UNEP Collaborating Centre for Energy Efficient Lighting

Lighting Compliance Testing: Training Workshop

Report and Agenda

2 – 4 November 2016 • Beijing, China

I. Background

The success of efficient lighting policies and programmes depends on an effective system of monitoring, verification and enforcement (MVE) infrastructure. Without ongoing and effective market control activities, non-compliant lighting products may enter markets, disappoint users and reduce expected energy and financial savings. Compliance testing in particular is one of the most fundamental components of an MVE scheme. It allows for verifying whether a product lives up to its energy-efficiency claims. Data collected through product testing provides policymakers with the information they need to encourage, measure and enforce regulatory compliance.

On-site assessment and stakeholder consultations conducted in Peru reveal that compliance testing is one of the most challenging and resource-intensive MVE activities for developing economies. Current capacity of testing laboratories in Peru is limited, and in need of an upgrade.

To address these needs, a training workshop was organized for Peru by the Global Efficient Lighting Centre, Beijing. The training was implemented as an activity under the UN Environment "Lighting Market Transformation in Peru" funded by the Global Environment Facility.

II. Objectives of the Training Workshop

The objective of the training workshop was to strengthen the capacity of Peruvian lamp testing laboratories to produce reliable test results and measure gains in energy efficiency from specific innovations or techniques**.**

III. Agenda

A detailed training workshop agenda is provided in Annex II

IV. Training Sessions

2 November 2016: Day 1 – Session 1
Welcome address by Global Efficient Lighting Centre and introduction of experts and participants

Ms. Qian Liu, Deputy Director of Global Efficient Lighting Centre, opened the training workshop by welcoming the four Peruvian participants. She then introduced the objectives of the training workshop to the participants. They were encouraged to be interactive and inquire from the experts if any issues or questions needed to be addressed. She then introduced the experts contributing to the training workshop:

- Mr. Xin Hongzheng, Senior Testing Expert, Global Efficient Lighting Centre
- Mr. Steve Coyne, UN Environment consultant, Director of Light Naturally

Since all participants were new to Global Efficient Lighting Centre, Ms. Liu presented the Centre and its accomplishments. At the end, the group reviewed the agenda of the training together.

2 November 2016: Day 1 – Session 2
How does a lighting laboratory play its role in quality control?

Ms. Jing Wang gave a presentation titled "How does a lighting laboratory play its role in quality control?" According to her, laboratories are the hardware support and platform to the product quality monitoring and control system. She explained the key elements of a lighting laboratory, and the main points to consider when improving laboratories. Laboratories play an important role in four phases: customs check, testing before delivery, market checking test and certification. Ms. Wang explained in detail how a laboratory works in each of these four phases by providing technical experts and testing data to improve and strengthen the product quality monitoring and control system.

2 November 2016: Day 1 – Session 3
LED lighting technology developments and trends

Ms. Jing Wang gave a presentation titled "LED lighting technology development and trends", focusing on:

- Lighting technology status: Ms. Wang introduced advanced LED lighting technology, and summarized its different structure, lighting principles and characteristics, compared with traditional lighting technologies. She analysed the main radiation problem for LED products, which has significant impact on luminous efficacy, luminous flux and lifetime.
- Intelligent control in lighting: Smart lighting or intelligent lighting is not a new word in lighting area. Control protocol has been introduced in lighting. For example, Wi-Fi, Zigbee, and Bluetooth, have all signed Memorandum of Understanding cooperation

agreements with Technical Evaluation Alliance for Solid State Lighting. Intelligent control protocol in LED lighting is being researched and to be created soon.

- Nonvisual lighting: Use of LED lighting in agriculture is a hot topic. At present, LED lighting in agriculture is mainly used in greenhouses, plant factories and plant tissue cultures. Although use of LED lighting in agriculture is still at the initial stages, many countries and economic communities such as China, the European Union and Japan are planning the prospects of its application.
- Future lighting development trends: Along with the development of intelligent lighting, lighting systems comprised of lamps and luminaires will be important. In future, human-centric lighting will be at the core of development of lighting technologies.

2 November 2016: Day 1 – Session 4
Visit to Global Efficient Lighting Centre and the National Lighting Test Centre

Ms. Huidan Liu took the participants for a tour of the National Lighting Test Centre and the Global Efficient Lighting Centre. During the tour, the participants were shown lighting distribution test laboratory, two lighting performance test laboratories, lifetime test room, safety test laboratory, electromagnetic compatibility test laboratory, mercury test laboratory, objective evaluation research laboratory, and solid state lighting reliability research laboratory. The tour gave the participants a general view of what a comprehensive and specialized lighting laboratory looks like, and what kind of equipment it uses.

The participants were excited to visit the laboratories, in particular the different kinds of testing facilities. They expressed their excitement to visit a large lighting laboratory and were impressed by the variety of work done at such a laboratory.

2 November 2016: Day 1 – Session 5
Failures in lighting tests: key findings

Mr. Xin Hongzheng gave a presentation titled "Failures in lighting tests: key findings". He explained, based on his more than 10 years of testing experience, the key failures in the lighting tests. He summarized potential solutions, useful for when conducting lighting tests:

- Light source safety: e.g. marking, interchangeability, bending moment, protection against electrical shock, insulation resistance and electric strength, mechanical strength, cap temperature rise, resistance to heat, resistance to flame and ignition, fault conditions, disturbance voltage, harmonic current, blue light hazard
- Light source performance: e.g., electrical parameters, photometric parameters, colorimetric parameters, luminous efficacy, initial failure, maintenance
- Luminaires safety: e.g., marking, construction, creepage distances and clearances, provision for earthing, terminals, external and internal wiring, protection against accidental contact with live parts, thermal endurance, IP testing, insulation resistance and electric strength, , resistance to heat, resistance to flame and ignition, fire and impression, disturbance voltage, harmonic current, radiated electromagnetic disturbances
- Luminaires-performance: e.g., electrical parameters, photometric parameters, colorimetric parameters, luminous efficacy, initial failure, applied working condition, maintenance

2 November 2016: Day 1 – Session 6

Fundamentals of colorimetry and practical color measurements

Mr. Xin Hongzheng provided a presentation titled "Fundamentals of colorimetry and practical color measurements" focusing on:

- Photometric parameters
  Luminous flux, illuminance and luminance
- Measurement method of total luminous flux
  - Spacial integrating method (Co-ordinates systems and gonio-photometers)
  - Integrating sphere method
- Colorimetric parameters
  Color coordinate, CCT and CRI
- How to calculate the colorimetric parameters
  - CIE 1931 RGB system
  - CIE 1931 XYZ system
  - CIE 1960 UCS system
  - CIE 1960 LUV system
  - CIE 1976 Lab system
  - Calculation of color coordinate
  - Calculation of Tc and CCT
  - Calculation of CRI and Ra
- Measurement method of SPD
  - Principle of measurement of SPD
  - Procedure of measurement of SPD
  - Key elements in the measurement of SPD

3 November 2016: Day 2 – Session 6
Introduction to standards LM 79, LM 80 and TM 21

Mr. Xin Hongzheng provided a presentation titled "Introduction to standards LM 79, LM 80 and TM 21."

- LM 79 The Electrical and Photometric Measurements of Solid State Lighting Products. This standard provides test methods to address the requirements for measurement of solid state lighting products. It describes the procedures to be followed and precautions to be taken in performing reproducible measurements of total luminous flux, electrical power, luminous intensity distribution and chromaticity of solid state lighting products for illumination purposes, under standard conditions.
- LM 80 Measuring Lumen Maintenance of LED Light Sources. This standard covers the measurement of lumen maintenance of inorganic LED-based packages, arrays and modules. Light output, efficacy and lumen maintenance as well as the life of the light source are key information required. The standard describes the procedures with which LED light sources can be operated under controlled conditions so as to obtain optimally comparable data on changes in light output during the life of a lighting.
- TM 21 Projecting Long Term Lumen Maintenance of LED Light Sources. This standard provides recommendations of a method for projecting long-term lumen maintenance of LED light sources using data obtained when testing them as per LM 80 standard.

3 November 2016: Day 2 – Session 7

The common issues in lighting testing and potential solutions (Key technical measurement requirements based on CIE S 025)

Mr. Xin Hongzheng provided training on "The common issues in lighting test and potential solutions (Key technical measurement requirements based on CIE S 025)." CIE S 025: 2015 Test method for LED lamps, LED luminaires and LED modules was published on March 20 2015. This is an international test method intended for harmonized solid state lighting testing and accreditation worldwide. The presentation covered the following points:

- Background of CIE S 025
  How the CIE S 025 developed, and the expectation of it to be adopted internationally for harmonized solid state lighting testing and accreditation. This standard specifies the requirements for measurement of electrical, photometric and colorimetric quantities of LED lamps, LED modules and LED luminaires.
- Special requirements in CIE S 025
  Standard test conditions and tolerance interval
  Measurements of the photometric, colorimetric and electrical characteristics of a LED device shall be performed by means of appropriate equipment and procedures under defined standard test conditions. The standard test conditions, which include a Set Value and a Tolerance Interval, were introduced to the participants.
- Common components of measuring uncertainty of LED devices
  For the purposes of testing, if all tolerance conditions are met without corrections, each test report may show uncertainty values for a typical product of the similar type, with a statement that indicates so in the test report. Mr. Xin explained in detail each parameter relating or contributing to uncertainty of test results, especially the luminous flux and color quantity uncertainty. He also provided advice on how to use an uncertainty budget,and the procedures to do an uncertainty evaluation.

3 November 2016: Day 2 – Session 8
Training in the laboratory: Performance testing (integrating sphere)

Mr. Xin Hongzheng took the training group to the Global Efficient Lighting Centre performance testing laboratory. Mr. Xin showed the participants the integrating sphere, and all the key facilities of the laboratory. He explained how the sphere system is used. He demonstrated and explained step by step how to measure a lamp, including standard lamp measurement, lamp pre-burning, lamp mounting, lamp stability, lamp measurement, circuit diagram installation, self-absorption, spectral mismatch correction, data calculation and analysis. During the training, the testing procedure, correction and data analysis were explained in detail, which the participants considered to be the most important part of the training. The participants and Mr. Xin used LED samples to go through the testing process together. The practical training session allowed the participants to understand well the theories they learned in the previous training sessions, and got a chance to learn how the lamp measurement operate.

4 November 2016: Day 3 – Session 9
Overview of international lighting standards

Mr. Steve Coyne provided a presentation of "Overview of International Lighting Standards". The following four parts were included:

- International Standard Organizations
  Three main international standard organizations, together with their responsibilities in lighting area and relationships in developing lighting standards, were introduced.
  International Electrotechnical Commission (IEC) TC34 – lamps and related equipment
  International Commission on Illumination (CIE)
  International Organization for Standardization (ISO) TC274 – Light and lighting
- Lighting Standards Types and relevant standards bodies
  The lighting standards included product safety requirements, product performance requirements, product test methods, lighting application design requirements, lighting design methods, and lighting audit methodologies. The typical hierarchy of standards was also introduced.
- Summary of testing standards
  The main international standards for CFLs, FLs, and LEDs were introduced. Two clear tables (one for CFL lamps, one for LED lamps) to compare the requirements among those comparable standards were provided.
- International standard development trends
  LEDs are becoming more popular in the market, after incandescent and CFL lamps. In 2013, a new LED Lamp Classification was proposed by the National Lighting Test Centre, which has been adopted by IEC TC34 Committee. In this proposal, the LED lamp is

classified by lumen rather than wattage. This proposal led a totally new concept in lighting, and is regarded as a milestone in lamp classification.

In the future, more comprehensive lighting systems will be developed with intelligent controls. This is expected to be a challenge to lighting standards.

4 November 2016: Day 3 – Session 10
Spectral correction of photodetectors for LED products

Mr. Steve Coyne's gave a presentation titled "Spectral correction of photodetectors for LED products".

Measurement of light requires a detector that has the same spectral response as the human eye under typical lighting conditions. At the outset, Mr. Coyne introduced photopic vision, scotopic vision, and mesopic vision. He gave several examples of detectors with different f'1 (the deviation of relative spectral responsivity from the V(λ) function), and their effects to the different light sources on measurements. Mr. Coyne finished by explaining how to correct the mismatch when calibrating the detector against a Standard Reference Lamp if the lamp type is different from the Standard Reference Lamp and the correcting test measurement.

4 November 2016: Day 3 – Session 11
Measurement of directional lamps in an integrating sphere

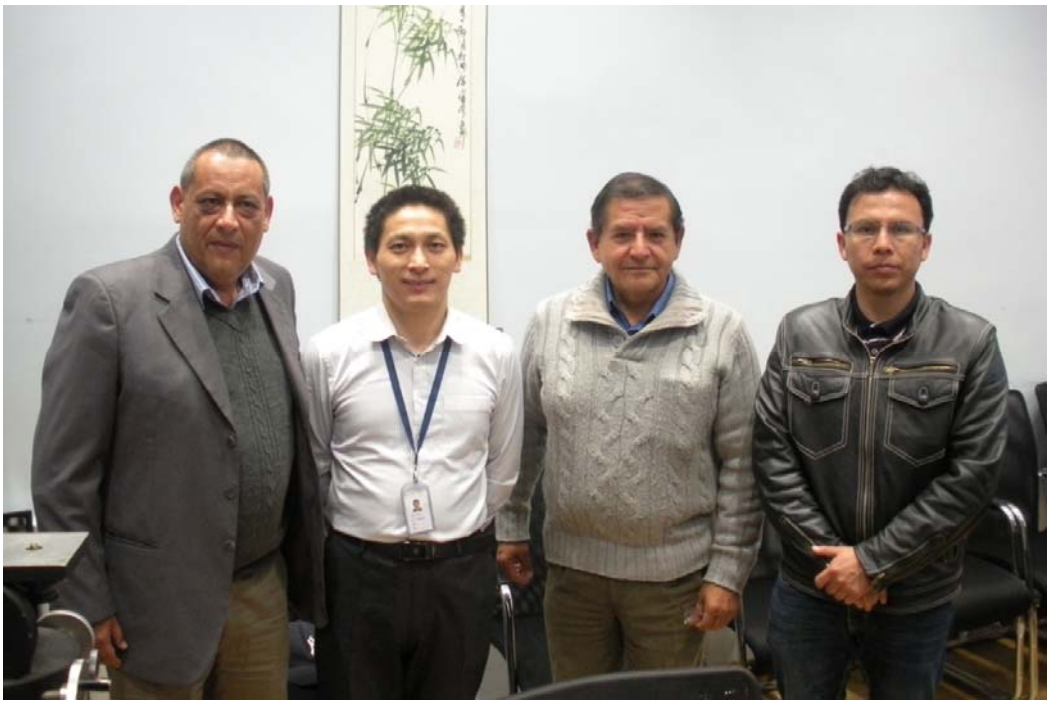
Mr. Steve Coyne gave a presentation titled "Measurement of Directional Lamps in an integrating sphere". Mr. Coyne presented a general view of the integrating sphere measurement with a directional lamp and typical problems that are encountered. Then he explained several specific topics in detail:

- Sphere responsivity
- Measuring partial sphere response
- Spatial response distribution function
- Normalized spatial response distribution function
- Calculating the sphere response factor
- Understanding the errors due to angular distribution of lamps
- Understanding magnitude of errors: influencing factors
- Beam angle variations

At the end, Mr. Coyne provided practical considerations and recommendations: maintain a range of reference lamps with appropriate beam angles/distributions; undertake calibration measurements of various lighting distribution lamps against the omin-directional standard reference lamp to determine correction factors for future use with test lamps; if measuring a significant quantity of lamps of similar light distribute, calibrate one on a goniophotometer system.

4 November 2016: Day 3 – Session 12
Evaluation, final remarks and certification ceremony

Ms. Jing Wang acknowledged the support of UN Environment and Peruvian government. The intention is to support the capacity building to the laboratories in Peru. The training workshop would not remain as a one-off activity but would be a beginning for cooperation. Ms. Wang welcomed the participants and the other international partners to work together with Global Efficient Lighting Centre in the lighting area. She concluded by thanking all the participants for their encouraging response. To end, a certification ceremony was conducted. Mr. Coyne and Ms. Wang presented a certification to each participant.



4 November 2016: Day 3 – Session 13
Field visits to the market based efficient lighting product and technologies

The participants visited the largest lighting market in Beijing, known as “China’s first lighting city”. It covers more thant 50,000 square meters in area, and has millions of different kinds of lighting products. The participants saw the most popular LED lighting products in the market, e.g. lighting bulbs, LED tubes, LED panel lighting, LED street lighting and tunnel lighting, LED downlight, LED reflector, LED strip, etc.

Feedback

Overall, the participants indicated their satisfaction with the training. They considered the sessions and content were good, and said they gained important knowledge of efficient

lighting, and improved their quality control and testing capacities.

The participants would have liked to learn more about measurement and would have hoped the training would have been longer (more than a week).

Both laboratories showed interested in conducting an inter-laboratory comparison test with the Global Efficient Lighting Centre laboratory.

Annex I: List of Participants

Lighting Compliance Testing Training Workshop
2-4 November 2016, the Global Efficient Lighting Centre, Beijing, China

Peru

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Annex II: Agenda

Lighting Compliance Testing Training Workshop
2-4 November 2016, the Global Efficient Lighting Centre, Beijing, China

Day 1 – 2 November, 2016

9:00-9:10	Welcome words and greeting	Ms. Qian Liu, Deputy Director of GELC
9:10-9:20	Introduction of participants	All
9:20-9:50	How does a lighting laboratory play its role in quality control?	Ms. Jing Wang
9:50-10:20	LED lighting technology developments and trends	Ms. Jing Wang
10:20-10:35	Coffee Break	
10:35-11:10	Visit to laboratory	Ms. Huidan Liu
11:10-12:00	Failures in lighting tests: key findings Questions and Discussion	Mr. Xin Hongzheng
12:00-13:30	Lunch	
13:30-15:00	Fundamentals of photometry and colorimetry	Mr. Xin Hongzheng
15:00-15:30	Coffee Break	
15:30-17:00	Fundamentals of photometry and colorimetry (cont.)	Mr. Xin Hongzheng

Day 2 – 3 November, 2016

9:00-10:30	LM79, LM80 and TM-21	Mr. Xin Hongzheng
10:30-10:50	Coffee Break	
10:50-12:10	Common issues in lighting test and potential solutions (Key technical measurements requirements based on CIE S 025)	Mr. Xin Hongzheng
12:10-13:30	Lunch	
13:30-15:00	Training in the lab: Performance testing (Integrate sphere)	Mr. Xin Hongzheng

15:00-15:30	Coffee Break	
15:30-17:00	Training in the lab: Performance testing (Integrate sphere) (cont.)	Mr. Xin Hongzheng

Day 3 – 4 November, 2016

9:00-10:00	Overview of international lighting standards	Mr. Steve Coyne
10:00-10:20	Coffee Break	
10:20-12:10	Calibration of integrating spheres for directional LED product	Mr. Steve Coyne
12:10-13:30	Lunch	
13:30-15:00	Spectral correction of photodetectors for LED products	Mr. Steve Coyne
15:00-15:30	Coffee Break	
15:30-16:15	Open questions and discussion	All
16:15-16:45	Evaluation and final remarks; Certificates ceremony	Mr. Steve Coyne Ms. Jing Wang
16:45-18:00	Field visits to the market based efficient lighting product and technologies	
18:00-20:00	Dinner	

End of training sessions