nmisa
National Metrology Institute of South Africa

AC Power and Energy National Measurement Standards: Foundations for Accuracy and Trust

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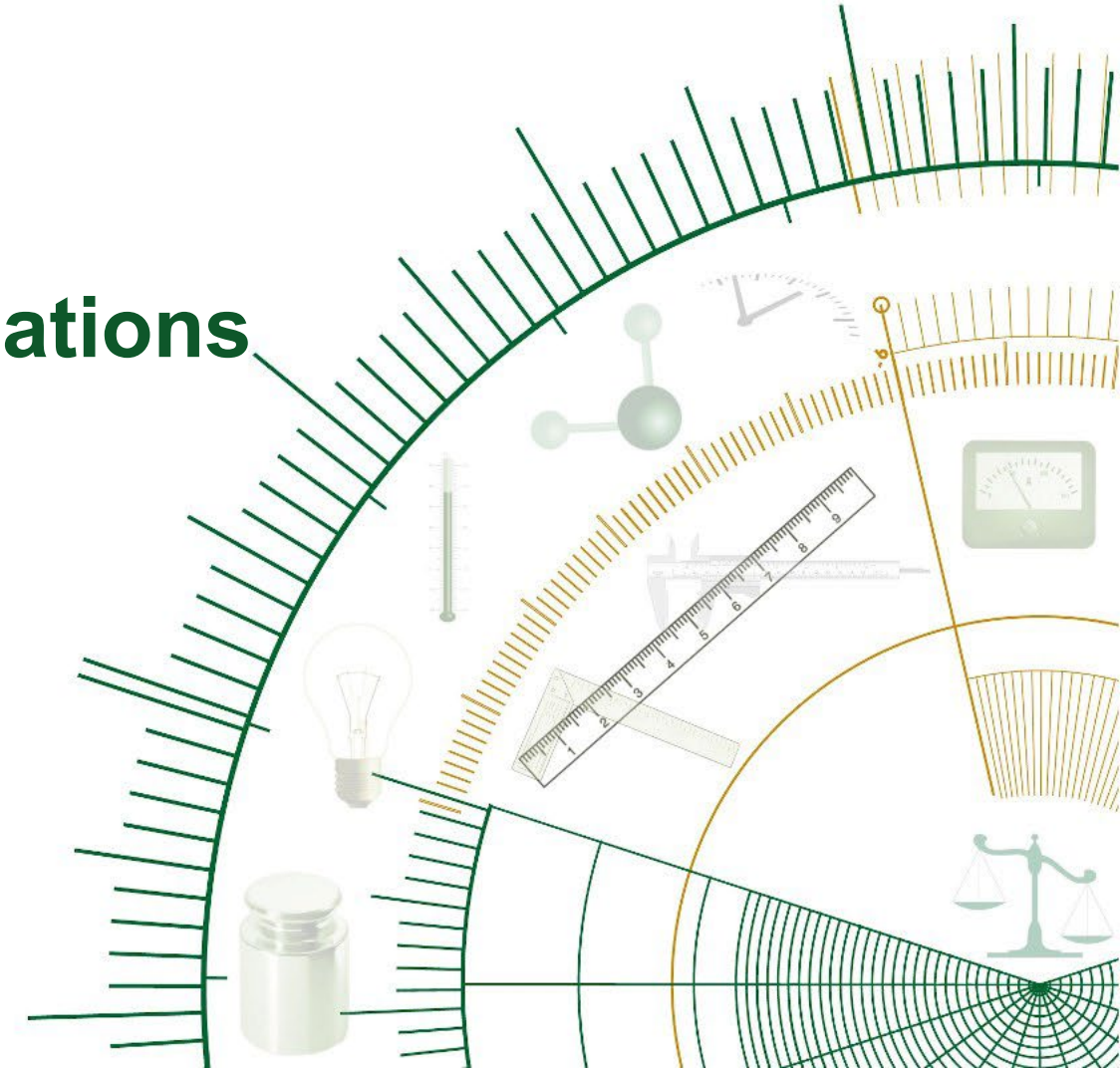

Your measure of excellence

Presentation Outline

1. National Measurement Standards (NMS) in act 18
2. ac Power and Energy NMS traceability to the SI
3. Ac Power NMS
    - Digital Simultaneous Sampling Technique System (DSST)
    - NMS Performance Characteristics
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National Measurement Standards (NMS) in act 18

The Measurement Units and Measurement Standards Act, 18 of 2006 recognise NMISA as responsible to

- *"designate national measurement standards (NMS) and provide for keeping and maintaining NMS and units; and*
- *disseminate traceability in the South African industry"*

NMS:

"The value of a national measurement standard in relation to the SI units must:

(a) be the value as determined by the National Metrology Institute (NMISA);

(b) be regarded as the most accurate value of that national measurement standard;"

Traceability:

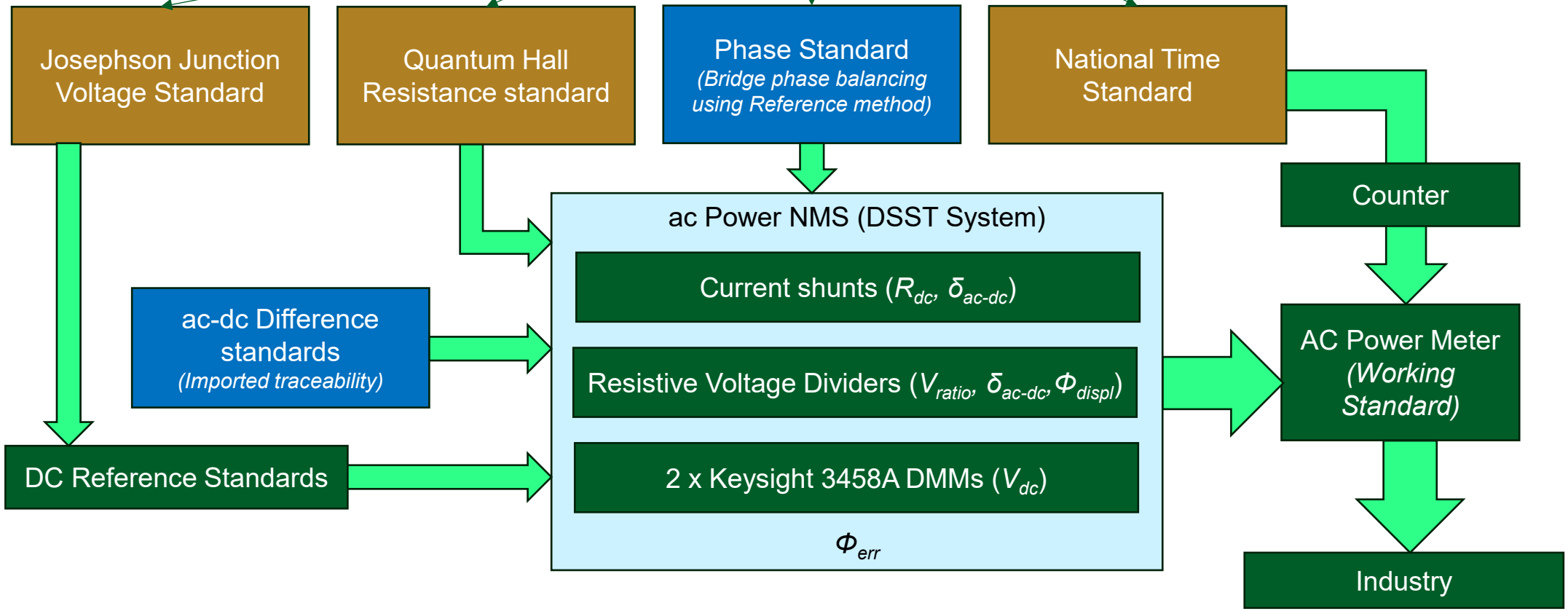
"A measurement standard which is not an NMS must:

(a) for the purposes of measurement for any legal purpose, be traceable to one or more NMS;

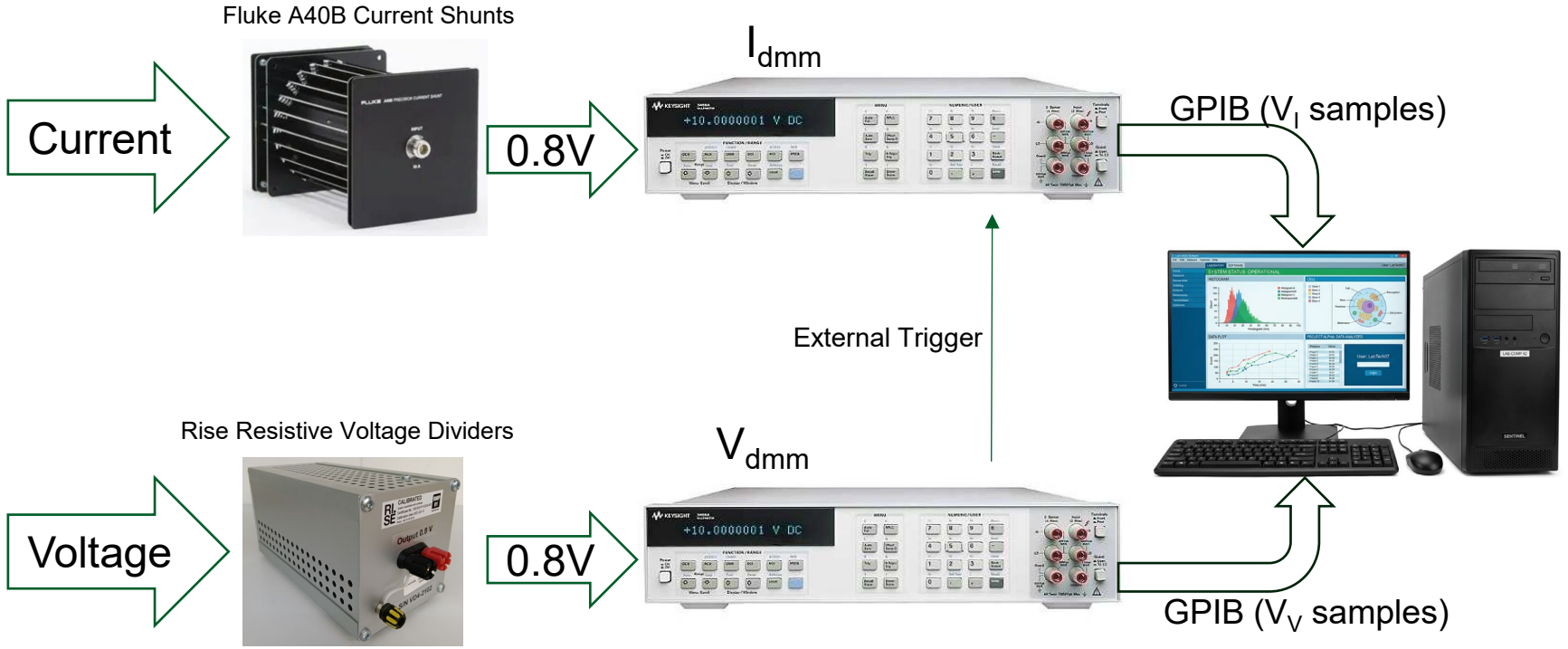
(b) be so traceable that the measurement standard is related to one or more NMS as contemplated in paragraph (a) through an unbroken chain of comparisons" (achieved through calibration)

ac Power and Energy NMS traceability to the SI

$$E = V \cdot I \cdot \cos\emptyset \cdot t \quad (W.s)$$

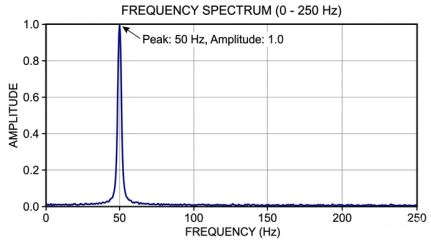


Ac Power NMS - Digital Simultaneous Sampling Technique System (DSST)



$$V_{V(RMS)} = \sqrt{\frac{1}{T}\int_0^T v_{Vdmm}(t)^2\,dt}$$

$$V_{I(RMS)} = \sqrt{\frac{1}{T}\int_0^T v_{Idmm}(t)^2\,dt}$$



FFT produce phase difference information Φ

$$P = (V_V\,.\,Ratio_{RVD}).\left(\frac{V_I}{R_{shunt}}\right).\cos(\emptyset_{Vdmm} - \emptyset_{Idmm})$$

- Keysight 3458A is an 8 ½ digit multimeter renowned for its high-speed digitizing capabilities
- Fourier transform produce phase information

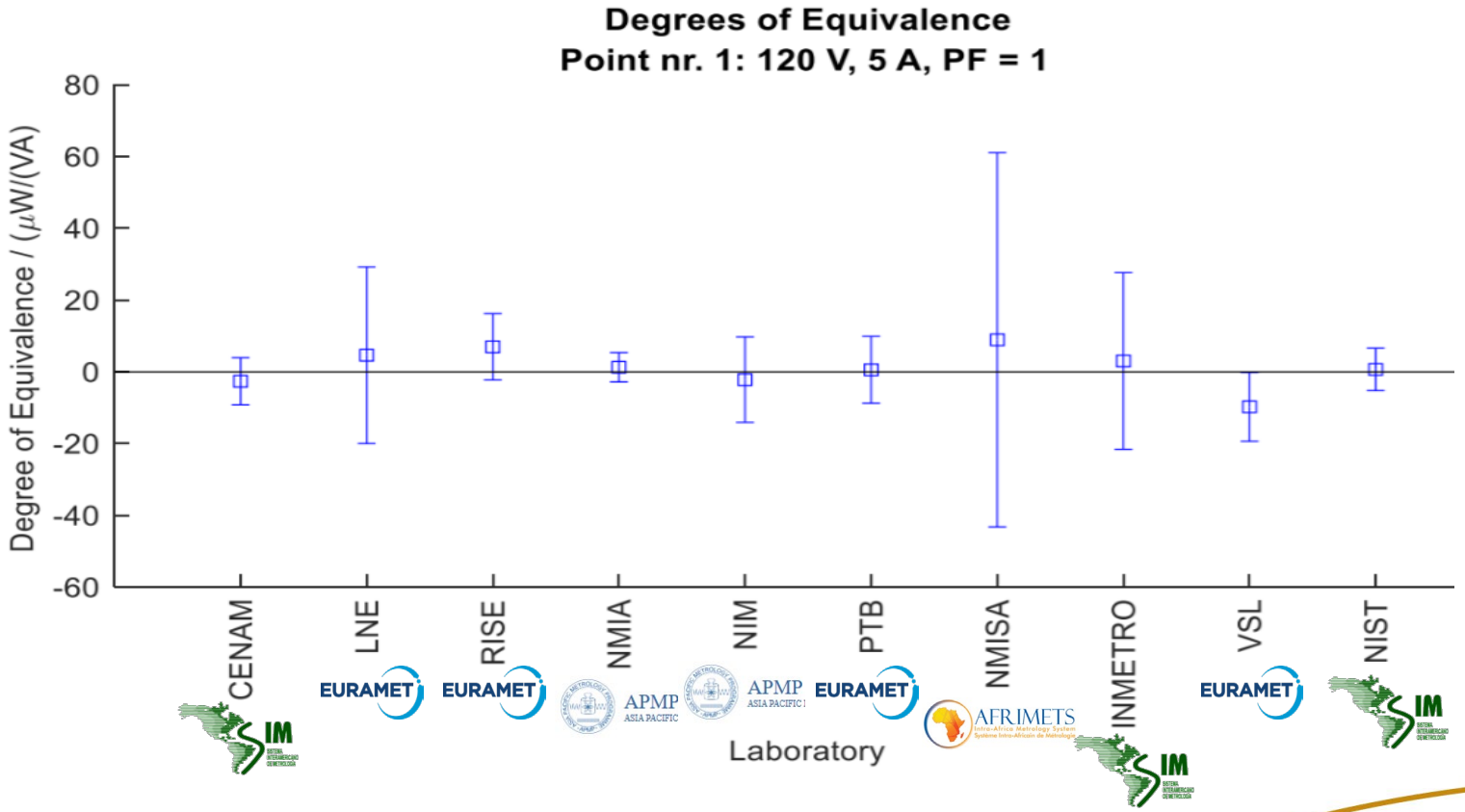
NMS Performance Characteristics

120V					PF 1		PF 0.5		PF 0	
Main uncertainty components Estimated			Divisor factor	Standard uncertainty	Sensitivity coefficient	Uncertainty contribution $u(R_i)$	Sensitivity coefficient	Uncertainty contribution $u(R_i)$	Sensitivity coefficient	Uncertainty contribution $u(R_i)$
y_i				$u(y_i)$	c_i	µW/VA	c_i	µW/VA	c_i	µW/VA
ESDM of the calibration error of the UUT		µW/VA	1		1	3.3	1	5.3	1	12.3
DMM (V) uncertainty	4.5	µV/V	1	4.5	1	4.5	0.5	2.3	0	0.0
DMM (I) uncertainty	4.5	µV/V	1	4.5	1	4.5	0.5	2.3	0	0.0
RVD input to output ratio calibration	30	µV/V	2	15.0	1	15.0	0.5	7.5	0	0.0
Shunt dc resistance calibration (0.16Ω)	1	µΩ/Ω	2	0.5	1	0.5	0.5	0.3	0	0.0
Shunt ac-dc difference calibration	29.4	µA/A	2	14.7	1	14.7	0.5	7.4	0	0.0
Shunt dc resistance 12 month stability	18.0	µΩ/Ω	1.732	10.4	1	10.4	0.5	5.2	0	0.0
RVD + DSST meters phase calibration	34	µrad	1.732	19.6	0.000	0.0	0.866	17.0	1.000	19.6
Shunt phase displacement accuracy	18	µrad	1.732	10.4	0.000	0.0	0.866	9.0	1.000	10.4
Combined standard uncertainty and effective degrees of freedom:						24.5		23.4		25.4
Expanded uncertainty (95.45 % coverage factor):						50		47		51

Typical uncertainty: 50µW/VA (Class 0.005)

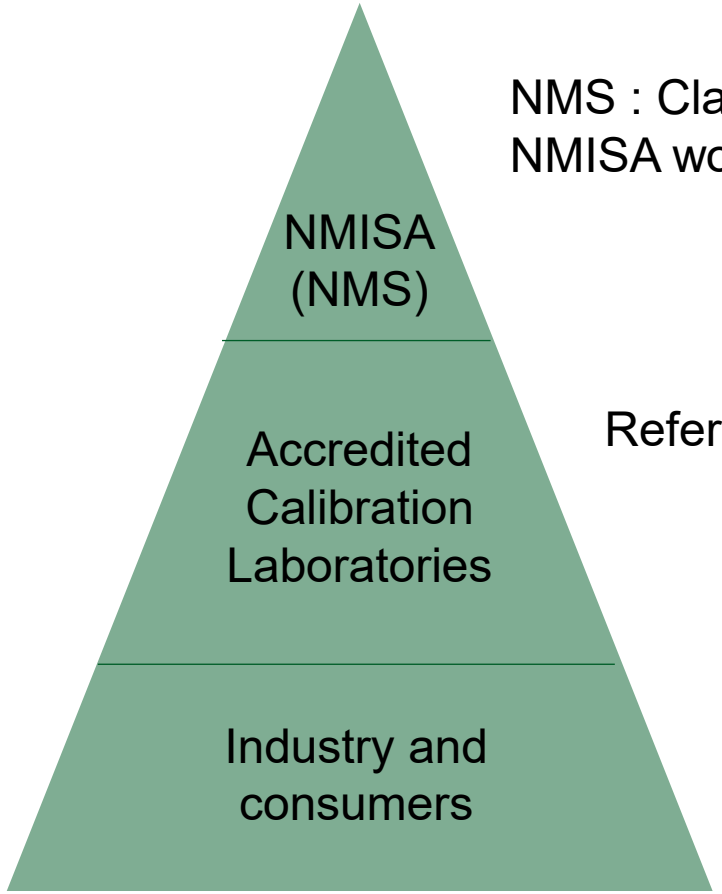
International Equivalence

NMISA participated in the CCEM-K5 Key Comparison, Measurements completed in 2020, final report issued in 2026



Dissemination of measurement Traceability

Each link in the calibration chain introduces additional uncertainties:



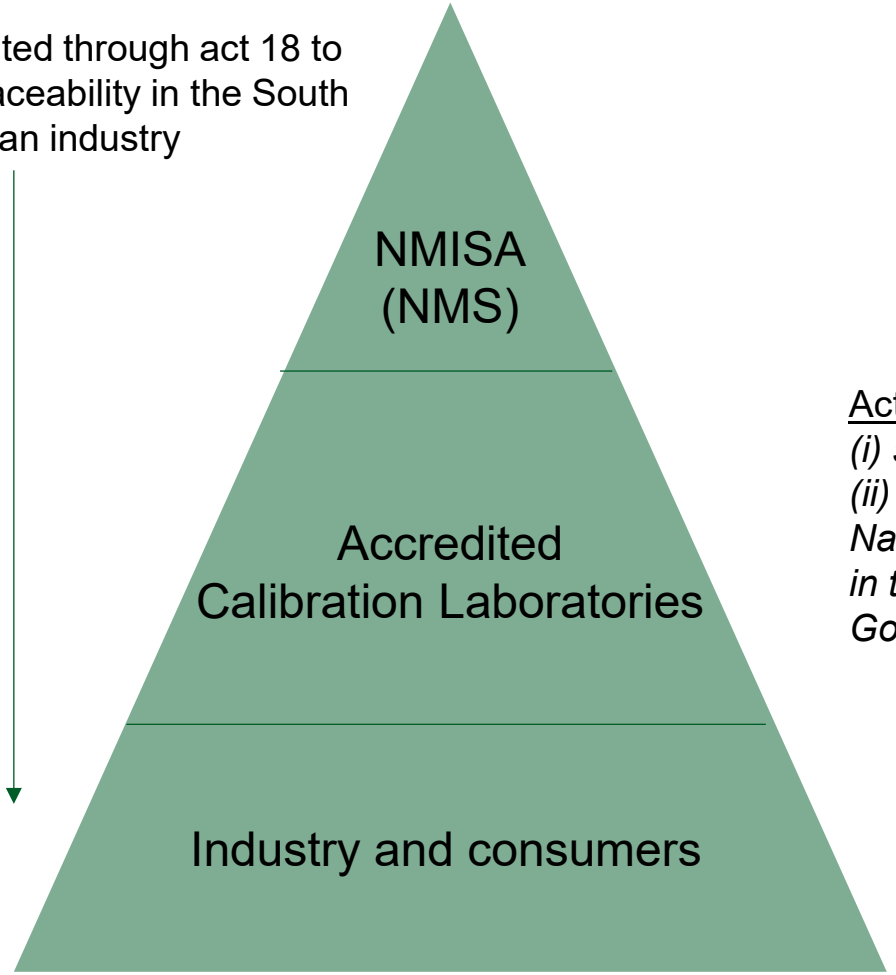
NMS : Class 0.005
NMISA working standard: Class 0.008

Reference standards (Typical): Class 0.02

Industry energy meters: Class 0.2 to Class 3

Traceability to NMS in SA

NMISA mandated through act 18 to disseminate traceability in the South African industry



Act 18 Par 5. (3) … *"through an unbroken chain of comparisons—*
(i) stating appropriate uncertainties of measurement; and
(ii) carried out by a calibration laboratory accredited by the South African National Accreditation System (SANAS) or an accreditation body enabled in terms of the Accreditation for Conformity Assessment, Calibration and Good Laboratory Practice Act in that specific area of metrology."

SANS 474/NRS 057 Code of practice for electricity metering
"All meters shall be calibrated at an accredited calibration laboratory indicating the error in measurement at different load points and power factors in accordance with the relevant standard."

Accredited Calibration Laboratories

Typical energy meter calibration bench used in accredited calibration laboratories

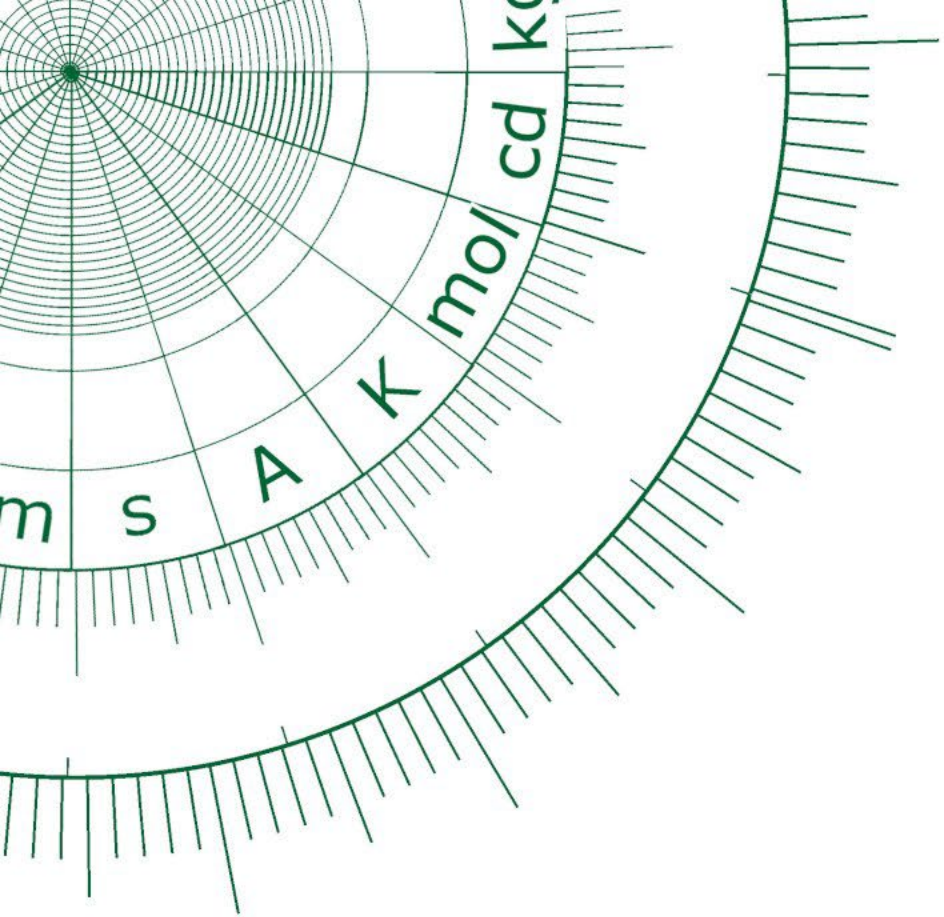
- Example of an energy meter calibrated in this system
- Measurements from these meters feed directly into billing information

Reference Standard Meter

- The calibration bench uses a Reference Standard Meter to import traceability
- Calibrated at NMISA with typical accuracy of 100 to 200 µW/VA (Class 0.02)
- Only 1 accredited laboratory in SA, 3 others withdraw accreditation in the past 5 years

Key Takeaways

- The technical quality infrastructure in South Africa supports metrology in energy measurements through various RSA Acts, regulations (NRS) and standards (SANS)
- This extends to energy meter calibration and the traceability chain to NMS which ensures accuracy and compliance to meter specifications, however limited accredited calibration laboratories in industry
- NMISA supports confidence in energy-related decisions by maintaining the NMS, ensuring international equivalence, and thereby fostering trust in energy systems and policy implementation



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Thank You

We measure what matters