Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin
Nationales Metrologieinstitut

Legal requirements on gas meters in Germany and the interoperability of national gas grids

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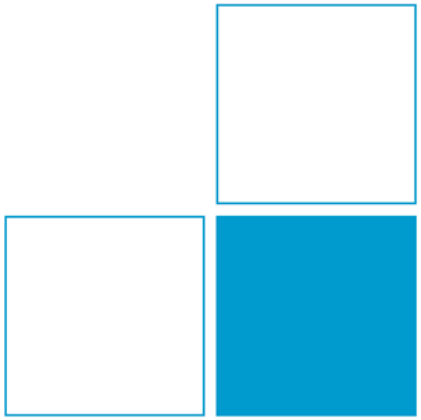

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- EU regulation 2015/703
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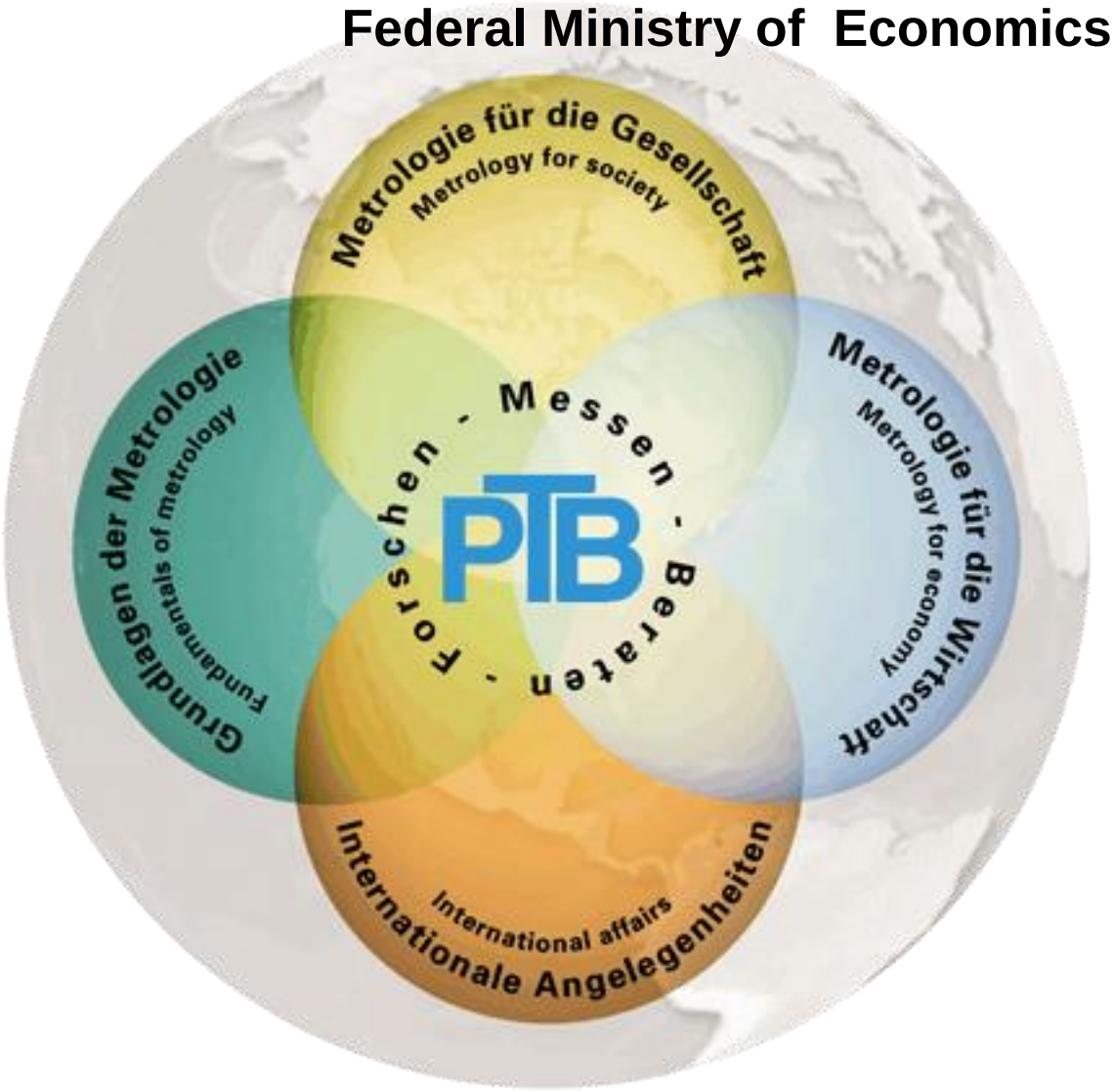
General Information about PTB

Highest metrological authority under the auspices of the Federal Ministry of Economics (BMWi) in Germany



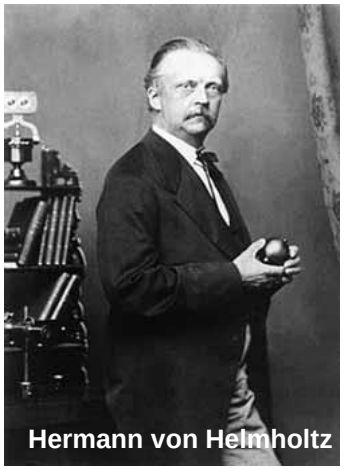
working areas of PTB

- Fundamentals of metrology (realisation of units)
- metrology for society, (legal metrology and other law related activities)
- metrology for economy, (calibrations, accreditation)
- international affairs (standardization, consulting)

General Information about PTB

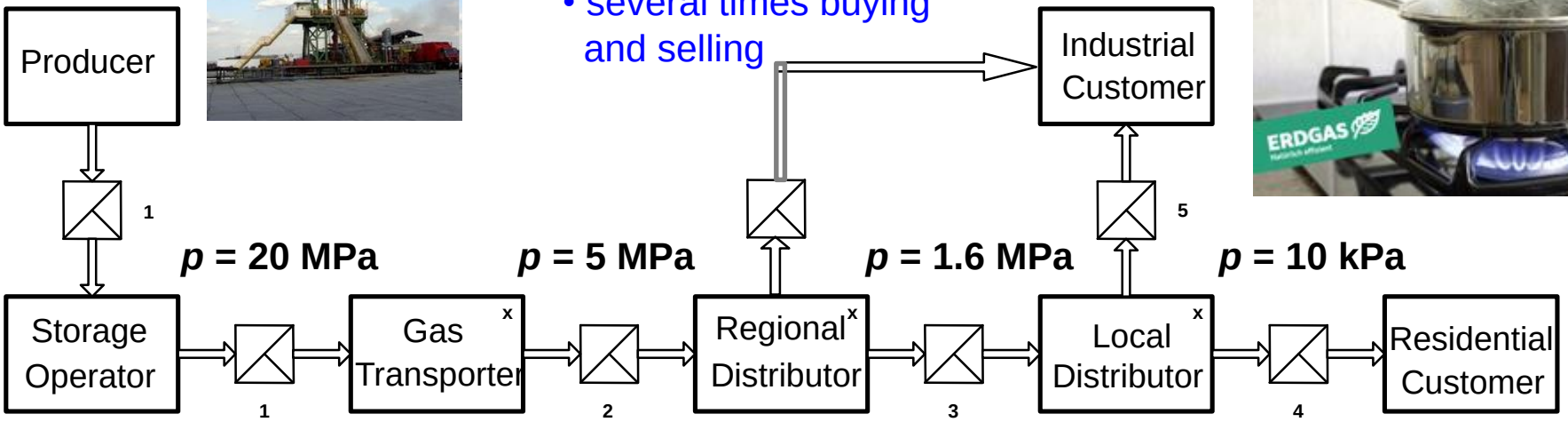
Highest metrological authority under the auspices of the Federal Ministry of Economics (BMWi) in Germany

Sites:	Braunschweig, Berlin-Charlottenburg
Historical:	Founded in 1887 as the Physikalisch-Technische Reichsanstalt on the basis of the ideas of Werner von Siemens and Hermann von Helmholtz
Staff:	1500 staff members
Budget:	about 130 million Euro
Structure:	Nine scientific and technical divisions (two of them in Berlin), subdivided into sections and working groups
Department 1.4 Gas	cares about all aspects related to gas measurements (realisation of unit volume and mass for low and high pressure, legal metrology, calibration, work in national and international organisations)


Hermann von Helmholtz

Trade Chain for Natural Gas

- amount of gas is several times measured between production and consumer
- several times buying and selling



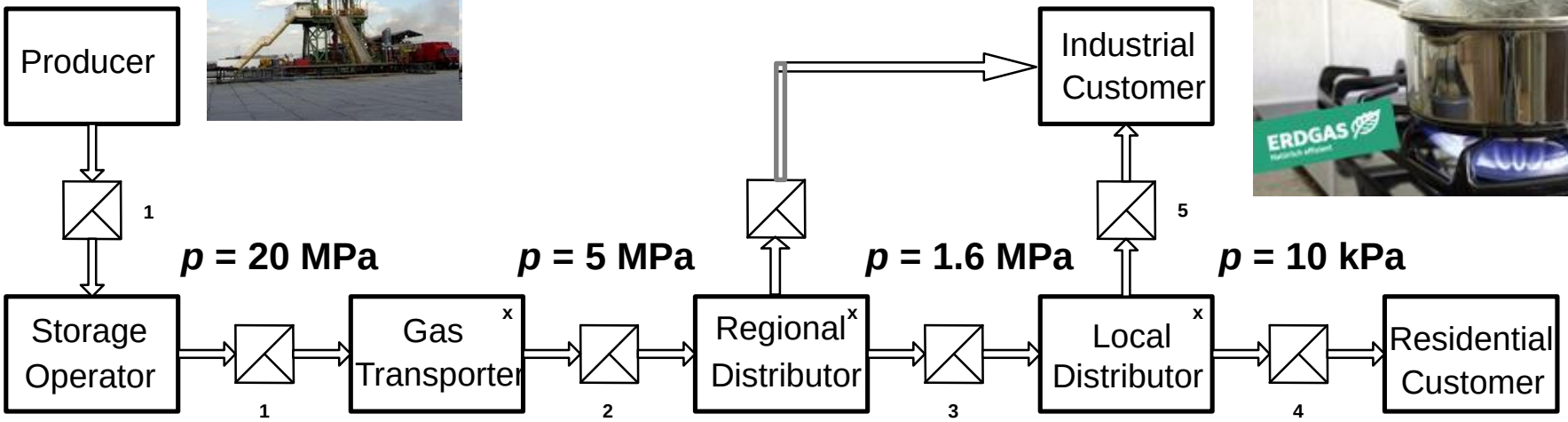
range of high pressure gas calibrations
large scale metering

verifications with atmospheric air are accepted.

0.5 MPa

Trade Chain for Natural Gas

- **CO_2-monitoring**
  Monitoring guide



- **Operation of interconnection points**
  EU 703/2015 => EN 1776

- **German verification law**
  Billing procedures
  obligatory below $1.5 \cdot 10^5$ Nm^3/h

- **German verification law**
  Determination of CV
  in CV-reconstruction systems

COMMISSION REGULATION (EU) 2015/703

establishing a network code on interoperability and data exchange rules

Regulations

A "regulation" is a binding legislative act.

It must be applied in its entirety across the EU.

https://europa.eu/european-union/eu-law/legal-acts_en

Article 7 Measurement principles for gas quantity and quality

3. The adjacent transmission system operators shall agree on measurement principles which shall at least include:

(a) a description of the metering station including measurement and analysis equipment to be used and details of any secondary equipment that may be used in case of failure;

(b) the gas quality parameters and volume and energy that shall be measured, as well as the range and the maximum permissible error or uncertainty margin within which the measurement equipment shall operate, the frequency of measurements, in what units and according to what standards the measurement shall be made as well as any conversion factors used;

(c) the procedures and methods that shall be used to calculate those parameters which are not directly measured;

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establishing a network code on interoperability and data exchange rules

Article 7 Measurement principles for gas quantity and quality

(d) a description of the method of calculation in respect of the maximum permissible error or uncertainty in the determination of energy transported;

(e) a description of the data validation process in use for the measured parameters;

(f) the measurement validation and quality assurance arrangements, including verification and adjustment procedures to be agreed between the adjacent transmission system operators;

(g) the way data, including frequency and content, is provided among the adjacent transmission system operators in respect of the measured parameters;

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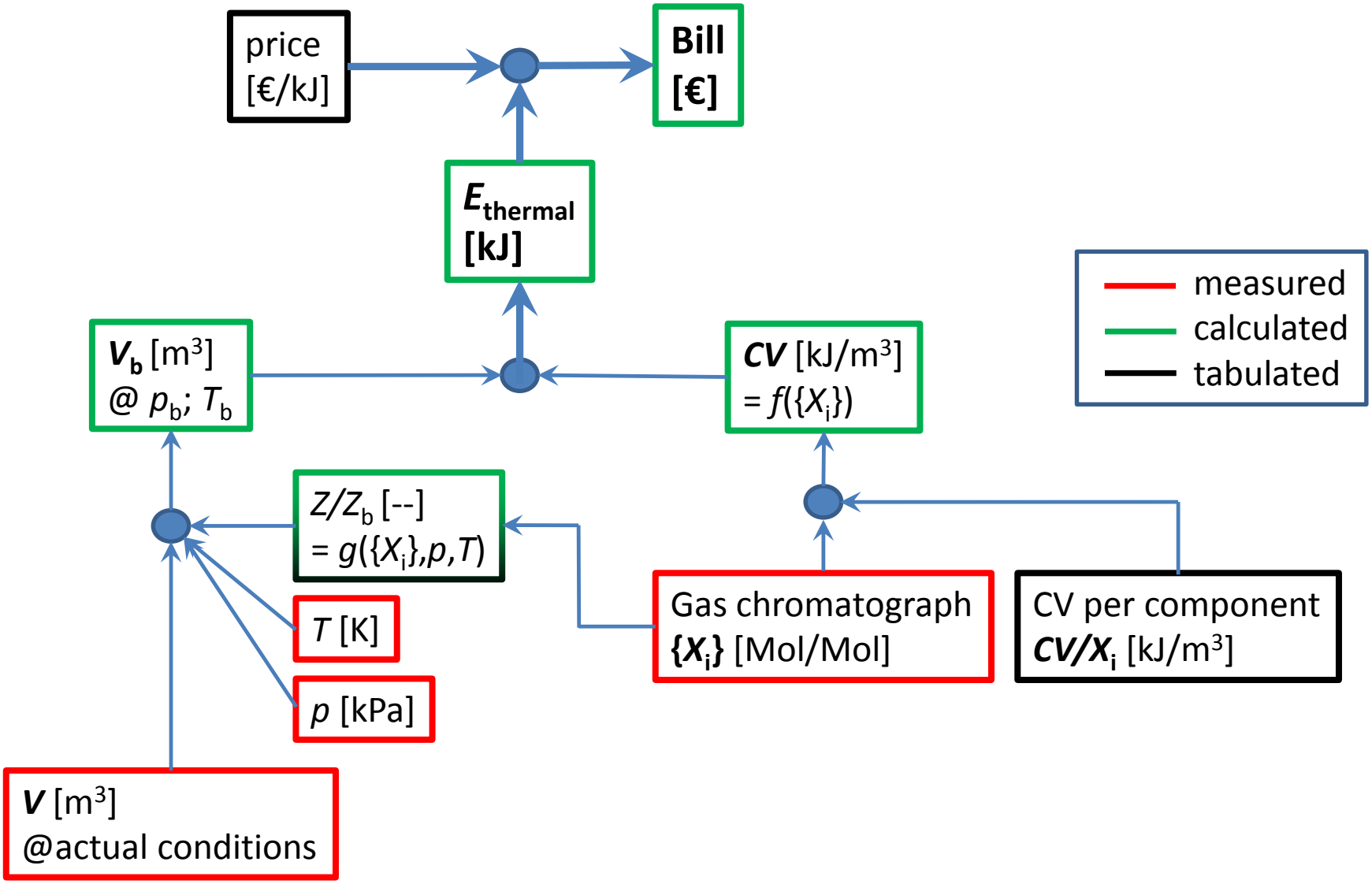
Article 7 Measurement principles for gas quantity and quality

4. If the adjacent transmission system operators fail to comply with their obligations provided for in paragraphs 1 and 3:

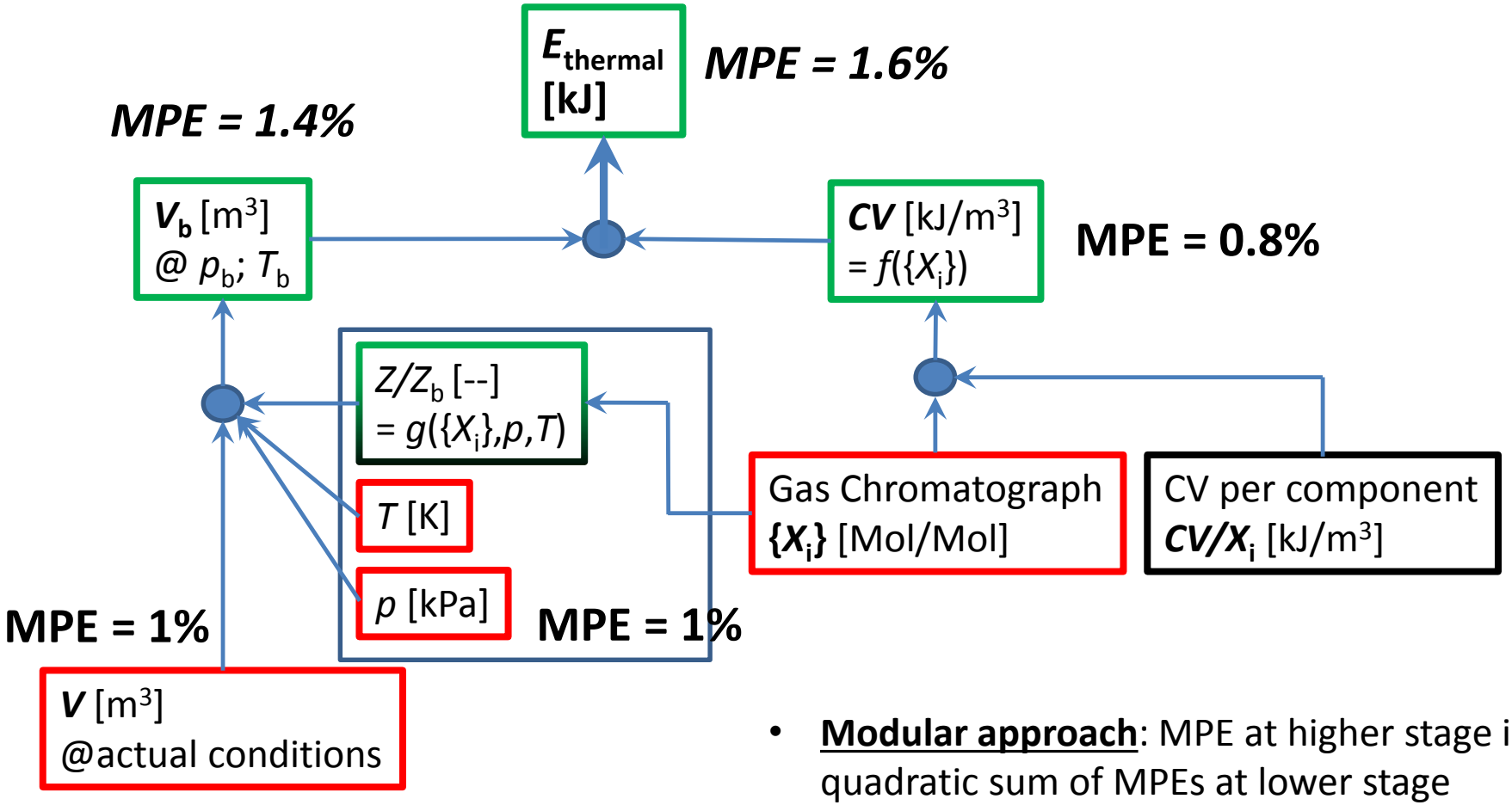
(a) the transmission system operator in control of the measurement equipment shall be responsible for the installation, operation and maintenance of such equipment and for providing the other transmission system operator with the data regarding the measurement of gas flows at the interconnection point in a timely manner;

(b) the European standard EN1776 'Gas Supply Natural Gas Measuring Stations Functional Requirements' in the version applicable at the time shall apply.

Energy Determination as billing base



Targets for MPEs
(German MEG [verification law])



- **Modular approach**: MPE at higher stage is quadratic sum of MPEs at lower stage
- Note: MPE is not uncertainty!
- In-Service MPE is twice verification MPE

MPE/MU required by different laws/regulations

		V_{actual}	V_{base}/mass	Energy
MEG (German verif. law)	initial in service	MPE 1% MPE 2%	*MPE 1,4%* *MPE 2,8%*	*MPE 1,6%* *MPE 3,2%*
CO_2-monitoring (category C)	initial in service	-- --	-- MU 1,5%	-- --
EN 1776 (class A) [EU 703/2015]	initial in service	-- --	-- --	-- MU 1,2%
OIML-R140 (class A)	initial	MPE 0,7%	MPE 0,9%	MPE 1%

CO_2-monitoring:
category C for $Q_{m,CO2}$ > 500 000 t/a
i.e roughly a metering line with G1000 @25bar

Notes on supporting documents

- Although large scale gas trade is not always under legal control the related documents are very helpful for orientation and the principles should be applied.
- For metrology at highest level, all available documents and standards should be taken into account.

Requirements (MPE/MU/accuracy classes)
MEG [German verif. law] (MID)
CO_2 monitoring
EN 1776
OIML R-140
OIML R-137

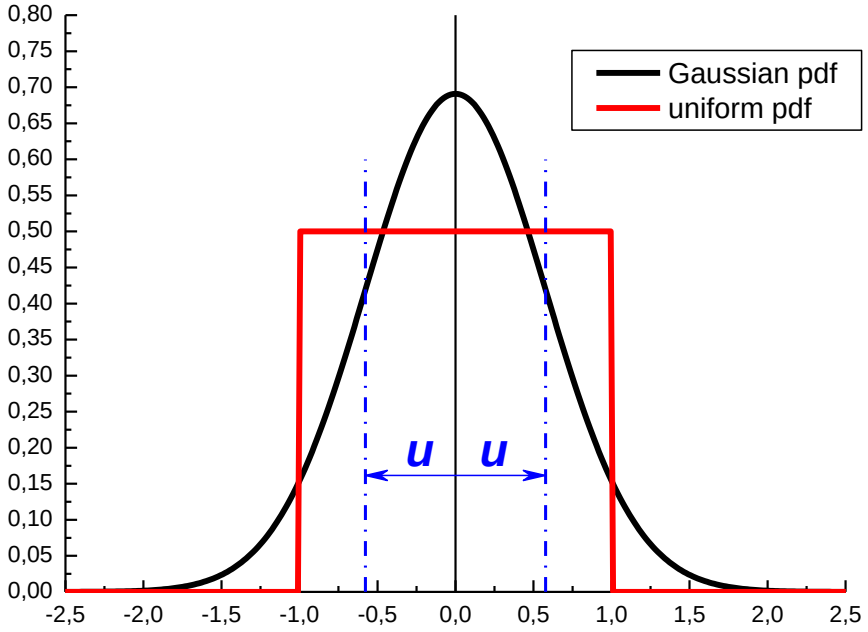
Metrological Infrastruture
OIML D-05
OIML D-16
ISO 10012

Technologies/procedures + metrological tests/approv.
OIML R-137
EN 12261 (turbines)
EN 12450 (rotary meters)
EN 12405 (conversion dev.)
ISO 17089 (ultrasonic meters)
ISO 5167 (dp-meters)
ISO 15112 (energy determination)
…

Uncertainty Calculation
GUM
ISO 5168 (unc. in flow)

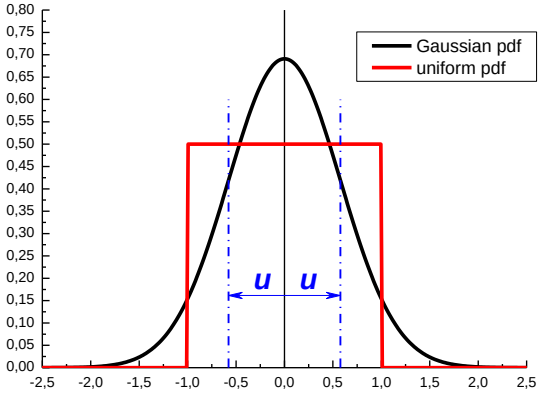
Notes on MPE vs. MU

- MPE is a term of legal metrology.
- MPEs can be translated into requirements on uncertainties.
- Assuming uniform pdf, the standard uncertainty of measurand is $u_{k=1}$ = MPE/$3^{0.5}$ if certified based on a MPE criteria and infinite degree of freedom.
- E.g. MPE = 1% => standard u = 0.577 %
- This is equivalent to a Gaussian pdf with expanded uncertainty of U = 1.13 %



EN 1776 is a big challenge!

		V_{actual}	V_{base}/mass	Energy
MEG (German verif. law)	initial in service	MPE 1% MPE 2%	*MPE 1,4%* *MPE 2,8%*	*MPE 1,6%* *MPE 3,2%*
CO_2-monitoring (category C)	initial in service	-- --	-- MU 1,5%	-- --
EN 1776 (class A) [EU 703/2015]	initial in service	-- ***MU 0,75%***	-- ***MU 0,95%***	-- MU 1,2%
OIML-R140 (class A)	initial	MPE 0,7%	MPE 0,9%	MPE 1%



EN1776: MU shall include all effects on the meter indication in the range of rated operating conditions:

- Pressure
- Temperature
- Linearity
- **Long term stability**
- Gas composition

…

Re-Verification Periods in Germany

- **8 years for large scale meters (turbines, USM).**
- **Can be exceeded under specific conditions for meter lines with two meters in series.**

Two meters of two different measurement principles in series:
There is no need for re-verification as long as the difference of indication is not changing more than 0.5% compared to the initial situation (annual on-site check).

Additional for two USM in series:
requires two different meter designs and indicated SoS among pathes shall not change more than 0.3% (annual on-site check).

EN 1776 is a big challenge!

		V_{actual}	V_{base}/mass	Energy
MEG (German verif. law)	initial in service	MPE 1% MPE 2%	*MPE 1,4%* *MPE 2,8%*	*MPE 1,6%* *MPE 3,2%*
CO_2-monitoring (category C)	initial in service	-- --	-- MU 1,5%	-- --
EN 1776 (class A) [EU 703/2015]	initial in service	-- ***MU 0,75%***	-- ***MU 0,95%***	-- MU 1,2%
OIML-R140 (class A)	initial	MPE 0,7%	MPE 0,9%	MPE 1%

Factor 3!!

- **German law requires 8 years for re-verification period or limit of 0.5% for changes of indication difference for two meters in series to keep 2% MPE in service,**
- **Hence, much higher effort is necessary to satisfy an expanded uncertainty in service of *U* = 0.75%!**
- **There is no detailed regulation how to reach this goal but it is your responsibility!**

Apply the priciple but adopt the numbers!
e.g. for EN1776 Class A roughly by factor three
=> re-cal. interval 8/3 years
and check limits 0.5/3 % in 4 month period

Uncertainties in Traceability

Accuracy class 0.5
(i.e. MPE for indication error = 0.5%)

Uncertainty for type approval
≤ 1/5 MPE; i.e. ≤ **0.1% for Class 0.5**

Uncertainty for verification
≤ 1/3 MPE; i.e. ≤ **0.17% for Class 0.5**

Uncertainty of primary standard
≤ 0.05%

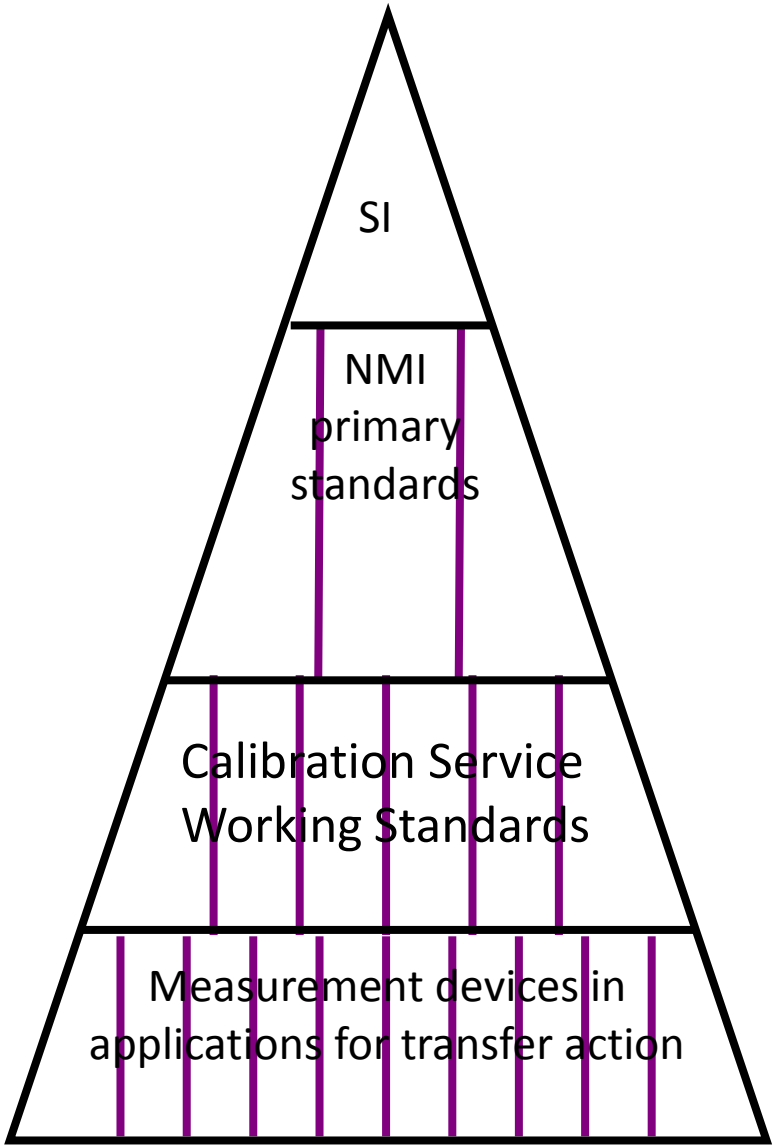
Uncertainty of primary standard
≤ 0.09%

OIML R-137: Uncertainties needed for

Verification: 1/3 MPE
(or 4/3MPE – U_{test})

Type approval: 1/5 MPE or
(6/5MPE - U_{test})

Uncertainties in Traceability



Technologies for primary standards for HP gas:

U (k =2) = **0.06** … 0.25 %

Technologies for working standards for HP gas:

U (k =2) = **0.13** … 0.35 %

Technologies for application (except residential):

U (k =2) = 0.3 … 1 %

Conclusions

- Beside the German Verification Law there are other regulations to be considered for large scale metering:
  - * CO_2 monitoring
  - * Interoperability of interconnection point (EU 2015/703)
- Compared to the Verification Law, the requirements regarding the measurement uncertainty in service (on site) are significant higher, especially if EN 1776 is applied.
- It is in the responsibility of the operator to fulfill the requirements; specifically the **periods of re-calibration/verification and check limits for meters in series should be adopted adequately**.
- The uncertainties needed in the traceability are close the high end what test rigs can provide.

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