NMC Capability and Achievement in Supporting

Energy Efficiency Measurements & Climate Change

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APMP Midyear Symposium
08 Jun 2016

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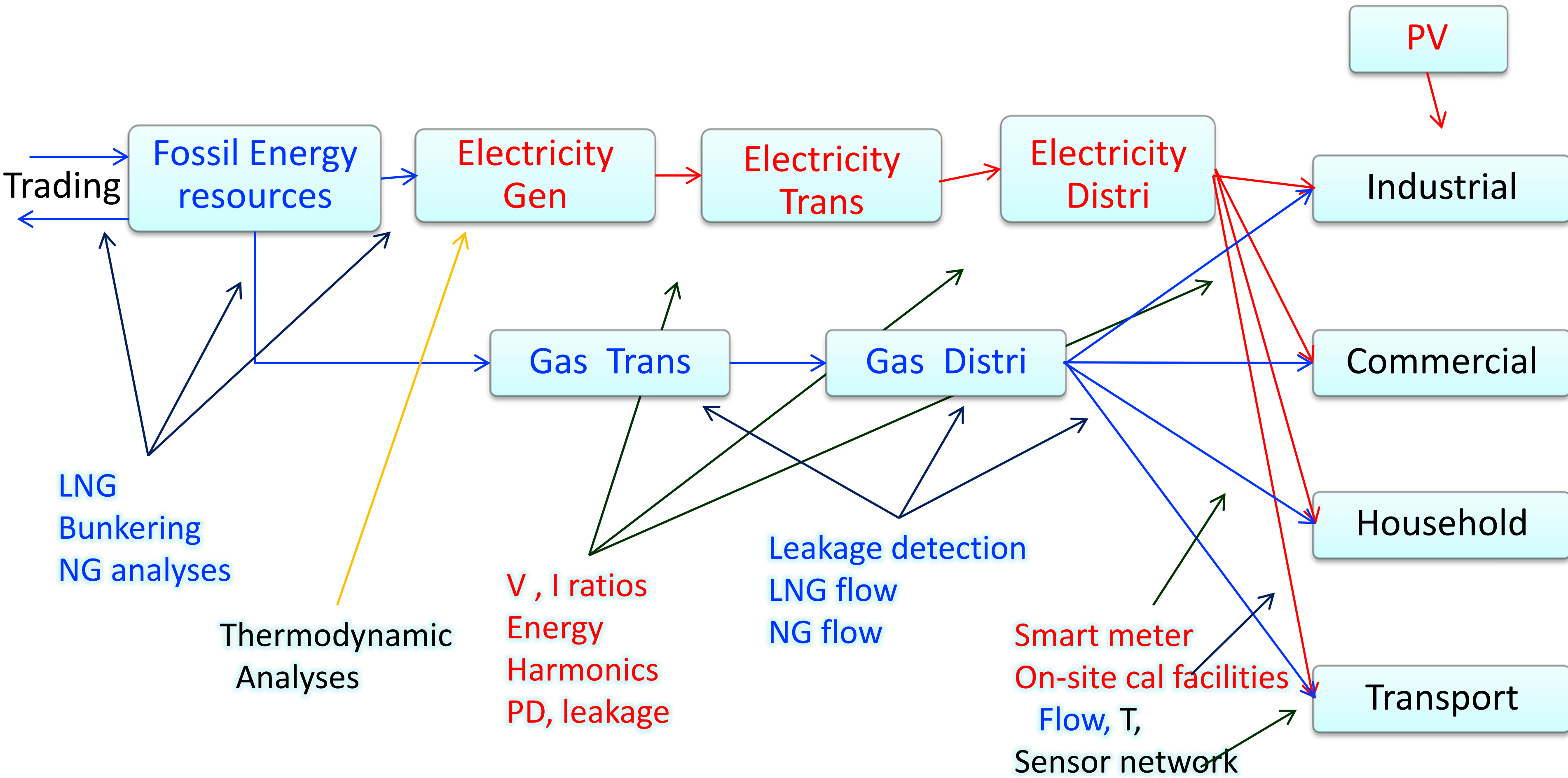
- Singapore energy flow and measurement needs
- NMC's capability in supporting such measurements, in
  - Energy trading and transmissions
  - Energy consumptions
- NMC's effort in supporting climate change

Energy Flow and Measurement Demands



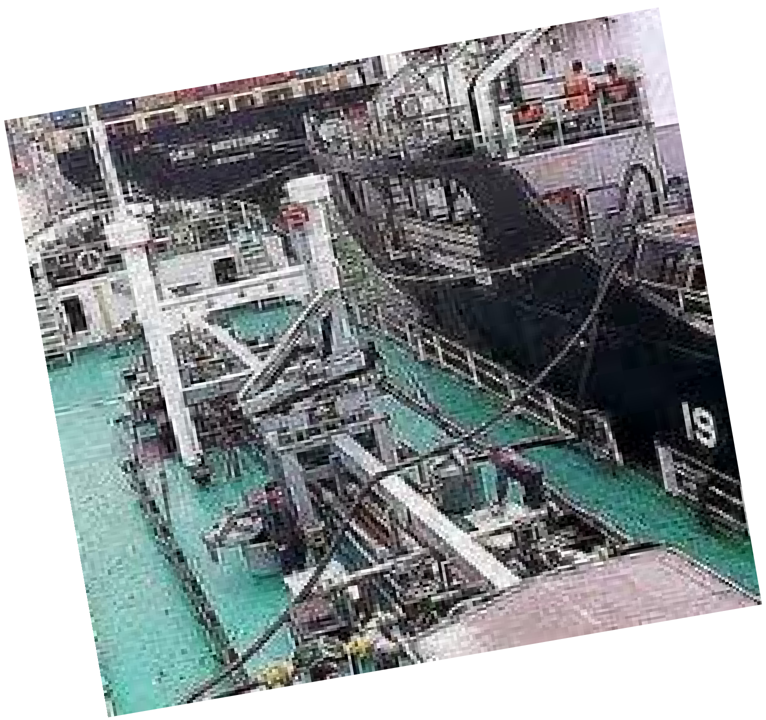
National Metrology Centre

NMC's capability in supporting energy trading and transmissions

- Liquid flow and gas flow measurements
- NG calorific value analyses
- Electrical measurement
- Photovoltaic cells characterization

Capability in Liquid Flow Measurement

Range, kg/h	Capability
340 - 43,200	0.05%



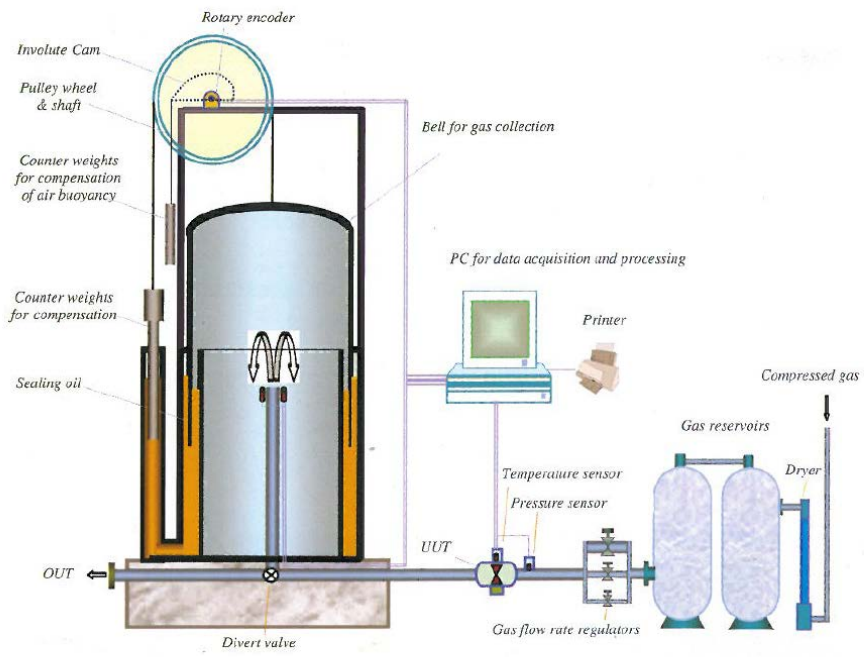
- Bunkering Ind
- Marine & Offshore Ind
- Water/wastewater treatment
- Chemical, beverage, pharmaceutical …

Achieving Mass Flow Meter (MFM) in Singapore




Item	Tank Gauging	MFM	NMC's Contributions
Standard	SS600:2008	SS600:2014 **TR48:2015**	1. WG member & main tech advisor, in dev'ing the TR. 2. Validated data for MFM acceptance on board. 3. C**appuccino study**: to clarify gauging issues. 4. Dev'ed course on TR48 and MFM technology for bunker surveyors and cargo officers, operators
Manpower	At least 4 involved in a measurement	Automatically	
Productivity	Low. Measured manually	Save >3 hours per delivery	
Accuracy	Not ensured	Ensured with traceably MFM verification on board barges	

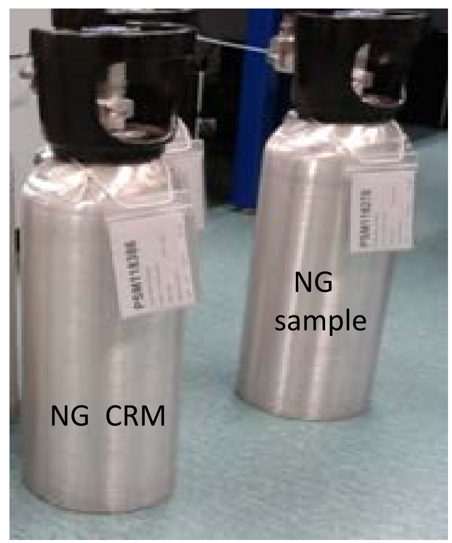
Capability in Gas Flow Measurements



Range	Capability
3 – 110 m^3/h	0.5%

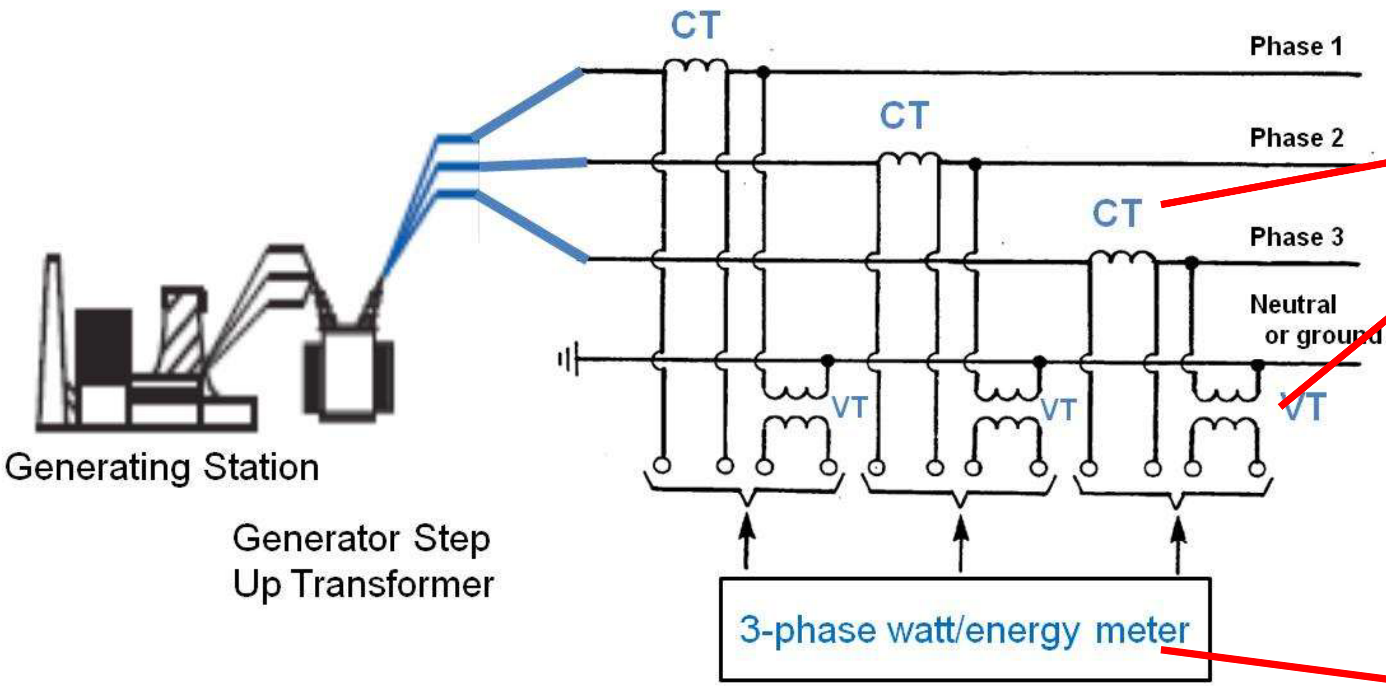
Capability in Determining NG Calorific Values

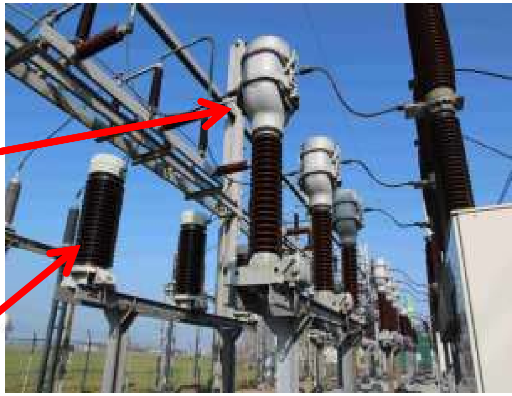
- Commutability of NG depends on its compositions, and determined by analyzing its calorific value
- Certified Reference Material (CRM) are needed for this purpose.



NG Mixture	
N2	n-C4
CH4	neo-C5
CO2	i-C5
C2H6	n-C5
C3	n-C6
i-C4	

Electricity Measurements





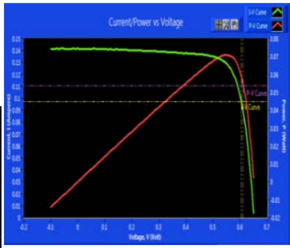
- CT: Current transformer for current ratio
- VT: voltage transformer for voltage ratio
- Watt/Energy meter: metering readings/records

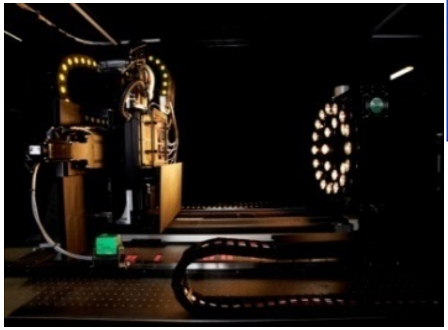
Capability in Electricity Measurements

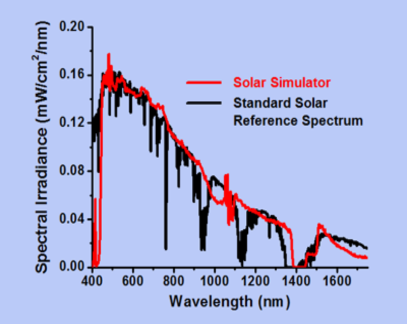
- Voltage ratio
  - AC 100 kV at 0.016 %,
  - DC 200 kV at 0.007 %
- Current ratio
  - AC 20 A at 0.02 %, 100 A at 0.1%
- Watt meter
  - 50/60 Hz, 0.01 %
  - 400 Hz, 0.02 %

Capability in Solar Cell Measurements

- **Primary calibration of reference solar cells**
  - Absolute / differential spectral irradiance responsivity (285 nm - 1195 nm) at irradiance levels from 0.1 – 1.1 Sun
  - Short circuit current under IEC standard testing conditions with measurement uncertainty ~ 1% (k =2)
- **I-V characteristics of solar cells**
  - V at open circuit
  - I at short circuit
  - Evaluation of solar cell efficiency
- **Solar simulator**
  - Spectral power distributions
  - Irradiance's non-uniformity and instability







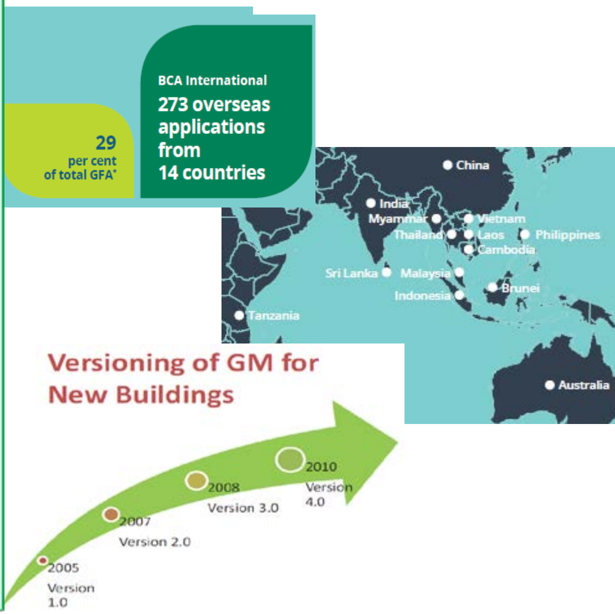
NMC's capability in supporting measurement of energy consumption

- Chilled water system energy efficiency
  - Green Mark requirement
  - Singapore standard SS 591
  - Temperature measurement & evaluation (M&V)
  - Consultancy in chiller plant survey and setting up M&V facilities
- Lighting efficiency determination
- Power quality analyses

Green Mark – building sustainability scheme, Building and Construction Authority (BCA), Singapore

- Since inception in 2005, Singapore has certified about 29 per cent of its buildings for sustainability under the Green Mark Scheme up to 2015
- Nation's vision of greening 80 per cent of the city-state's buildings by 2030
- More than 250 projects in 75 cities from 14 countries have adopted the Green Mark Scheme up to 2015
- Requirement of measurement & evaluation of temperature, flow and power for central chilled water system in the latest version GMV4.0 2010

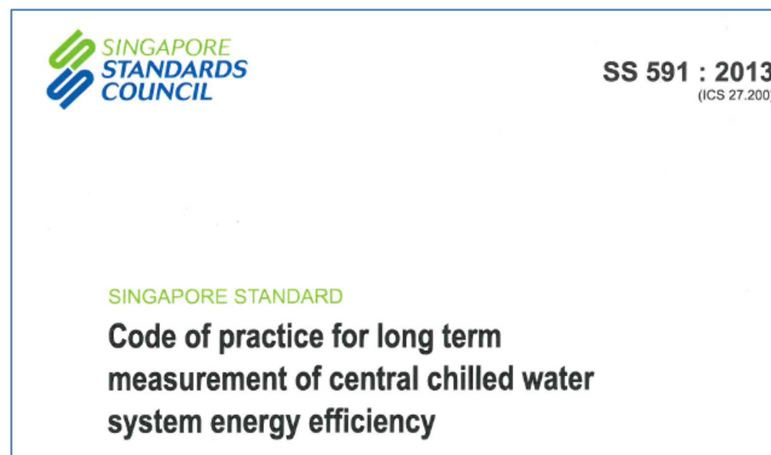
BCA GREEN MARK






Singapore standard SS591 – Code of practice for long term measurement of central chilled water system energy efficiency

- Description of measurement and verification
- Measurement and instrumentation required
  - Temperature measurement system with measurement uncertainty within 0.05 °C
  - Flow measurement uncertainty within 1-2 %
  - Power measurement uncertainty within 2%
- Data collection, handling and presentation
- Testing and commissioning
- Long term monitoring


SINGAPORE STANDARDS COUNCIL

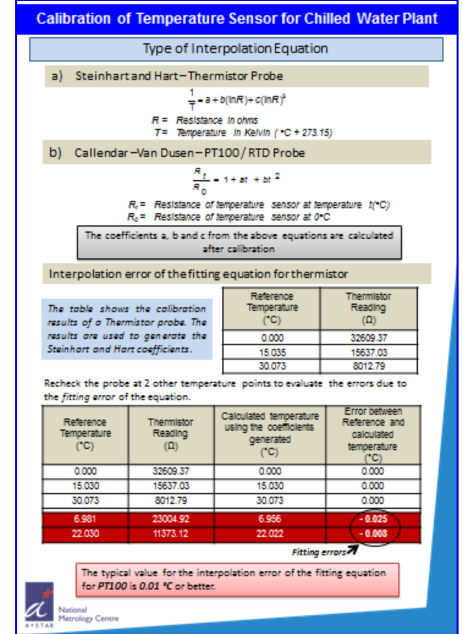
SS 591 : 2013
(ICS 27.200)

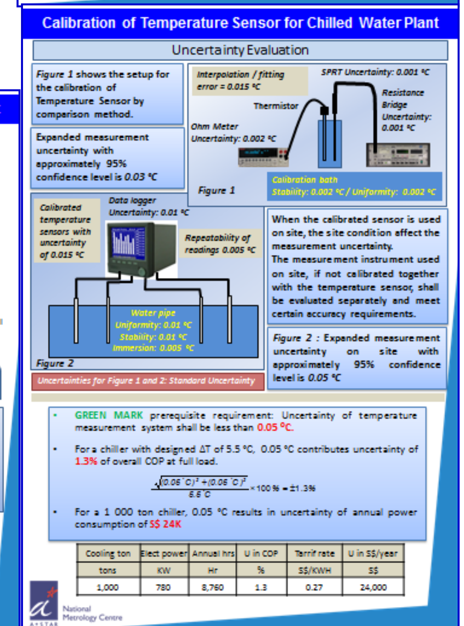
SINGAPORE STANDARD

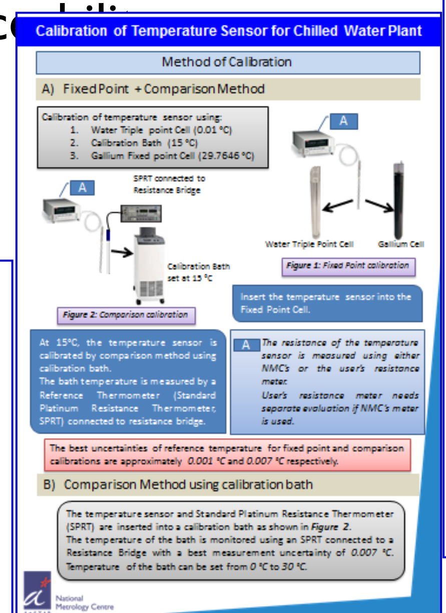
Code of practice for long term measurement of central chilled water system energy efficiency

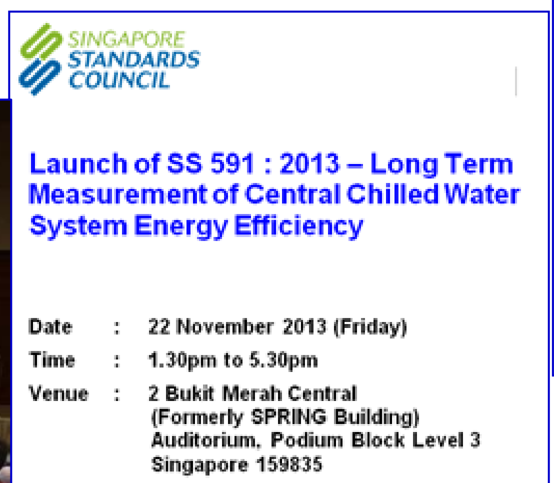
NMC's contribution

- Key contributor for the development of SS591 in particular for setting up the criteria for temperature measurement instrumentations and uncertainty evaluations
- Public awareness in calibration of thermometers to fulfill the GM needs
- Cooperated with SINGLAS accredited laboratories in meeting temperature trac requirement





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Launch of SS 591 : 2013 – Long Term Measurement of Central Chilled Water System Energy Efficiency

Date	:	22 November 2013 (Friday)
Time	:	1.30pm to 5.30pm
Venue	:	2 Bukit Merah Central (Formerly SPRING Building) Auditorium, Podium Block Level 3 Singapore 159835

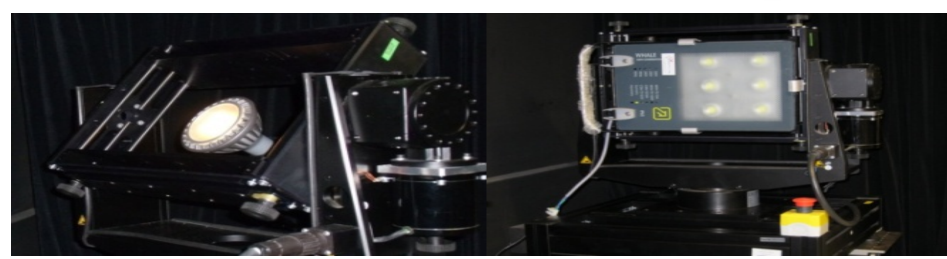
NMC's contribution

- Provided training for on-site temperature measurement and evaluation
- Provided consultancy in setting up temperature calibration laboratories
- Provided measurement solutions from selection of measurement systems to calibration and installation of the system

Capability in LED Lighting Tests

- Luminous flux 20-2000 lumen at 2.5 %
- Luminous efficacy
- Correlated Colour Temperature 2000-7000 K at 30 K)
- Colour Rendering Index 50-100 at 2
- Chromaticity co-ordinate values 0-1at 0.0015
- Input power, Power factor

1 meter integrating sphere

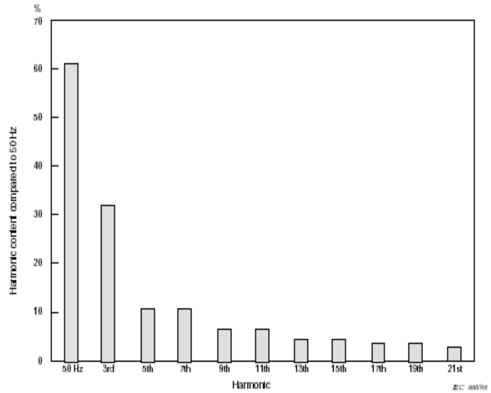


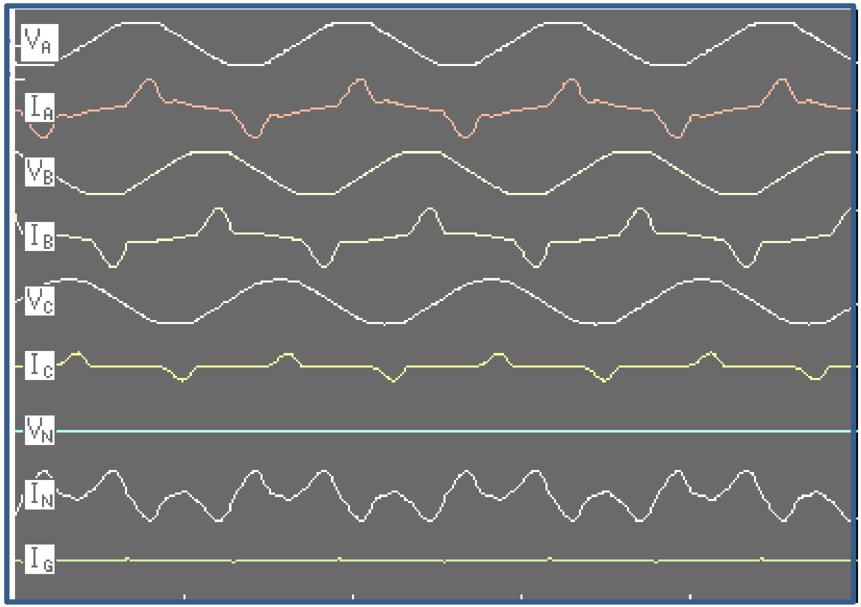
2-axis goniometer

Capability in Power Analyses

- Voltage: 0.01 %
- Current: 0.01 %
- Power: 0.02 %
- Phase:
  - V to I: 0.003 deg
  - V to V: 0.005 deg

For sinusoidal and non-sinusoidal signals





New technologies are needed for Environmental Sensing

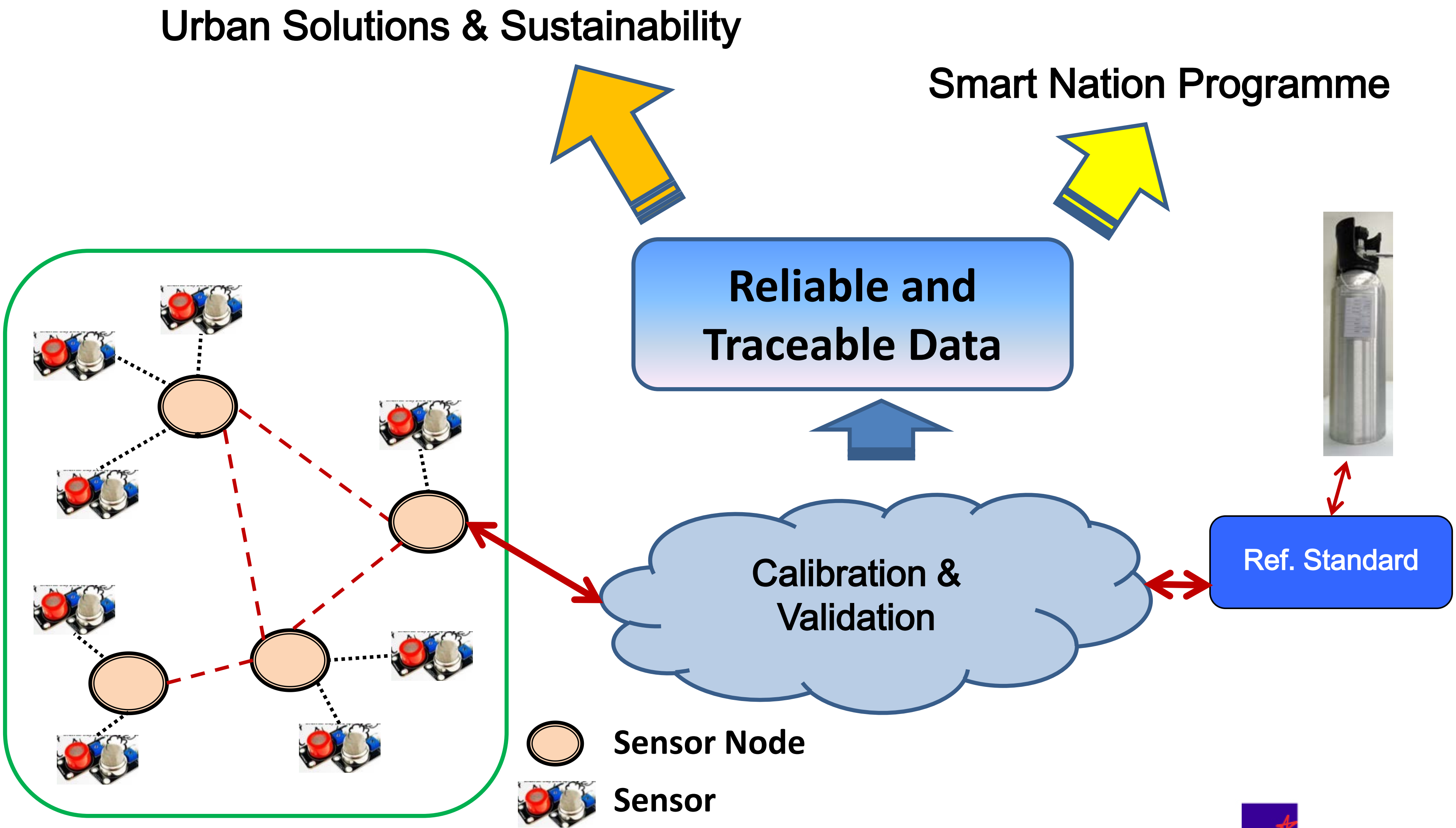
Traditional Approaches:

- ❑ Expensive, complex, stationary equipment
- ❑ Limited mostly to governments, industry and researchers
- ❑ Data are collected for compliance monitoring, enforcement, trends and research
- ❑ Accessed by government websites, permits records and research databases

New Paradigm:

- ❑ Lower-cost, easy-to-use, portable pollution monitors (Sensors)
- ❑ Provides high resolution data in near real-time
- ❑ Enhance a range of existing pollution monitoring capabilities
- ❑ Provide avenues to new monitoring applications
- ❑ Enhanced availability and accessibility of pollution monitoring data

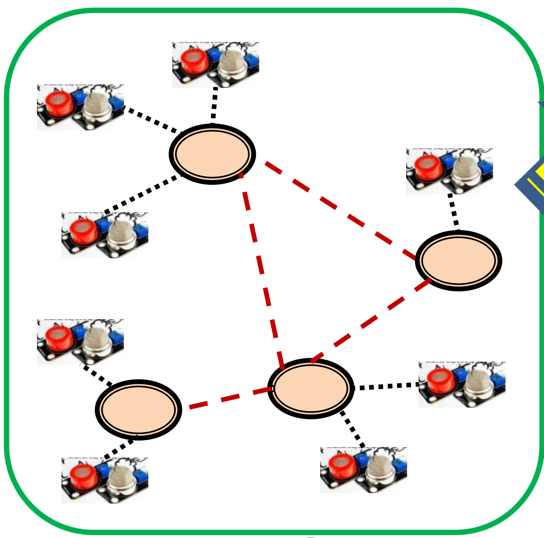
Metrology for Environmental Sensing



2016 APMP TCI project: Research on low-cost sensors

- ✓ Review commercial sensors.
- ✓ Effects of temperature and humidity on sensing methods.

- ✓ Current metrological assessment methods.
- ✓ Relevant regulations in Asia Pacific regions.



Sensor Sensor Node

APMP Team Discussion

Outcome

New information of metrology capabilities required to support urban air quality measurements

TCI Project Latest Development and Plans:

- **28 Apr 2016** — Received official award letter
- **16 May 2016** — Start of project
- **Jun 2016** — 1st Teleconference
- **26-28 Jul 2016** — 14th Workshop of APMP/TCQM GAWG
- **Nov 2016** — APMP 2016
- **15 Feb 2017** — End of project
- To create new multidisciplinary APMP projects

Main project team members:

10 researchers from 6 NMIs (NMC; NIM; NMISA; ITRI/CMS; LIPI; SIRIM)

- NMC, Singapore: Dr KAI Fuu Ming, Dr Wendy LIU, Dr FAN Yan, Dr CUI Shan
- NIM, China: Dr ZHOU Zeyi
- NMISA, South Africa: Dr James TSHILONGO
- ITRI/CMS, Chinese Taipei: Dr LIN Tsai-Yin
- LIPI, Indonesia: Dr Oman ZUAS
- SIRIM, Malaysia: Mr Fauzi bin Ahmad, Mr Arshad bin Selamat, Mrs Faridah Hussain

Thank you!