is shipped in carriers from liquefaction plants to large tanks in buyer countries
- These wessels can load from 145,000 to more than 200,000 m^3
- The energy volume of such a consignment corresponds to 1 – 1.4 TWh

- One LNG cargo represents the annual power consumption of roughly 200,000 households in Denmark.

LNG process

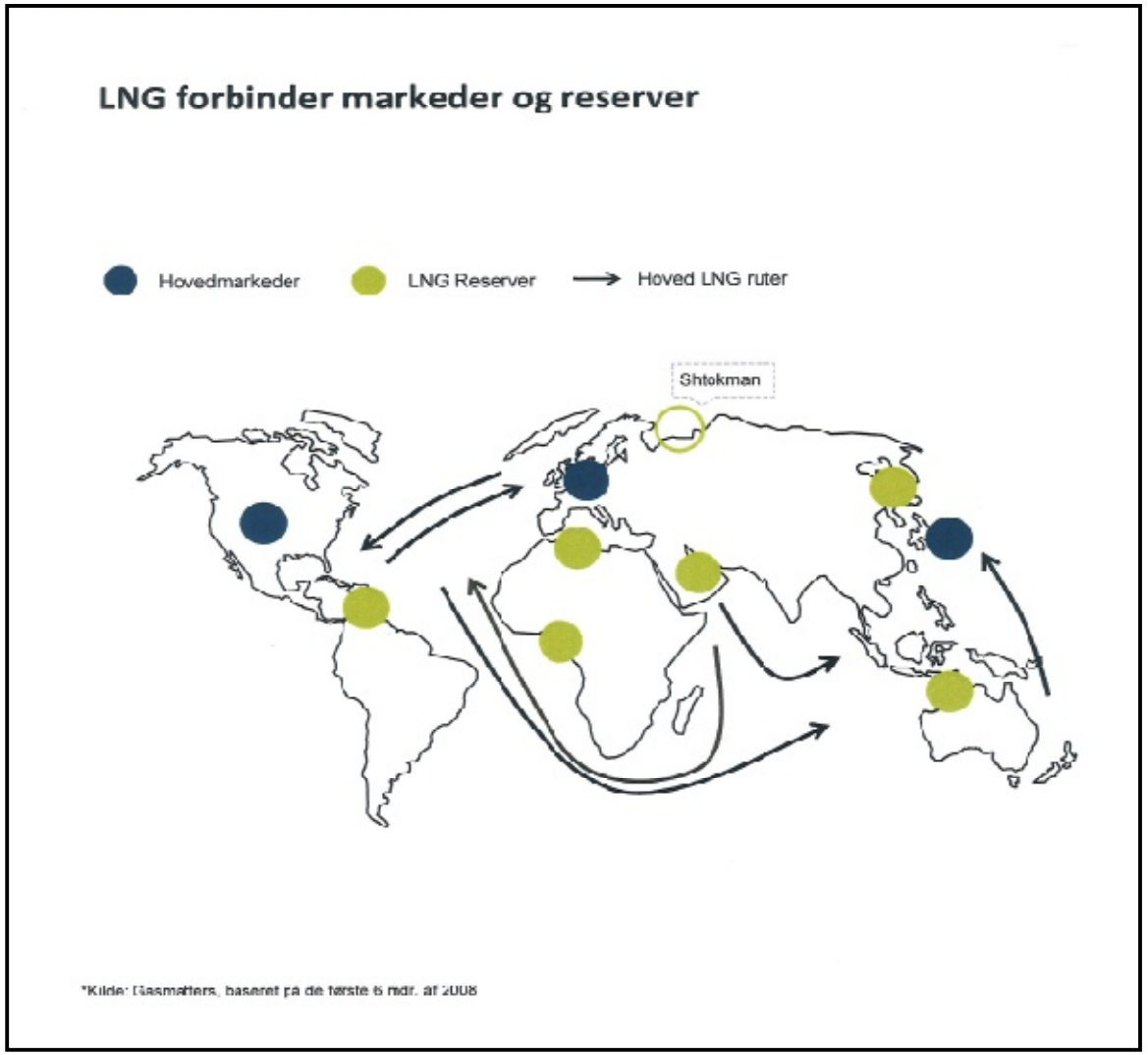
	Liquefaction	Shipping	Regasification
			
Loss:	8 – 10 %	1 – 4 %	1 – 2 %

1% = 440 M€/year in 2010 and 900 M€/year in 2015

Flow Metrology for LNG

Flowcenter Danmark

LNG globalt



% af total

Største importører	
Japan	38%
Korea	17%
Spanien	13%
Frankrig	6%
Taiwan	4%

Største eksportører	
Qatar	17%
Malaysia	13%
Indonesien	12%
Algeriet	11%
Nigeria	9%

LNG forventes at udgøre en stigende andel af de samlede gasforsyninger til Europa.

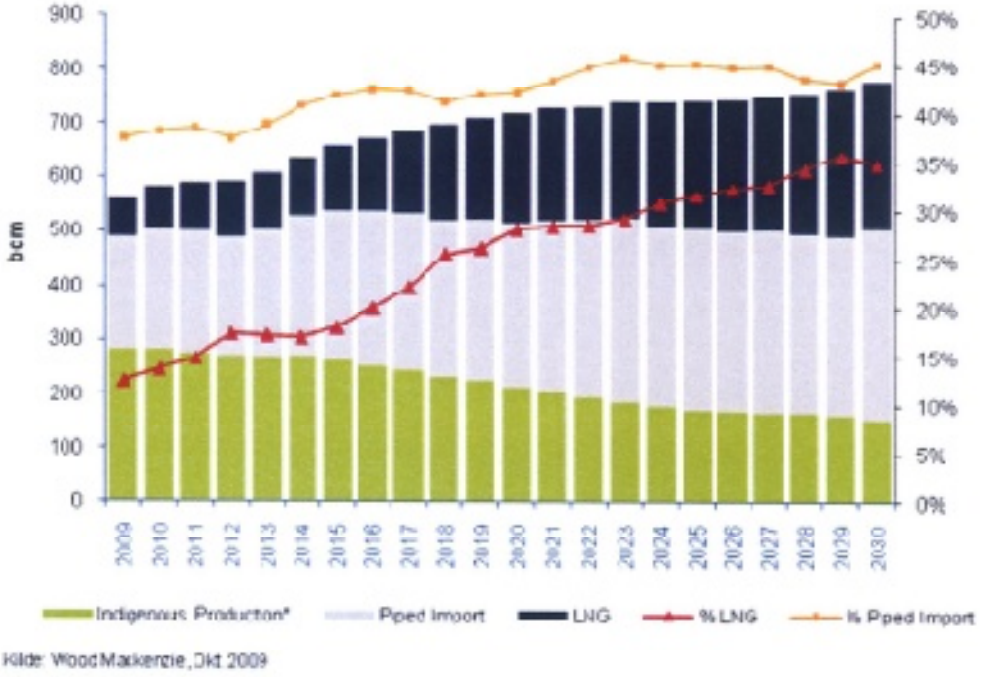
Europas gasproduktion er kraftigt faldende.

Det medfører stigende import fra bl.a. Norge, Rusland og den øvrige verden.

Spanien er Europas største importør af LNG

UK og Italien forventes at aftage størstedelen af den øgede europæiske LNG import

Men også Nordvesteuropa og Frankrig vil øge importen



Kilde: Wood Mackenzie, Okt 2009

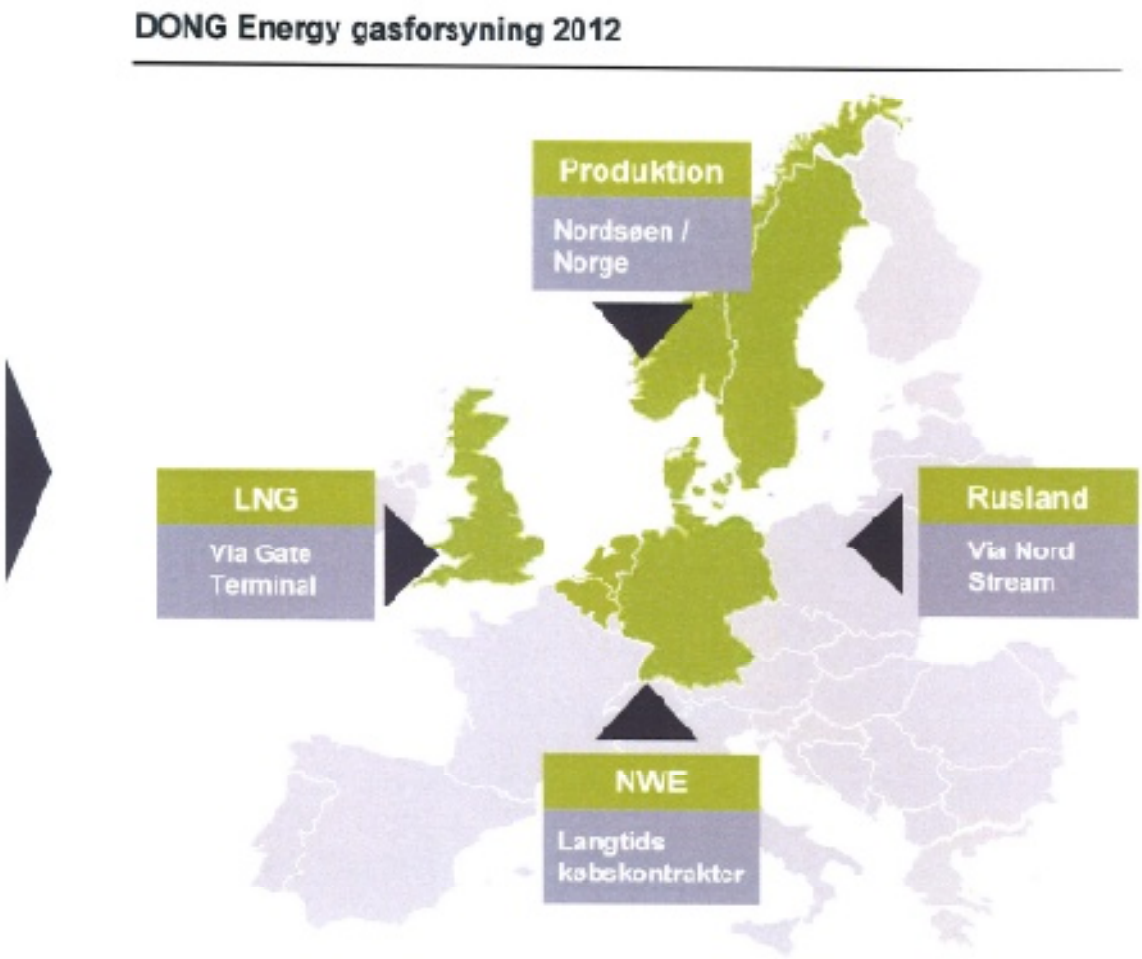
DONG Energy øger naturgas aktiviteterne i Nordvesteuropa

DONG energy

DONG Energy vil basere gasforsyningsporteføljen på en kombination af:

Egenproduktion, gas på langtids kontrakter fra Nordvesteuropa og Rusland samt LNG

Ved at sikre en diversificeret portefølje af leverandører og kontrakter opnår DONG Energy en høj grad af forsyningssikkerhed.



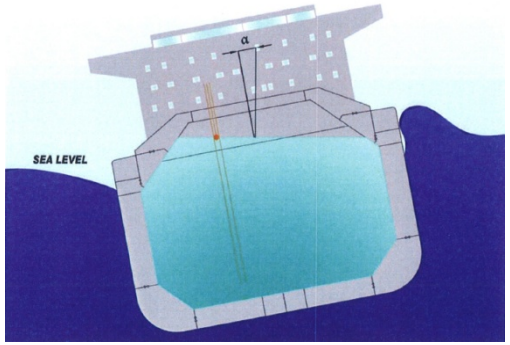
DONG Energy's adgang til LNG: Gate Terminal

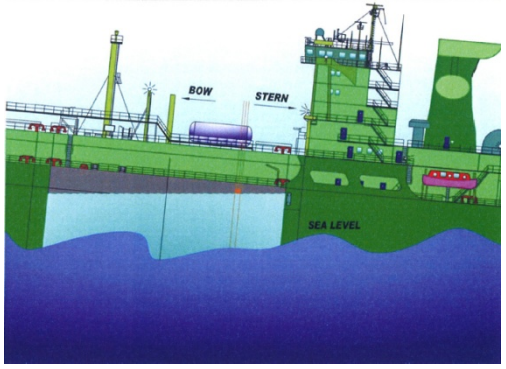
Fakta om Gate Terminal
Lokaliseret i Rotterdam havn
Start up 23.09.2011
3 lagertanke á 180.000 m3
Samlet kapacitet: 12 mia. m3 om året
Ca. 180 skibe om året ved fuld udnyttelse
Samlet investering: 950 mio. €

Firma	Ejerandel [%]	Kapacitetsandel [mia. m^3]
Vopak	40	
Gasunie	40	
DONG Energy	5	3
E.ON	5	3
OMV	5	3
RWE	5	3

The project's overall objective

- To contribute to a significant reduction of uncertainty (by at least a factor two) in the determination of transferred energy in LNG custody transfer processes
- (1% uncertainty = 440 M€/year in 2010 and 900 M€/year in 2015)
- Contribute to:
  - Improving existing methods
  - Validating new methods
  - Creation of new calibration systems with improved uncertainty
  - International technical and legal standards and guidelines

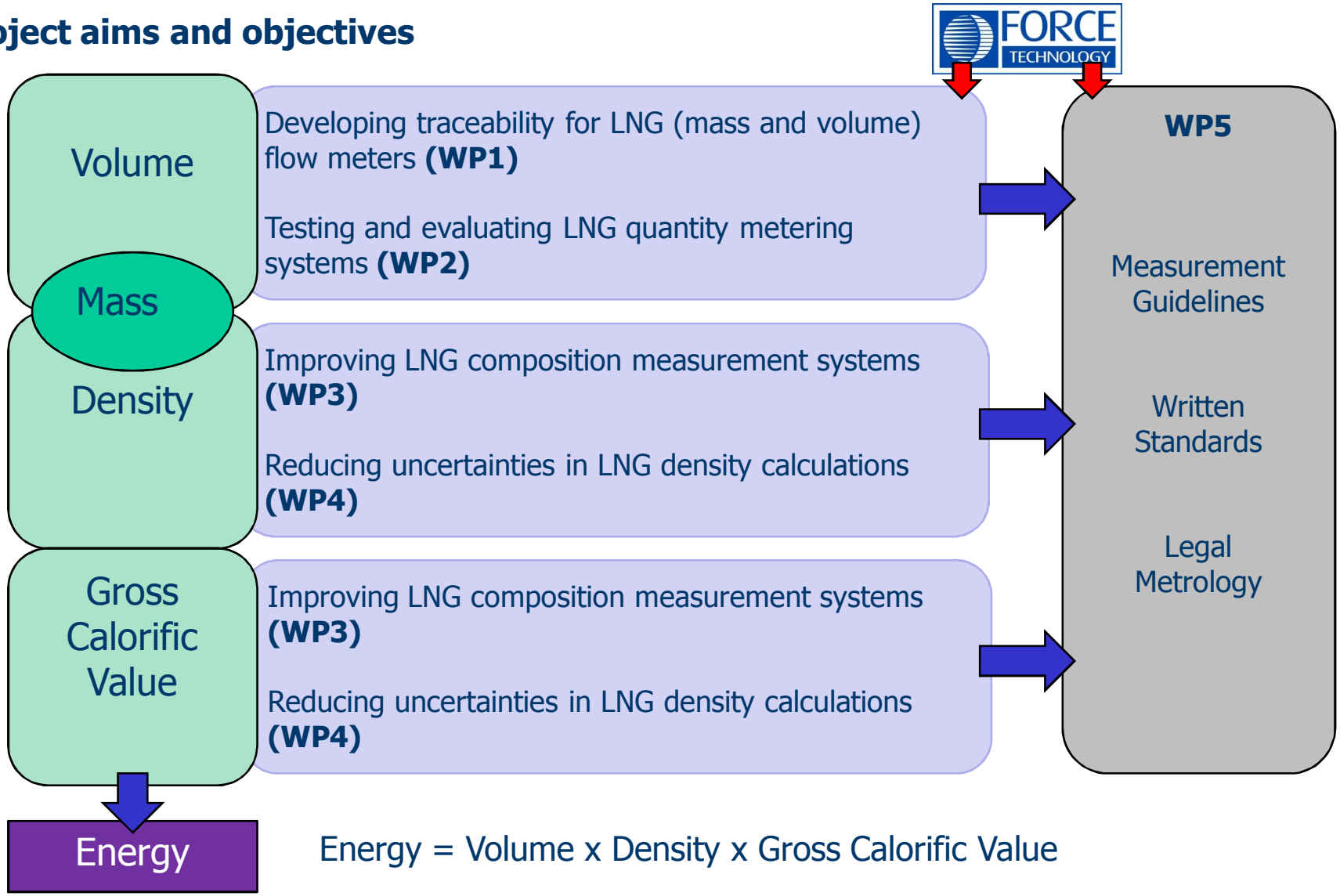




Flow Metrology for LNG

Flowcenter Danmark

Project aims and objectives

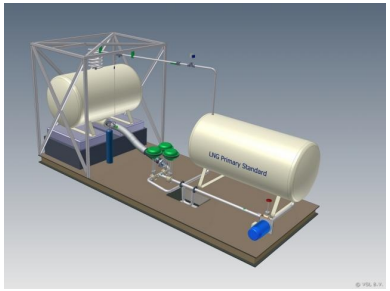


Flow Metrology for LNG

Flowcenter Danmark

WP1 Developing traceability for LNG flow meters

- Developing of a primary LNG mass flow standard (25 m^3/h, target uncertainty 0.05%)
- Uncertainty assessment upscaling method
- Developing simulation upscaling method
- Developing mid-scale flow standard / first stage upscaling standard (200 m^3/h, target uncertainty 0.07%)
- Comparing water, LN2 and LNG calibrations
- Defining economic calibration concept
- Studying technical feasibility and uncertainty of laser doppler velocimetry for LNG flow measurement



Flow Metrology for LNG

Flowcenter Danmark

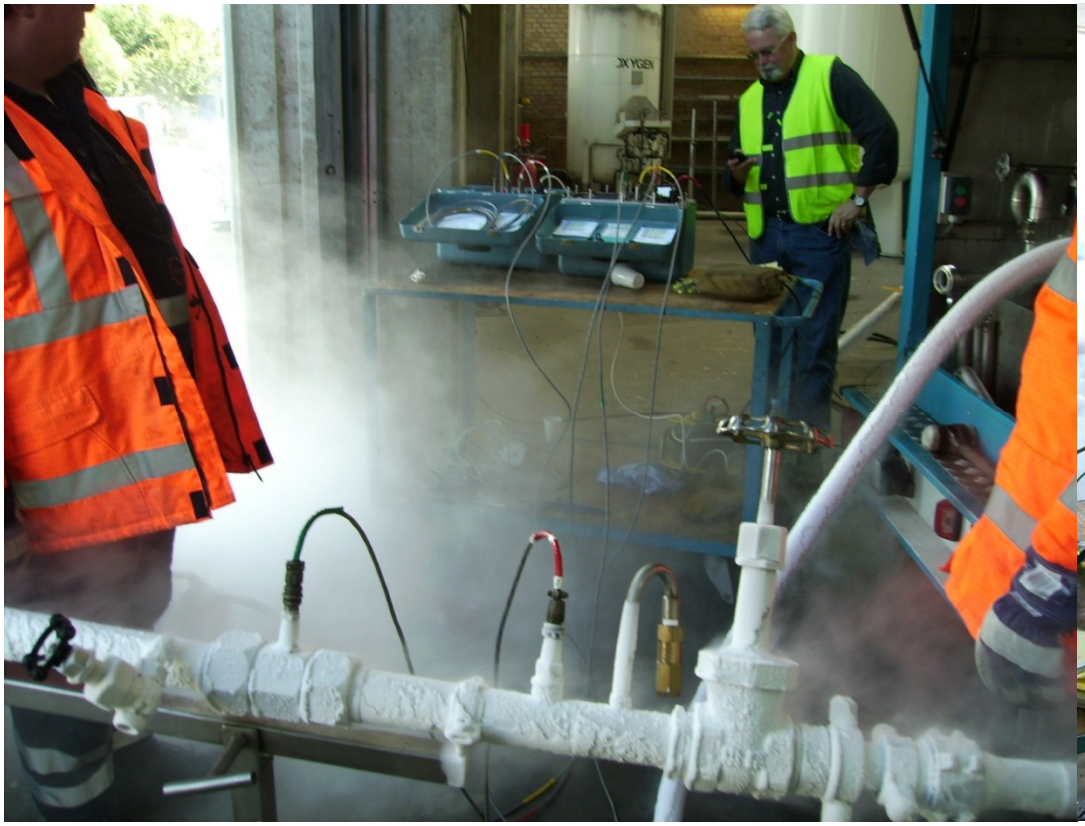
Developing a primary LNG mass flow standard

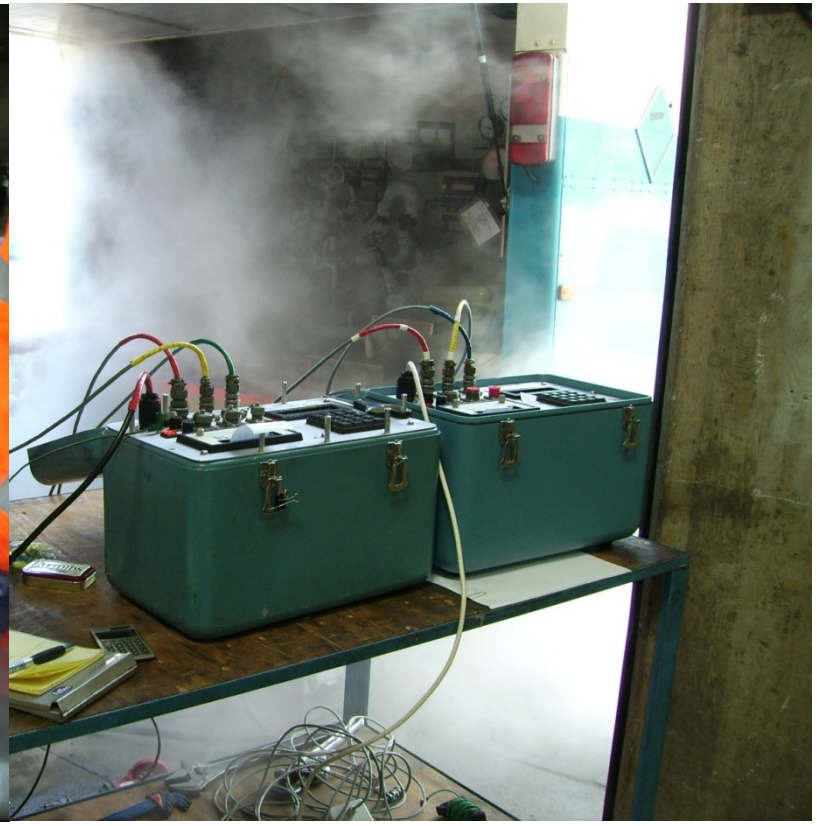
- Flow rate: Q = 5-25 m^3/h
- LIN and LNG (testing with LIN)
- Operation pressure: p = 3-4 bar(g)
- Operation temperature: T = -160 °C (-195 °C for LIN)
- Uncertainty target < 0.05%
  - Lower uncertainty than LN2 NIST facility (0.17 %)
  - Uncertainty VSL water facilities 0.02 %

Kalibrering af flowmåler med LIN - hvordan?

Temperatur: -195 °C
Diameter: 2”
Flow range: 130 – 700 l/min
Tryk: 2 – 3 bar

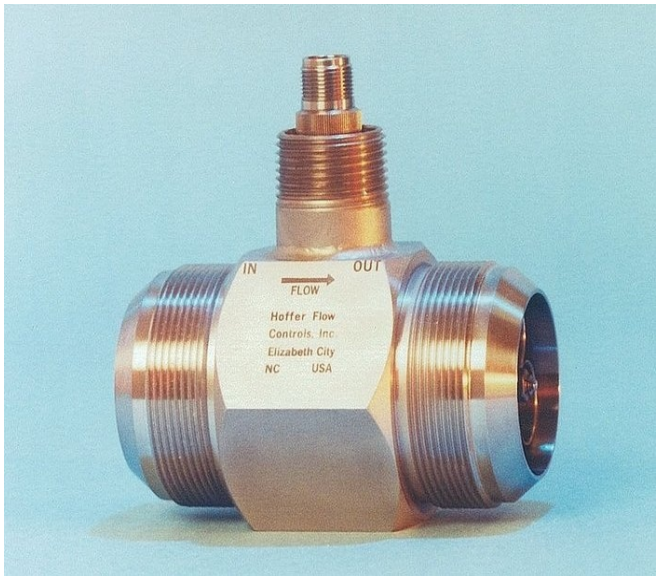
Kalibrering af flowmåler med LIN - mod hvad?





Master Meter: Hoffer HO11/2X11/2-8-130-CB-1M-1S
S/N: 107258
ID#: TE-635
Calibration Date and place: 21.03.2011 at NIST (US)

Test af flowmåler med LIN – hvilke(n) måler(e)?

	Coriolis	Vortex	Turbine
			
Accuracy	+	÷	-
Pressure loss	÷	+	+
Price	÷	-	+

Flow Metrology for LNG

Flowcenter Danmark

WP2 Testing and evaluating LNG quantity metering systems

- Evaluating uncertainty of shiptank based measurement systems
- Field testing: Comparing static (tank level) and dynamic (flow metering) quantity metering systems
- Studying (simulation and experiments) effect of cryogenic media on measuring system (flow meter, tempertaure and pressure sensors)
- Studying (simulation and experiments) of installation effects on LNG flow meters

Static versus dynamic volume measurements

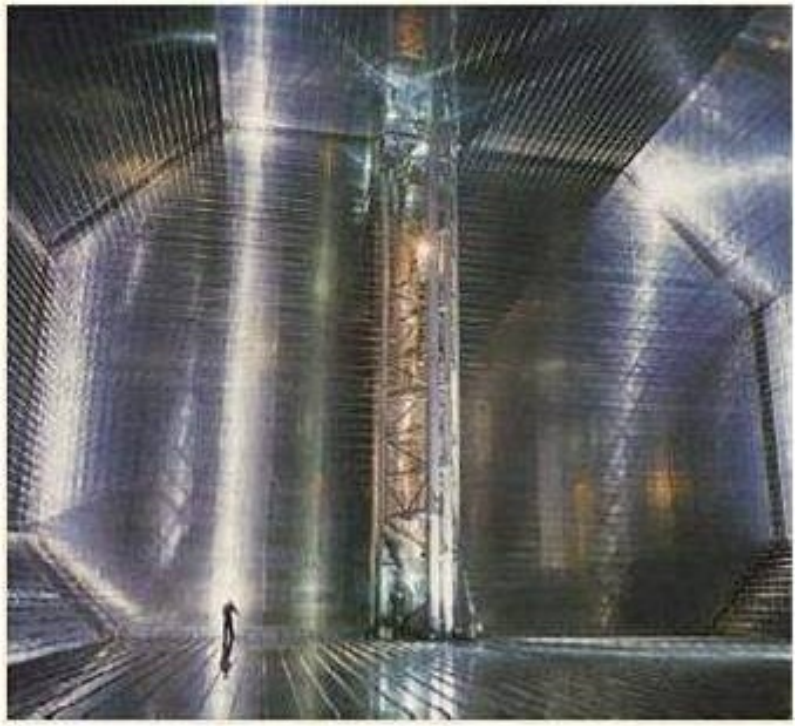
Typically

- Level gauging + gauge table (static)
- Uncertainty: 0.2 – 0.5 % ?

Alternative

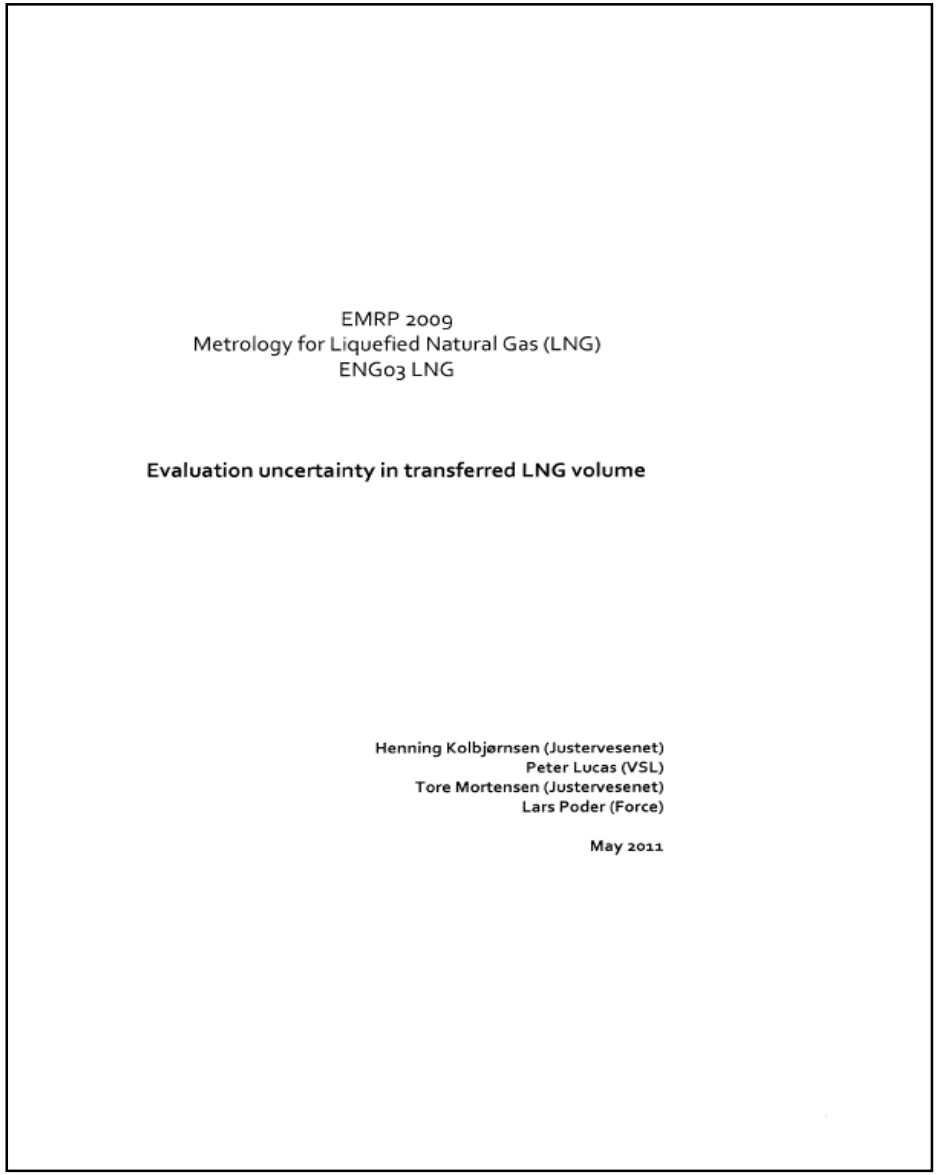
- Volume rate meters (dynamic)
- Uncertainty: 0.2 – 0.3 % ?
- No direct traceable link to SI units

Calibration facility required!



Flow Metrology for LNG

Flowcenter Danmark



EMRP 2009
Metrology for Liquefied Natural Gas (LNG)
ENG03 LNG

Evaluation uncertainty in transferred LNG volume

Henning Kolbjørnsen (Justervesenet)
Peter Lucas (VSL)
Tore Mortensen (Justervesenet)
Lars Poder (Force)

May 2011

Introduction

This study is part of the EMRP project "Metrology for Liquefied Natural Gas (LNG)" [17] and focuses on the uncertainty of static LNG volume measurements as encountered in (un)loading LNG ships. For the uncertainty in the (un)loaded LNG volume one usually refers to the LNG custody transfer handbook of G.I.I.G.N.L. [16], in which a value of 0.42% is claimed (level of confidence of 95%, see Section 15.5). However, the LNG custody transfer handbook is not a standard but a document providing guidance to the industry by describing common practice. It can, therefore, not be used as a norm or standard. In addition, a thorough uncertainty assessment is lacking in the view of the authors. For example, several uncertainty contributions have not been validated and covariance's are not accounted for in the combination of uncertainty sources. As of yet a thorough metrologically sound uncertainty budget has not been conducted, probably because LNG shipping is typically bound by long-term contracts. Furthermore, buyers and sellers see uncertainty as inherent to level gauging.

Conclusions

The present report summarizes the formulas used to determine the uncertainty associated with the LNG volume transferred to or from a ship. The results are applicable to both Moss type and Membrane type tanks.

Unlike other uncertainty estimations that can be found in the literature, the one presented in this work is fully in accordance with the GUM and it includes real shipment data.

The shipment data indicates that the uncertainty in level gauging is higher, potentially much higher, than stated elsewhere. For a Membrane type tank, for example, the total uncertainty is significantly higher than stated in the GIIGNL LNG custody transfer handbook. In case the differences in level gauging equipment are taken into account, the uncertainty is close to 1 %.

The largest uncertainty contribution comes from the main gauge table, while it is unsure what the coverage factor is.

Uncertainty contributions from trim and list are essential for terminals that are poorly protected from or are at open sea.

Flow Metrology for LNG

Flowcenter Danmark

WP5 Contributing to measurement guidelines, written standards and legal metrology

- Providing input to ISO and CEN standardization (ISO TC28/SC5, ISO 10976, ISO 8943-2007, ISO TC67/WG10, ISO TC193, ISO 6976, CEN TC282, EN 12838-2000)
- Providing information/guidelines to EURAMET TC-Flow
- Providing input to legal metrology (MID/OIML)
- Providing input to GIIGNL (custody transfer handbook) and LNG industry (Groupe International des Importateurs de Gaz Naturel Liquéfié)

TC-F Flow EURAMET Technical Committee

Flow Metrology for LNG

Flowcenter Danmark

- **Project duration:** May 2010 – May 2013
- **Project coordinator:** Ir. Oswin Kerkhof, VSL
- **Funding:** Approx. 3 M€ (46% EU/EMRP, 54% Metrology organisations)
- **Project partners:**

VSL, Netherlands
SP, Sweden
TUV NEL, United Kingdom
FORCE Technology, Denmark
Justervesenet, Norway
CMI, Czech Republic
Cesame, France
INRiM, Italy
PTB, Germany
ENAGAS, Spain
ELENGY, France
E.ON RUHRGAS, Germany

Flow Metrology for LNG

Flowcenter *Danmark*

www.lngmetrology.info