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Building Egypt's Photometric and Radiometric Measurement Capability to Support Energy Efficiency and Climate Action

NIS strengthened Egypt's photometry and radiometry infrastructure by establishing SI-traceable calibration services for luminous intensity, luminous flux, spectral responsivity, optical radiation, and, more recently, solar irradiance measurements

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The Challenge

Egypt has adopted national strategies to improve energy efficiency, reduce electricity consumption, and support climate action, particularly in the lighting sector, which accounts for a significant share of national electricity demand. Reliable measurements of lighting parameters, such as luminous flux, luminous intensity, spectral responsivity, and optical radiation characteristics, are essential for verifying the performance and efficiency of lighting products placed on the market. These needs have driven Egypt to develop more reliable measurement systems to support the effective implementation of energy-efficiency policies and standards and contribute to global climate action.

In recent years, testing laboratories have struggled to verify the energy-efficiency claims of lighting products, while regulatory authorities have faced difficulties enforcing energy-efficiency standards. This created a significant risk that non-compliant or inefficient lighting products could enter the market, leading to higher energy consumption and greater environmental impact. In the longer term, the lack of internationally recognized measurement traceability could also create technical barriers to trade.

The lighting manufacturing sector in Egypt faced significant measurement gaps that affected regulatory enforcement and industrial conformity assessment. Manufacturers and testing laboratories lacked reliable calibration services for luminous intensity, luminous flux, and spectral responsivity, and many measurements exhibited unacceptably high uncertainties, thereby reducing overall confidence in test results.

The Solution

To address these challenges, NIS strengthened its national metrological capabilities in photometry and radiometry. The intervention primarily supports the goals towards affordable and clean energy by strengthening the verification of energy-efficient lighting products. It also contributes indirectly to climate action goals by enabling more reliable verification of energy-efficient lighting products, which can help reduce electricity demand and associated greenhouse-gas emissions.

Before the intervention, the sector faced several metrology-related challenges, including the limited availability of SI-traceable calibration services in photometry and radiometry and limited participation in internationally recognized regional and international measurement comparisons. The metrological intervention included improvements to national photometric measurement standards and infrastructure; the establishment and upgrading of calibration

services for luminous intensity, luminous flux, spectral responsivity, and optical radiation measurements; and the evaluation of measurement uncertainty in accordance with ISO/IEC 17025 *Testing and calibration laboratories* requirements and relevant international metrology guidance. As a result of this intervention between 2013 and 2020, the spectral responsivity calibration and its expanded measurement uncertainty was reduced from 5 % to 1.5 %, with a coverage factor of $k = 2$, and the available wavelength range was extended from 400-700 nm to 300-1000 nm.

Data quality and reliability were ensured through uncertainty evaluation in accordance with international metrology guidelines, calibration procedures compliant with ISO/IEC 17025, and participation in interlaboratory comparisons. This included NIS participation in several regional and international measurement comparisons, including APMP.PR-K3.a, APMP.PR-S8, GULFMET.PR-K4.2021.2, and BILC 51-014-21. The results demonstrated satisfactory performance within the stated uncertainties and supported metrological traceability to the SI through the international metrology system. NIS also participated in regional activities within the Intra-Africa Metrology System (AFRIMETS) and provided calibration services and technical support to testing laboratories, industry, and regulatory authorities. These services include SI-traceable calibration of reference standards and measuring instruments for luminous intensity and luminous flux, spectral-responsivity calibration of optical detectors, and calibration and characterization services for optical-radiation measurements. They are supported by documented calibration procedures, measurement uncertainty budgets, and calibration certificates providing traceability to the SI.

A Quantifiable Impact

The impact of the intervention is supported by several sources of data, including calibration results and uncertainty evaluations from the NIS photometry and radiometry laboratories; results from regional and international interlaboratory measurement comparisons; performance data from national photometric standards; industry calibration records; conformity-assessment results; and feedback from regulatory authorities and testing laboratories on improved measurement reliability. Following the intervention, NIS laboratories were able to provide locally available, SI-traceable calibration services for key photometric and radiometric quantities, supported by documented uncertainty budgets and verified through interlaboratory measurement comparisons. For spectral responsivity calibration, the expanded measurement uncertainty was reduced 3-fold (from 5 % to 1.5 %). Participation in the internationally-recognized measurement comparisons supported the demonstration of measurement equivalence within the stated uncertainties. These activities strengthened Egypt's national quality infrastructure and improved measurement comparability at the regional and international levels.

The intervention resulted in measurable improvement in the capabilities of NIS calibration services in photometry and radiometry. This, in turn, has directly improved the accuracy and reliability of measurements for lighting products and increased confidence in conformity

assessment, while also enhancing the capacity of national laboratories to provide calibration services locally and strengthening measurement traceability to the SI. These improvements support more effective enforcement of energy-efficiency regulations and reduce the risk of inefficient lighting products entering the market. Furthermore, an increase in industrial compliance with national and international standards has been observed, which is anticipated to reduce technical barriers to trade. The intervention also makes a complementary contribution to sustainable consumption goals by supporting reliable product conformity assessment and encouraging the production and use of compliant, energy-efficient lighting products.

By obtaining SI-traceable calibration certificates from NIS, lighting manufacturers and testing laboratories can verify the accuracy of their reference standards and use more reliable measurement results in product conformity assessment. This reduces the risk of disputed or non-comparable test results, strengthens confidence in claims concerning the performance and energy efficiency of lighting products, and enables regulators to enforce compliance with energy-performance requirements. Ultimately, the strengthened photometry and radiometry capabilities have improved the integration of metrology-based services into national strategies for energy efficiency and sustainability. Through AFRIMETS, these activities have also strengthened regional cooperation, improved the comparability of photometric and radiometric measurements across Africa, and supported Africa's industrial competitiveness, regulatory effectiveness, and environmental sustainability.

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