

Flow Metrology for Liquefied Natural Gas (LNG)

EMRP Project – Introduction and overview



October 2011
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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 m³
- 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 %

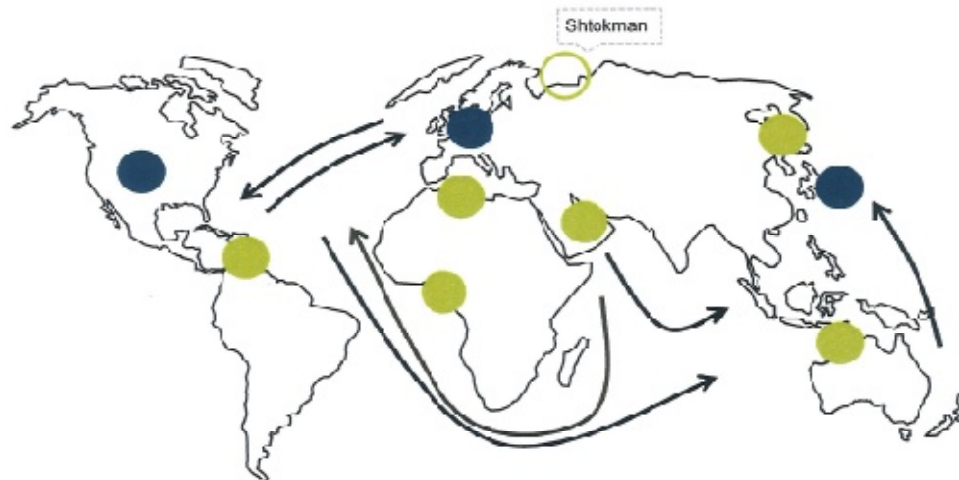
1% = 440 M€/year in 2010 and 900 M€/year in 2015



LNG globalt

LNG forbinder markeder og reserver

● Hovedmarkeder ● LNG Reserver → Hoved LNG ruter



*Kilde: Gasmarkets, baseret på de første 5 mdr. af 2008

% 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.

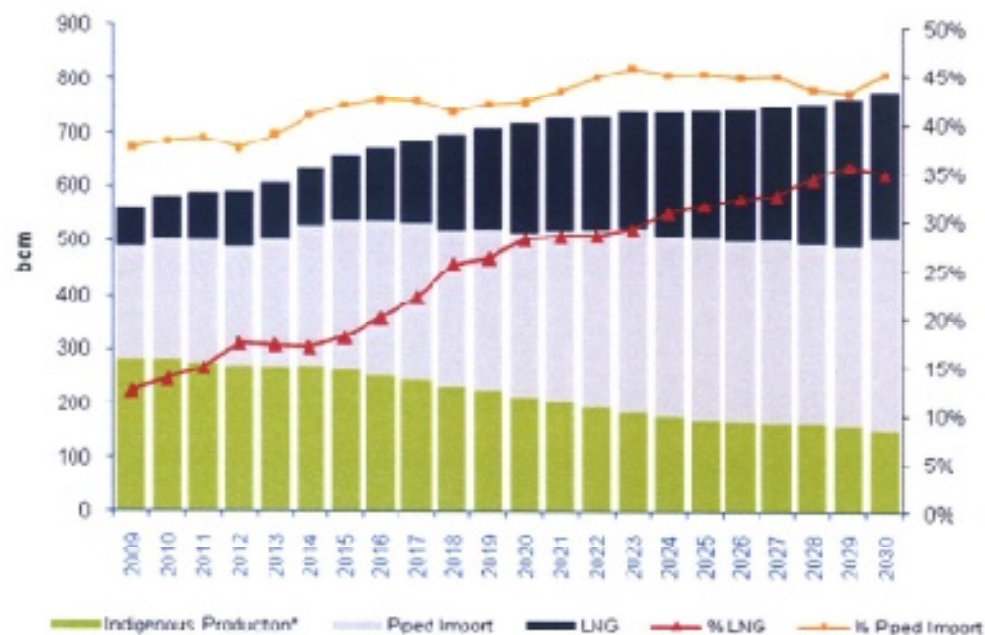
Europas gasproduktion er kraftigt faldende.

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: WoodMackenzie, Dkt 2009



DONG Energy øger naturgas aktiviteterne i Nordvesteuropa

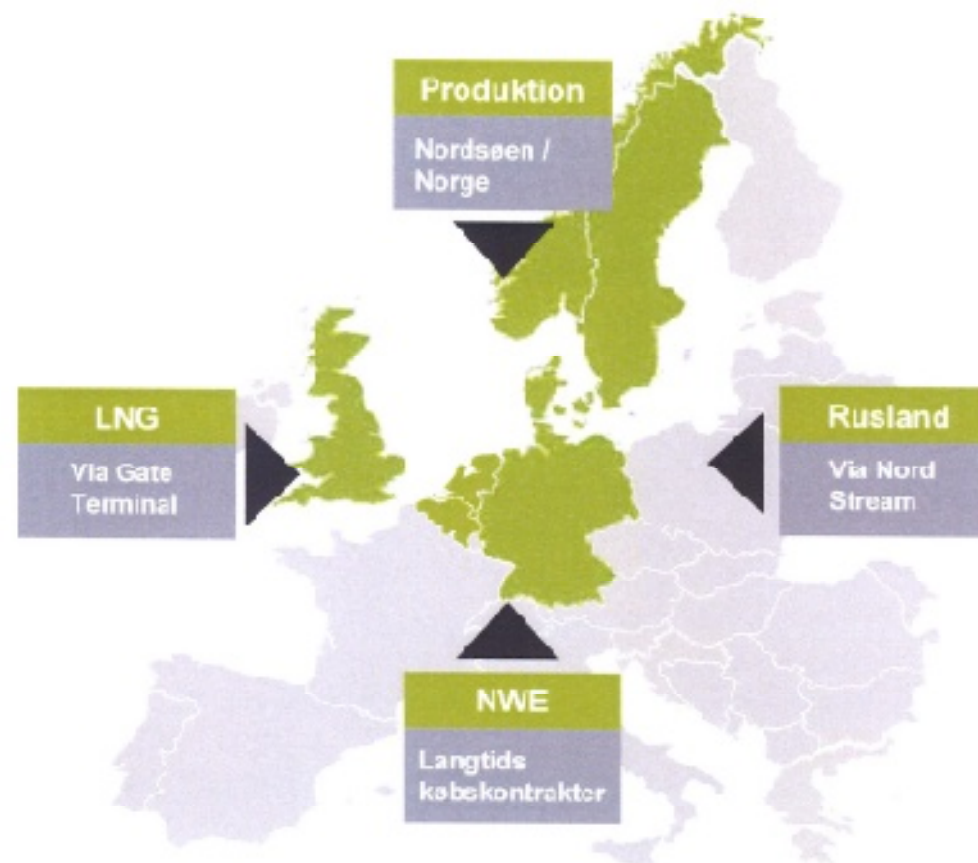


DONG Energy gasforsyning 2012

DONG Energy vil basere gasforsyningsporteføljen på en kombination af:

Egenproduktion, gas på langtidskontrakter fra Nordvesteuropa og Rusland samt LNG

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





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. €

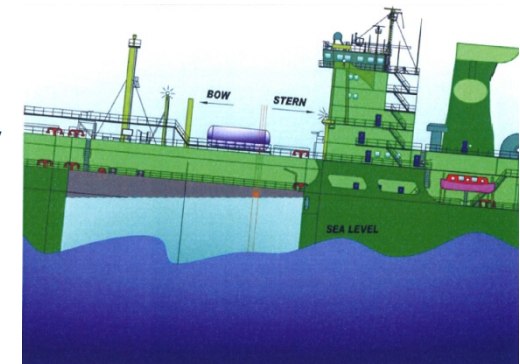
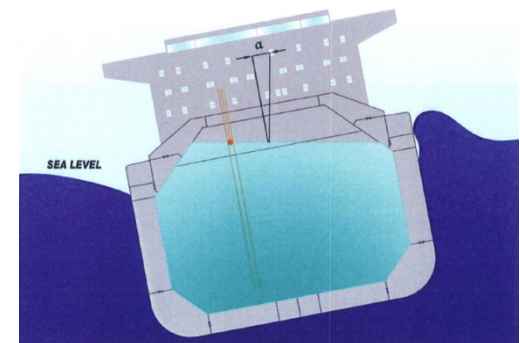
Firma	Ejerandel [%]	Kapacitetsandel [mia. m ³]
Vopak	40	
Gasunie	40	
DONG Energy	5	3
E.ON	5	3
OMV	5	3
RWE	5	3





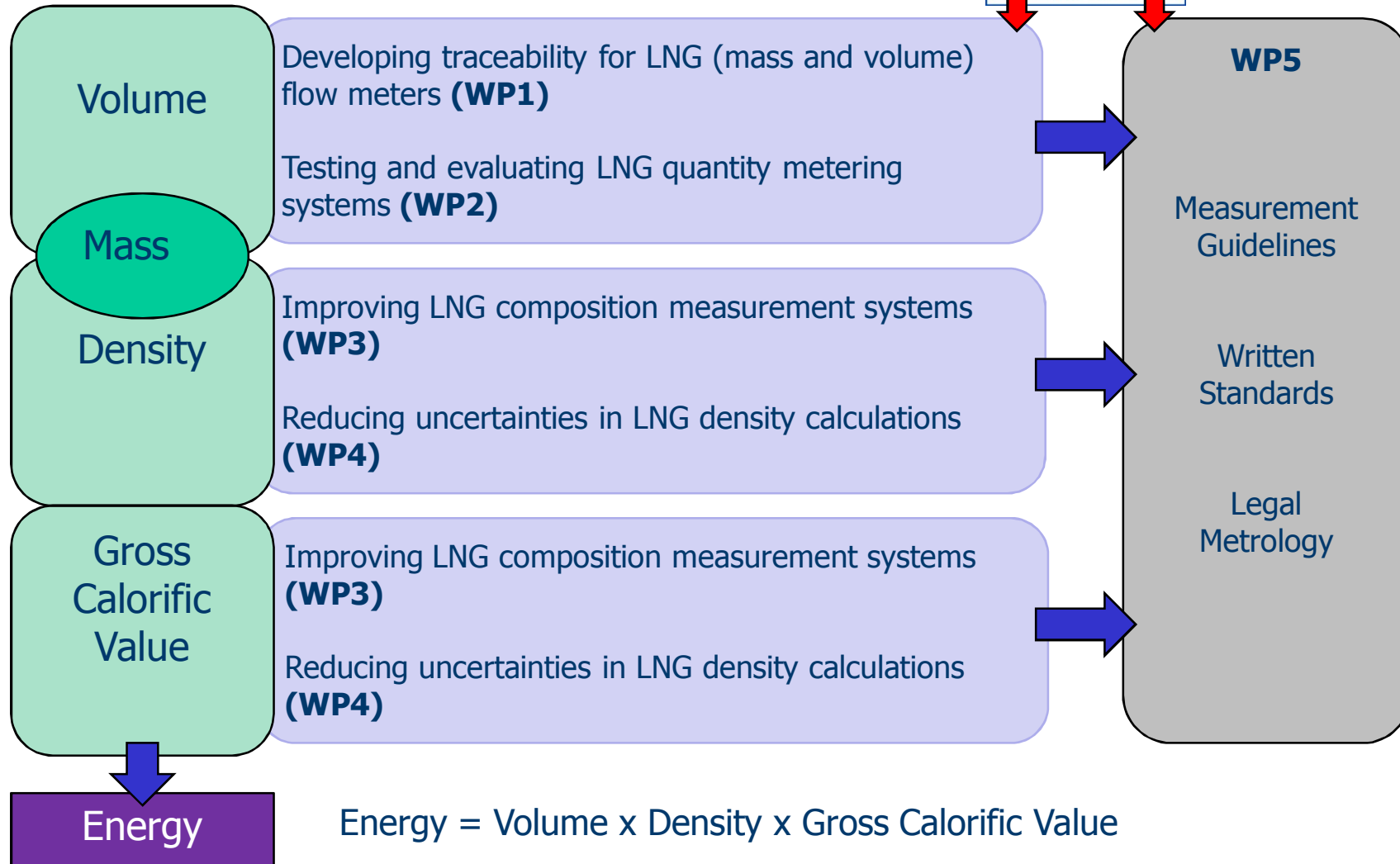
The project's overall objective

- 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





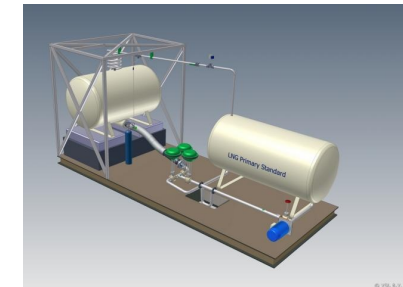
Project aims and objectives





WP1 Developing traceability for LNG flow meters

- Developing of a primary LNG mass flow standard (25 m³/h, target uncertainty 0.05%)
- Uncertainty assessment upscaling method
- Developing simulation upscaling method
- Developing mid-scale flow standard / first stage upscaling standard (200 m³/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





Developing a primary LNG mass flow standard

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





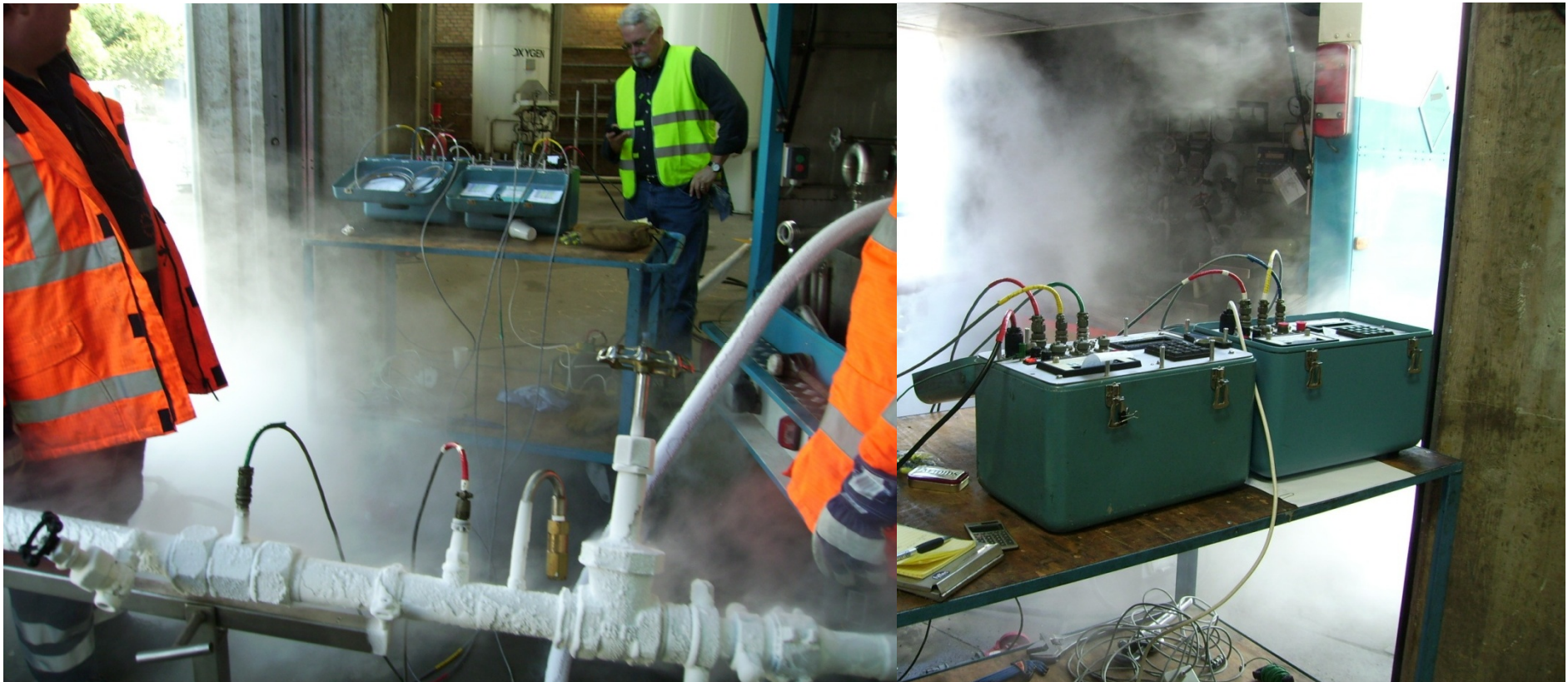
Kalibrering af flowmåler med LIN - hvordan?



Temperatur: $-195\text{ }^{\circ}\text{C}$
Diameter: 2"
Flow range: 130 – 700 l/min
Tryk: 2 – 3 bar



Kalibrering af flowmåler med LIN - mod hvad?

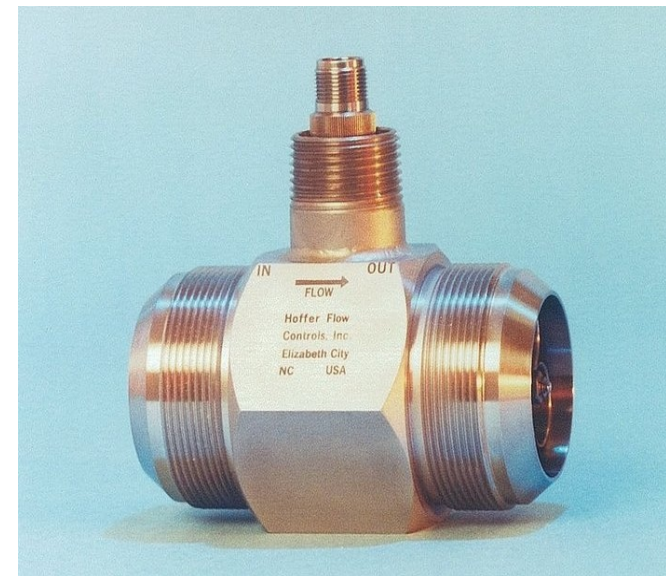
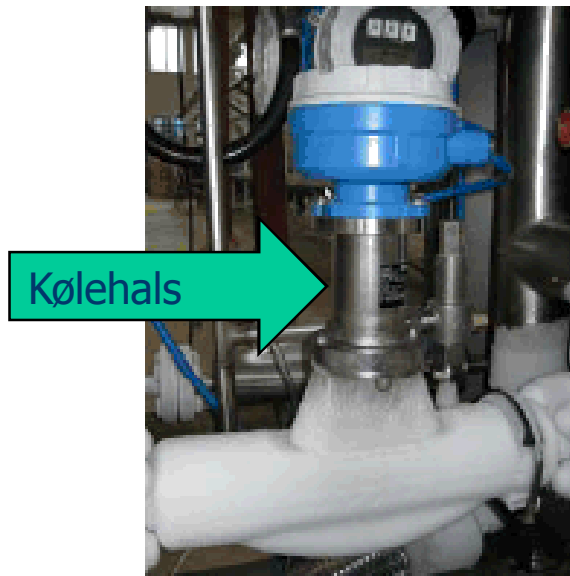


Master Meter: Hoffer HO11/2X11/2-8-130-CB-1M-1S
S/N: 107258
ID#: TE-635
Calibration Date and place: 21.03.2011 at NIST (US)



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

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



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, temperature and pressure sensors)
- Studying (simulation and experiments) of installation effects on LNG flow meters





Static versus dynamic volume measurements

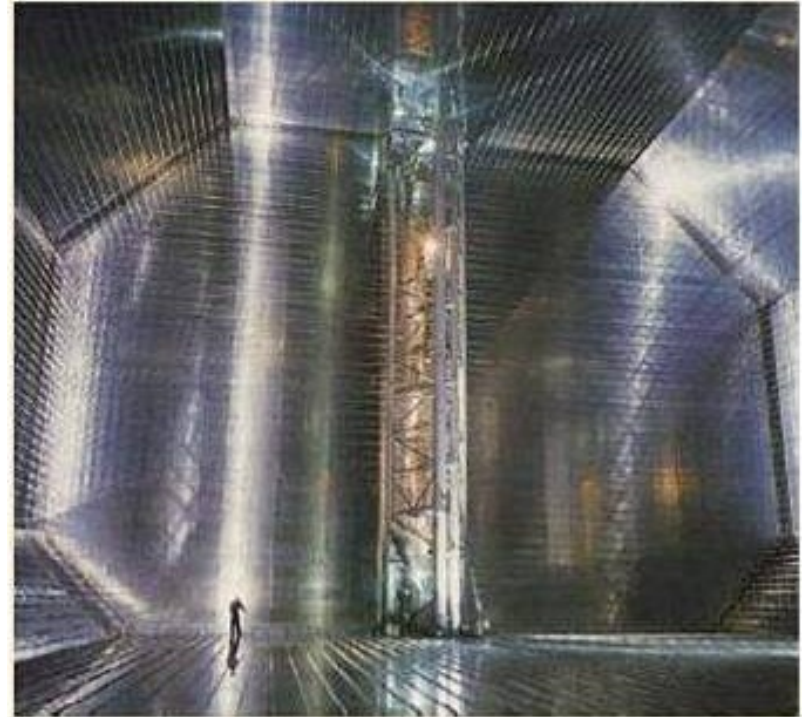
Typically

- 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!





EMRP 2009
Metrology for Liquefied Natural Gas (LNG)
ENGo3 LNG

Evaluation uncertainty in transferred LNG volume

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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.



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)





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



Flow Metrology for LNG

Flowcenter *Danmark*

www.Ingmetrology.info

The screenshot shows the Metrology for LNG website in a Windows Internet Explorer browser window. The browser's address bar shows the URL <http://www.Ingmetrology.info/>. The website header includes the logo and navigation links for "e-mail us", "Log out", and "My account".

Search this site:

Lars Poder

- News
- Project summary
- Partners
- Collaborators
- Work packages
- Image galleries
- Advisory group
- Project publications
- Publications
- Events
- Links

Project news

[Metrology for LNG, July 1st 2010 by VSL](#) [more](#)

Traceability in LNG measurement


Welcome to the Metrology for LNG website

This website is dedicated to the European Research project¹ "Metrology for LNG" and intends to provide information to and bring together stakeholders from the LNG industry.

In the navigation menu we provide you information about the project aims and results obtained, about the partners involved and industrial stakeholders that are contributing to the project.

Visitors can read the discussions on the forums and can vote in the polls.

Registered users have access to all summary reports, workshop presentations, photograph sections and can subscribe to project newsletters. If you are interested to become even more closely linked to the project please read the [collaborator](#) section and/or the [Advisory group](#) section and contact the project coordinator.



- Whenever there is trade, there are measurements involved to quantify the transfer of goods.
- Whenever there are measurements, there are errors and uncertainties involved.
- Metrology is all about providing standards that are internationally accepted and allow one to quantify the error or uncertainty of any measurement.
- Without a quantification of the associated uncertainty any measured value has no meaning; one would be left in the dark.
- This project aims to improve and develop the metrology for LNG custody transfer measurements leading to smaller measurement uncertainties, reduction of financial risks of transactions and more transparency in the trade of LNG.

Cordially yours,
Oswin Kerkhof
Project Coordinator
March 1st, 2011

¹This project is a so-called Joint Research Project (JRP) and carried out as part of the European Metrology Research Program (EMRP)

Project events

- 2nd International Workshop - Metrology for LNG East**
Kilbride - UK, October 31st, 2011

Other events

- 15th International Congress of Metrology Paris - France,**
October 3rd 6th, 2011
- 25th World Gas Conference**
Kuala Lumpur - Malaysia, June 4-8th, 2012

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The Windows taskbar at the bottom shows the Start button and several open applications, including "Inbox - Microsoft Out...", "Slides til i morgen - M...", "HONEYWELL (3)", "Welcome to the Metr...", "Installationsforhold [...]", and "Metrology for LNG". The system tray shows the Internet icon, network status, and a 100% zoom level. The time is 12:00.