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PRODUCT SELECTION AND PROCUREMENT FOR LAMP PERFORMANCE TESTING

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FOREWORD

In 2014, lighting accounted for approximately 15% of global electricity consumption. The United Nations Secretary-General's Sustainable Energy for All initiative identified energy efficient lighting as a "high impact opportunity", with the potential to reduce countries' greenhouse gas emissions, generate significant economic benefits and improve people's wellbeing.

High efficiency lighting technologies, such as light emitting diode lamps and smart control systems, offer up to an 85% improvement in efficacy, compared with conventional lighting technologies, while providing a better quality service.

Minimum energy performance standard programmes are a crucial policy tool for improving the energy efficiency of lighting, by contributing to the elimination of the least efficient products from the market, and accelerating the phase-in of energy saving technology replacements. However, while an increasing number of countries are adopting minimum energy performance standards, the continued availability of non-compliant, inefficient products jeopardises the achievement of countries' energy efficiency goals.

Robust monitoring, verification and enforcement schemes are crucial to safeguarding the energy efficiency benefits of performance standards and regulations. These activities protect markets from products that fail to perform as declared, or required; guarantee that products meet consumers' expectations; and ensure that policymakers, government regulators and programme administrators attain their energy saving objectives. Monitoring, verification and enforcement activities also protect suppliers' competitiveness by ensuring that they are all subject to the same market entry conditions.

Successful monitoring, verification and enforcement implementation requires long-term policy commitment and planning. The Government of Australia has long been committed to the development and implementation of monitoring, verification and enforcement policy and activities on its own territory, as part of its Equipment Energy Efficiency Program. Since 2009, Australia has been assisting other developed and developing countries to follow the same path, by sharing its expertise and best practices, and making its resources available to other countries[1].

Most recently, the Government of Australia has provided its financial and technical support to the United Nations Environment Programme-Global Environment Facility en.lighten initiative to strengthen capacities for monitoring, verification and enforcement in Southeast Asia and the Pacific. As part of this project, and drawing on the experience and knowledge of international experts and practitioners, the United Nations Environment Programme developed a series of six guidance notes on specific aspects of monitoring, verification and enforcement.

This guidance note and its associated publications are designed as manuals for government officials, technical experts and others around the world responsible for developing, implementing and refining structured and effective monitoring, verification and enforcement programmes. They describe the technical, methodological and institutional resources required, and provide easy-to-use, generic tools and templates that readers can adapt to their particular country situations.

We hope that these guidance notes will convince governments of the importance and benefits of monitoring, verification and enforcement and assist with implementation. We strongly encourage policymakers and those involved in implementing monitoring, verification and enforcement policies to take advantage of the practical advice presented.

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1 Including: International Electrotechnical Commission (IEC), International Energy Agency 's Energy Efficient End-use Equipment Solid State Lighting Annex (IEA 4E SSL Annex), lites.asia, Pacific Appliance and Labelling Programme (PALS), Vietnam Energy Efficiency Standards and Labels (VEESL), and others

ABOUT THE UNEP–GEF EN.LIGHTEN INITIATIVE

The United Nations Environment Programme (UNEP)-Global Environment Facility (GEF) en.lighten initiative was established in 2010 to accelerate a global market transformation to environmentally sustainable, energy efficient lighting technologies, as well as to develop strategies to phase out inefficient incandescent lamps to reduce CO_2 emissions and the release of mercury from fossil fuel combustion.

The en.lighten initiative serves as a platform to build synergies among international stakeholders; identify global best practices and share this knowledge and information; create policy and regulatory frameworks; address technical and quality issues; and encourage countries to develop National and/or Regional Efficient Lighting Strategies.

The United Nations Secretary General's Sustainable Energy for All (SE4ALL) initiative selected the UNEP en.lighten initiative to lead its lighting 'Energy Efficiency Accelerator'.

The initiative is a public/private partnership between the United Nations Environment Programme, OSRAM and Philips Lighting, with the support of the Global Environment Facility. The National Lighting Test Centre of China became a partner in 2011, establishing the Global Efficient Lighting Centre, and the Australian Government joined in 2013 to support developing countries in Southeast Asia and the Pacific.

In 2015, based on the lessons learned from the en.lighten initiative, UNEP launched the United for Efficiency (U4E) initiative to support countries in their transition to energy efficient appliances and equipment, including room air conditioners, residential refrigerators, electric motors, distribution transformers and information and communication technologies.

ABOUT THE UNEP–GEF EN.LIGHTEN INITIATIVE MONITORING, VERIFICATION AND ENFORCEMENT SERIES

This guidance note is one of a series of six publications on monitoring, verification and enforcement (MVE) commissioned by the UNEP-GEF en.lighten initiative under its Southeast Asia and Pacific Monitoring, Verification and Enforcement Project, funded by the Australian Government:

- *Developing Lighting Product Registration Systems;*
- *Efficient Lighting Market Baselines and Assessment;*
- *Enforcing Efficient Lighting Regulations;*
- *Good Practices for Photometric Laboratories;*
- *Performance Testing of Lighting Products;*
- *Product Selection and Procurement for Lamp Performance Testing.*

The series provides practical tools in support of lighting policy compliance frameworks and to help countries achieve a successful transition to energy efficient lighting. These publications build on the existing guidance given in the UNEP-GEF en.lighten reference manual, *Achieving the Global Transition to Energy Efficient Lighting Toolkit*. They focus on individual aspects of an effective MVE infrastructure and how these contribute to improved product compliance and the success of policies that aim at transforming the market to efficient lighting.

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ABBREVIATIONS AND DEFINITIONS

CCT	correlated colour temperature
CFL	compact fluorescent lamp
CIE	Commission Internationale de l'Eclairage/International Commission on Illumination
CO_2	carbon dioxide
CRI	colour rendering index
GEF	Global Environment Facility
IEC	International Electrotechnical Commission
IESNA	Illuminating Engineering Society of North America
IEV	International Electrotechnical Vocabulary
LED	light emitting diode
lm	lumen
MEPS	minimum energy performance standard
MVE	monitoring, verification and enforcement
MW	megawatts
rms	root mean square
s	seconds
sr	steradian (SI unit of solid angular measurement)
UNEP	United Nations Environment Programme
W	watt

GLOSSARY

C

compliance: conforming to a rule, such as a law, policy, specification or standard.

E

efficacy: see luminous efficacy.

I

illumination: application of light to a scene, objects or their surroundings so that they may be seen. (IEC)

incandescent (electric) lamp: lamp in which light is produced by means of an element heated to incandescence by the passage of an electric current. (IEC)

International Electrotechnical Vocabulary: Comprehensive electrotechnology terminology database compiled by the International Electrotechnical Commission.

L

lamp: source made in order to produce an optical radiation, usually visible. Note: This term is also sometimes used for certain types of luminaires. (IEC)

life (of a lamp): the total time for which a lamp has been operated before it becomes useless, or is considered to be so according to specified criteria. Note: Lamp life is usually expressed in hours. (IEC)

light emitting diode: solid state device embodying a p-n junction, emitting optical radiation when excited by an electric current. (IEC)

lumen (lm): SI unit of luminous flux. The luminous flux emitted in unit solid angle (steradian) by a uniform point source having a luminous intensity of 1 candela. (IEC)

luminaire: apparatus which distributes, filters or transforms the light transmitted from one or more lamps and which includes, except the lamps themselves, all the parts necessary for fixing and protecting the lamps and, where necessary, circuit auxiliaries together with the means for connecting them to the electric supply. (IEC)

luminous efficacy: quotient of the luminous flux emitted by the power consumed by the source. Unit: lm/W; symbol: η_v or η. (IEC)

luminous flux: quantity derived from radiant flux Φ_e by evaluating the radiation according to its action upon the CIE standard photometric observer. Unit: lm. (IEC)

M

maximum mercury content: maximum amount of mercury added to gas discharge lamps to enable their operation.

mercury (Hg): a metallic element, the only one that is liquid at room temperature.

minimum energy performance standard (MEPS): a mandatory minimum performance level that applies to all lamp products sold in a market, whether imported or manufactured domestically.

O

omnidirectional lamp: emits light in all (or near to all) directions.

P

p-n junction: a boundary or interface between two types of semiconductor material.

product life: see rated lifetime.

R

radiant flux: power emitted, transmitted or received in the form of radiation. (IEC)

rated lifetime: the declared lifetime of a lamp model (not a single lamp), in operating hours. Generally, the time after which 50% of a specified number of lamp units, of that model, would cease to operate in a (useful) manner according to specified criteria.

GLOSSARY

R

rated luminous flux (of a type of lamp): the value of the initial luminous flux of a given type of lamp declared by the manufacturer or the responsible vendor, the lamp being operated under specified conditions. Unit: lm. Note 1: The initial luminous flux is the luminous flux of a lamp after a short ageing period, as specified in the relevant lamp standard. Note 2: The rated luminous flux is sometimes marked on the lamp. (IEC)

rated power (of a type of lamp): the value of the power of a given type of lamp declared by the manufacturer or the responsible vendor, the lamp being operated under specified conditions. Unit: W. Note: The rated power is usually marked on the lamp. (IEC)

rated voltage or rated voltage range: nominal voltage/ range of voltage at which a piece of electrical equipment is designed to operate.

rating (of a lamp): the set of rated values and operating conditions of a lamp which serve to characterise and designate it. (IEC)

S

self-certification: practice of submitting information about one's product in a formal statement, rather than being obliged to ask a third party to do so.

SI unit: any of the units adopted for international use under the Système International d'Unités.

special purpose lamp: designed for specific applications and not suitable for general illumination.

T

truth-in-claim: validity of the rated values being reported by the manufacturer or supplier.

tungsten filament lamp: incandescent lamp whose luminous element is a filament of tungsten. (IEC)

tungsten halogen lamp: gas-filled lamp containing halogens, or halogen compounds, the filament being of tungsten. (IEC)

EXECUTIVE SUMMARY

This guidance note describes the steps required when selecting and procuring residential lamps to undergo performance testing, including defining the product scope, selection methodology, and the procurement and tracking protocol.

The target audience is governmental authorities with a role in national decision-making or policy development for efficient lighting monitoring, verification and enforcement activities; and, government agencies responsible for implementing monitoring, verification and enforcement strategies. The focus is on residential lighting products and includes the common lamps found in various countries around the world.

The guidance note discusses methodologies for cost effective identification and selection of lamps for establishing a market baseline prior to regulation, as well as for identifying lamp models when conducting lamp testing for compliance in an already regulated market.

Performance testing programmes, whether for gathering market intelligence, monitoring compliance with minimum energy performance standard and labelling programmes, verifying manufacturer/retailer declarations or conducting product benchmarking, all require product and performance parameter scopes to be established. The key considerations are to clearly set the objective of the investigation, unequivocally define the scope of products to be included, and specify the key metrics to be captured.

As all of these programmes include performance testing activities, it is critical to establish an appropriate budget. During planning, it is important to have an accurate understanding of the costs involved, such as: the cost of the procurement activity itself; the cost of the laboratory test for each of the nominated performance parameters, and for the number of models and samples of each, to be tested; the cost of transporting the samples to and from the testing laboratory; and the cost of disposing of the samples after testing.

After establishing the scope and the budget, but before selecting any lamps, a thorough understanding of the lamp market has to be obtained to facilitate the sourcing of an appropriate representation of the intended market sectors to meet the objectives of the programme. This information can be difficult and onerous to find due to the complexities of trade and logistics of a mass volume, low cost, consumable product. Ultimately, a profile of the products in the market (product performance and its market segment) will be drawn from: any existing voluntary or mandatory registration system for energy performance or labelling; customs import and export volumes; in-store surveys; industry bodies or individual companies; and catalogue data.

To ensure the robustness of performance testing results against manufacturer/supplier challenges, a systematic and transparent approach to lamp acquisition and documentation must be established. Care in developing a step-by-step methodology, with an associated documentation trail, and personnel accountabilities are key to achieving this outcome. Personnel roles and responsibilities, sample acquisition protocols, provision of authority to conduct the product acquisition, developing effective lamp identification and transparent record keeping systems are all contributing elements to a defensible system.

However, unless the sample lamps arrive safely at the testing laboratory, there will be no legitimate characterisation, through testing, of the performance of a model of lamp. Important consideration must therefore be taken for safe arrival, including: careful packaging and clear identification of the products enclosed; secure delivery tracking; and direct communication with the testing laboratory on the transit and receipt of the samples.

1 INTRODUCTION

Increasingly, governments are investigating the use of energy efficient lighting policy measures to attain goals such as energy security, easing of electricity generator construction, CO_2 emissions reduction and climate change mitigation. Understanding the performance of the products in a market before implementing any regulation, and subsequently while monitoring and enforcing a regulated market, is key to the successful initiation, and continuation, of the transition to any energy efficient product, including lamps.

This guidance note describes the steps required when selecting and procuring residential lamps to undergo performance testing, including defining the product scope, selection methodology and the procurement and tracking protocol. It discusses methodologies for cost effective identification and selection of lamps for establishing a market baseline prior to regulation, as well as for identifying lamp models when conducting lamp testing for compliance in an already regulated market. In order to facilitate the laboratory testing of samples of these selected lamps, guidance is also provided on: the transparency and traceability of procurement options; development of an identification system for the samples; and packaging and transportation practices.

Although this guidance note focuses on the lamps typically used in residential situations in countries around the world,[2] many of the principles and steps can also be applied to product selection for other lamp types, or even other electric appliances.

Figure 1 provides an insight into the topics and the sub-components which make up the chapters in this guidance note.

⇨ **CHAPTER 2** provides information on how to establish the scope of the testing programme, including clearly setting the overall objective, specifying the range of lamp products to be included and identifying the key performance metrics to be captured.

⇨ **CHAPTER 3** demonstrates how to calculate a budget for product testing programmes, including procurement, testing, transportation and disposal costs.

⇨ **CHAPTER 4** focuses on how to establish a profile of the products in the market and how to determine the appropriate process for selecting products to be tested, depending on the objective of the programme.

⇨ **CHAPTER 5** presents a methodology for lamp acquisition and documentation, including information on: personnel roles and responsibilities; sample acquisition protocols, including authority to conduct the acquisition; and developing robust lamp identification and transparent record keeping systems.

⇨ **CHAPTER 6** discusses procedures for ensuring the safe arrival of sample lamps at the testing laboratory, including consideration of packaging and declarations, communication with the laboratory and delivery tracking.

⇨ **CHAPTER 7** summarises the recommendations for effective selection and procurement of lighting products for performance testing.

⇨ **CHAPTER 8** signposts resources that provide additional information for policymakers, laboratory personnel and other practitioners and stakeholders.

⇨ **CHAPTER 9** lists the documents which were referred to during the compilation of this guidance note.

Examples of supporting documentation are given in the annexes.

2 Such as: mains voltage (100V – 240V), single-cap lamps for general indoor lighting applications, including those with incandescent, tungsten halogen incandescent, compact fluorescent and light emitting diode light sources; mains voltage (100V – 240V) and extra low voltage (12V) directional lamps; and dual-cap linear fluorescent lamps.

Figure 1

Product selection and procurement process for lamp performance testing

SCOPE OF INVESTIGATION

- Setting the objective
- Defining the product scope
- Identifying the key metrics to be investigated
- Identifying of competent test laboratories

BUDGET CALCULATION

- Cost of tests
- Number of samples
- Transportation costs
- Disposal
- Sample budget

ESTABLISHING A PRODUCT PROFILE

- Sources of information
- Selecting lamps to test

LAMP ACQUISITION

- Programme personnel
- The sampling process
- Method of sample selection
- Lamp identification
- Record keeping system

TRANSPORTATION

- Packaging
- Secure delivery tracking
- Communication with testing laboratory

2 ESTABLISHING THE SCOPE OF THE INVESTIGATION

Whether for market intelligence, monitoring compliance with minimum energy performance standard (MEPS) and labelling programmes, or for verifying manufacturer/retailer declarations, selecting lamp samples for product benchmarking requires product and performance parameter scopes to be established. This chapter discusses the key considerations, such as: clearly setting the objective of the investigation; unequivocally defining the scope of products to be included; and specifying the key metrics to be captured.

2.1 SETTING THE OBJECTIVE

The first step in developing a lamp performance test programme is to establish the objective of the investigation, so that relevant results are generated at the most efficient cost that the requirements allow for. Typical objectives include:

UNDERSTANDING MARKET PERFORMANCE

A testing programme may be instigated to inform the development of a new regulatory, or voluntary, approach to promoting efficient lighting. For example, when developing a new MEPS,[3] the focus would be to obtain a broad understanding of where average (and median) market performance levels lie, and identify the range of performances (from minimum to maximum) available in the market. This will provide information on what portion of the market might be removed in the event of introducing MEPS or, conversely, what higher performing portion of the market might warrant a performance rating or label. When reviewing existing MEPS, a similar broad market testing approach would be appropriate. More detailed information on establishing a product profile can be found in the UNEP-GEF en.lighten initiative guidance note, *Efficient Lighting Market Baselines and Assessment*.

COMPLIANCE WITH MEPS OR LABELLING PROGRAMMES

Testing programmes may also be part of a monitoring, verification and enforcement (MVE) strategy for a MEPS or labelling programme. The success of a performance regulation can be judged on the absolute degree to which it achieves penetration into the market place. Where strong regulatory regimes (including MVE) exist, there are good market outcomes, and where protections are weak, outcomes are inevitably poor. Verification testing is primarily focussed on testing products to ensure that they are compliant with an existing minimum energy performance, or labelling, standard or similar scheme. The rigorousness of testing must be more stringent here because a result that falls below the required performance standard (for energy or technical parameter performance) will be subject to enforcement actions.

TRUTH-IN-CLAIM VERIFICATION

Testing may also be instigated to evaluate truth-in-claim, i.e. the validity of the rated values being reported by the manufacturer or supplier. For consumers to have faith in the products in the market, there needs to be a process of verification of the rated values being reported by the manufacturer or supplier. Any performance metric that is rated, and marked on the packaging (or other public materials, such as brochures and websites), may be substantiated by an independent test report. This is the focus of truth-in-claim testing which is generally the domain of a country's consumer protection agency.

3 More information on developing MEPS can be found in the UNEP-GEF en.lighten guidance note, *Developing Minimum Energy Performance Standards for Lighting Products*, available at http://www.enlighten-initiative.org/ResourcesTools/Publications.aspx

2

2.2 DEFINING THE PRODUCT SCOPE

The scope of lamps to be tested (and therefore sampled from the market) should be clearly defined. The relevant features, such as lamp technology type, shape (see Annex A), cap type (see Annex B), lumen output, colour temperature, voltage and/or wattage, should be clearly articulated. These characteristics are chosen so that they include lamp types that have significant existing, or potential, market penetration (which may be determined through a market survey). At times, it may be easier to include a description of characteristics that exclude particular lamps types that are not to be included within the product scope, such as products that are neither typically used, nor likely to be used in the future. Inclusion of these products in the testing programme would only reduce the efficiency of the typically limited budgets available for these investigations. The product scope should also be designed so that it is easy for the purchasers to determine whether a product is included or not.

The product scope may also be as specified by an existing standard or regulation. Some example product scopes for existing standards/regulations are provided in Table 1, which also serves to highlight the different needs of various economies.

Table 1
Examples of product scopes

Jurisdiction	Lamp type	Scope

European Union	Non-directional household lamps	A lamp that is intended for household room illumination and not a directional lamp; it does not include special purpose lamps.
		
		The requirements (set out in the regulation) shall not apply to the following household lamps:
		• Lamps having the following chromaticity coordinates x and y:
		  • $x < 0{,}200$ or $x > 0{,}60$,
		  • $y < -2{,}3172\,x^2 + 2{,}3653\,x - 0{,}2800$, or
		  • $y > -2{,}3172\,x^2 + 2{,}3653\,x - 0{,}1000$;
		• Directional lamps;
		• Lamps having a luminous flux below 60 lumens or above 12,000 lumens;
		• Lamps having:
		  • 6% or more of total radiation of the range 250-780 nm in the range of 250-400 nm,
		  • The peak of the radiation between 315-400 nm (UVA) or 280-315 nm (UVB);
		• Fluorescent lamps without integrated ballast;
		• High intensity discharge lamps;
		• Incandescent lamps with E14/E27/B22/B15 caps, with a voltage equal to, or below, 60 V and without integrated transformer in Stages 1-5 according to Article 3.
		
		(COMMISSION REGULATION (EC) No 244/2009

Jurisdiction	Lamp type	Scope
China	Self-ballasted fluorescent lamps for general lighting service	Lamps of which: • Lamps having the following chromaticity coordinates x and y: • Rated voltage is 220 V; • Frequency of AC power is 50 Hz; • Rated power is 3W~60 W; • It adopts screw caps or bayonet caps; • It is used for domestic and similar general lighting services; and • It is integrated with control starting and stable ignition components. (GB19044-2013)
Australia	General lighting service tungsten filament lamps	Lamps that have the following attributes: • Shapes: A50-A65, PS50-PS65, M50-M65, T50-T65 (as generally outlined in IEC 60630[4]) or E50-E65; • Caps: E14, E26, E27, B15 or B22d; • Nominal voltage ≥ 220 V; • Nominal wattage < 150 W. Coloured lamps, reflector lamps, crown-reflector lamps or lamps with a halogen gas fill are not included. (AS4934.2-2011)
Hong Kong	Non-integrated type CFLs	Lamps that are a non-integrated type CFL which is electrically connected to permanently wired external ballast and is intended for general lighting purposes having the following characteristics: • Rated voltage of 220 V; • Rated input current frequency of 50 Hz; and • Rated lamp wattage up to 60 W. The scheme shall apply to non-integrated type CFLs designed for multilevel and/or dimming operation. Non-integrated type CFLs operated with cold cathode and reflector type lamps are excluded from this scheme. (VEELS Non-integrated CFL 2012)

2.3 IDENTIFYING THE KEY METRICS TO BE INVESTIGATED

Once the scope of the sampling exercise has been established, the specific metrics to be tested should be selected. The test methods to be used should also be considered at this time. Where they exist for the metric in question, it is recommended that international, agreed standards are specified, where appropriate.[5]

Table 2 provides a description of some key phenomena/parameters that may be considered when developing a lamp testing programme. The intent of this table is to assist policymakers in understanding these terms, and their relevance, to facilitate the discussion on which phenomena/parameters to select relevant to individual country, and energy efficiency programme, needs. Not all of these phenomena/parameters are relevant to all lamp technologies, for example, mercury level testing

4 IEC 60630:1994/AMD7:2014 Amendment 7, *Maximum lamp outlines for incandescent lamps*

5 The International Electrotechnical Commission (IEC) has standards in place for the majority of metrics. However, testing standards for many LED metrics are still under development, notably by the IEC and the International Commission on Illumination (CIE).

2

applies only to mercury containing lamps (e.g. CFL and linear fluorescent lamps).

Each description includes, where published, an official definition from an international standards body, such as the International Electrotechnical Commission (IEC) (including its International Electrotechnical Vocabulary (IEV)[6] reference or the relevant IEC standard number) or the International Commission on Illumination (CIE) (including its International Lighting Vocabulary (eILV) reference)[7], as well as a simplified definition to assist with the understanding of the phenomena/parameter and a short explanation of its relevance.

Table 2

Key phenomena/parameters that may be considered when developing a lamp testing programme

Phenomenon/ parameter	Official definition (from an international standards body)	Simplified definition	Relevance
Energy Efficiency			
Luminous efficacy	**CIE eILV 17-729 luminous efficacy (of a source) [ηv; η]:** quotient of the luminous flux emitted by the power consumed by the source. Unit: lm/W	The ratio of the total amount of visible light of a lamp (luminous flux) to the electrical power consumed in producing it.	The higher the efficacy value, the more energy efficient the lighting product. This criterion provides information on how well the light source produces visible light – an important indicator for saving energy and money.
Light quality metrics			
Luminous flux	**CIE eILV 17-738 luminous flux [Φv; Φ]:** quantity derived from the radiant flux, Φ_e, by evaluating the radiation according to its action upon the CIE standard photometric observer. Unit: lm	Quantifies the total amount of visible light of a lamp.	Luminous flux must be measured in order to determine the efficacy of the product. Luminous flux is also important in evaluating the accuracy of manufacturer/retailer lamp equivalency claims, which assist consumers in making the transition to efficient lighting. The importance of this aspect will diminish over time as products cease to be sold according to claimed equivalencies and consumers begin to select lamps on the basis of light output (lumens) rather than wattage. The accuracy of luminous flux claims is also important because lamp luminous flux (along with lighting design) determines overall illumination levels, which can be important for meeting illumination standards for safety and work conditions.
Lamp lumen maintenance factor	**CIE eILV 17-635 lamp lumen maintenance factor:** See "lamp luminous flux maintenance factor" **CIE eILV 17-636 lamp luminous flux maintenance factor [fLLM]:** ratio of luminous flux of lamp at a given time in the life to the initial luminous flux. Unit: 1	Quantifies the degradation of the luminous flux of the lamp over a specified period of time.	Important for consumer information – allowing comparison of the relative useful life of different lighting products. High lumen maintenance over time (and therefore longer useful life) helps to justify the (typically) higher initial costs of these products

6 See www.electropedia.org. (International Electrotechnical Commission, 2014)
7 See eilv.cie.co.at (International Commission on Illumination)

Phenomenon/ parameter	Official definition (from an international standards body)	Simplified definition	Relevance
Light quality metrics			
Lamp life	**CIE eILV 17-656 life (of a lamp):** total time for which a lamp has been operated before it becomes useless, or is considered to be so according to specified criteria.	The total time (in hours) for which a lamp operates before it becomes useless. Typically, this involves failure to start or to operate continuously or to generate a sufficient amount of light. Note: For a lamp model (i.e. not a single lamp), the rated (declared) product life is typically the time after which 50% of a specified number of lamp units, of that model, become useless.	Important for consumer information – providing information on how long it will typically take a lighting product to fail. Longer life times can help the consumer to save money.
Endurance (supply switching test)	**IEC 62612 Section 11.3.3:** At test voltage, the lamp shall be switched on and off for 30 s each. The cycling shall be repeated for a number equal to half the rated life in hours (Example: 10 000 cycles if rated life is 20 000 h.)	The rapid switching on and off of a solid state lighting product to simulate how a product will be used over its lifetime. The test is carried out to stress a solid state lighting product over a short period of time to determine the failure rates of a product.	Can help verify that a lighting product will not fail when used in a typical consumer application (e.g. on for relatively short durations).
Luminous intensity	**CIE eILV 17-739: luminous intensity (of a source, in a given direction) [Iv; I]:** quotient (I_v) of the luminous flux, $d\Phi v$, leaving the source and propagated in the element of solid angle, $d\Omega$, containing the given direction, by the element of solid angle. Unit: cd = lm/sr	Quantifies the amount of visible light emitted from a light source in a particular direction from a two dimensional angle.	This is an important criterion to evaluate the performance of directional lamps/products, particularly in terms of the centre beam luminous intensity.
(Spatial) distribution of luminous intensity	**CIE eILV 17-1204 (spatial) distribution of luminous intensity (of a source):** presentation, by means of curves or tables, of the values of the luminous intensity of the source as a function of direction in space.	The spatial distribution pattern of the measured luminous intensity of a lighting product.	It is of high importance to measure this because many 'omnidirectional' products currently being sold, such as LED lamps, only poorly approximate the light distribution of the products they claim to replace.

Phenomenon/ parameter	Official definition (from an international standards body)	Simplified definition	Relevance
Light quality metrics			
Colour rendering index (CRI or CIE R_a)	**CIE eILV 17-154 general colour rendering index [R_a]:** mean of the CIE 1974 special colour rendering indices for a specified set of eight test colour samples. Note: **CIE eILV 17-155 Special colour rendering index (R_i):** measure of the degree to which the psychophysical colour of a CIE test colour sample illuminated by the test illuminant conforms to that of the same sample illuminated by the reference illuminant, suitable allowance having been made for the state of chromatic adaptation.	A measure of the ability of a light source to reveal the psychophysical colours of eight CIE 1974 test-colour samples (CIE13.3) equally in comparison with a reference illuminant having the same CCT as the light source. The highest CRI attainable is 100, with index values dropping to less than 60 for some light sources used in applications where accurate colour reproduction is less important.	Colour rendering is important for consumer satisfaction with a lighting product. Colour is important for specialised tasks where colour is important (such as, food preparation, applying makeup, and painting). Incandescent lighting (including halogen lamps) has a CRI of, or very close to, 100. Note 1: CRI shall be measured according to CIE 13.3-1995. *Method of Measuring and Specifying Colour Rendering of Light Sources.* Note 2: Other metrics for colour rendering are currently under consideration by the international standards bodies.
Correlated colour temperature (CCT)	**CIE eILV 17-258 correlated colour temperature [T_{cp}]:** temperature of the Planckian radiator having the chromaticity nearest the chromaticity associated with the given spectral distribution on a diagram where the (CIE 1931 standard observer based) u', $⅔v'$ coordinates of the Planckian locus and the test stimulus are depicted. Unit: K	A measure of the colour 'shade' of white light emitted by a lamp, relating to the colour of light emitted by an ideal blackbody radiator when heated to a particular temperature, measured in Kelvin. Spectrally, 'warm' shades contain more yellowish/red light content and are at lower Kelvin (2,700 -3,500 K), while 'cool' shades contain more blue (5,000+ K) to create their overall white 'colour' appearance.	Important for consumer information – allowing the selection of the appropriate product depending on light colour preference and matching of light colour across different manufacturer lighting products. The accuracy of the colour temperature claim is therefore important and some MEPS may specify a maximum tolerance for colour temperature.
Operation			
Starting time	**IEC 60969[7]:** Time needed, after the supply voltage is switched on, for the lamp to start fully and remain alight. Note: There is a time delay in the starting device between the time when power is applied to this device and the time when power is applied to the lamp electrodes. The starting time is measured from the latter moment.	The time it takes for a lamp to start when switched on.	Short start times are important for consumer acceptance. Short start times are necessary for emergency situations and general safety. They are preferable in tasks where the light will only be on briefly (i.e. pantries, toilets and for outdoor security).

Phenomenon/ parameter	Official definition (from an international standards body)	Simplified definition	Relevance
Operation			
Run-up time	**IEC 60969**[8]**:** The time needed for the lamp after start-up to emit a defined proportion of its stabilised luminous flux. Note: For CFLs the IEC defined proportion is 60%; for amalgam lamps it is 80%.	The time it takes for a lamp to reach maximum brightness when switched on.	Important for the same reasons as start time. Market testing has found a wide variation in run-up times for CFLs and some MEPS regulations may specify a maximum acceptable start- or run-up time.
Electrical parameters			
Power factor	**IEC 60969:** Ratio of the measured active input power to the product of the supply voltage (rms) and the supply current (rms).	The ratio of the power that a lamp consumes to the volt-ampere product of the supplied power. This (total) power factor is more recently being discussed in terms of its primary metrics – fundamental power factor (also called displacement power factor) and non-fundamental power factor (also called distortion power factor). These primary metrics are more sophisticated than the composite metric power factor.	This is of importance to electricity distributors and generators in some countries as it may mean they must generate more than the minimum amperes necessary to supply the real power, which increases generation and transmission infrastructure capacity requirement and costs and increases power line losses. Additionally, the distortion of the mains current can affect the quality of the electrical utility grid. The level of importance in part depends upon the nature (transmission distance and existing capacity) of the generation network and the root causes (displacement and/or distortion).
Fundamental power factor	**IEC 61000-1-7:** Clause 6.5.2.[9]	The fundamental power factor is sometimes called displacement factor or displacement power factor. It quantifies the displacement (phase-shift) between the fundamental current and voltage waveforms by calculating the cosine of the phase-shift angle. Fundamental power factor is a more detailed measure to quantify the displacement of the current and its effect on the power supply network.	Same as power factor.

8 IEC 60969:1988+AMD1:1991+AMD2:2000 CSV Consolidated version, *Self-ballasted lamps for general lighting services - Performance requirements*

9 IEC 61000-1-7, *"Electromagnetic compatibility (EMC) Part 1-7: General - Power factor in single phase systems under non-sinusoidal conditions"*, will be published in March, 2016.

Phenomenon/ parameter	Official definition (from an international standards body)	Simplified definition	Relevance
Electrical parameters			
Non-fundamental power factor	**IEC 61000-1-7:** Clause 6.5.3.	The non-fundamental power factor is sometimes called distortion factor or distortion power factor. It quantifies the distortion of the current. Furthermore, the non-fundamental power factor is proportional to the Total Harmonic Distortion (THD) of the mains current and consequently to the individual harmonic components. The individual harmonic components are the preferred measures to quantify the distortion of the mains current and its effect on the power supply network.	Same as power factor.
Total harmonic distortion (THD)	**IEV 551-20-13:** Ratio of the r.m.s. value of the harmonic content to the r.m.s. value of the fundamental component or the reference fundamental component of an alternating quantity. Note: The harmonic content is the sum of the harmonic components of a periodic quantity [IEV 551-20-12].	THD is proportional to the non-fundamental power factor (see IEC 61000-1-7 clause 6.5.3). Furthermore, the THD is proportional to the individual harmonic components. The individual harmonic components are a more detailed measure to quantify the distortion of the mains current and its effect on the power supply network.	Same relevance as non-fundamental power factor.
Harmonic Component	**IEV 551-20-07:** sinusoidal component of a periodic quantity having a harmonic frequency.	The individual harmonic components are the more detailed measures to quantify the distortion of the mains current and its effect on the power supply network.	Same as non-fundamental power factor. The international limits for the harmonic components are given in IEC 61000-3-2:2014[10].

10 IEC 61000-3-2:2014, *Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*

Phenomenon/ parameter	Official definition (from an international standards body)	Simplified definition	Relevance
Electrical parameters			
Dimmer compatibility	None	An evaluation of whether a retro-fitted ballast-driven lamp (fluorescent) or circuit-driven lamp (LED) will operate sufficiently well with existing installed dimmers used for incandescent light sources.	Dimmer compatibility is of high importance for the consumer as many solid state lighting products are often not completely compatible with commonly available dimmers (resulting in noticeable flicker, slow oscillation in light output or failure to operate). The wide variety of dimmers and controls installed in housing stock in some markets makes it difficult for a manufacturer to claim 100% compatibility. Some MEPS or labelling may require product marking regarding dimmer compatibility.
Health and safety issue parameters			
Safety requirements and marks	None	An indication that a product meets electrical safety and marking requirements in an economy.	All products must meet all safety regulations of the country or region in which it is sold and used, while marking requirements give consumers assurance that the product meets these regulations.
Photobiological hazard class (UV and blue light)	**IEC 62471**[11]**:** Ultraviolet (UV) and blue light hazard (BLH) risk group classes as defined in CIE S009/IEC 62471 specify the limits of optical radiation emitted by a lighting product in range of 100-400 nm and 400-500 nm spectrums, respectively.	A definition of a classification system for the possible health risks related to short-wavelength light emitted by the lamp.	Photobiological hazard classification is important for consumer safety. UV and blue light can cause irreparable damage to eyesight. Some human health conditions also result in high sensitivity from skin exposure to these wavelengths. Some regulations may require that products be evaluated to determine their appropriate photobiological hazard class and/or specify UV emission levels.
Mercury content	None	The small amount of mercury that is integral to the operation of discharge lamps such as compact and linear fluorescent lamps.	As mercury is a hazardous substance, requirements exist (For example, IEC 60969) which require that lamps do not contain more than a designated amount. This will minimise exposure to mercury in the event that a lamp tube is broken.

11 IEC 62471:2006, *Photobiological safety of lamps and lamp systems.*

Phenomenon/ parameter	Official definition (from an international standards body)	Simplified definition	Relevance
Health and safety issue parameters			
Flicker	**IEV 845-02-49:** Impression of unsteadiness of visual sensation induced by a light stimulus whose luminance or spectral distribution fluctuates with time.	A relatively low frequency (below approximately 100 Hz) variation in brightness and/or colour of a lighting product that is directly perceived as unacceptable by an average observer.	Minimal flicker is important for consumer satisfaction and resultant acceptance of different technology lamp products. Certain human health conditions are characterised by severe reactions to light sources that flicker at certain frequencies, with effects ranging from headaches to extreme seizures.
Stroboscopic effect	For both 'stroboscopic effect' and the 'stroboscopic visibility measure' (SVM), no official definitions exist. The following definition is currently proposed in CIE: Change in motion perception induced by a light stimulus whose luminance or spectral distribution fluctuates with time, for a static observer in a non-static environment.	A 'stroboscopic effect' is an effect which is visible for an average observer when relatively high frequency variation in brightness and/or colour of a lighting product is illuminating a moving or rotating object. The effect occurs when the rate of rotation or movement is close to the frequency of the light ripple. It may appear that a rotating object is standstill or a 'wagon-wheel effect' can be perceived.	For installations where lighting is placed near or illuminating working machinery or equipment, such as a manufacturing line, this effect could cause a hazard if it were to make moving machinery or a production line appear to be still or slowly moving. Also in sport stadiums or sports courts 'stroboscopic effect' may lead to unwanted effect.

2.4 IDENTIFICATION OF COMPETENT TEST LABORATORIES

Once the key metrics have been selected, it is important to identify that there is a sufficient number of competent and available test laboratories which can conduct testing of the selected metrics to the desired standards. The selection of the test laboratory, or laboratories, will be based on a combination of different criteria, including: International Laboratory Accreditation Cooperation (ILAC), or reciprocal body such as Asia Pacific Laboratory Accreditation Cooperation (APLAC) or European Accreditation (EA), accreditation for the required test standards; competency; availability; value/cost; location; and quality of work.

It is critical that a laboratory be accredited as this assures the basic competence and quality assurance of the institution related to particular photometric tests. Accredited laboratories may not be available in-country, but often can be found regionally and could be consulted.

It is imperative that laboratories can undertake the tests according to the relevant standard test method that is required.

A lamp testing programme might require a large volume of lamp testing to be conducted. The availability of particular test laboratories to schedule the tests when required may be an issue. To mitigate this risk, a number of test laboratories (local and international) could be invited, and duly assessed for competence, capability and price, to provide the required testing services. Depending on procurement rules, all (or the nominated number) of the qualifying laboratories (i.e. satisfying the requirements) could be placed on a panel for providing this work (with the option to refresh the panel on a periodic rotation). As a round of lamp testing is required, a request regarding availability and capacity could be issued to potential test laboratories and then, depending on the responses, one or a number of photometric test laboratories may be selected to meet the needs for that round of benchmarking/verification testing.

3 BUDGET CALCULATION

When planning a performance testing programme, it is important to have an accurate understanding of the costs involved and to establish an appropriate budget. This chapter gives an overview of some of the key considerations, such as: the cost of the laboratory test for each of the nominated performance parameters, and the number of models and samples of each, to be tested; the cost of transporting the samples to and from the testing laboratory; the cost of disposing of the samples after testing; and the cost of the procurement activity itself.

3.1 COST OF TESTS

The cost of the photometric testing itself is the biggest single cost in a performance testing programme and this cost can vary widely. The cost is generally dependent on the sophistication of the test equipment, the type of product under test, the photometric parameters to be tested and the time required for testing these.

The cost of testing also varies between photometric laboratories, depending on whether they are accredited or otherwise, and also as a function of: their location (within developed or developing countries); the size of laboratory; the experience levels of their staff; the cost of their equipment; and the expenses associated with maintaining calibration confidence. Only accredited test laboratories will give legitimacy to the results required for MVE testing, but it should be noted that cost differences do also exist between accredited test laboratories. More information on laboratory selection is included in the UNEP-GEF en.lighten guidance note, *Performance Testing of Lighting Products*.

Total luminous flux is a fundamental metric that usually forms the core of any lamp testing programme. It can be measured using either a goniophotometer or an integrating sphere. Goniophotometer testing has the advantage that in the process of testing for luminous flux, it measures the spatial distribution of luminous intensity which additionally informs about the distribution pattern of light and hence the beam angle, while the integrating sphere does not provide this. However, a goniophotometer is more costly to purchase and maintain, and the time to complete a test on a single lamp is greater than with an integrating sphere; therefore the cost of testing is greater. In comparison, the integrating sphere is relatively inexpensive for the laboratory to purchase, calibrate and use; and the test time is shorter. Integrating spheres are suitable for testing only where parameters such as directional beam angle are not required (however the total forward facing (hemispherical) light output of a directional lamp can still be measured. Further information on testing procedures and equipment can be found in the UNEP-GEF en.lighten initiative guidance note, *Good Practices for Photometric Laboratories*.

Three metre integrating sphere
(Photograph courtesy of VSL, Delft)

Goniophotometer at Electrical and Electronics Institute laboratory, Thailand
(Photograph courtesy of Marie Leroy, UNEP)

These factors should all be taken into account when specifying a performance testing regime, relative to the objective of the programme. For example, for compliance verification testing of efficacy of directional lamps, it would be preferable to choose the less expensive, and less time consuming, integrating sphere test method if the accuracy and uncertainty of measurement was acceptable to the administrators of the programme for the lamps types under test. From a cost perspective, this allows for greater market surveillance in order to protect the consumer and the suppliers.

3.2 NUMBER OF SAMPLES

The cost of purchasing all the lamps required for testing should be included in the budget calculation for a performance testing programme. The number of samples for each lamp model that should be purchased for testing will differ, depending on which parameters are to be tested, and the level of confidence of product integrity that is required, based on the purpose of the testing.

GENERAL QUALITY TESTING

If testing is being performed only for the purpose of informing on the general quality of products that are available for purchase on the market (possibly in advance of developing a MEPS or labelling programme), testing a limited number of samples (as low as only one) of each lamp model would be sufficient. For example, this might involve only testing for luminous flux and power to allow the calculation of the luminous efficacy of the lamps.

COMPLIANCE TESTING

For verifying the performance of lamps that are enforced under a MEPS, the minimum sample size should be as specified in the relevant national, or international, standard or the regulation. It is typical that there will be a minimum in the range of 10 or 20 samples for each lamp model to be tested for luminous flux and efficacy. Other parameters, such as mercury content, will typically only require three models to be tested. As an example, Table 3 shows the sampling requirements under the Australian energy efficient lighting regulations, as per the Australian standard AS/NZS 4847.2:2010, *Self ballasted lamps for general lighting services – Part 2: Minimum Energy Performance Standards (MEPS) requirements*.

LED lamps procured in Cambodia for performance testing
(Photograph courtesy of International Institute for Energy Conservation)

Attribute	Sample size
Maximum starting time (seconds)	10
Maximum run-up time (seconds)	10
Minimum efficacy in lm/W (bare lamps)	10
Minimum efficacy in lm/W (covered non-reflector lamps)	10
Minimum efficacy in lm/W (reflector lamps)*	10
Minimum lumen maintenance	10
Maximum premature lamp failure rate	10
Minimum life (hours)	10
Minimum True Power factor	10
Colour appearance	10
Minimum CRI	10
Maximum mercury content (mg)	3
Minimum switching withstand	10
Harmonics	1
Immunity	1

Table 3

Sampling requirements under the Australian energy efficient lighting regulations, as per the Australian standard AS/NZS 4847.2:2010, *Self ballasted lamps for general lighting services – Part 2: Minimum Energy Performance Standards (MEPS) requirements*

It is important to also have provision (in procedures or regulation) to purchase some additional lamps as a backup. This assists in the management of the risk in the event of a failure amongst the lamps selected, or as cover for the possibility of damage during transport to the testing laboratories. In some cases, part of the same lamp sample may be used for multiple tests, while for other tests (such as mercury testing, lumen maintenance or switching withstand) the test may destroy, or alter the performance of the lamp, meaning that it cannot be used for other tests.

Box 1 Example of LED sampling requirements: Thailand

Standard	Test parameter	Number of samples
IESNA LM79-08*	CCT, CRI, change of chromaticity, lumen maintenance luminous efficacy , luminous flux, power factor, lamp wattage	10
IEC 62612:2009	Supply voltage switching test	10
IESNA LM79-08	Centre beam intensity, beam angle, luminous intensity distribution	1

Note: there is no provision for additional backup lamps to be purchased during sampling procurement.
* IES LM-79-08, *Electrical and Photometric Measurements of Solid-State Lighting Products*

If there is a MEPS or labelling scheme in place, the number of lamps required for testing should be listed either in the test method standard associated with that MEPS programme or in the regulation/law itself. If no programme sample size guidance is available, it makes enforcement very difficult due to conjecture on whether sufficient samples have been tested to constitute a statistically representative sample set of the product on the market.

STANDARDS REVIEW TESTING

If the testing is being performed as part of a review (and potential upgrade) of a MEPS, the minimum number of samples for luminous flux testing may again be less than the requirement for compliance activities. This is because the objective is to understand the overall performance of the market, rather than accurately assess the performance of a particular model. However, it still may be useful to test some models with a full sample size in order to demonstrate the accuracy of the testing regime.

3.3 TRANSPORTATION COSTS

The cost of postal, or courier, delivery to and from the testing laboratory should also be taken into account. Testing may be conducted in-country or, in some cases, overseas. If testing is to be conducted overseas, there may be an additional import duty and tax; for simplicity, it is recommended (though not compulsory) that the import duty and tax be included in the testing fee (this will be subsequently reflected in the budget).

When budgeting for transportation, it should be kept in mind that the lamps will need to be delicately packaged, with a shock-absorbent buffer, so that they are not accidentally damaged in transit, and that the physical size of the package/s may incur extra charges, beyond those for the weight of the packages.

3.4 DISPOSAL

A decision must be made about the future of the test lamps once testing is complete. If there is some further use for them, the lamps may be returned to the organising government authority; the lamps might also stay with the laboratory as test samples. If any lamps fail, they are typically retained for the duration of the enforcement action that may follow. Lamps do carry their own value, but further transportation to return the lamps will incur additional postage charges. For liability reasons, some governments are not able to donate test lamps to other entities such as charity bodies. In these situations waste disposal or recycling facilities may be the only alternative available to a government MVE programme. These solutions are not without their own costs (e.g. transportation, landfill tax or recycling fee) which should also be included in the budget.

Box 2 Example of sample lamp disposal, Thailand

The Electricity Generating Authority of Thailand has different processes to manage sample lamps upon completion of testing, dependent on the test results for Label No. 5 criteria.

If the lamps pass, a committee considers how to use these lamps beneficially for specific purposes, including donation, charity events, or some further use at the Electricity Generating Authority of Thailand office (to reduce their procurement budget).

If the lamps fail, the manufacturer must buy back the failed samples at the same price that they were purchased from the market.

3.5 SAMPLE BUDGET

A sample budget is shown in Table 4, using hypothetical relative costing, for photometric testing of 20 lamp products, with 10 samples of each model (200 lamps in total). It shows an indicative breakdown of relative costs for lamp acquisition and transport, the labour for these tasks and for the photometric testing itself. This will vary based on the country/programme and which services are provided internally within the government (e.g. market acquisition of lamps, transportation and testing laboratories). Specific values have not been included, as the cost of testing and labour costs for acquiring the lamps from the market varies quite widely depending on test location/country. Instead, percentages have been used to provide a perspective on the potential relative costs for each of the tasks indicated. However, as an indication of the likely cost, the following suite of tests would potentially attract an overall fee of approximately $200 per lamp tested. It is evident from the breakdown that the cost of the laboratory testing is by far the greatest cost component. In Thailand, where the Electricity Generating Authority of Thailand uses its own staff and transport to conduct the procurement of lamp samples, the photometric testing accounts for approximately 75 per cent of their budget.

Table 4
Sample budget for photometric testing of 200 lamps

Activity		Percentage of total
Photometric Testing	**200 lamps (20 lamp products (models), 10 samples of each)**	**88.0%**
Integrating sphere	Total luminous flux (includes power) - CCT (T_c) - Colour CIE x,y chromaticity coordinates	
Lamp purchasing		**5.0%**
	20 products, 10 samples for each model	
Transportation		**4.5%**
	200 products, including packaging	3.0%
	Import duty and tax (for international testing)	1.5%
Labour		**2.5%**
	Lamp purchasing (2 personnel, 4 hours)	1.0%
	Record lamp details, label lamps, arrange transportation, communicate with laboratory (2 personnel, 6 hours)	1.5%
Total		**100%**

Table 5 gives an indication of the additional relative costs of using a goniophotometer, rather than an integrating sphere, to measure total luminous flux (and gather data on spatial distribution of luminous intensity and colour) and for conducting spectral and colour quality measurements using an integrating sphere.

Table 5
Relative cost of additional photometric testing

Activity		Percentage relative to the total cost in Table 4
Photometric testing	**200 lamps (20 lamp products (models), 10 samples of each)**	
Goniophotometer	Total luminous flux (includes power, intensity distribution)	250%
Integrating sphere	Relative spectral measurement (includes CRI)	250%

4 ESTABLISHING A PRODUCT PROFILE AND SELECTING PRODUCTS FOR TESTING

A thorough understanding of the lamp market is the starting point for any selection process. Finding this information can be difficult and onerous due to the complexities of trade and logistics of a mass volume, low cost, consumable product. This chapter briefly discusses how to establish a profile of the products in the market and then, in more detail, how to determine the appropriate process for selecting products to be tested, depending on the objective of the programme.

4.1 SOURCES OF INFORMATION

This section provides a brief overview of the sources of information that can be used to supply market data. More detailed information on establishing a product profile and conducting market surveys can be found in the UNEP-GEF en.lighten initiative guidance note, *Market Baselines and Surveillance for Efficient Lighting Products*.

When developing a market product profile, Governments may consider obtaining product information and sales volumes using:

- Any established product registration systems;
- Sales/stock information from market players, such as retailer and wholesaler associations, local manufacturers and suppliers, lighting industry associations;
- Import and export volumes from the customs authorities;
- Third party research/consumer agencies.

From these sources, it should be possible to determine: indicative annual sales volumes; typical sales prices; location; production volumes; and import and export volumes. However, it should be noted that international efforts reveal that the market is very complex. There are 'original equipment manufacturers' that produce lamps which are then sold to a number of 'private labellers'. This means that one single model might be on the market in a variety of packages and under a variety of 'manufacturer' brands. It is important that those involved in compliance verification activities understand this relationship; or this may result in testing of multiple versions of the same product (in cases where the regulatory regime would have permitted the use of shared results from the testing of the same underlying basic model). In addition, government representatives from some countries have identified situations where lamp models are not available in the open market but are distributed directly to construction projects. It is of concern that information is very difficult to obtain on these situations.

REGISTRATION SYSTEMS (PERFORMANCE AND SAFETY REGISTRIES)

Products regulated for fire and electrical safety or for MEPS or labelling programmes may have to be registered with the programme and meet a number of legal requirements before they can be sold, or offered for supply, in the market. The programme regulator may therefore have registered product information stored in a database, and this may be accessible for research purposes.

It should be noted that the scope of products listed in performance and labelling programmes will be limited as not all available lighting product types will be represented, so if a broader market survey is required, care should be taken to ensure that products exempt from these schemes are captured by some other method (if the profile of products is intended to be broader than the range of currently regulated products).

Voluntary labelling schemes may also have an associated registration database. Typically though, the products registered for voluntary schemes will be the better performing products on the market, as these suppliers are taking the intended opportunity to differentiate their product.

RETAILERS AND SUPPLIERS

Local manufacturers (if applicable), lighting industry associations and retailer and wholesaler groups may be willing to provide information on the products supplied into the market. They will generally offer to supply anonymous data so that sensitive competition intelligence is not provided to competitor suppliers. This offer would most likely be contingent on the information not being so refined so that an individual supplier's sales data could be identified, due to its dominance in the marketplace in a particular lamp category.

Online sources such as manufacturer and distributor catalogues may provide additional information. However, because of the global trading nature of the major manufacturers, some products in catalogues may not be available in all countries. Online retailer websites are useful sources of information as their products are available for shipment to any country, but online searching is very time consuming and tedious. The best advice would be to concentrate on local online retail stores and, for international web stores, to restrict searches to mainstream search engines and trading websites as these will be most visible to the inquisitive consumer.

In addition to specialist outlets, lamps for residential use are often distributed via consumer goods channels, such as grocery, hardware and home supply retailers. Store surveys are a good way to obtain market information. When conducting a store survey, some points to consider are described below:

- **Survey locations:** Geographical coverage of the surveys should account for the range of quality and cost implications across the jurisdiction, as market characteristics could be different from one place to the other. For example, lighting markets in Viet Nam are reported to be vastly different between the northern and the southern regions;

- **Store categories:** Ideally, the cross section of retailers to be surveyed will include a range of sources, such as:

    - Large retailers (chain stores), including major supermarkets and hardware superstores,
    - Medium-sized retailers, such as independent supermarkets, lighting specialist chain stores and smaller hardware stores,
    - Smaller independent lighting retailers,
    - Discount stores;

- **Lamp technology and lamp type:** Data should be obtained on all lamp types and models sold in a location that fit within the survey's scope. Governments should avoid collecting information only on the known brands, most popular models or perceived 'best' quality products as this will distort the findings on the breadth of the actual market. For example:

    - If surveys are being conducted to ascertain what products are available on the market, the survey should include all types of lamp technology and shape that could possibly be used in a domestic setting,
    - If the purpose is to monitor the market for benchmarking against a performance standard, lamps surveyed should be a reflection of the types defined in the scope of the standard. In addition, any lamps that sit just outside of a standard's scope could also be included to determine if it might be necessary to extend the scope for their inclusion (due to significant change in market uptake as a market reaction to the regulation) or to detect products that have been inaccurately described, possibly to avoid being subject to the regulation.

A sample store survey is provided in Annex D and good practice guidance on conducting store surveys is given in the UNEP-GEF en.lighten initiative guidance note, *Market Baselines and Surveillance for Efficient Lighting Products*.

CUSTOMS AUTHORITIES

All products that enter or leave a country are controlled by the customs authority which monitors and clears goods and administers payment of tariffs. A multipurpose international product nomenclature known as the Harmonised Commodity Description and Coding System[12] (simply referred to as the Harmonised System) has been developed by the World Customs Organisation. Within this Harmonised System, there is a six digit code (HS code) that defines every commodity to pass through a customs authority. It is used extensively by governments, international organisations and the private sector for many purposes such as internal taxes, trade policies, monitoring of controlled goods, rules of origin, freight tariffs, transport statistics, price monitoring, quota controls, compilation of national accounts and economic research and analysis.

12 http://www.wcoomd.org/en/topics/nomenclature/overview.aspx

This information is very useful in developing a product profile and can normally be purchased from the country's statistics bureau or obtained by subscription to a customs brokerage software package. Countries have the opportunity to append a four digit statistical code to the HS code which can further refine the category of lamps. Whereas the HS codes are common between more than 200 countries, these statistical codes may, or may not, be common between countries.

Box 3

Example of HS codes and Australia's statistical codes

HS codes for some electric filament and light emitting diode lamps

85.39: Electric filament or discharge lamps, including sealed beam lamp units and ultra-violet or infra-red lamps; arc-lamps.

- 8539.21 - Tungsten halogen
- 8539.31 - Fluorescent, hot cathode
- 8539.32 - Mercury or sodium vapour lamps; metal halide lamps

85.41: Diodes, transistors and similar semiconductor devices; photosensitive semiconductor devices, including photovoltaic cells whether or not as assembled in modules or made up into panels; light emitting diodes; mounted piezo-electric crystals.

- 8541.40 - photosensitive semiconductor devices, including photovoltaic cells whether or not as assembled in modules or made up into panels; light emitting diodes.

Australia's National statistical codes for some electric filament lamps

The addition of an additional 4-digit national statistical code at the end of the HS code provides an opportunity for national refinement of product description:

8539.21: Tungsten halogen filament lamps (excluding ultra-violet or infra-red)

- 8539210050 - with reflector, ≤ 13 V
- 8539210051 - with reflector, > 13 V but ≤ 200 V
- 8539210052 - with reflector, > 200 V
- 8539210053 - without reflector, ≤ 13 V for motor vehicles
- 8539210054 - without reflector, ≤ 13 V other than for motor vehicles
- 8539210055 - without reflector, >13 V but ≤ 200 V
- 8539210056 - without reflector, >200 V

⇨ THIRD-PARTY RESEARCH DATA AGENCIES

Independent market research agents can be hired to research a range of data sources to create a complex data set. The data may be sourced directly from product creators in raw formats or from other resources such as journal articles, books and online media. Data management firms can aggregate information from sites across the internet that show not only the range of products available but also interests in particular products based on browsing and purchasing behaviour

4.2 SELECTING LAMPS TO TEST AND VERIFY FOR COMPLIANCE WITH REGULATIONS

Dependent on whether for market intelligence, compliance or for verifying truth-in-claim, the next step is to determine a selection protocol for products to test. This can be based on:

- Focus lamp categories for the current round of testing;
- Potential high risk groups (including previous offenders, new market entrants);
- Complaints received and market intelligence;
- Performance levels (for compliance);
- Questionable claims (for truth-in-claim).

4.2.1 WHERE THE COMPLIANCE SYSTEM INCLUDES A REGISTRATION DATABASE

The objective of verification testing is to check whether products meet the MEPS or labelling requirements. Thus for MEPS it is whether the product meets the minimum performance levels, while for a rating label, it is whether the performance fits within the claimed rating level. Where there are packaging requirements, it is also relevant to check the accuracy of the parameter levels shown on the packaging with tested levels. It may be the case that, over time, the performance of a registered model does not maintain the original test performance level, and tested values fall below MEPS or labelled levels; and so compliance testing will capture these lamps from continuing to be sold in the market.

Verification that approved lamps are maintaining their compliance with registration programme rules requires selecting, purchasing and testing of a proportion of all lamp models on the market. The higher the proportion

(percentage) of registered lamps tested, the higher the risk for a supplier of a non-compliant product being detected. Ideally this risk needs to be viewed by such a supplier as an unacceptable risk. Ultimately, the proportion of models tested must be based on local factors and experience; it may take several iterations for regulators and their staff to determine an acceptable and appropriate level for their country. The actual size of the proportion will be influenced by the available budget for verification and enforcement and may, in early years, be higher than it is in later years, when the market has settled to the structure and testing rigour of the programme.

The following example demonstrates how a registration database can be used to establish a lamp model selection methodology. This selection principle applies equally to registration databases that have rated performance data and to those that have independent test data.

To decide which lamp models to select for testing for each subsequent round of a verification programme, an approach that targets products and suppliers within particular 'groups of interest' (those that warrant closer scrutiny) should be adopted. To illustrate this concept, Figure 2 depicts a hypothetical graph of performance data for a particular product class within a registration database, with the minimum energy performance line providing the lower limit performance boundary. Those 'groups of interest' that warrant closer scrutiny are explained below and Figure 3 provides a suggested balance of target categories for sampling, testing and verification of claims.

HIGHEST PERFORMERS

These are the small percentage of products that have the highest claimed performance (Figure 2, Section A). These would be unlikely to fail the minimum performance criteria. However, if the claimed performance is well above the actual performance, this may distort user's confidence in the products that are registered as very high performing. This would disadvantage manufacturers of genuinely high performing products, as well as harm the image and integrity of the registration system as an independent, accurate product performance database. Testing these products relates more to truth-in-claim than MEPS compliance, but this is still a critical component in maintaining community confidence in any energy efficient lighting programme.

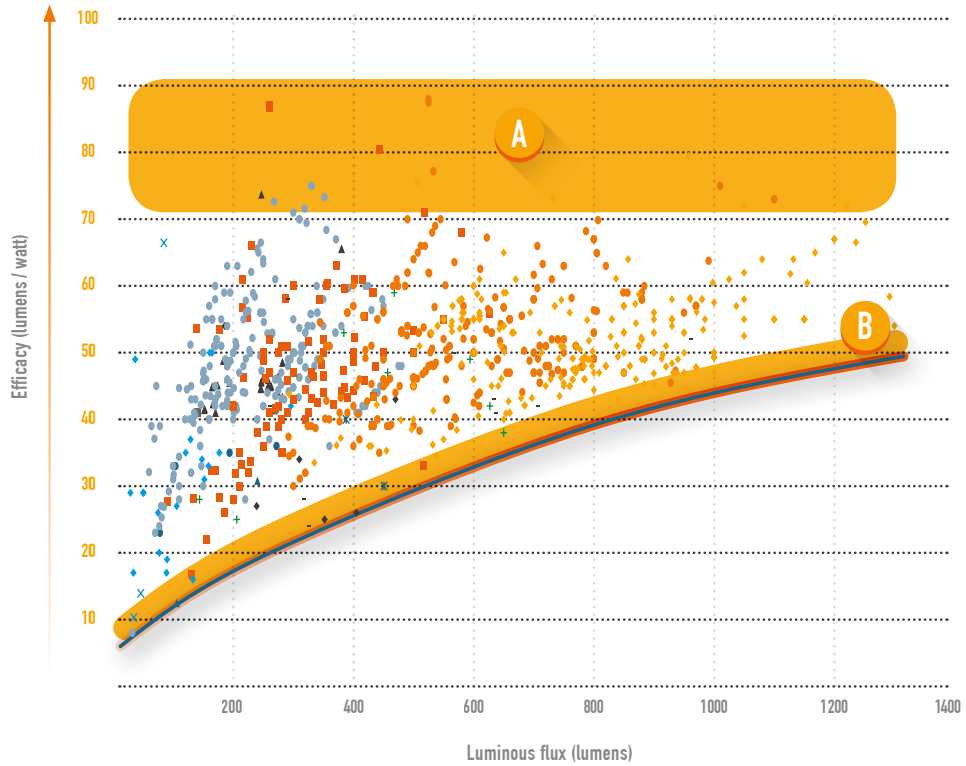


Figure 2
Illustrative data plot (using 'rated' performance levels) for choice of product from a registration database

A
Highest market performers

B
Products borderline with the minimum energy performance level

Minimum energy performance line

4

BORDERLINE PERFORMERS

Registered product performance claims that are very close to the performance criteria limit (Figure 2, Section B) are at greatest risk of non-compliance because of the reduced leeway for performance-affecting variations during manufacture. It would be beneficial if regulators were to issue guidance on measurement and uncertainties to help manufacturers, suppliers and retailers understand how borderline performance results may be interpreted and possibly challenged. Challenges are costly and time-consuming for all parties.

NEW MARKET ENTRANTS

New players in the market may present a higher risk of non-compliance because they may: be unfamiliar with regulated product compliance systems; have untested quality control systems for their products; or lack experience in handling the technical aspects of photometric assessment of their product.

PREVIOUS OFFENDERS

Manufacturers, distributors or retailers that have previously submitted products that failed the verification process should have future registered products checked with a greater frequency. This is to ensure that they have implemented, and are maintaining, an internal mechanism for ensuring the accuracy and integrity of reported performance values for their products. Products registered with a test report from a testing laboratory with a history of inaccurate testing may also be a priority. Monitoring this group will provide confidence to the market that enforcement is effective and ongoing. It should also help to build renewed trust in the supplier's compliance with the regulations.

COMPLAINTS/MARKET INTELLIGENCE

Regulators should assess on an individual basis whether to follow up consumer complaints, private sector concerns or market intelligence (such as blog postings) that have indicated a problem with a lighting product. The regulator requires firm evidence before issuing a formal warning or requesting a response from a manufacturer.

NO CHECK HISTORY

Choosing models of products from brands/suppliers that have never been included in verification rounds will help minimise the number of brands/suppliers which, by chance, have never been selected for testing. This is particularly pertinent for models that are a typically average performing product (as illustrated by those situated in the middle of the performance graph shown in Figure 2) which therefore do not come under scrutiny by many of the selection categories discussed here.

RANDOM

Random selection sends a clear message to the manufacturers and suppliers in the market that any product can, and will, potentially be selected for verification testing. This prompts registrants to monitor the performance of their products and remain honest in their claims.

UNREGISTERED PRODUCTS

These will not be identified initially through a registration database. However, store surveys provide an opportunity to check (randomly or systematically) that products on the shelf are listed on the registration database. Any products found not to be on the database are automatically non-compliant products, and should be dealt with accordingly.

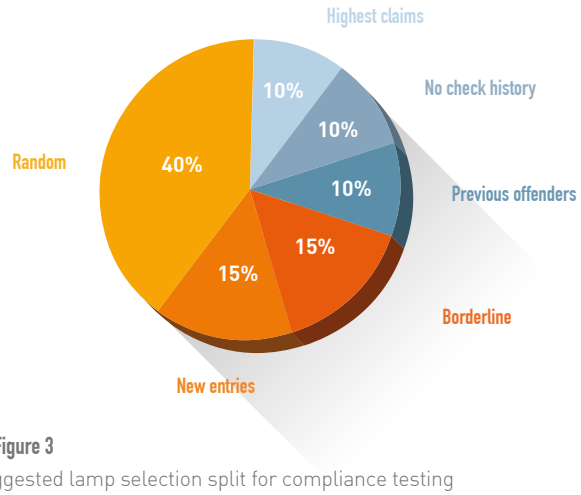


Figure 3
Suggested lamp selection split for compliance testing

Box 4

Example of selection protocol, Thailand

Under the selection protocol for the Thailand Label No. 5, the Electricity Generating Authority of Thailand prioritises:

- Volume of sales of models depending on registration database (number of labels);
- Newer model entrants;
- Products with a record of non-compliance;
- High star rating products (golden sample);
- Complaints from customers about low quality product.

Dependent on the budget, 10% of all models that participate in the programme are sampled.

In practice, when conducting spot checking, if a selected model is not available, a model from a second backup list is chosen.

4.2.2 WHERE THERE IS NO REGISTRATION DATABASE

To begin the process of identifying potential models to select for the procurement, there is a need to identify the kind of points of sale where consumers typically purchase their lamps in the particular location/country. This will maximise confidence that the results reflect the current situation in the residential sector rather than being a random selection of various kinds of points of sale. Once this has been achieved, a similar selection method with relevant categories (similar to the approach in Section 4.2.1 above) can be logically developed with appropriate percentages.

MAJOR BRANDS FROM MAIN RETAIL/HARDWARE/CONVENIENCE STORES/ELECTRICAL APPLIANCE SHOPS

Authorities responsible for market sampling should focus on capturing brands and lamp models that customers are most likely to buy, because this acts as a proxy for lamp models that have the greatest market penetration. Many people will typically purchase their lamps in main retail, hardware and convenience stores. However, local conditions vary considerably, depending on the structure of retail business.

MODELS FROM TYPICAL ONLINE STORES

A section of the population purchase lamps through major online stores, but many specialist lighting websites are also available. The range of lamps available through these sources is more extensive, so it is best to select a range of lamp types from as great a variety of brands as fiscally feasible from websites known to be popular with the local community.

MODELS FROM THE INFORMAL SECTOR

In developing countries, it is very common for electrical and electronic items to be marketed on the street or in bazaars and night markets. Many counterfeit products appear in these venues due to the transient nature of some of the vendors. In such situations, sophisticated lamp benchmark testing may not be appropriate, because by the time products have been tested (which may take a period of several months) the vendor may no longer be operating. It could be argued though that the trading longevity of any particular vendor is irrelevant to the gathering of product information as the 'typical' vendor in these locations would have similar quality products in order to compete at the 'typical' price point established within that bazaar or night market.

MODELS FROM WHOLESALERS

Wholesalers will often directly supply to electrical tradespersons, commercial lighting installers and to the building industry for installation in new and renovated housing. As such, these products will often be sold and installed in bulk quantities, so their presence in the market should be monitored.

4.2.3 CONDUCTING A PRELIMINARY ASSESSMENT PRIOR TO LABORATORY TESTING

Prior to obtaining lamps for laboratory testing, it may be useful to conduct a preliminary check for compliance with labelling and product registration requirements, if they exist. This can be carried out directly by observation of the products and their packaging or by photographing and recording product details for later evaluation.

The relatively new 'lab in a suitcase' method of testing, which employs the use of portable test equipment to perform on the spot testing, offers another alternative for preliminary assessment. In this case, a simple calculation will determine whether the tested lamp has a likelihood

of meeting the minimum requirement within a slightly increased error margin (uncertainty). Any lamp test results which are deemed to be indeterminate (i.e. in a range where the minimum requirement is within the uncertainty range of the test result) may result in the vendor receiving a warning (depending on the regulation and compliance policy of the region) or preferably the lamps could then be referred for more accurate laboratory testing.

Where non-compliance of labelling and performance is discovered, appropriate actions under the enforcement regulations could follow: for example, immediate removal of the product from sale, or, issuing of a breach notice.

Box 5

Example of a market assessment study, Philippines

This example demonstrates the type of classifications that can be created and the type of information that can be obtained to assist with developing the market profile and ultimately the strategies for influencing the transition to energy efficient lamps.

The Philippines Department of Energy report, *A Market Assessment Study on Energy Efficient Lighting Products in Philippine Urban Centers (Arthur Andersen, 2000)*, included surveys of consumer lighting product purchasing habits to ascertain how the local CFL market had evolved since the wide scale introduction of these lamps in the mid-1990s.

Key findings were that CFL purchases of Metro Manila households are mainly influenced by the availability of brands and variants; on the prices of lamps; and the purchasing power of the households. Affluent households (AB segment) accounted for 9% of the purchasing market, while middle class (C) households accounted for approximately 50%, the less affluent segment (D) for 32% and the lowest (E) for 11%.

Purchasing habits showed that AB households would generally buy popular models from the 'Big 3' – General Electric , Osram, and Philips. These are the most expensive models in the market but were preferred due to perceived quality. This category of household would also try out low-cost alternatives in addition to the Big 3 models.

C, or middle class, households would also purchase Big 3 models, but in smaller numbers, and they would be more inclined to try low cost alternatives, including unauthorised copies of well-known brands.

The bulk of purchasing by D and E households comprised of CFL models that are either relatively unknown brands or unauthorised copies of the big brands, sold at low prices.

CFL retail outlets were typically modern supermarkets, 'regular' supermarkets and hardware stores. Informal retail outlets, such as sidewalk stalls, would typically stock low cost CFL brands and unauthorised variants of big brands. The latter would often locate and vend their trade near shopping complexes and supermarkets where they could directly compete with organised retail establishments.

5 LAMP ACQUISITION

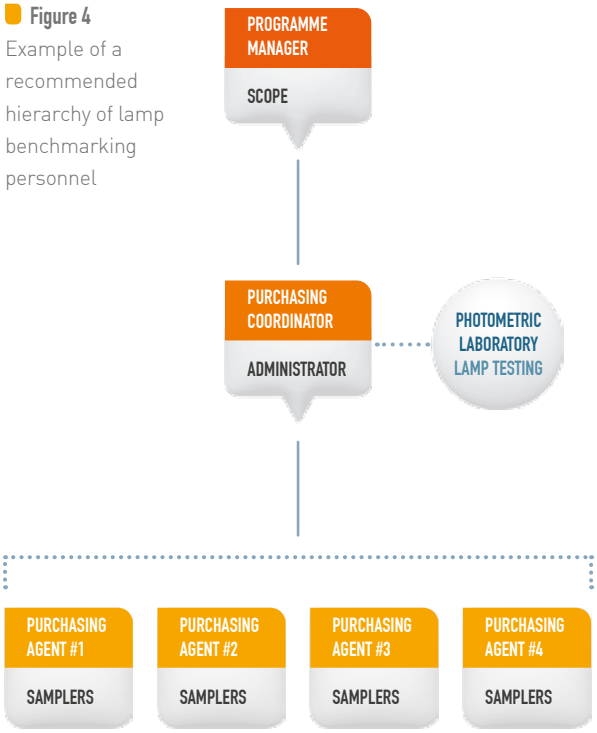
To ensure the robustness of performance testing results against manufacturer/supplier challenges, a methodical approach to lamp acquisition and documentation must be established. This chapter describes a step-by-step methodology for achieving this, including information on: personnel roles and responsibilities; sample acquisition protocols, including the provision of authority to conduct the acquisition; and developing strong lamp identification and transparent record keeping systems.

5.1 PROGRAMME PERSONNEL

5.1.1 PROGRAMME ROLES

For the performance testing programme to run in a smooth and consistent manner, management of the programme will require a clear, multi-tiered structure of personnel to carry out specific tasks. Figure 4 provides an example of a recommended hierarchy of personnel roles.

Figure 4
Example of a recommended hierarchy of lamp benchmarking personnel



PROGRAMME MANAGER

The Programme Manager will usually be a government employee, in charge of coordinating the implementation of the MVE strategy. The role involves defining the scope of the project, and sourcing and allocating government resources to ensure that the objectives of the testing programme are met. This person will receive the results from photometric testing and check for, and follow up on, enforcement measures for non-compliant products (such as, immediate removal of the product from sale, or the issuing of a breach notice).

The Programme Manager may also be responsible for appointing a Purchasing Coordinator (although they may carry out both roles) and will also organise contracting with Purchasing Agents.

PURCHASING COORDINATOR

The Purchasing Coordinator's role is to centrally organise the administration tasks associated with lamp acquisition, record keeping, lamp labelling, lamp transportation to and from the laboratory and communication with the laboratory. This person will also communicate with the Purchasing Agents, where necessary, to ensure that purchasing tasks have been successfully achieved. More detail on these processes is found in following sections of this document.

PURCHASING AGENTS

Purchasing agents are the location-based personnel charged with physically visiting retail outlets and acquiring the lamp samples.

Box 6

Example of programme personnel hierarchy, Australia

In recent verification testing conducted by the Australian Government Department of Industry and Science, lamp samples were purchased by a third party contracted to the Department to provide lamp market surveillance and purchasing services. Lamps were purchased by the contractor's personnel in major Australian capital cities. Lamps were delivered to a central co-ordinator of the contractor who logged and photographed the lamps and stored them in preparation for delivery to testing laboratories.

In the future, Greenhouse and Energy Minimum Standards (GEMS) Inspectors, appointed under the GEMS Act of 2012 and located in several Australian capital cities, will purchase samples as directed and deliver lamps to the Department. A GEMS Inspector within the Department will log all lamps, take detailed photographs of the lamps and packaging and will organise shipment of lamps to test laboratories. Under the GEMS Act, suitably accredited testing laboratories may also be contracted to purchase lamp samples.

5.1.2 PERSONNEL TRAINING

It may be necessary to provide training for the Purchasing Coordinator and Purchasing Agents in terms of which products to select, how to identify them, and how to record critical lamp information correctly and how to communicate with store managers. This might include the provision of photographic or diagrammatic guides of the different lamp types and cap types. An example of these guides are supplied in Annexes A and B respectively.

5.2 THE SAMPLING PROCESS

Each Purchase Agent should provide at least two Samplers to carry out the sampling activities at each venue – one of whom shall be designated as the group leader. This is important to ensure that each can check and verify the others' work to be correct.

5.2.1 AUTHORITY AND IDENTIFICATION

The Purchasing Agents should issue an official letter to be carried by the Samplers to explain the purchasing purpose and to certify that the Samplers have the authority to conduct the acquisition. The method of identification and the approach to store entry should be as specified in any relevant regulation. However, in general, the letter will include a telephone number and contact email address for inquiries and verification, if needed by the personnel in the sampling venue. When entering the sampling venue, Samplers should show the official letter to a manager, and if requested, show a personal/government identity card, and explain the purpose of the lamp sampling exercise. An example of a form letter template is given in Annex C.

5.2.1 CONFIDENTIALITY AND PROFESSIONAL INTEGRITY

Samplers should maintain confidentiality and professional integrity throughout the process. For example, they should not inform manufacturers of the models to be sampled and should not accept any gift or any meal invitations from any industry representative or store staff. They should focus solely on the sampling task. For example, they should not do any sightseeing or conduct any other client's (or personal) business during the sampling process.

Those conducting sampling should be briefed and trained concerning the scope of their authority under any relevant regulation. The group leader should keep a record of any problems and submit them in writing (by email) to the regulatory programme coordinators.

5.3 METHOD OF SAMPLE SELECTION

Financially, the method of lamp acquisition varies depending on local regulations and law. Some examples of acquisition processes are:

- Lamps are purchased (using cash or debit or credit cards) from points of sale;
- Lamps are requisitioned (i.e. without payment) from the points of sale with a formal notification which provides the retailer with a right to compensation/replacement from the supplier;
- Lamps are requisitioned (without payment) directly from the supplier. This method is not recommended as it risks provision of a 'golden sample' i.e. samples which are known to be the highest performers off the manufacturing line.

Once it has been determined from where the selected lamp models are to be acquired, the Samplers should conduct an initial investigation, to confirm that there are a sufficient number of samples of each product required for acquisition.

The following aspects should be considered when choosing which lamps and types to purchase:

- Models from different brands and different manufacturers are preferable;
- For a single lamp model, authorities should try to obtain samples from different manufacturer batches by purchasing from different cities/vendors (for example, 20 samples from four different locations). This checks for consistency of production, provided that it is ensured that they are the same lamp model by checking that the information on the lamp and packaging are the same;
- At the time of purchasing, or before shipment to the testing laboratory, authorities should check that all samples of each model operate satisfactorily. If the volume of lamps is very high, this may not be practical. An alternative might be to conduct a random check of samples.
- Authorities may wish to purchase extra units of each lamp model to ensure the required amount for testing can still be met, even if some lamps are broken in transit.

5.4 LAMP IDENTIFICATION

An important component of sample lamp purchasing is the marking of each lamp, and the lamp packaging, with a unique identifier code/number. This helps with:

- Tracking individual lamps and the overall product sample through the verification process;
- Lamp identification for possible re-testing if questionable test results obtained;
- Tracing lamps back to their point of sale.

It is recommended that the code is chosen to help with easily decipherable identification and that there are enough digits to allow appropriate sorting in analysis software – this component is critical to the amount of time required to analyse the test results when they are received. Sorting and filtering tools within analysis software packages must be able to satisfactorily segment the data as needed by the analyst. Rules (such as having the same number of digits and characters in the code regardless of the number of procurers, countries, models, and samples purchased) are crucial in sorting data. These needs will vary depending on the scale and duration of such programmes. Some examples might be:

PC LED 001 – representing a light emitting diode product (LED), of a model identified using a three digit number, acquired by third party Purchasing Agent, 'Professional Consultant' (PC). This permits that in the long term this agent could acquire up to 999 LED lamps without a need to change the code structure.

VNM CFL 25A – representing a compact fluorescent lamp (CFL) product purchased in Vietnam. The lamp model is one of (up to) 99 which will potentially be tested over the long term. The 'A' at the end indicates that there is more than one lamp of that same model being tested, i.e. that there is also a 'VNM CFL 25B' and so on.

Examples of lamp identification numbering taken from an Australian LED sampling exercise are shown in Figure 5. To indelibly mark the product with the code, use a point

Figure 5
Examples of identification codes on a MR16 LED lamp and a linear LED lamp and their packaging

tipped permanent marker, and write the code somewhere on the lamp that does not obstruct light output, and preferably where the lamp will not get too hot otherwise the mark might fade or wear off (i.e. avoid writing on the heat-sink section of an LED lamp, if possible). Also mark the same code on the top of the lamp packaging, so the lamp can be returned to its correct packaging after being tested.

Where the models that are to be purchased have been identified prior to procurement (such as from a registration database), the list of models and number of required samples of each can be constructed against their codes in advance. Where the models for procurement are going to be determined when in the field (at the points of sale), a template table will need to be constructed that allows direct entry of the lamp details against the codes as they are purchased.

5

5.5 RECORD KEEPING SYSTEM

In order to withstand possible manufacturer/retailer challenges to testing results, it is important to have in place a comprehensive, robust and transparent record keeping system which documents: the acquisition process and details of the lamps sampled; communications with the testing laboratory; the testing requirements; and the outcomes of testing. This section discusses some of the key considerations associated with this.

5.5.1 LAMP MODEL PURCHASE SHEETS

The Purchasing Coordinator could provide a spreadsheet template for sampling/purchasing personnel. Ideally, this will enable logging of a comprehensive summary of: all lamp details; performance claims on the packaging and lamp; procurement location details; and transaction specifics, including price and date of purchase.

It is recommended that Samplers write in block capital letters, ensuring the words are easy to recognise; that if anything is written incorrectly and needs to be revised, two strikethrough bars "~~sample~~" are drawn across the words that need to be revised; and that the revision is confirmed by a signature aside. Lamp model purchase sheets should be signed by at least two Samplers who have responsibility for the accuracy and completeness of the sampling sheet. A witnessing signature from a sales representative would be advantageous if they are willing, or allowed by their manager/employer, to be involved. An example of an individual lamp model purchase sheet is provided in Annex E.

A copy of the purchase receipts and the sampling sheet should be kept with the samples.

5.5.2 SAMPLED LAMPS DATABASE

In order to facilitate comprehensive analysis of the lamp and market information and impending test results from the sampled lamps, a substantive database needs to be established for entry of the information. The assigned lamp code, the information from the lamp model purchase sheets and the resulting test data are entered into this. These are described in detail below.

LAMP DETAILS

Tabulate important lamp information about the brand and general type of lamp, including information about warranty if that was provided. The range of details to be recorded will depend on the purpose of the survey and/or the requirements of any MEPS or labelling programme, however an example is shown in Figure 6.

Lamp Information	
Lamp Code	LN LED 001
Country	AUS
Manufacturer or Retailer Brand	LED Brand
Model Number	ER126LN-WFL
Product Name	Super Bright LED Downlight
Lamp Tech	LED
Directional/ Omni	Directional
Cap	GU5.3
Lamp Type	MR16
Warranty (years)	3

Figure 6
Example of lamp details tabulation

Other details that could be recorded include:

- The product bar code (more properly known as the International Article Number or EAN-13 barcode), as illustrated in Figure 7;
- Lamp etching data (any text/images printed onto the lamp, as illustrated in Figure 8).

Figure 7
Product barcode with International Article Numbering Association (EAN) number

Figure 8
Lamp etching showing lamp specification details

LAMP PERFORMANCE CLAIMS

The sampled lamps database will typically also capture any performance characteristics that may be written on the packaging of the lamp, or on the lamp itself. An example is provided in Figure 9.

PROCUREMENT LOCATION DETAILS (MULTIPLE SITES)

Keep a list of the details for all outlets or suppliers where products were purchased, as per the example in Figure 10.

SALE PRICES AND DATES OF PURCHASE

In addition to asking for an invoice or receipts, which should be kept for the record, it is recommended that purchase information is also tabulated in the sampled lamps database. An example of this is shown in Figure 11.

Performance claims	
Beam angle (°)	36
Life (hours)	36000
Colour temperature	Warm white
CCT (K)	3000
CRI	85
Power (W)	8
Voltage (V)	12
Luminous flux (Lm)	600
Efficacy (Lm/W)	75
Dimmability	yes
Dimmer type	Leading/trailing edge
Wattage equivalence	35

Figure 9
Example of lamp performance claims tabulation

Procurement locations	
Purchase site	Shop name, website name
Address and contact name	Physical or website address
Purchase outlet type	Superstore, online lighting store, others
Notes	Any extra information that might be relevant or useful

Figure 10
Example of procurement location tabulation

Purchase details	
Date of purchase	1/10/2014
Cost	AUD 37.00
Purchase location	Shop name, website name
Purchase outlet type	Superstore, online lighting store, others
Notes	Any extra information about transaction

Figure 11
Example of purchase details tabulation

5

5.5.3 PHOTOGRAPHIC EVIDENCE

It is good practice for Samplers to take photographs of all the lamp samples and their packaging, purchase receipt and sampling venue to provide proof of where the lamps where acquired. Examples of photographic evidence captured during an Australian sampling exercise are provided in Figure 12. When taking photographs, try to avoid camera flash flare on the surface of the packaging, as depicted in the right-hand packaging photograph in Figure 12. All sides of the packaging and the product that display product information and numbering should be photographed. Photographs should be checked at the time of taking to confirm that text, numbers and other marking are legible.

Figure 12

Photographs of purchase invoice, and lamp and lamp packaging in various orientations

6 TRANSPORTATION

Safe arrival of sample lamps to the testing laboratory is a critical component in the legitimate characterisation of the performance of a lamp model through testing. This chapter discusses the key considerations for achieving this, including: careful packaging and clear identification of the products enclosed; secure delivery tracking; and direct communication with the testing laboratory on the transit and receipt of the samples.

6.1 PACKAGING

Lighting products are very fragile and postal deliveries are often not handled gently. To minimise the risk that lamps will be broken or damaged during transport, lamps should be packed in packing boxes, surrounded by shockproof materials such as bubble wrap or packaging noodles. The package should be strong enough to endure drops and impacts and should be labelled as fragile. An example of secure shockproof packing of lamps for transport to laboratories, taken from a 2014 lamp sampling exercise in Lao PDR, is shown in Figure 13.

Optionally, hiring professional packing services would help ensure compliance with any requirements for shipments of hazardous materials, such as mercury-added lamps (compact/linear fluorescent lamps).

Figure 13
Secure shockproof packing of lamps for transport to laboratories (Photographs courtesy of International Institute for Energy Conservation)

PACKING LIST

A comprehensive packing list with details of all the lamps and their codes should be included in the package. This should be signed by at least two Samplers, who have responsibility for the accuracy and completeness of the packing list. The sampling organisation could keep a copy for their records. A sample packing list is shown in Figure 14 in Section 6.3, which discusses additional aspects relating to the use of packing lists.

SECURITY OF SAMPLES WITHIN PACKAGING

Use sealing tape to close the box securely. At least two Samplers should witness the sampling and packing process. The Samplers should take photos to record the sampling and packing process. Samplers should use sealing tape to seal the box after packaging and sign across the join of the sealing tape. The use of sticky tape to cover the whole sealing tape for the purpose of protecting the signatures is also recommended to avoid smudging or rubbing off during transportation.

CLEAR IDENTIFICATION ON PACKAGES

The packages should be clearly identified with sender and recipient details and marked as fragile. In addition, if the lamps are being tested in another country and it is possible that import duty may be charged, mark the packaging as: "Samples for quality testing, not for commercial purposes".

PACKAGE NUMBERING

If there are multiple packages to be delivered, it is good practice to number each of these using the following method: "1 of 3", "2 of 3" and "3 of 3". This will make it easier for the receiver to immediately determine if all packages have been received.

6.2 SECURE DELIVERY TRACKING

A delivery method should be used that allows for secure parcel tracking and keep a record of the tracking number. It may be helpful to also communicate the tracking details to the laboratory.

6.3 COMMUNICATION WITH THE TESTING LABORATORY

Good communication with the testing laboratory on the transit and receipt of samples is an integral part of ensuring the smooth transfer of these lamps to the testing venue. It is recommended that a record is kept of these communications.

NOTIFICATION AND ACKNOWLEDGEMENT

It is good practice to inform the testing laboratory, via email, that the samples have been sent, and provide the transportation tracking number. It might be useful to indicate the expected date of arrival and ask the laboratory staff to provide acknowledgement upon their receipt of the samples and explicit confirmation of the arrival of the full consignment.

Figure 14
Example of packing list containing lamp test details

Lamp information								Contract			Tests to be done					
Lamp code	Manufacturer or retailer brand	Product brand/name	Base	Lamp Type	Rated Beam Angle (°)	Rated Power (W)	Rated Voltage (V)	9 Filament reflector lamps	40 LED lamps	56 CFL lamps	IEC 60064	IEC 60969	IEC 62612	UV	START TIME	RUN-UP TIME
LNCFL 060A	Megaman	BR0620-ES-30K	ES	PAR38	110	20	240			✓		✓				
LNCFL 060B	Megaman	BR0620-ES-30K	ES	PAR38	110	20	240			✓		✓				
LNCFL 060C	Megaman	BR0620-ES-30K	ES	PAR38	110	20	240			✓		✓				
LNHAL 001A	Venture	MR16 Halogen Lamp	GU5.3	MR16	9	37	12			✓		✓				
LNHAL 001B	Venture	MR16 Halogen Lamp	GU5.3	MR16	9	37	12			DO NOT TEST						
LNHAL 003A	Venture	MR16 Halogen Lamp	GU5.3	MR16	25	37	12			✓		✓				
LNHAL 003B	Venture	MR16 Halogen Lamp	GU5.3	MR16	25	37	12									
LNHAL 010A	Osram	Halogen spot R50 ES	E14	R50	30	28	240	✓			✓					
LNHAL 010B	Osram	Halogen spot R50 ES	E14	R50	30	28	240									
LNINC 001A	Philips	Reflector Bulb	E27	E80	80	75	240	✓			✓					
LNLED 001	Megaman	LED Reflector MR16	GU5.3	MR16	36	6	12		✓				✓			
LNLED 005	Get Green	SP-HPSA	GU10	PAR16	60	6	240		✓				✓			
LNLED 006	Get Green	SP-HPSA	GU10	PAR16	60	6	240		✓				✓			
LNLED 009A	Philips	Master LED MR16 LV Dimm	GU5.3	MR16	60	10	12		✓				✓			
LNLED 009B	Philips	Master LED MR16 LV Dimm	GU5.3	MR16	60	10	12									
LNLED 013	Cree	Mini. High Power LED Light	B22	A	180	10	85-265		✓				✓			
LNLED 014	Cree	LED PAR38 Dimmable	E27	PAR38	110	20	240		✓				✓			
LNLED 015	Osram	Parathom Classic A 40	B22	A	180	8	240		✓				✓			

PACKING LIST AND TEST SCHEDULE

The reasons for testing, and the scope of lamps to be tested, will determine which photometric tests will be required. There may be a range of lamps to be tested in one test round that require different tests to be carried out. For example, an LED lamp will not require a mercury test (as LED products do not contain any mercury), whereas a CFL or linear fluorescent product will.

It can be helpful to the laboratory for the Purchasing Coordinator to provide a spreadsheet with the lamps that includes rows that list all lamps to be tested (with lamp identification codes and basic lamp parameters) and columns that outline which tests and/or test methods are to be carried out on each given lamp (i.e. the packing list with a test schedule for the specified lamps). Figure 14 shows an example of how this might look. Notice that there are rows which have been shaded grey and that the words "DO NOT TEST" have been written over the first example of this. This is a mechanism to indicate that these are spare lamps provided to the laboratory in case of lamp failure. Note in the example how the spare lamps have been given their own lamp identification code (e.g. LNHAL 001B) to indicate that they are a duplicate of the lamp in the row above that is to be tested (LNHAL 001A).

REQUESTED SERVICES FROM THE LABORATORY

The contract with the testing laboratory should be clear about the tests to be performed and the required timing of provision of final lamp test results, including the contract commencement and end dates. The Programme Manager may also wish to provide the laboratory with specific instruction regarding requirements for the accredited test reports, a compliance pro forma for the specific MEPS requirements, and disposal arrangements.

Specific instructions on the form that test reports shall take should state that they be in accordance with the relevant test standard. It is recommended that the test reports should also cover the following aspects:

- Service provider details;
- Product description, including photographs of lamps and packaging labels;
- Test standards and variations;
- Instrumentation and set up;
- Product specific technical content;
- Test results;
- Test uncertainty of measurement levels as relevant to all pieces of laboratory test equipment.

Each individual sample model tested must have its own complete separate report, in PDF format, provided as an electronic copy. It is also good practice that the following documents be affixed to each test report:

- Document control sheet;
- Stewardship record for the test sample;
- Results summary page;
- Photograph page including:
  - General photograph of the test sample,
  - Photograph of the control panel/s,
  - Photograph of the energy label (if relevant/ provided),
  - Photograph of the product identification plate.

It is suggested that a complete summary of all lamp test results is requested, in Microsoft Excel spreadsheet format, as an electronic copy. A template for this could be provided to the testing laboratory so that it synchronises with the format of the sampled lamps database discussed in 5.5.2.

7 RECOMMENDATIONS

Developing a well-structured and defined framework for selection and procurement of lighting products for performance testing as part of government energy efficient lighting programmes is paramount to their success. Performance testing programmes are costly, conducted over an extended period and, if compromised in integrity, the entire programme's results could be deemed un-enforceable. Thus, careful planning with consideration for the detailed information provided throughout this guidance note, and summarised below, is strongly recommended.

CLEARLY DEFINE THE PROGRAMME OBJECTIVE AND PARAMETERS

Performance testing programmes, whether for market intelligence, monitoring compliance with MEPS and labelling programmes, verifying manufacturer/retailer declarations, or conducting product benchmarking, all require product and performance parameter scopes to be established. The key considerations are to clearly set the objective of the investigation, unequivocally define the scope of products to be included, and specify the key metrics to be captured.

IDENTIFY THE BUDGET REQUIRED

As all of these programmes include performance testing activities it is critical to establish an appropriate budget. During planning, it is important to have an accurate understanding of the costs involved, such as: the cost of the procurement activity itself; the cost of the laboratory test for each of the nominated performance parameters, and for the number of models and samples of each, to be tested; the cost of transporting the samples to and from the testing laboratory; the cost of disposing of the samples after testing.

ESTABLISH A MARKET PROFILE

After establishing the scope and the budget, but before selecting any lamps, a thorough understanding of the lamp market has to be obtained to facilitate the sourcing of an appropriate representation of the intended market sectors that meet the objectives of the programme. This information can be difficult and onerous to find due to the complexities of trade and logistics of a mass volume, low cost, consumable product. Ultimately, a profile of the products in the market (product performance and its market segment) will be drawn from: any existing voluntary or mandatory registration systems for energy performance or labelling; customs import and export volumes; in-store surveys; industry bodies or individual companies; and catalogue data.

ENSURE A SYSTEMATIC AND TRANSPARENT APPROACH TO LAMP ACQUISITION AND DOCUMENTATION

To ensure the robustness of performance testing results against manufacturer/supplier challenges, a systematic and transparent approach to lamp acquisition and documentation must be established. Care in developing a step-by-step methodology with a documentation trail and personnel accountabilities are key to achieving this outcome. Personnel roles and responsibilities, sample acquisition protocols, provision of authority to conduct the product acquisition, developing effective lamp identification and transparent record keeping systems are all contributing elements to a defensible system.

ESTABLISH ROBUST TRANSPORTATION PROCEDURES

Unless the sample lamps arrive safely at the testing laboratory, there will be no legitimate characterisation, through testing, of the performance of a model of lamp. Important considerations for safe arrival include: careful packaging and clear identification of the products enclosed; secure delivery tracking; direct communication with the testing laboratory on the transit and receipt of the samples.

LAMP TESTING AND ANALYSIS

Once the lamp samples have safely reached the testing laboratory, they will undergo the stipulated tests and the reported results, along with a statement of the associated uncertainties of measurement, may then be analysed. Guidance on these processes is provided in the UNEP-GEF en.lighten guidance note, *Performance Testing of Lighting Products*.

8 RESOURCES

To support countries and regions in the development of efficient lighting activities and strategies, the UNEP-GEF en.lighten initiative, CLASP and other organisations offer a wide array of practical tools. The most relevant of these are described below.

UNEP-GEF EN.LIGHTEN INITIATIVE PUBLICATIONS

Achieving the Transition to Energy Efficient Lighting Toolkit – delivers best practice guidance for policy development and provides technical and practical tools for those directly involved in national phase-out activities. This toolkit is available online in five languages: Arabic, English, French, Russian and Spanish.

http://www.enlighten-initiative.org/ResourcesTools/EfficientLightingToolkit.aspx

Developing Minimum Energy Performance Standards for Lighting Products: Guidance Note for Policymakers - illustrates how to develop MEPS for lighting products. It is a practical resource for governments on the processes to follow when establishing MEPS in a national or regional market.

http://www.enlighten-initiative.org/ResourcesTools/Publications.aspx

Developing Lighting Product Registration Systems: Guidance note – provides practical guidance and examples to energy efficiency programme administrators on how to develop, operate and maintain a registration system for lighting products.

http://www.enlighten-initiative.org/ResourcesTools/Publications.aspx

Efficient Lighting Market Baselines and Assessment: Guidance note – provides practical guidance to policymakers and energy efficiency programme administrators on how to determine national baselines, use this data for market monitoring purposes, and how to monitor the market to continuously update the baselines.

http://www.enlighten-initiative.org/ResourcesTools/Publications.aspx

Enforcing Efficient Lighting Regulations: Guidance note – presents best practices for enforcing energy efficiency regulations for lighting products. It can be used as a practical resource by policymakers and enforcement bodies when developing or revising their enforcement regime.

http://www.enlighten-initiative.org/ResourcesTools/Publications.aspx

Good Practices for Photometric Laboratories: Guidance note – provides guidance on the operation of photometric laboratories to ensure that testing results are fully supported by evidence of the legitimacy of the measurement values obtained and to give confidence in the accuracy of these results and conformance with test procedures/conditions.

http://www.enlighten-initiative.org/ResourcesTools/Publications.aspx

Performance Testing of Lighting Products: Guidance note - outlines the process for carrying out energy efficiency performance testing for lamps, and how to interpret and use the data. It is a practical resource for energy efficiency policymakers and programme administrators.

http://www.enlighten-initiative.org/ResourcesTools/Publications.aspx

Product Selection and Procurement for Lamp Performance Testing: Guidance note – provides guidance on the steps required when selecting and procuring residential lamps to undergo performance testing, including defining the product scope, selection methodology, and the procurement and tracking protocol.

http://www.enlighten-initiative.org/ResourcesTools/Publications.aspx

Global Compact Fluorescent Lamp Check Test Results and Analysis Report – provides results and analysis of the safety, performance and mercury content of 47 models of CFLs tested at the Global Efficient Lighting Centre in 2013. The lamps were sampled in 10 countries (Azerbaijan, Chile, Costa Rica, Dominican Republic, Guinea-Bissau, Lebanon, Panama, Tonga, Tunisia and Uruguay) with the support of the UNEP en.lighten initiative.

http://www.enlighten-initiative.org/ResourcesTools/Publications.aspx

Inter-laboratory Comparison Testing of Light Emitting Diode (LED) Lamps - presents the results of an inter-laboratory comparison testing exercise undertaken by six laboratories in Southeast Asia in 2015 (in accordance with ISO/IEC 17043, *Conformity assessment - General requirements for proficiency testing*), with the Global Efficient Lighting Centre as the nucleus laboratory.

http://www.enlighten-initiative.org/ResourcesTools/Publications.aspx

Lamp Sampling in Cambodia, Indonesia, Lao PDR, the Philippines, Thailand and Viet Nam – presents a summary of a 2014 lamp sampling exercise coordinated by the International Institute for Energy Conservation to identify and sample compact fluorescent and LED lamps in six target countries. The objective of the exercise was to provide participating agencies with guidance on, and experience in, conducting a retailer survey, lamp purchasing and witnessing, and packing and shipping; and to sample lamps for subsequent testing undertaken by the Global Efficient Lighting Centre.

http://www.enlighten-initiative.org/ResourcesTools/Publications.aspx

Southeast Asia Compact Fluorescent Lamp Performance and Mercury Testing and Analysis Report – presents the results and analysis of testing undertaken by the Global Efficient Lighting Centre on CFLs purchased in six Southeast Asian countries (Cambodia, Indonesia, Lao PDR, Philippines, Thailand and Viet Nam in 2014.

http://www.enlighten-initiative.org/ResourcesTools/Publications.aspx

Southeast Asia Light Emitting Diode Lamp Performance Testing and Analysis Report – presents the results and analysis of testing undertaken by the Global Efficient Lighting Centre on LED lamps purchased in six Southeast Asian countries (Cambodia, Indonesia, Lao PDR, Philippines, Thailand and Viet Nam in 2014.

http://www.enlighten-initiative.org/ResourcesTools/Publications.aspx

CLASP PUBLICATIONS

Energy Efficiency Labels and Standards: A Guidebook for Appliances, Equipment and Lighting – provides guidance for government officials and others responsible for developing, implementing, enforcing, monitoring, and maintaining labelling and standards-setting programmes.

http://clasp.ngo/Resources/Resources/StandardsLabelsGuidebook

Compliance Counts: A Practitioner's Guidebook on Best Practice Monitoring, Verification, and Enforcement for Appliance Standards & Labeling - provides guidance on designing and implementing effective compliance frameworks, and directs the reader to references and other relevant resources.

http://clasp.ngo/Resources/MVEResources/MVEGuidebook

Assessment of Opportunities for Global Harmonization of Minimum Energy Performance Standards and Test Standards for Lighting Products - presents an assessment of test procedures and MEPS globally and identifies key gaps and similarities between them. It also examines the opportunities for the alignment of various economies to one global test procedure, and corresponding MEPS, for CFLs and LEDs and provides recommendations on possible steps to encourage and accelerate the global uptake of energy-efficient lighting technologies.

http://clasp.ngo/Resources/Resources/PublicationLibrary/2011/Global-Harmonization-Lighting-MEPS-TestStandards

Assessment of Verification Testing Capacity in the APEC Region and Identification of Cost Effective Options for Collaboration- presents the results of a comprehensive survey of APEC countries to identify qualified testing facilities and analyse cost-effective policy options for conducting compliance testing.

http://clasp.ngo/Resources/MVEResources/MVEPublicationLibrary/APEC-Assessment-of-Testing-Capacity-Facilitates-Compliance-Collaboration

EXPERTISE AND COLLABORATIVE PROGRAMMES

UNEP-GEF en.lighten initiative Centre of Excellence – comprised of a network of over 50 lighting experts representing over 30 countries – offers recommendations, technical guidance and efficient lighting expertise to assist countries in the shift to energy efficient lighting. The Centre is based in Paris, France.

http://www.enlighten-initiative.org/

UNEP-GEF en.lighten initiative online support centre, 'en.lightened learning' - provides targeted technical advice and contains forecasting tools, publications and guidance documents. It also includes a series of informational webinars that provide more detailed guidance on specific aspects of MVE including:

- *Best Practices for Enforcing Efficient Lighting Regulations;*
- *CIE Test Method Standard for LED Lamps;*
- *Communication of Lighting Product Performance Standards and Labelling Programmes to Supply Chain Providers;*
- *Developing a Legislative Framework to Support Successful Monitoring, Verification and Enforcement Activities for Energy Efficient Lighting;*
- *Evaluation Indicators for Energy Efficient Lighting MVE Policy;*
- *How to Create and Operate a Lighting Product Registration System;*
- *Lamp Product Performance Tests and Interpretation of Results;*
- *Lighting Product Benchmarking as an Energy Baseline for Change;*
- *Lighting Product Registration Systems: Design and Operation;*
- *Market Baselines and Surveillance for Efficient Lighting Products;*
- *Testing Lamp Efficacy, Lumen Maintenance, Rated Life and Uncertainties.*

http://learning.enlighten-initiative.org/

UNEP Collaborating Centre for Energy Efficient Lighting, China - GELC offers a wide range of technical services to developing countries including laboratory training and establishing systems for lamp quality control.

http://www.enlighten-initiative.org/About/GlobalEfficientLightingCentre.aspx

lites.asia - is a network of lighting efficiency regulators and policy makers in the Asia region. Since its formation in 2009, membership of the lites.asia network has increased to over 700 participants from 30 economies, with delegates actively participating in IEC meetings, sharing knowledge on local standards and labelling electronically and in regional meetings, plus a number of other cooperative actions. The *lites.asia* website contains a range of resources on lighting efficiency and regulation including presentations from regular regional meetings and collaborative project and survey results, such as the regional labelling display survey.

http://www.lites.asia/

Australian and New Zealand Equipment Energy Efficiency (E3) Program - is a cooperative government programme that applies a combination of MEPS and energy rating labelling to a range of energy using products including lighting in order to inform consumers and increase the range of efficient products in the market. The Energy Rating website contains a range of reports on lighting related baseline data and analysis for the Australian and New Zealand markets, as well as a publically accessible database of registered lighting products.

http://www.energyrating.gov.au/

CLASP - Works to improve the environmental and energy performance of appliances and related systems, lessening their impacts on people and the world around us. CLASP develops and shares practical and transformative policy and market solutions in collaboration with global experts and local stakeholders. It is a non-profit international organisation promoting energy efficiency standards and labels for appliances, lighting, and equipment. Since 1999, CLASP has worked in over 50 countries on six continents pursuing every aspect of appliance energy efficiency, from helping to structure new policies to evaluating existing programmes.

http://www.clasponline.org/en

The Clean Energy Ministerial's Clean Energy Solutions Center - offers no-cost expert policy assistance, webinars and training forums, clean energy policy reports, data, and tools provided in partnership with more than 35 leading international and regional clean energy organisations.

https://cleanenergysolutions.org/

IEA - the International Energy Agency (IEA) is an autonomous organisation which works to ensure reliable, affordable and clean energy for its 28 member countries and beyond. The IEA's four main areas of focus are: energy security; economic development; environmental awareness; and engagement worldwide. Founded in response to the 1973/4 oil crisis, the IEA's initial role was to help countries coordinate a collective response to major disruptions in oil supply through the release of emergency oil stocks. It has a staff of 260 professionals (energy analysts, modellers, data managers/statisticians, technicians, secretaries and support staff) working together on global energy challenges.

http://www.iea.org/

IEA 4E Solid State Lighting Annex – the Solid State Lighting Annex was established in 2009 under the framework of the International Energy Agency's Efficient Electrical End-Use Equipment (4E) Implementing Agreement to provide advice to its ten member countries seeking to implement quality assurance programmes for solid state lighting. This international collaboration brings together the governments of Australia, China, Denmark, France, Japan, The Netherlands, Republic of Korea, Sweden, United Kingdom and United States. China works as an expert member of the Annex. The Annex website provides information on recommended performance specifications for LED lighting, as well as reports and advice on LED product testing, lighting and health and lifecycle analysis.

http://ssl.iea-4e.org/

LED Lighting Facts - LED Lighting Facts® is a programme of the United States Department of Energy that showcases LED products for general illumination from manufacturers who commit to testing products and reporting performance results according to industry standards. Their website contains information on their verification testing policy, a list of accredited laboratories in the United States and a list of products with their energy performance information. This is a useful web portal for policymakers and programme administrators to inform themselves about efficient lighting policies and testing.

http://www.lightingfacts.com/

SEAD Initiative - The Super-efficient Equipment and Appliance Deployment (SEAD) Initiative is a voluntary collaboration among governments working to promote the manufacture, purchase, and use of energy-efficient appliances, lighting, and equipment worldwide. SEAD is an initiative under the Clean Energy Ministerial and a task of the International Partnership for Energy Efficiency Cooperation.

www.superefficient.org.

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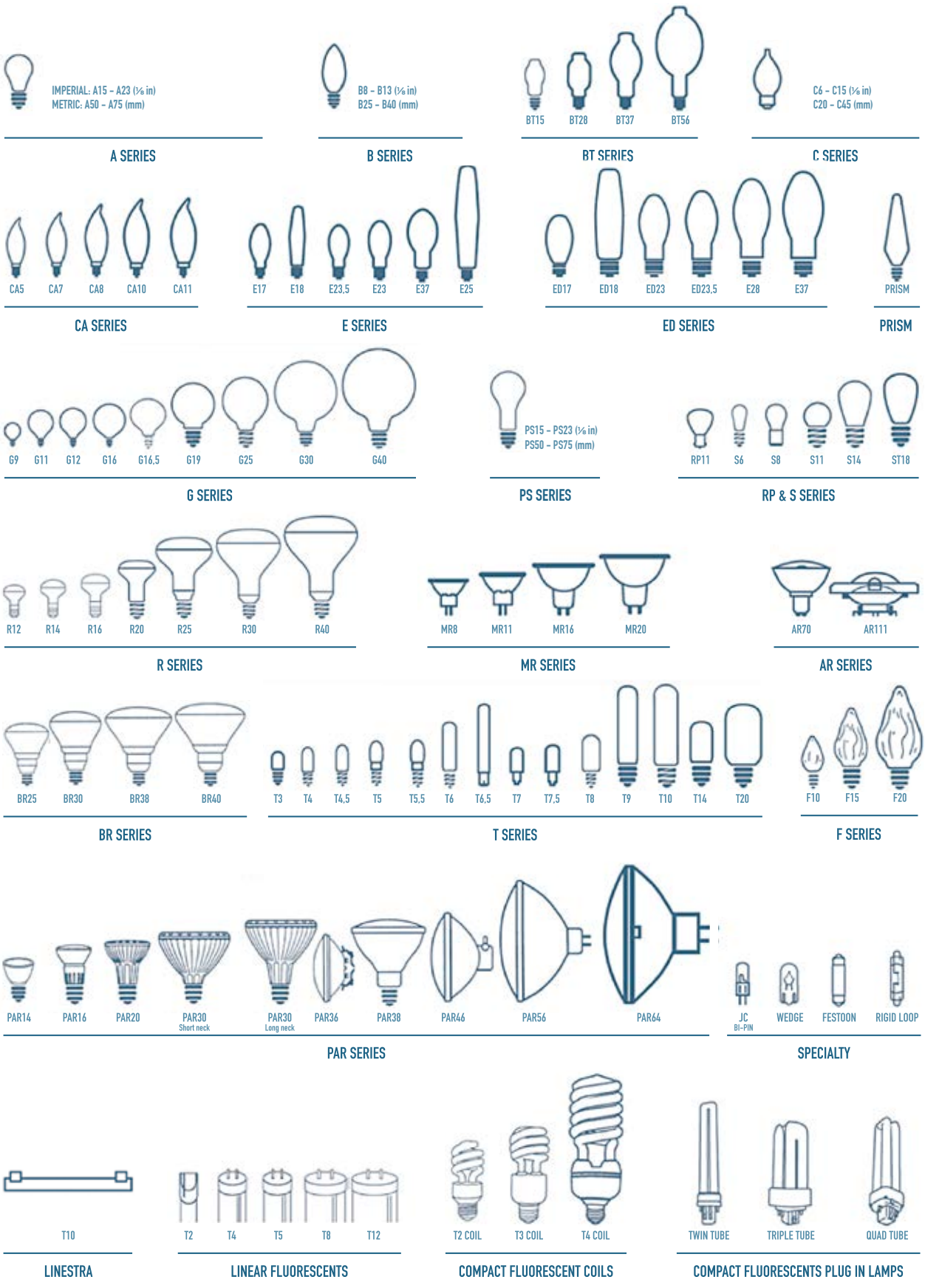
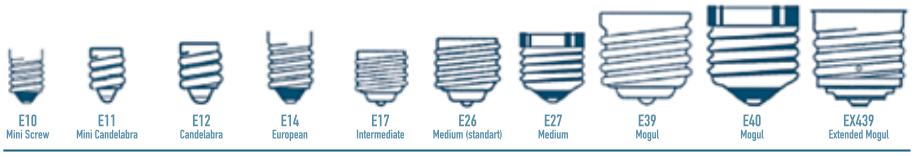
ANNEX A

COMMON LAMP SHAPE CLASSIFICATIONS

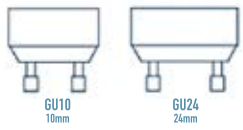


ANNEX B

COMMON LAMP BASE AND FILAMENT CLASSIFICATIONS



SCREW BASES

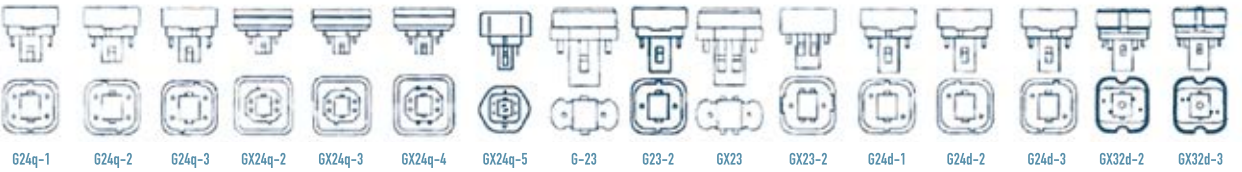


TWIST & LOCK BASES

SPECIALTY BASES

BI PIN BASES

FLUORESCENT PIN BASES



COMPACT FLUORESCENT PLUG IN LAMP BASES

FILAMENTS

ANNEX C

LETTER OF AUTHORISATION

Letter of authorisation to conduct lamp retailer surveys and initiate lighting product purchases for MVE activities. Note highlighted sections must be tailored as necessary.

[Company X]
[#th Floor, Building Name, Number]
[Street, Suburb, City POSTCODE, COUNTRY]

[Date]

To whom it may concern,

[Company X] was appointed by the [Government of Y], which is building efforts to strengthen national and regional resources for efficient lighting monitoring, verification and enforcement [MVE]. Under this assignment, representatives of [Company X] will conduct lamp retailer surveys and purchase samples of compact fluorescent lamps [CFLs] and light emitting diode [LED] lamps in the [target premises, region, etc.]. The samples will then be shipped to the [Accredited Photometric Testing laboratory] in [City, Country], for comprehensive testing and evaluation.

We would appreciate if you could provide relevant information to our representatives during the survey. In case we purchase lamp samples from your shop, please acknowledge the purchase by providing official receipts or signing on the sampling sheet presented by our representatives.

Should you have any questions regarding our activities, please do not hesitate to contact our office at [contact telephone number and email address].

Sincerely yours,

[Name]
[Position, Company X, Region]

ANNEX D

LAMP SAMPLING SURVEY SHEETS

Examples of lamp survey sheets for compact fluorescent and LED lamps for use in retailer stores are provided below.

Compact Fluorescent Lamp Sampling Survey

IIEC is conducting a lamp sampling survey on behalf of the United Nations Environment Programme's *en.lighten initiative* in order to strengthen the national and regional resources for efficient lighting monitoring, verification and enforcement (MVE). The survey will be conducted in six Southeast Asian countries. Website: *http://www.enlighten-initiative.org/*

Country	City	Date
Sampler's name	phone	email
Name of retailer	Address and telephone of retailer	□ Shopping mall □ Specialized lighting shop □ Electrical/Hardware shop □ Others_____

1. Lamp Wattage and Color (note color description and/or color temperature in Kelvin, such as 2700K, "warm white")

5W	DL		13W	DL		20W	DL	
	CW			CW			CW	
	WW			WW			WW	
6W	DL		14W	DL		21W	DL	
	CW			CW			CW	
	WW			WW			WW	
7W	DL		15W	DL		22W	DL	
	CW			CW			CW	
	WW			WW			WW	
8W	DL		16W	DL		23W	DL	
	CW			CW			CW	
	WW			WW			WW	
9W	DL		17W	DL		24W	DL	
	CW			CW			CW	
	WW			WW			WW	
10W	DL		18W	DL		25W	DL	
	CW			CW			CW	
	WW			WW			WW	
11W	DL		19W	DL		greater than 25W	DL	
	CW			CW			CW	
	WW			WW			WW	
12W	DL		DL="daylight" CW="cool white" WW="warm white"					
	CW							
	WW							

2. Manufacturer and/or Brand Information

A		E		I		M	
B		F		J		N	
C		G		K		O	
D		H		L		P	

3. Lamps: Bulb and Base Types

Lamp	Bulb type (circle if available)	bare, spiral			bare, U-bend			covered			
	Base type (circle if available)	E26 or E27		G23		B22		GU10		Other	

4. Average Price, per Wattage of Lamp

Local currency: _____	5W-8W		9W-12W		13W-20W		21W-28W		greater than 28W	

5. Qualitative Comments

Retailer	Best selling brand		Best selling color (white)		Best selling lamp type		Customers' common questions about compact fluorescent lamps
Sampler							

Light Emitting Diode Lamp Sampling Sheet **Ref. No.:_____**

IIEC is conducting lamp sampling on behalf of the United Nations Environment Programme's *en.lighten initiative* in order to strengthen the national and regional resources for efficient lighting monitoring, verification and enforcement (MVE). The lamp sampling will be conducted in six Southeast Asian countries. Website: *http://www.enlighten-initiative.org*

Country	City	Date
Sampler's name	phone	email
Name of retailer	Address and telephone of retailer	□ Shopping mall □ Specialized lighting shop □ Electrical/Hardware shop □ Others_____

1. Lamp Wattage, Model Number and Color (specify lamp wattage, note model number,color description and/or color temperature in Kelvin, such as 2700K, "warm white")

	DL	
	CW	
	WW	

Note:
1) Use one sampling sheet for only one lamp model
2) Lamp wattage equal to or greater than five watts and equal to or less than fifteen watts (≥5W and ≤15W)
3) Sampling quantity = 20 samples per model
4) DL="daylight" CW="cool white" WW="warm white"

2. Manufacturer and/or Brand Information (specify if not on the list, and circle)

A	GE	E	Sylvania	I	
B	OSRAM	F	Toshiba	J	
C	Panasonic	G		K	
D	Philips	H		L	

3. Lamps: Bulb and Base Types

Lamp	Bulb type (circle if available)	covered		bare		other					
	Base type (circle if available)	E26 or E27		G23		B22		GU10		Other	

4. Average Price, per Wattage of Lamp

Local currency: _____		5W-7W		8W-10W		greater than 10W		

5. Qualitative Comments

Retailer	Best selling brand		Best selling color (white)		Best selling lamp type		Customers' common questions about light emitting diode lamps
Sampler							

6. Signatures

Samplers and Witnesses	1	Signature	Name	Title	Organization
	2	Signature	Name	Title	Organization
	3	Signature	Name	Title	Organization
	4	Signature	Name	Title	Organization

ANNEX E

INDIVIDUAL LAMP MODEL PURCHASE SHEETS

Examples of individual lamp model purchase sheets for compact fluorescent and LED lamps are provided below.

Compact Fluorescent Lamp Sampling Sheet **Ref. No.:_____**

IEC is conducting lamp sampling on behalf of the United Nations Environment Programme's *en.lighten initiative* in order to strengthen the national and regional resources for efficient lighting monitoring, verification and enforcement (MVE). The lamp sampling will be conducted in six Southeast Asian countries. Website: *http://www.enlighten-initiative.org*

Country	City	Date
Sampler's name	phone	email
Name of retailer	Address and telephone of retailer	□ Shopping mall □ Specialized lighting shop □ Electrical/Hardware shop □ Others_____

1. Lamp Wattage, Model Number and Color (specify lamp wattage, note model number,color description and/or color temperature in Kelvin, such as 2700K, "warm white")

	DL	
	CW	
	WW	

Note:
1) Use one sampling sheet for only one lamp model
2) Lamp wattage equal to or greater than five watts and equal to or less than thirty watts (≥5W and ≤30W)
3) Sampling quantity = 30 samples per model
4) DL="daylight" CW="cool white" WW="warm white"

2. Manufacturer and/or Brand Information

A	GE	E	Sylvania	I	
B	OSRAM	F	Toshiba	J	
C	Panasonic	G		K	
D	Philips	H		L	

3. Lamps: Bulb and Base Types

Lamp	**Bulb type** (circle if available)	bare, spiral		bare, U-bend		covered					
	Base type (circle if available)	E26 or E27		G23		B22		GU10		Other	

4. Average Price, per Wattage of Lamp

Local currency: _____	5W-8W		9W-12W		13W-20W		21W-28W		greater than 28W	

5. Qualitative Comments

Retailer	Best selling brand		Best selling color (white)		Best selling lamp type		Customers' common questions about compact fluorescent lamps	
Sampler								

6. Signatures

Samplers and Witnesses	1	Signature	Name	Title	Organization
	2	Signature	Name	Title	Organization
	3	Signature	Name	Title	Organization
	4	Signature	Name	Title	Organization

Light Emitting Diode Lamp Sampling Sheet **Ref. No.:_____**

IIEC is conducting lamp sampling on behalf of the United Nations Environment Programme's *en.lighten initiative* in order to strengthen the national and regional resources for efficient lighting monitoring, verification and enforcement (MVE). The lamp sampling will be conducted in six Southeast Asian countries. Website: *http://www.enlighten-initiative.org*

Country	City	Date
Sampler's name	phone	email
Name of retailer	Address and telephone of retailer	□ Shopping mall □ Specialized lighting shop □ Electrical/Hardware shop □ Others_____

1. Lamp Wattage, Model Number and Color (specify lamp wattage, note model number,color description and/or color temperature in Kelvin, such as 2700K, "warm white")

	DL	
	CW	
	WW	

Note:
1) Use one sampling sheet for only one lamp model
2) Lamp wattage equal to or greater than five watts and equal to or less than fifteen watts (≥5W and ≤15W)
3) Sampling quantity = 20 samples per model
4) DL="daylight" CW="cool white" WW="warm white"

2. Manufacturer and/or Brand Information (specify if not on the list, and circle)

A	GE	E	Sylvania	I	
B	OSRAM	F	Toshiba	J	
C	Panasonic	G		K	
D	Philips	H		L	

3. Lamps: Bulb and Base Types

Lamp	**Bulb type** (circle if available)	covered		bare		other					
	Base type (circle if available)	E26 or E27		G23		B22		GU10		Other	

4. Average Price, per Wattage of Lamp

Local currency: _____		5W-7W		8W-10W		greater than 10W		

5. Qualitative Comments

Retailer	Best selling brand		Best selling color (white)		Best selling lamp type		Customers' common questions about light emitting diode lamps	
Sampler								

6. Signatures

Samplers and Witnesses	1	Signature	Name	Title	Organization
	2	Signature	Name	Title	Organization
	3	Signature	Name	Title	Organization
	4	Signature	Name	Title	Organization

ABOUT THE UNEP DIVISION OF TECHNOLOGY, INDUSTRY AND ECONOMICS

Set up in 1975, three years after UNEP was created, the Division of Technology, Industry and Economics (DTIE) provides solutions to policy-makers and helps change the business environment by offering platforms for dialogue and co-operation, innovative policy options, pilot projects and creative market mechanisms.

DTIE plays a leading role in three of the seven UNEP strategic priorities: **climate change, chemicals and waste, resource efficiency.**

DTIE is also actively contributing to the **Green Economy Initiative** launched by UNEP in 2008. This aims to shift national and world economies on to a new path, in which jobs and output growth are driven by increased investment in green sectors, and by a switch of consumers' preferences towards environmentally friendly goods and services.

Moreover, DTIE is responsible for **fulfilling UNEP's mandate as an implementing agency for the Montreal Protocol Multilateral Fund** and plays an executing role for a number of UNEP projects financed by the Global Environment Facility.

The Office of the Director, located in Paris, coordinates activities through:

- → **The International Environmental Technology Centre** - IETC (Osaka), which promotes the collection and dissemination of knowledge on Environmentally Sound Technologies with a focus on waste management. The broad objective is to enhance the understanding of converting waste into a resource and thus reduce impacts on human health and the environment (land, water and air).
- → **Sustainable Lifestyles, Cities and Industry** (Paris), which delivers support to the shift to sustainable consumption and production patterns as a core contribution to sustainable development.
- → **Chemicals** (Geneva), which catalyses global actions to bring about the sound management of chemicals and the improvement of chemical safety worldwide.
- → **Energy** (Paris and Nairobi), which fosters energy and transport policies for sustainable development and encourages investment in renewable energy and energy efficiency.
- → **OzonAction** (Paris), which supports the phase-out of ozone depleting substances in developing countries and countries with economies in transition to ensure implementation of the Montreal Protocol.
- → **Economics and Trade** (Geneva), which helps countries to integrate environmental considerations into economic and trade policies, and works with the finance sector to incorporate sustainable development policies. This branch is also charged with producing green economy reports.

DTIE works with many partners (other UN agencies and programmes, international organizations, governments, non-governmental organizations, business, industry, the media and the public) to raise awareness, improve the transfer of knowledge and information, foster technological cooperation and implement international conventions and agreements.

For more information,
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This guidance note describes the steps required when selecting and procuring residential lamps to undergo performance testing, including defining the product scope, selection methodology and the procurement and tracking protocol. It discusses methodologies for cost effective identification and selection of lamps for establishing a market baseline prior to regulation, as well as for identifying lamp models when conducting lamp testing for compliance in an already regulated market. In order to facilitate the laboratory testing of samples of these selected lamps, guidance is also provided on: the transparency and traceability of procurement options; development of an identification system for the samples; and packaging and transportation practices.

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