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Metrology for Sustainable, Safe and Energy-Efficient LED Lighting in Brazil

INMETRO developed a measurement infrastructure in photometry with specialized technical services for luminous efficacy measurement, including photometric and goniophotometric testing applied to public and indoor luminaires

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The Challenge

Inefficient lighting projects across Brazil lead to substantial energy waste and light pollution, exacerbated by the rapid growth in Light Emitting Diode (LED) luminaires and lamps for public and private use. According to the 2020 Brazilian National Energy Balance (BEN) report,¹ the residential, commercial, and public sectors account for over 50 % of Brazil's electricity consumption. Inadequate phototechnical design increases individual and sectoral energy use and contributes to excessive light emissions that disrupt ecosystems and urban environments. In addition to energy-efficiency concerns, the rapid transition to LED technologies has introduced new challenges in lighting quality, including flicker, stroboscopic effects, and excessive blue-light content, all of which may affect visual comfort, human health, safety, and environmental sustainability.

The challenge was that the metrological infrastructure needed to accurately measure the performance, safety, and quality parameters of LED luminaires and lamps was unavailable. Without this capability, the various deficiencies in energy efficiency and lighting quality could not be properly addressed. As the NMI for Brazil, the National Institute of Metrology, Quality and Technology (INMETRO) was motivated to address these challenges by developing metrology capability that aligns with national efficiency programs like Procel Reluz² and supports decarbonization goals amid expanding LED markets and regulatory demands for certification under Ordinances Inmetro 62/2022³ and 69/2022.⁴

The Solution

Laboratory metrological testing precisely measures the luminous efficacy of LED luminaires and individual lamps by quantifying total luminous flux output relative to electrical power input, and mapping the luminous intensity distribution across angular fields (see **Figure 1**) in

¹ EPE – ENERGY RESEARCH COMPANY. Brazilian Energy Balance 2020: Year 2019. Rio de Janeiro, Brazil EPE, 2020. Available: <https://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/balanco-energetico-nacional-2020>

² PROCEL – National Electric Energy Conservation Program. Procel Reluz. Rio de Janeiro, Brazil. Available: <https://www.procel.gov.br/sites/dev/SitePages/Procel-Reluz.aspx>

³ Inmetro – National Institute of Metrology, Quality, and Technology. Ordinance No. 62, February 17, 2022. Approves the Technical Quality Regulation and the Conformity Assessment Requirements for Public Road Lighting Luminaires. Rio de Janeiro, Brazil: Inmetro, 2022. Available: http://www.inmetro.gov.br/legislacao/detalhe.asp?seq_classe=1&seq_ato=2921

⁴ Inmetro – National Institute of Metrology, Quality, and Technology. Ordinance No. 69, February 16, 2022. Approves the Technical Quality Regulation and the Conformity Assessment Requirements for LED Lamps with Integrated Control Gear. Rio de Janeiro, Brazil: Inmetro, 2022. Available: http://www.inmetro.gov.br/legislacao/detalhe.asp?seq_classe=1&seq_ato=2922

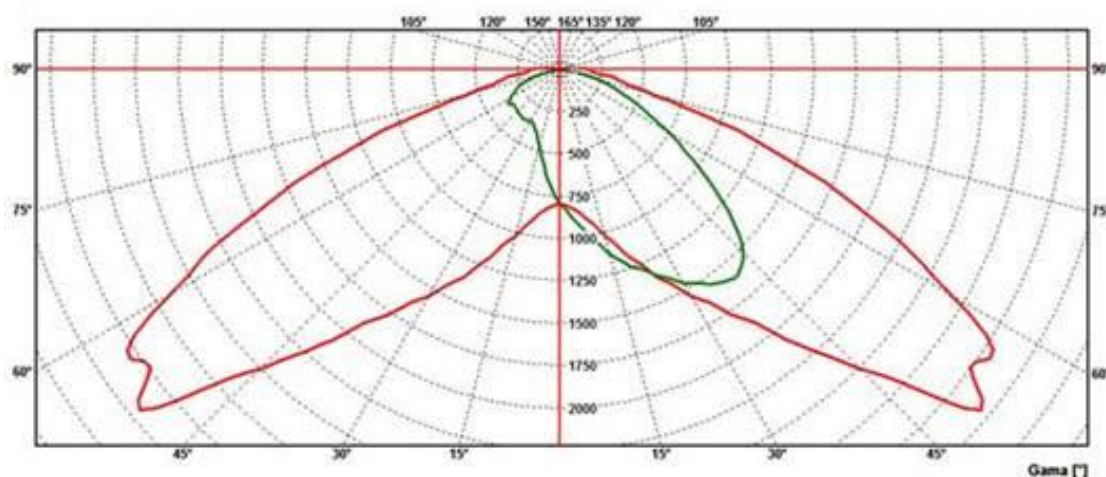


Figure 1. Luminous intensity distribution curves for a street lighting luminaire.

accordance with standards such as IESNA LM-79-08⁵ and ABNT NBR 5101.⁶ These tests enable a comprehensive evaluation of energy efficiency for LED luminaires and systems, verification of suitability for specific applications (e.g., public lighting or interiors), and quantification of stray light in undesired directions to assess light pollution risks.

Over the last two decades, INMETRO has progressively expanded the capabilities of the Optical Applications Laboratory (Laopt) and the Radiometry and Photometry Laboratory (Laraf) to establish metrologically traceable measurement capabilities for lighting products (see **Figure 2**). In addition to photometric measurements, spectroradiometric analyses are performed to determine correlated color temperature (CCT), spectral power distribution, and blue-light content.⁷ To support the implementation of forthcoming national technical regulations for LED lighting products, the laboratory is currently developing and validating measurement capabilities for temporal light modulation, including flicker⁸ and stroboscopic effects,⁹ using the PstLM (Short-Term Light Modulation indicator) and SVM (Stroboscopic Visibility Measure) metrics.

Infrastructure enhancements, including photometric benches, cryogenic radiometers, and spectral responsivity setups, ensure metrological traceability via SI-traceable primary measurement systems, supporting calibration services for the Brazilian Calibration Network (RBC) and market surveillance.

⁵ IESNA LM-79-08. IES – Illuminating Engineering Society. LM-79-08: Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products. New York: IES, 2008

⁶ BRAZILIAN ASSOCIATION OF TECHNICAL STANDARDS (ABNT). ABNT NBR 5101:2018 – Public lighting – Procedure. Rio de Janeiro, Brazil: ABNT, 2018.

⁷ IEC – International Electrotechnical Commission. IEC 62778:2014: Application of IEC 62471 for the Assessment of Blue Light Hazard to Light Sources and Luminaires. Geneva: IEC, 2014.

⁸ IEC – International Electrotechnical Commission. IEC TR 61547-1:2020: Equipment for General Lighting Purposes – EMC Immunity Requirements – Objective Light Flickermeter and Voltage Fluctuation Immunity Test Method. Geneva: IEC, 2020.

⁹ IEC – International Electrotechnical Commission. IEC TR 63158:2018: Equipment for General Lighting Purposes – Objective Test Method for Stroboscopic Effects of Lighting Equipment. Geneva: IEC, 2018.

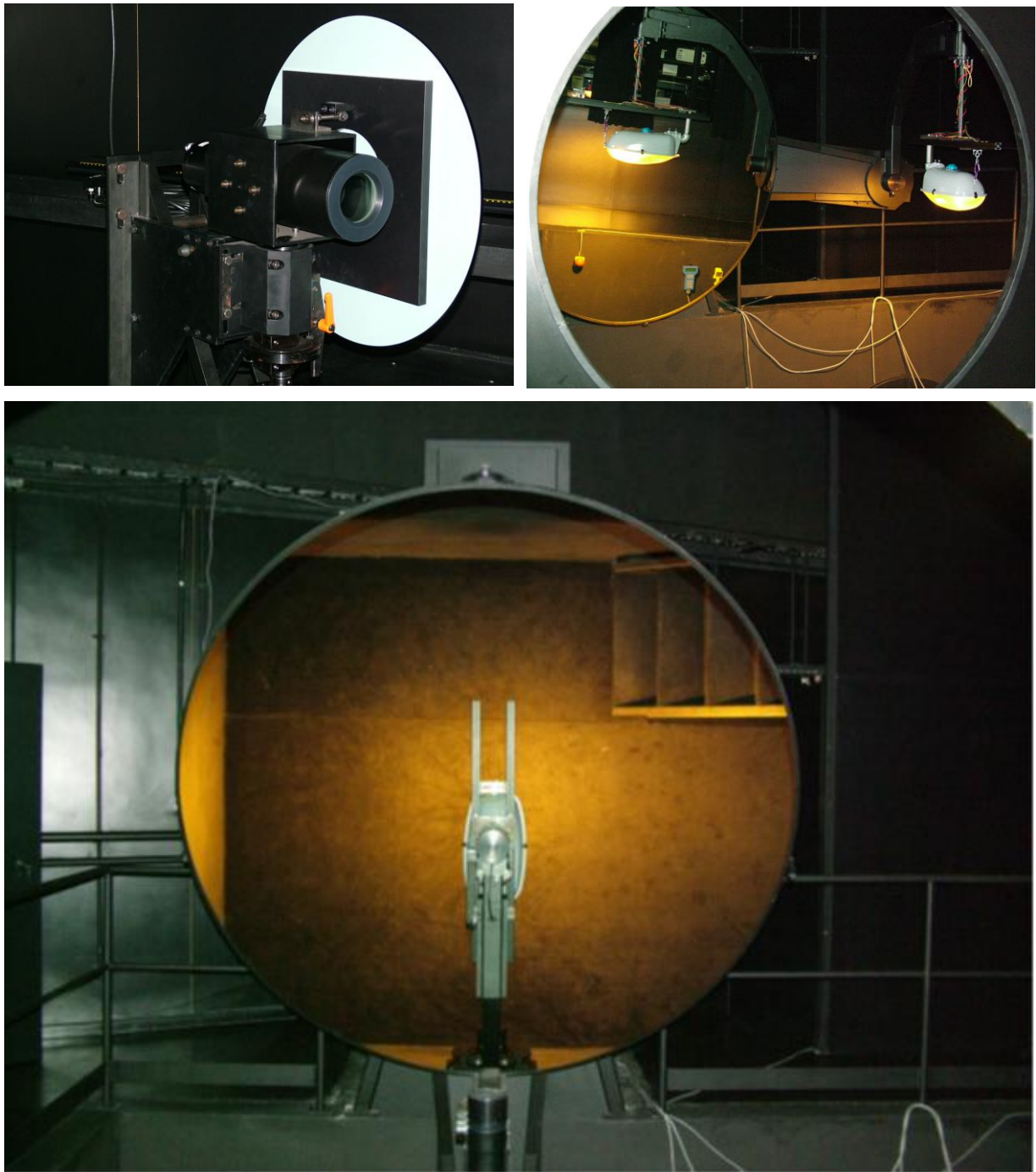


Figure 2. Photos of the goniophotometer at Inmetro's Optical Metrology Division.

A Quantifiable Impact

The results of the metrological intervention directly reflect the consolidation of the national measurement infrastructure in photometry and the strengthening of energy efficiency in the lighting sector. Specialized technical services have focused on luminous efficacy measurement and the characterization of luminous intensity and light distribution has been implemented and expanded. This has had a particular emphasis on photometric and goniophotometric testing applied to public and indoor luminaires.

Since 2006, more than 390 photometric tests for public lighting luminaires and approximately 280 tests for indoor luminaires have been conducted, reflecting sustained and growing national testing activity and demonstrating consistent support for evaluating the energy performance of these systems. In addition, measurement, analysis, and development services for luminaires accounted for over 200 activities during the same period, directly contributing to improved lighting design and increased product efficiency.

In addition, INMETRO has contributed technical expertise to the development of technical and regulatory frameworks that incorporate metrics such as PstLM (Short-Term Light Modulation indicator) and SVM (Stroboscopic Visibility Measure), supporting future assessments of flicker, stroboscopic effects, and blue-light exposure in lighting systems. INMETRO has also contributed to the development of national regulations addressing lighting efficiency, light distribution, photobiological safety, and temporal light modulation.

As a result, energy labeling programs (PBE/Procel) have been strengthened, regulatory compliance has improved, and the reliability of measurements used in certification processes has increased. Since 2006, the laboratory has supported the evaluation of more than 670 lighting products through photometric testing and has performed over 200 additional measurements and development activities related to lighting systems, resulting in a cumulative portfolio of nearly 900 activities that reflects a substantial and sustained national testing capacity in lighting metrology.

From an energy sector impact perspective, the availability of these services has increased energy efficiency in public and private lighting projects and reduced electricity consumption. This is of particular note for a sector that is responsible for a significant share of national energy use. The increase in efficiency ultimately mitigation of greenhouse gas emissions associated with lower energy demand. Improvements in lighting quality and reduced light pollution provide a direct, positive benefit to the quality of life of the environment and urban populations. Furthermore, the continuous delivery of these metrologically sound testing and measurement services over the years has demonstrated the consolidation of technical expertise and the sustainable strengthening of national metrology capacity for clean energy technologies, while addressing national-level regulatory demands to sustain urban development.

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