LH_2 measurement standards

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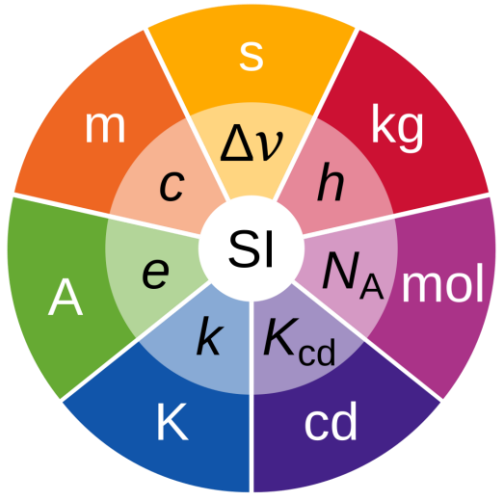
What is metrology about?

VSL: National **Metrology** Institute

- A: Measurement science
- B: International system of units (SI-units)
- C: Reference measurement standards
- D: Studying the weather



Metrology ≠ Meteorology

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Global Measurement Infrastructure

Regulation & Trade
(regulation, enforcement and certification)

Rijksinspectie Digitale Infrastructuur
Ministerie van Economische Zaken en Klimaat

Standardization

NMI appointed by ministry:
- Primary Standards
- Physical measurements

Competent Laboratories

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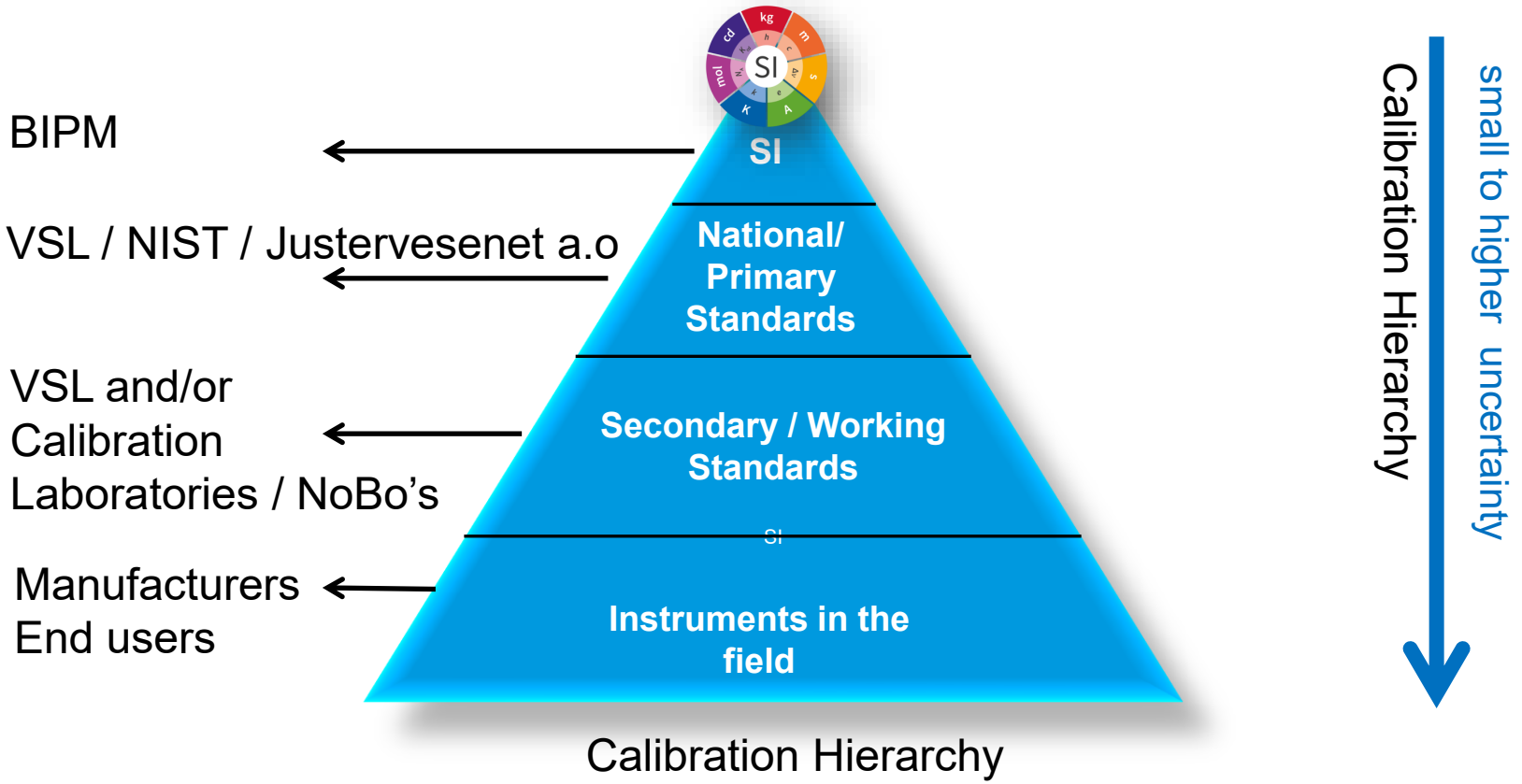
National Metrology Institutes (such as VSL and NIST)

In the top of the metrological pyramid



Metrological traceability requires an established calibration hierarchy

What is metrology about?

Measurement Standard ≠ Documentary Standard

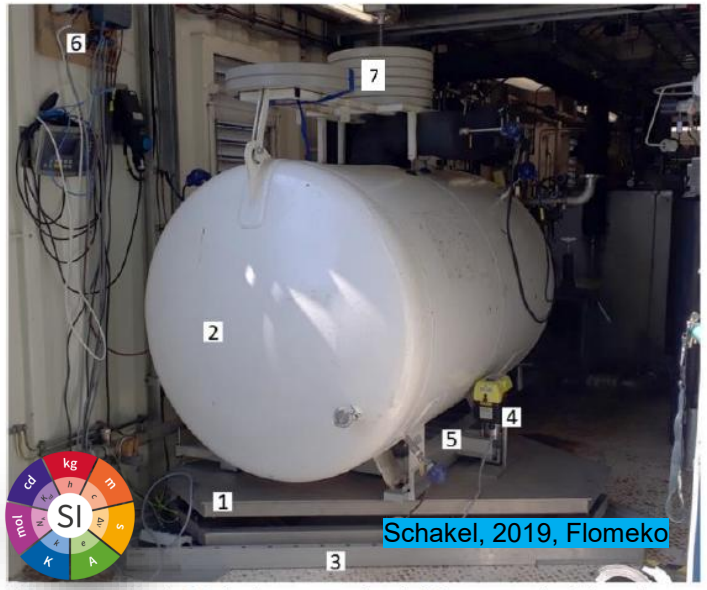
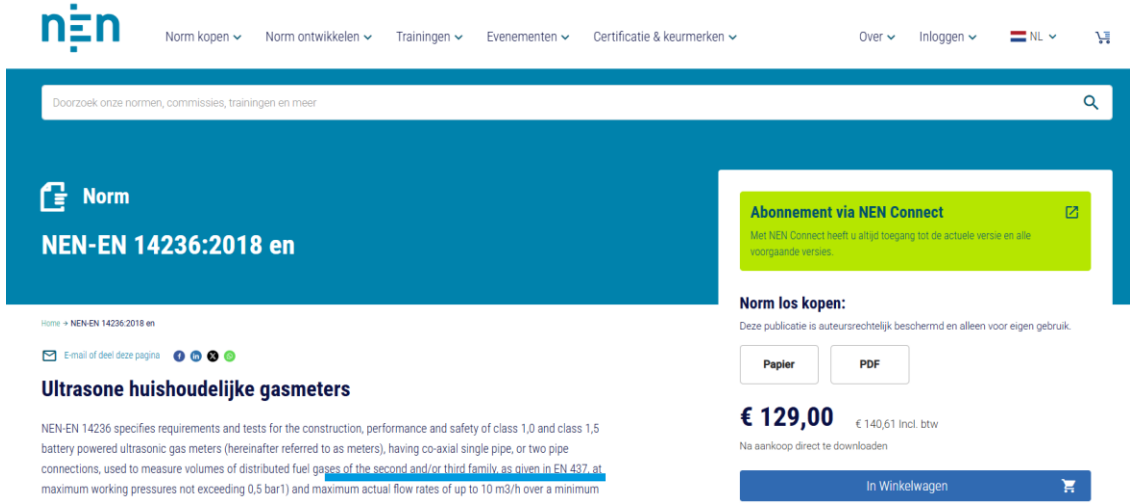


Figure 3: The LCS, balance, and weighing vessel of the primary LNG mass flow standard. Components are: balance (1), weighing vessel (2), floor board (3), actuators (4), tank frame (5) LCS control system (6), and calibration weights (7).



Nederlandse norm

NEN-EN 14236

(en)

Ultrasonic domestic gas meters

Subtlety: documentary standards for measurement equipment require metrological performance tests

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How do you know that the gas meters' measurements are correct?

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Relation metrology and documentary standard

Nederlandse norm

NEN-EN 14236

(en)

Ultrasonic domestic gas meters

5 Metrological performance
(of gas meter)

5.3 Permissible errors
(of gas meter)

Need physical measurement standard (to compare with gas meter)

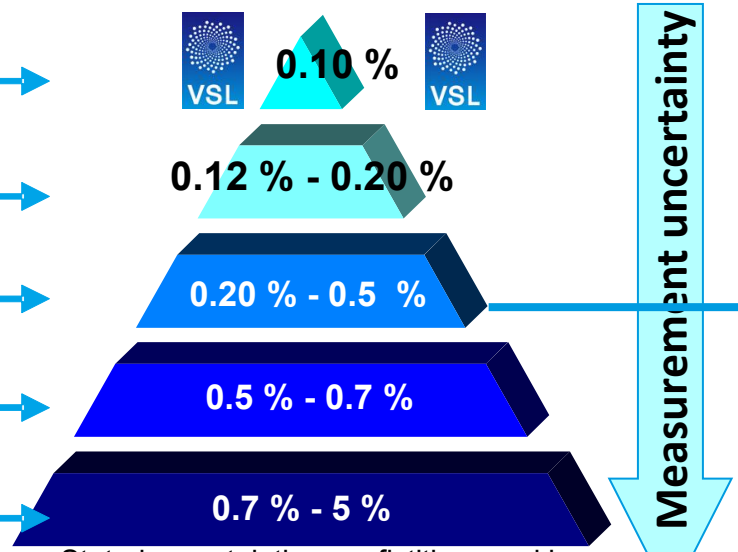
Primary measurement standard

Secondary measurement standard

Accredited laboratories (ISO/IEC 17025)

Measuring departments industry

Measuring & operating processes industrial production



Stated uncertainties are fictitious and bear no resemblance with a specific application

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Need for LH_2 measurement standards

- Accurate LH_2 measurement is needed to develop the needed technology and LH_2 economy in a safe manner:
  - Sustainable aviation
  - Sustainable transportation
  - Import terminals

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Problem: LH_2 accuracy cannot be ascertained with current measurement standards

- Current measurement standards are fit-for-purpose for natural gas based energy supply system
  - Typical uncertainty at about 0.2 % (with approximately 95 % confidence)

Dedicated measurement standards for natural gas ensure high accuracy for natural gas trading across the entire value chain

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Extreme example of what can happen without cryogenic measurement standards

- Meter shows –7 % error, way more than the stated accuracy
- Using water all seemed fine, but when using it on LNG results in the error displayed
- This is known because VSL developed the appropriate measurement standard: VSL LNG facility
- See cited paper for the entire context
- Trust in measurements are crucial to stimulate usage of NG/LNG/LH_2!

van der Beek 2014, Metrologia

van der Beek et al., Metrologia 2014

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VSL's LNG calibration and test facility

- World's first research outputs on LNG and liquefied biomethane measurement accuracy
  1. Systematic measurement errors of LNG flow meters and temperature sensors
  2. Potentially strong effects from meter insulation
  3. Proven achievable accuracy with current technology

- Developing measurement standards can take a couple of years: <u>timely start is strongly recommended</u>

Schakel et al., Flomeko 2022; OIML bulletin 2024

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State-of-the-art for LH_2 measurement standards

- Initiatives:
  - Transfer standard for LH_2 flow measurement (currently lacks direct link with SI-units)
  - References to the SI for the ortho/para isomeric composition
  - Reference to the SI for <-196 °C temperatures (liquid nitrogen)
  - Accurate measurements of multiphase flows

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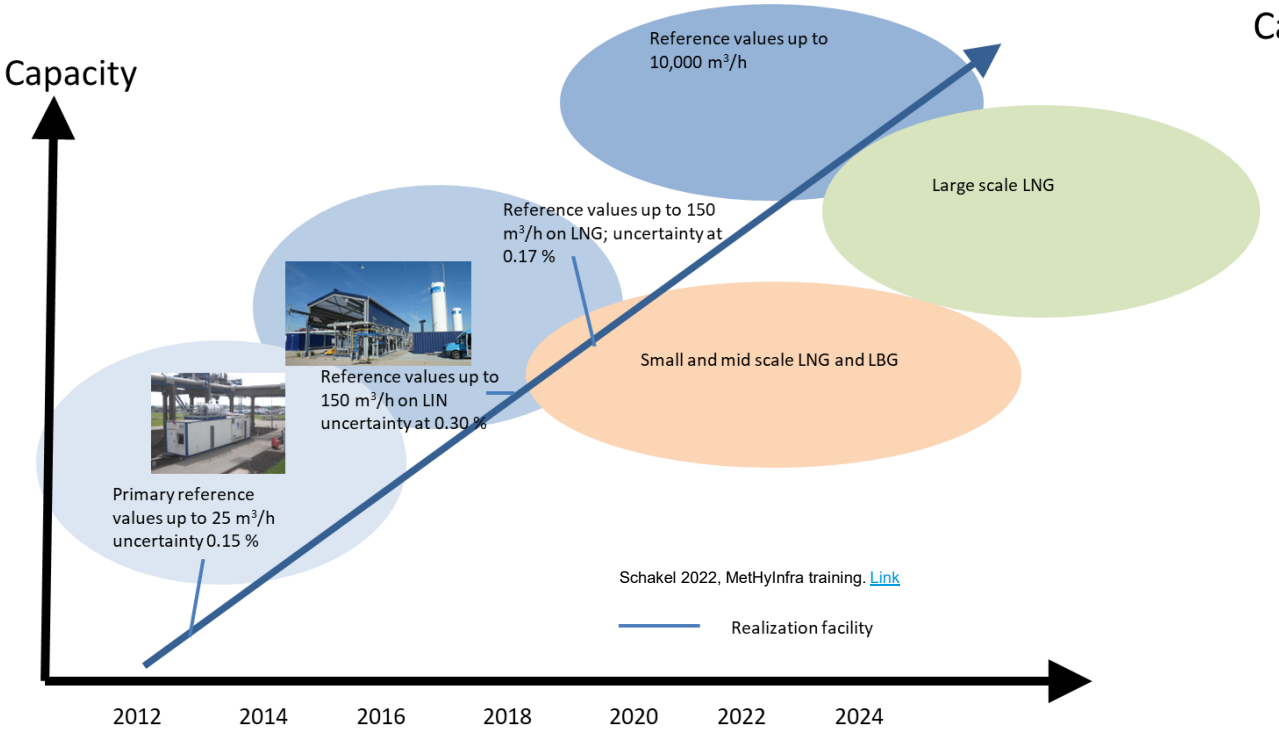
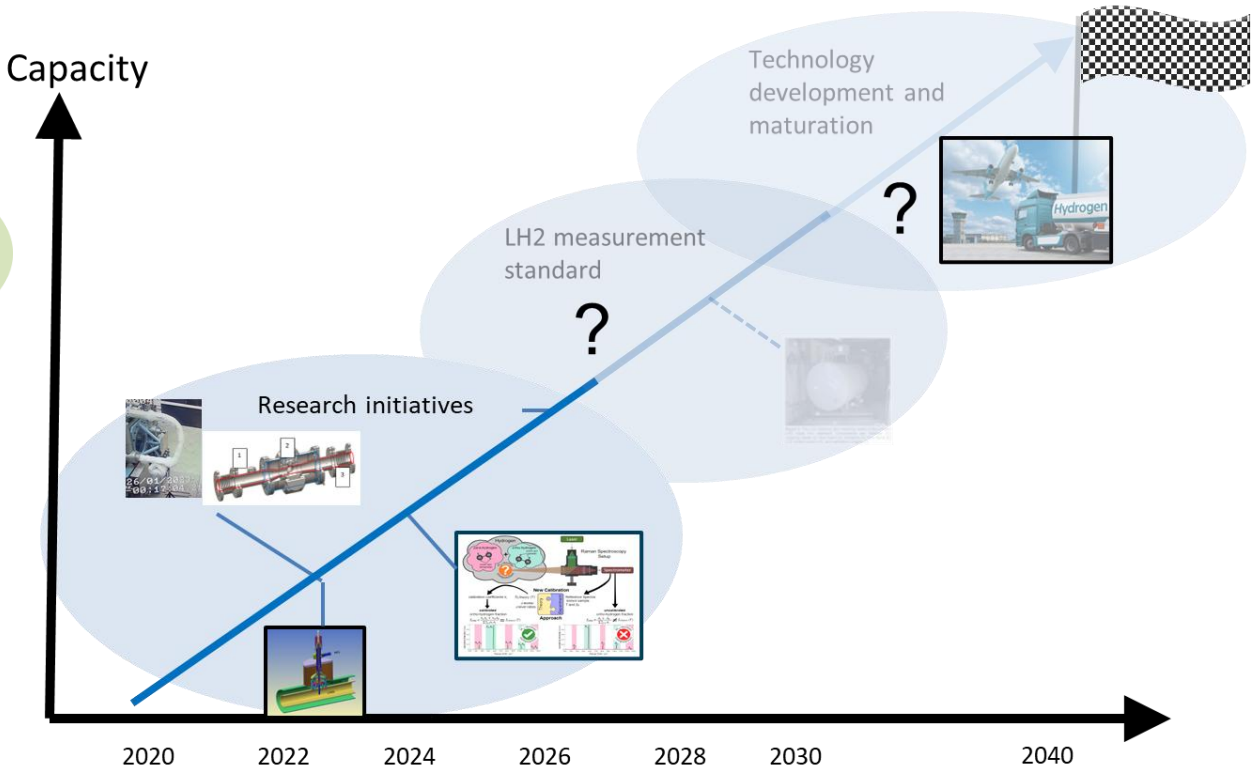
Need for LH_2 measurement standards

1. LH2 measurement standard is needed for transitioning from natural gas to hydrogen-based energy system
2. Ensure accuracy in similar fashion as for natural gas: safeguard NL's economic interest during LH2 import (quality and quantity) to protect NL business
3. NL can independently determine LH2 reference values, no need to rely on other countries
4. Direct access for NL's stakeholders to the measurement standard
5. Technology development in the NL

Timely start is recommended



LNG measurement standard timeline



Potential LH_2 measurement standard timeline

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