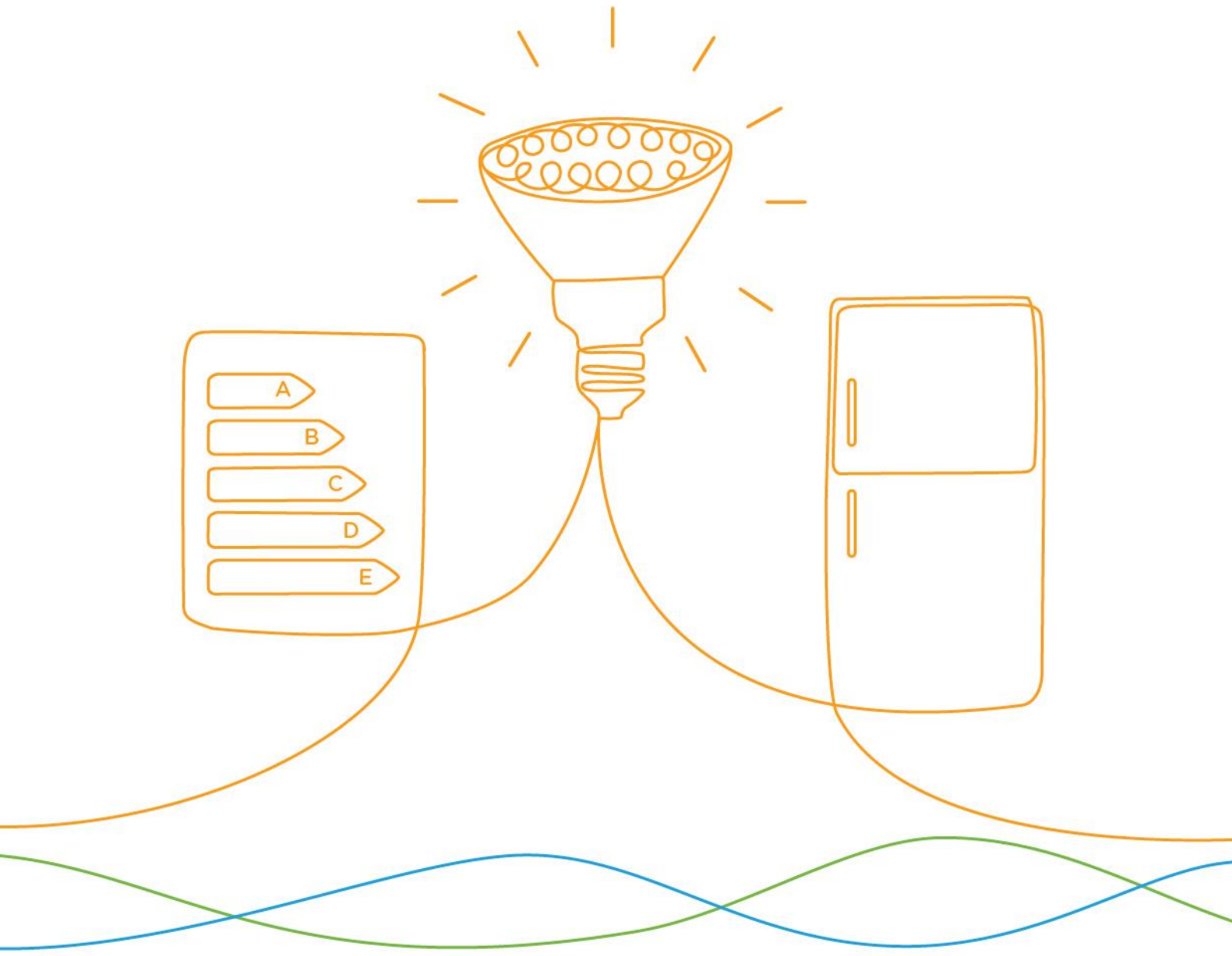
Scoping Study for the Mapping and Benchmarking of General Service Lamps

9/1/2014

Erik Page & Associates, Beletich Associates, Jeffcott Associates



REPORT PREPARED BY

Beletich Associates energy consultants

Erik Page & Associates

JA Jeffcott Associates

DISCLAIMER

The authors believe that the information contained in this document is correct and that any estimates, opinions, conclusions or recommendations contained in this document are reasonably held or made as at the time of compilation. However, no warranty is made as to the accuracy or reliability of any estimates, opinions, conclusions, recommendations or other information contained in this document and, to the maximum extent permitted by law, the authors disclaim all liability and responsibility for any direct or indirect loss or damage which may be suffered by any recipient through relying on anything contained in or omitted from this document. Furthermore, no endorsement of any product, technology or service is made in this report, whether implied or otherwise.

Table of Contents

Introduction

This document aims to define the scope and terms of reference for a Mapping and Benchmarking activity that will assist national and regional regulators, manufacturers and other stakeholders in the transition from traditional incandescent general service lamps (from this point onward simply referred to as Incandescents) to appropriate alternative technologies, and increase the likelihood that the resulting products are of a quality and efficiency appropriate to local needs.

Specific proposals for activities are presented herein which prioritize a core of activities with the greatest likely impact on lighting products' efficiency through influencing standards and labelling development, as well as country coverage, implementation and compliance frameworks.[1] As such, this proposal may easily be modified to suit any particular focus or funding constraint by reference to the hierarchy of options.

"Knowledge Requirements"

The first step in the scoping process is to provide a framework for identifying the most critical actions. Within this context it is useful to reiterate the knowledge requirements, and the goals of this knowledge acquisition.

As defined in the original Terms of Reference for this study, for target countries, the Mapping and Benchmarking activities seek to:

a. Develop national Mappings that:

- Identify national market sizes for selected product groups, and the apparent trends in these markets;
- Capture sufficient product performance data (both manufacturer claimed and test data) to demonstrate the efficiency of products currently being sold to these markets, and the associated test methodologies used to define these efficiencies and other associated performance metrics;
- Detail the standards and labelling initiatives that are currently, or expected to be imminently, influencing the markets.

The goal of this mapping exercise is to:

- Confirm that the scope (in particular the specified technical requirements) of the benchmarking activities defined below will yield results that are appropriate to the major product groups currently being sold into the target markets;
- Provide sufficient input data to the benchmarking process to facilitate outputs that demonstrate the comparative national position in comparison with other countries, regions and international norms.

b. Undertake trans-national Benchmarking to:

- Compare the current test procedure, performance metrics and standards and labelling regimes identified in the Mapping activities to clarify:

[1] At present it is not possible for CLASP to confirm the likely budget available for the ultimate study or studies, nor the primary target countries or regions[1] as these are highly dependent on the specific funding route secured. Funding itself is somewhat dependent on the outcomes/benefits of addressing any particular product grouping and/or region. Therefore, this scoping study seeks to define a hierarchy of options.

- Differences in the *test* regimes employed and, in particular, any issues that may cause incomparability of product performance declarations/test results. Where potential incomparabilities are identified, seek/develop suitable normalization algorithms to enable comparison of product performance and regulatory frameworks;
- Differences in the performance requirements in the *regulatory* regimes and, in particular, any issues that may cause incomparability of product performance declarations/test results. Where potential incomparabilities are identified, seek/develop suitable normalization algorithms to enable comparison of product performance and regulatory frameworks.

- Based on the data captured during the mapping activities and any conversion algorithms considered necessary, Compare:
  - MEPS levels/labelling requirements across the geographical target groups. Primarily these comparisons should be based on the efficiency metrics, but the inclusion/exclusion of other performance parameters that influence efficiency should also be noted with comments on the likely impact;
  - Manufacturer claimed performance in comparison to the local (and potentially other international) labeling/MEPs performance requirements[2]. Where possible, current data should be compared with available historic data;
  - Product test data in comparison with manufacturer claimed performance and the local (and potentially other international) labeling/MEPs performance requirements[2]. Where there is misalignment of claimed and required performance, attempt to identify the causes of this difference, e.g. shortcoming in the regulatory or compliance framework(s), lack of clarity in testing requirements, etc.

The goal of this Benchmarking activity is to furnish national regulators, manufacturers and other stakeholders in individual markets with sufficient information to allow:

- Comparison of the stringency of their national regulatory regime with comparable economies and international best practice and hence encourage (and provide the evidence for) strengthening of these regimes and/or the development of harmonized regional requirements where appropriate;
- Comparison of the requirements of national regulatory regimes with the manufacturer performance claims of actual products available within the individual market (and ideally historically available performance data) to establish the impact of existing regulation and any areas where compliance actions may need to be strengthened;
- Comparison of the performance of current products available across markets to provide transparent information on the potential for improvement in product performance that could be attained in national markets;
- Identification of areas where manufacturer claims do not align with actual product performance, and the underlying causes of this misalignment, to inform consideration of strengthening national (or international) standards, labelling and compliance frameworks where appropriate.

[2] Note for some regulatory agencies, and some potential funders, comparison of national product performance with non-national performance requirements is sensitive.

c) Undertake supporting testing of products:

- Where necessary and resources allow, undertake testing to support the Mapping and Benchmarking activity, particularly where there is limited national data on product performance, and/or where test data is limited to compare claimed and actual product performance.

Task 1: Project Scope: Geographic and Technical Focus

Within the context of the "knowledge requirements", it is first necessary to define a hierarchy of geographical and lamp priorities on which the study should focus. This hierarchy is based on the likelihood of yielding the greatest impact given the desire to influence the efficiency of lighting products through standards and labelling development, implementation and compliance frameworks. Given limits on resources, highest priority is placed on the fewest elements that can provide the greatest value.

1.1. Geographical Study Focus

A global study of replacement lamps is likely to be excessively costly in the short term, and excessive stretching of resources is likely to yield results that are too general for application at the local level. Therefore, there seems value in separately examining regions of potential study, and the impact additional Mapping and Benchmarking information may bring to bear in these regions. This impact may be at the point of manufacture (e.g., by raising manufacturer awareness of the regulatory framework in their customer economies) or directly by influencing the regulatory framework in the target economies.

1.1.1. Potential Regional Groupings

The most obvious breakdown is by geographic regions, i.e. broadly Asia/Australasia, North/South Africa, Europe, North America and South America. Nevertheless, there are a number of alternative options. One is segmentation by stage of economic development which is likely to influence the type, number and quality of products purchased; another is by areas with regional trade agreements and potential to influence regulatory frameworks on a pan-national basis. However, on a *very* broad scale, a geographical breakdown aligns with both regional trade organizations (ASEAN, ECOWAS, NAFTA, etc.) and general stage of economic development. Therefore, as an initial basis for analysis, geographical regions will be used as a mechanism for grouping.

1.1.2. Potential Impact of Outcomes: Lighting Energy Consumption and Savings Potential

Clearly the Mapping and Benchmarking exercise seeks to maximize outcomes, i.e. assist in the reducing the energy consumption (or slowing the growth of energy consumption) from lighting use, in this case through examining replacements of Incandescent lamps. Therefore, as an initial filter, there is obvious benefit in establishing where most savings potential lies in this action; and the potential impact such an assessment may have in these regions[3].

Fortunately, the UNEP en.lighten initiative's country lighting assessments[4] provide a data source for this analysis. These assessments provide an estimate of the energy savings potential (in 2010) from a switch to efficient lighting in 150 countries[5]. Whilst the country assessments themselves are based on a number of assumptions, and it is somewhat simplistic to assume the projected savings result only from a switch from incandescents to replacement products, the assessments provide the only

[3] Note that an alternative option would be to focus on the areas where most lighting products originate and seek to directly influence manufacturers and the quality of products they produce with the ultimate goal of increasing compliance in consumer markets. However, in order to influence manufacturers, it is first necessary to understand the regulatory frameworks of the consumer countries and the current quality of products supplied to those countries. Hence the focus on the largest consumer countries (ie those that have the most potential for manufacturers) would still be the first step in influencing the supply side. Once this mapping and benchmarking data is available, the option remains to move focus from regulators/enforcers in consumer countries to manufacturers in supply countries.

[4] United Nations Environment Programme (UNEP), 2012. On-Grid Country Lighting Assessments accessed on 25/9/2013, see: http://www.enlighten-initiative.org/CountrySupport/CountryLightingAssessments/WhataretheCountryLightingAssessments.aspx

[5] Note the EU is treated as a single country by the lighting assessments.

comprehensive global data source for such analysis and are likely to be sufficiently robust for the level of analysis necessary.

Based on the lighting assessments, Annex 1 details the potential benefits from a switch to more efficient lighting in each of the 150 countries including:

- The quantity of electricity consumed by lighting;
- Lighting electricity consumption as a percentage of total domestic electricity consumption;
- The potential energy savings from a switch to more efficient lighting as an absolute consumption measure, and as a proportion of national and global electricity consumption.

Figure 1 provides a summary of this analysis based on the geographic regions identified in the previous section. Clearly the largest lighting energy consumption and the greatest potential savings (at the national/regional and global level) are in Asia, followed by North America and Europe at broadly the same level. *Relatively* speaking, consumption and savings in Africa and South America are marginal, although the savings potential in South America is almost twice that of Africa as a whole.

However, when examining what impact may be achieved with the outputs of the mapping and benchmarking study, it seems realistic to assume that influence will be limited on the well-established regulatory development mechanism and compliance frameworks in the EU[6]. Thus, Figure 2 provides the same geographical breakdown excluding the EU and the USA. The impact of this change is to bring North America broadly in line with South America and Africa in terms of saving potential, with Europe at twice this level. However, by excluding the EU and the USA, Asia now holds 65% of the total global energy savings potential.

Even when the regional Asian giants are removed (China, Japan, Korea and India) in Figure 3, as the influence of information provided by the study may be proportionately more limited, Asia still represents well over a third of the potential global savings opportunities. The next largest is Europe, but Russia represents approximately 65% of this European total, or equivalent to the saving potential of South America.

Therefore, based only on energy savings potential of the countries where the CLASP study is most likely to have impact, the primary focus of the Mapping and Benchmarking activity should be Asia.[7] Such a focus would align with a number of existing actions being undertaken by the UNEP en.lighten initiative and the Australian Government, and build on previous activities by (among others) CLASP and USAID/ECO-Asia[6].

Nevertheless, both Africa and South America are likely to exhibit significant growth in lighting energy consumption in the near future. Further, a brief look at the en.lighten initiative's policy map demonstrates that these areas are currently lacking much of the regulatory structure necessary to effectively manage their growing lighting energy consumption. Should resources allow, additional activities could be undertaken in South America and Africa in order to provide base data to assist in the justification for and development of these regulatory structures.

---

[6] This does not preclude existing, easily accessible, performance/test data from the EU and USA being included in comparative benchmarking of product performance, or any outputs being made available to the EU and US regulatory/compliance processes. However, the Mapping and Benchmarking results will be one of many inputs to these processes and are hence likely to have proportionately lower impact that in other geographical regions where processes are less developed and less baseline information is available.

[7] Due to their size/energy consumption, the inclusion of India and China would be ideal. However, if resources are limited, it may be appropriate to exclude these countries on the basis they have already developed some national capacity. Russia may also be added to the target countries should the political situation allow. Korea and Japan should be excluded on the same basis as outlined for the EU and USA in footnote 6.

Figure 1 – Summary of lighting energy consumption and savings potential within major geographical regions

Country Name	Electricity Consumption (TWh)	Electricity Consumption by Lighting (TWh)	Lighting Consumption as a Percentage of Electricity Consumption	Lighting Electricity Consumption as a Percentage of Global Lighting Electricity Consumption	National/ Regional Efficient Lighting Saving Potential (TWh)	Lighting Savings Potential as Percentage of Lighting Electricity Consumption	Efficient Lighting Savings Potential as Percentage of Electricity Consumption	Efficient Lighting Saving Potential as Percentage of Global Efficient Lighting Saving Potential
TOTAL ALL REGIONS	18,621	2,743	14.7%	100%	957.6	34.9%	5.1%	100%
Africa	582	80	13.7%	2.9%	27.2	33.9%	4.6%	2.8%
Asia/ Australasia	7,887	1150	14.5%	41.9%	363.8	31.6%	4.6%	37.9%
Europe	4,453	660	14.8%	24.0%	258.5	39.1%	5.8%	27.0%
North America	4,792	712	14.8%	25.9%	260.3	36.5%	5.4%	27.1%
South America	905	139	15.3%	5.0%	47.7	34.2%	5.2%	4.9%

Figure 2 – Summary of lighting energy consumption and savings potential within major geographical regions excluding the EU and USA

Country Name	Electricity Consumption (TWh)	Electricity Consumption by Lighting (TWh)	Lighting Consumption as a Percentage of Electricity Consumption	Lighting Electricity Consumption as a Percentage of Global Lighting Electricity Consumption	National/ Regional Efficient Lighting Saving Potential (TWh)	Lighting Savings Potential as Percentage of Lighting Electricity Consumption	Efficient Lighting Savings Potential as Percentage of Electricity Consumption
Africa	582	80	13.7%	2.9%	27.2	33.9%	4.6%
Asia/ Australasia	7,887	1150	14.5%	41.9%	363.8	31.6%	4.6%
Europe less EU	1,352	183	13.5%	11.0%	79.6	43.4%	5.8%
North America less USA	4,792	104	13.9%	6.3%	37.6	35.9%	5.0%
South America	905	139	15.3%	5.0%	47.7	34.2%	5.2%

Figure 3 – Summary of lighting energy consumption and savings potential within major geographical regions excluding China, EU, India, Korea, Japan and the USA

Country Name	Electricity Consumption (TWh)	Electricity Consumption by Lighting (TWh)	Lighting Consumption as a Percentage of Electricity Consumption	Lighting Electricity Consumption as a Percentage of Global Lighting Electricity Consumption	National/ Regional Efficient Lighting Saving Potential (TWh)	Lighting Savings Potential as Percentage of Lighting Electricity Consumption	Efficient Lighting Savings Potential as Percentage of Electricity Consumption
Africa	582	80	13.7%	9.6%	27.2	33.9%	4.6%
Asia/ Australasia	2,285	325	14.2%	39.1%	107.1	32.8%	4.6%
Europe less EU	1,352	183	13.5%	21.9%	79.6	43.4%	5.8%
North America less USA	747	104	13.9%	12.5%	37.6	35.9%	5.0%
South America	905	139	15.3%	16.7%	47.7	34.2%	5.2%

1.1.3. Proposal

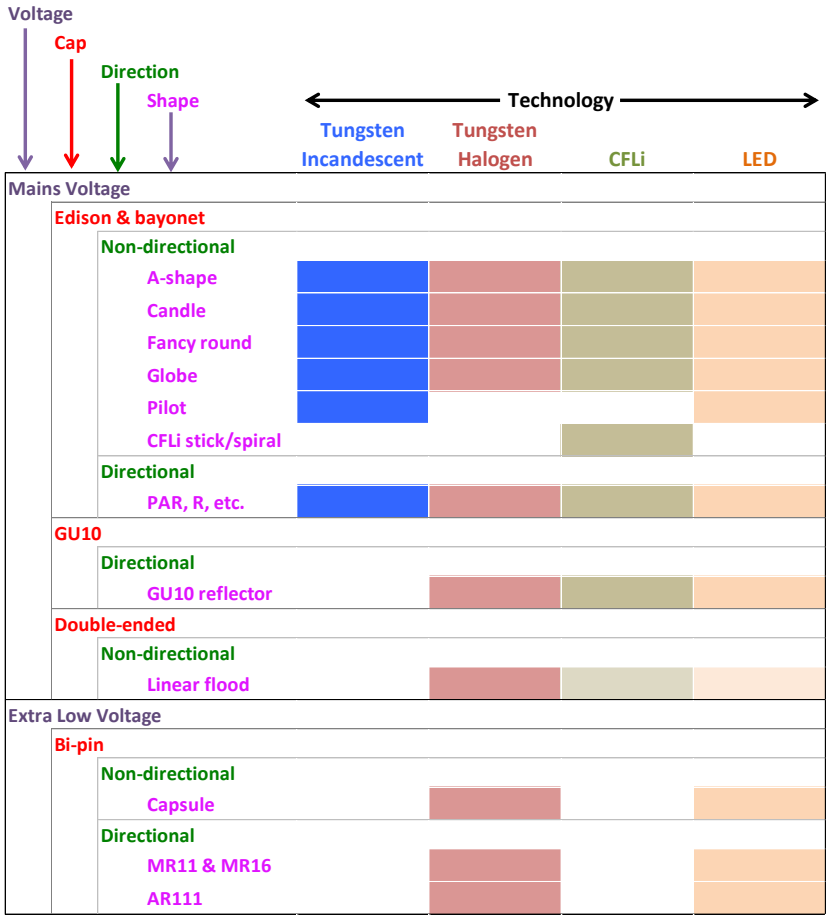
The proposed geographical scope should *primarily* focus on Asia (ideally including China and India but excluding Japan and Korea), plus Russia should the political situation allow. Should additional resources become available to CLASP, the study or subsequent studies should focus on the emerging lighting energy consumption in Africa and/or South America. Where existing, easily accessible, performance/test data from the EU, Japan, Korea and the USA is available, this should be included in comparative benchmarking of product performance.

1.2. Lamp Type and Performance Attributes

1.2.1. Lamp Technology, Shape and Size

Figure 4 lists the most common "residential" incandescent lamps (including halogen) and their CFL/LED equivalent replacements.

Figure 4 - Typical residential lamp types[8]



As can be seen, CFLs or LEDs represent a viable lamp replacement for most residential lamp types, with the exception of double-ended halogen flood lamps (although there are an increasing number of CFL/LED luminaire solutions for these).

Hence, the key questions to be answered in defining the lamp scope are stated and discussed below:

a. **Which technologies should be included in the Mapping and Benchmarking study scope?** A considerable amount is already known about incandescent and halogen lamps globally, and from the information currently available, the prevalence of halogen lamps is currently *relatively* limited in the domestic environment in much of Asia, Africa and South America. Further, the key aim of CLASP is to establish the availability, quality and performance of lamps that will offer significant energy savings by *replacing* these outdated incandescent and halogen technologies. Therefore, establishing a baseline of *relative* efficiencies of various incandescent lamps (halogen or

[8] GU24 lamps are not included in the graphic. However, the "lamp and ballast" element in GU24 lamps is identical to that in other products but with a GU24 base substituted for other types. Therefore, similar replacements are available for each application where GU24 based types are used.

otherwise) is of little value[9]. Thus, it is proposed the scope should be limited to replacement CFL/LED lamps.

b. **Should the Mapping and Benchmarking study focus only on direct-replacement "plug-and-play" lamps?** In some cases (e.g. 6" US downlights) the LED alternative to incandescent lamps may be a dedicated LED luminaire. In other cases an LED replacement solution may require a non-integral driver that needs to be "wired in". However, the realization of energy saving in the short term in most economies is reliant on cost effective "plug-and-play" replacements for existing lamps and this should be the primary focus of the study[10].

c. **Should directional lamps be included in the Mapping and Benchmarking study scope?** The Terms of Reference for this scoping study suggested that the primary scope should be omnidirectional lighting. This limitation appears to be based on the historic situation where the use of directional lighting in the domestic environment has been limited to more developed economies. However, with the growing urbanization of Asia and South America, the directional lamps popular in developed economies (e.g. in 6" downlights in the US and in MR16 downlights in Europe and Australia) are beginning to be adopted, particularly MR16 downlights. As in developed countries, use of MR16 includes specific directional applications, but these lamps are also used inappropriately for general purpose lighting. LEDs lend themselves particularly well to directional applications and are fast becoming a popular direct replacement for MR16 lamps.

   Therefore, as omnidirectional lamps will remain the dominant light source for domestic purposes for some time (and hence the area of maximum potential energy saving), omnidirectional lighting should continue to be the primary focus of the study. However, should resources allow, it is proposed that MR16 replacement lamps are included within the study if their availability in target markets is confirmed at the mapping stage.

d. **What size lamps should be included in the Mapping and Benchmarking study scope**? Ideally the Mapping activity should seek to characterize the entire omnidirectional Incandescent replacement market where possible, i.e. omnidirectional CFLi and LED replacements for omnidirectional Incandescent lamps in the 25-100W (250lm – 1200lm at 230V) range. Such an approach would capture typical replacements for all the major "incandescent wattage" ranges, i.e. 25W, 40W, 50W, 60W, 75W, 100W, but would avoid capturing larger non-residential lamps and smaller pilot lamps not used for general purpose illumination.

   However, attempting to study such a spread of lumen outputs would be onerous. Thus, pending confirmation from the Mapping activities, it is proposed that the primary performance comparisons undertaken in the Benchmarking are limited to 40W and 60W incandescent replacement products (i.e. in the 300lm-800lm) range as these are likely to be the most common products in use, and hence likely to represent the largest savings potential. Note however that lamps that *claim* to be replacements for 40W and 60W incandescent lamps should be captured,

---

[9] Note there is opportunities to improve the efficiency of halogen lamps in many countries, particularly those operating on 110/120V, e.g. by the addition of infra-red coatings. However, the improvements in efficiency is *relatively* small compared to the gains available from a switch to CFLs and LEDs of reasonable quality.

[10] Nevertheless there is rapid urbanization in many of the countries within the Asia, Africa and South American regions, and with it more development of building stock than in much of Europe and North America. This creation of new buildings offers the potential for "fully wired" and/or "integral luminaire" application of alternative technologies (in particular LEDs) without the need for plug-and-play retrofit solutions required elsewhere, and the inherent benefit of no switch back to incandescent lighting. There is also the potential to develop building regimes that offer integrated solutions such as off-grid solar/building lighting systems. A number of international organizations/activities are already working in this field but their activities are limited. Hence, while not within the core information requirement for this Mapping and Benchmarking study, should resources become available, there is value in CLASP commissioning an additional scoping study looking more deeply into how building design/construction in Asia, Africa and South America might be influenced to enable accelerated adoption of newer technologies without the need for the plug-and-play interim solutions necessary elsewhere.

even if those have lumen outputs less than 300lm or greater than 800lm. If resources allow, it would also be beneficial to test a smaller number of larger lamps - i.e. replacements for 75W and 100W incandescent lamps.

Should it be possible to include MR16 lamps in the study, it would be beneficial to target lamps that claim to be replacements for 35W and 50W MR16 halogen lamps, particularly those (mis)used for general purpose illumination. This is likely to include lamps with light outputs in the 100-900lm range, with a wide range of beam angles (noting that beam angle is not critical for general purpose illumination).

e. **What shape lamps should be included in the Mapping and Benchmarking study scope?** As Figure 4 illustrates, incandescent lamps come in a large number of physical shapes and sizes. For omnidirectional incandescent lamps, the particular shape makes very little difference to the overall performance of the lamp (light output, color, lifetime, etc.). Further, for incandescent lamps, the only key variable is if the lamp is clear or opaque, with opaque leading to slightly lower light output.

   Again as can be seem in Figure 4, there are CFL and/or LED replacement lamps for almost all shapes of lamp. However, these replacements are primarily limited to opaque lamps[11], and other variables become factors which may impact the performance of the lamps over the medium and long term operation, and/or the acceptability of the lamp to the consumer (e.g. heat dissipation for LEDs and physical size for CFLs affecting light output, distribution, etc.). Whilst investigation of the impact of shape on all these potential performance issues would be beneficial in terms of the information requirements specified above, it seems impracticable to investigate in any depth within the likely resource availability.

   Therefore, it is proposed that the Mapping activities attempt to characterize the market shape and size, but the Benchmarking study focuses on the likely most prevalent lamp types, i.e. opaque A-shape replacements (to be confirmed by the Mapping activities) and MR16 if resources allow.

f. **What lamp cap type should be covered in the Mapping and Benchmarking study scope?** There are a wide variety of cap types employed in omnidirectional lamps across Asia, in many cases several types within one dwelling. As there is generally no performance impact related to cap type in the 40-60W replacement range, both Edison screw and bayonet capped lamps should perform similarly and either/both can be included in the study.

1.2.2. Lamp Performance Attributes

Historically consumers have purchased incandescent lamps based on wattage (or more recently in some areas equivalent wattage halogens), with the key performance parameters limited to light output, efficiency, lifetime and, to a lesser degree, color. In recent years, efforts have been made, including on some labels, to move consumers toward light output (lumens), in order to encourage fair comparison across different lighting technologies.

However, due to their intrinsic design and operation, a number of other interdependent performance attributes of CFLs and LEDs become important for consumer acceptance and functional energy savings. In particular:

- Start-up time and warm-up time (relevant primarily to CFLs but some LEDs)

[11] Currently the majority of CFL and LED replacement lamps are primarily replacements for opaque incandescents as they lack the "sparkle" of clear filament lamps. While some recent LED developments have attempted to address the "sparkle" issue with optical solutions, these are currently limited and the lack of suitable products is restricting the drive to more efficient products in a number of economies. Consequently, CLASP may wish to consider future research activity to establish the extent of current (and soon to be available) LED lamps that address this issue to inform policy makers of developments in this area.

- Initial light output and efficiency
- Maintained light output and efficiency
- Color temperature
- Color rendering
- Color stability
- Color distribution
- Lifetime
- Flicker
- Luminous intensity distribution (relevant primarily to LEDs in non-directional applications)
- Dimming Capability
- [Mercury content[12]]

Given the interdependence of these variables, it is important to consider all when examining comparison of test standards, regulation and ideally lamp comparisons/compliance with regulations. However, should access to lamp data be limited in individual countries and testing data is required, it is possible that testing for all parameters would be exceedingly costly. Therefore, in an attempt to minimize costs yet still yield sufficient data for a meaningful comparison of lamp performance, it is proposed that the parameters highlighted in Figure 5 are measured at a minimum. Should additional resources be available, significant extra value would be achieved through the measurement of maintained efficacy and lifetime (or potentially failure rate at point of maintained efficacy tested).

It is worth noting there is currently discussion on whether the CRI measurement for LEDs has meaning. There is ongoing research in this area, including at the National Institute of Standards and Technology and the Lighting Research Centre in the USA, in particular on the development of a Color Quality Scale. However, at present there is little alternative at present than to use CRI as a color measurement for LEDs.

Should plug-and-play MR16 replacements be included in the study, it would be useful to additionally measure luminous intensity distribution (as for LEDs) as well as to make some assessment of their compatibility with incumbent transformers and dimmers.

Note, it is important to ensure that comparisons of the efficiency of lamps within each “incandescent wattage” replacement bin are limited to lamps of the same rated color temperature.

[12] Mercury content is not in itself a performance measure, but in some countries is increasingly important in regulation and/or consumer acceptance.

Figure 5 Primary lamp performance attributes to be measured if lamp testing is required

Performance Parameter	CFL	LED	MR16 replacements
Initial light output	X	X	X
Initial watts (calculate efficacy)	X	X	X
Maintained light output	X[13]	X[13]	X
Maintained watts (calculate efficacy)	X[13]	X[13]	X
Color temperature	X	X	X
Color rendering	X	X	X
Maintained color temperature	X[13]	X[13]	
Maintained color rendering	X[13]	X[13]	
Luminous intensity distribution		X	X
Start-up time	X[13]	X[13]	
Run-up time	X[13]	X[13]	
Flicker			
Lifetime	X	X	
Dimming / transformer capability			X
Mercury content			

1.2.3. Proposal

The proposed technical scope of the study is as follows:

- Lamp types under review will be limited to omnidirectional LED and CFL lamps with integral ballasts/drivers resulting in "plug-and-play" replacements of incandescent lamps in mains voltage applications. Plug-and-play MR16 lamps can also be studied if resources allow.
- For Mapping activities, characterization of the market should attempt to include lamps of all shapes (A-shape, fancy round, candle, globe, stick, etc.). However, for the Benchmarking, primary analysis will focus on opaque A-shape replacement products, although this shape selection should be confirmed as having the highest market presence at the Mapping Stage. Lamp cap is not considered of importance in the study. Plug-and-play MR16 lamps can also be studied if resources allow.
- For Mapping activities, the primary focus is limited to LED and CFL lamps replacing 25W, 40W, 60W, 75W and 100W Incandescent lamps. For Benchmarking activities, the primary comparison of performance will be undertaken on lamps replacing 40W and 60W incandescent lamps (350lm-800lm), although this smaller range should be confirmed as having the highest market presence at the Mapping Stage. Plug-and-play MR16 lamps can also be studied if resources allow.
- The performance attributes of most importance to consumer acceptance and regulatory rigor that are to be included in comparisons are shown in Figure 6. Should testing be required and resources limited, product performance data could be limited to those parameters

[13] Due to the requirement for high-speed sensors, the measurement of start-up and run-up time for LEDs and CFLs have a marginal additional cost (5-10% of the "initial tests" costs). Where possible these tests should also be included as they are important elements of consumer acceptance in some markets. However, if resources are extremely limited, these parameters may be excluded. The lamp aging and testing costs for maintained lumen output and wattage (and hence maintained efficacy) and maintained characteristics are broadly equal to the cost of the aging and testing of initial performance parameters. Again these maintained performance parameters are important from the consumer perspective (i.e. will the lamp provide appropriate illumination into the future?), but are also important for regulators to understand the practical lifetime of the products when undertaking economic analysis of regulations. Therefore, the inclusion of these tests is preferred, but not of primary importance.

highlighted in the “test” columns for both CFLs and LEDs (items marked with a * are highly desirable, but again may be discarded if resources are particularly limited).

Figure 6 Primary lamp performance attributes to be evaluated

Performance Parameter	CFL		LED	
	Ideal Comparison	Minimum Parameters for Lamp Testing	Ideal Comparison	Minimum Parameters for Lamp Testing
Initial light output	X	X	X	X
Initial watts (calculate efficacy)	X	X	X	X
Maintained light output	X	X*	X	X*
Maintained watts (calculate efficacy)	X	X*	X	X*
Color temperature	X	X	X	X
Color rendering	X	X	X	X
Maintained color temperature	X	X*	X	X*
Maintained color rendering	X	X*	X	X*
Luminous intensity distribution			X	X
Start-up time	X	X*	X	X*
Run-up time	X	X*	X	X*
Flicker			X	
Lifetime	X	Lifetime or Failure rate to point of maintained efficacy test*	X	Lifetime of Failure rate to point of maintained efficacy test*
Dimming capability	X		X	
Mercury content	X			

- Comparisons of the efficiency of lamps within each “incandescent wattage” replacement bin are limited to lamps of the same rated color temperature.

Should sufficient resources be available for the inclusion of comparison of MR16 replacement lamps, this technical scope should be extended to include:

- Luminous intensity distribution (as for LEDs)
- Compatibility with incumbent transformers and dimmers.

Task 2: Data Sources, Activities, Potential Limitations and Mitigation Strategies

The objective of this task is to identify as many relevant sources of information as possible that meet the "Knowledge Requirements" specified in the introduction, and develop a practical approach to the Mapping and Benchmarking activities within this data limitation. Further, an initial attempt has been made to note areas where data sourcing (or analysis) may be difficult or unnecessarily costly given the benefit of the knowledge obtained, and potential mitigation strategies.

2.1. National market sizes and trends

For the more developed economies, the structure and quantitative breakdown of products available/sold and installed is generally available in published reports and analysis, often as part of the analysis for regulatory purposes (e.g. from the US DoE rulemakings, the European Union EUP/ERP[14] process, etc.). To some extent this is also true in the less developed economies that form a large proportion of the target economies. However, in the latter case, these market analyses are often less robust and less prevalent. National statistics offices (e.g. Eurostat[15] and the National Bureau of Statistics of China[16]) and national lighting associations/bodies (e.g. Abilux[17] CALI[18] and ELCOMA[19]) are also potential sources. Limited data is also available from the country/regional reports produced by the UNEP en.lighten initiative[20], USAID Eco-Asia[21], BRESL[22], the IEA 4E Mapping and Benchmarking Annex[23] and lites.asia[24].

Unfortunately there is likely to be significant difficulty in accessing some of these data sources (e.g. those held by lighting associations), drawing together and aligning conflicting values from the diverse sources, and addressing other issues, in particular dealing with the potential need for translations of local language. However, as the primary function of this element of study is to confirm the appropriate scope of study (lamp sizes, shapes and color temperatures), there seems little value in expending extensive resources on the mapping of individual market sizes/trends. Therefore, it is proposed that a summary review of known sources is undertaken to prepare very brief national summary information, primarily identifying popular lamp sizes, shapes and color temperatures and confirming these through national bodies (government sources, trade associations and NGOs) where possible. Of particular interest is the extent to which target countries are transitioning to halogen, CFL and LED.

2.1.1. Proposal

National market studies should be undertaken *only* for those countries where product performance data is available, and Mapping and Benchmarking activities will be undertaken (refer to Section 2.2).

National market sizes and trends should be analyzed based on known and easily available sources. Very brief summary information is required, primarily the extent to which target countries are transitioning to halogen, CFL and LED, and for identifying popular lamp sizes, shapes and color

[14] eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:076:0003:0016:en:PDF
[15] http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home
[16] http://www.stats.gov.cn/english/
[17] http://www.abilux.com.br/portal/eng/
[18] http://www.cali-light.com/index.html
[19] http://www.elcomaindia.com/
[20] http://www.enlighten-initiative.org/ResourcesTools/Publications.aspx (see regional reports)
[21] http://eco-asia.org/
[22] http://bresl.com/
[23] http://mappingandbenchmarking.iea-4e.org/matrix?type=product&id=5
[24] http://www.lites.asia/library

temperatures). This information is needed so that the defined scope of products (and/or product test results available) broadly reflects the key products in each market. Where possible, the summaries of markets should be confirmed through national bodies (government sources, trade associations and NGOs).

2.2. Product performance data (both manufacturer claimed and test data) to demonstrate the efficiency of products currently being sold

- Product performance data is critical to the success of the project. There are three *primary* sources for such data: **National product registers,** both mandatory such as Australia, Canada, Korea, and Vietnam, and voluntary initiatives such as US ENERGY STAR[25]. Mandatory national registries provide the most comprehensive data source available for a particular market, but with the exception of Australia[26] few are actually directly accessible[27]. Further, this data suffers from the issue above, i.e. a registered product may not be sold in significant numbers, and in many cases only details *currently* registered products and hence any historical trends in product quality will not be evident.
- **Publically available (or accessible) product test/performance reports** clearly provide a significant data source. Specific sources may be full data sets from past, ongoing and planned testing (or any testing CLASP undertakes as part of this activity), or reports analyzing such data. The preference is for source test data as this can be analyzed as required. However, reports (e.g. Eco-Asia's "Confidence in Quality"[28]) can offer valuable background and historic trend information.
- **Manufacturer websites and catalogues:** To provide a truly comprehensive picture of product availability and claimed performance in individual countries, a thorough review of all manufacturer source data would be applicable. However, while web-crawling technologies are now available, time taken to source such data across a significant number of countries (e.g. the Asian region) is likely to be excessive, and it would be challenging to achieve any quantitative understanding of whether the data collected was representative of the market – many products are available, but not all are sold in significant numbers. Other issues would also be challenging and potentially resource intensive, again language in particular. Therefore it is suggested manufacturer data is used as secondary source only (e.g. to confirm claims made on packaging of products under test).

2.3. Test methodologies (national and international)

Annex 2 provides a listing of a significant proportion of test methods for CFLs, LEDs and MR16 lamps in use around the world. A provisional analysis of these test methods undertaken as part of this scoping (drawing heavily on previous work undertaken in particular by ECO-Asia, lites.asia[29], and the IEA 4E SSL Annex) suggests:

- **For omnidirectional CFLs:** The vast majority of countries have a CFL test method in place, and in most of these cases, the local test methods are based on IEC 60969; be it as a clone or in some modified form. The particular version of the IEC standard adopted varies, and in some cases some parameters are not tested (e.g. the start-time/warm-up tests have only been

[25] http://www.energystar.gov/productfinder/
[26] http://reg.energyrating.gov.au/comparator/product_types/
[27] Although in some cases CLASP may be able to able to seek access to this data directly or through SEAD
[28] Confidence in Quality: Harmonization of CFL to Help Asia Address Climate Change, USAid ECOAsia, 2007
[29] Efficient Lighting in Asia: Regional position paper on current status, opportunities and constraints, available at (http://www.lites.asia/downloads/lites-asia-position-paper)

added to *relatively* recent redrafts of the standard). However, where parameters are tested, the resulting outcomes should be comparable in general – however checks should be made on the specific conditions and any variation from the "standard" IEC methodology.

In a lesser number of cases, the IESNA LM-66-11 test method is employed, almost always directly or as a clone. However, the IEC and IESNA test methods differ little in practical terms in the raw performance results they return from the testing, with the exception of switch withstand where the "aging" cycle times differ which can lead to substantially differing outcomes.

Therefore, where comparisons are being undertaken, IEC 60969 (draft 2013) should be used as the base, and any new omnidirectional CFL tests undertaken should follow this standard.

- **For omnidirectional LEDs:** The picture of LEDs is less clear. Firstly a significant number of countries have yet to adopt LED omnidirectional test methodologies of any kind. Further, even where countries have adopted LED test measures, there appears to be little obvious consistency, although many are broadly based around IES LM-79[30]. While a number of test methods have been brought together under a new CIE/IEC methodology, this is yet to be formally made public, and it is highly unlikely that any existing or current testing/reporting follows this methodology exactly.

  Fortunately, the IEA 4E SSL Annex has undertaken a comprehensive study of the majority of test methods used internationally[31] and there seems little necessity to reproduce this comparison work. Further, given the breadth of the SSL Annex analysis, for the benchmarking activities, it should be sufficient to identify what test methodology was used for any specific data set under consideration and refer to the SSL Annex analysis for details of the conditions and difference with tests elsewhere. In some cases (e.g. temperature variation), conversion/correction factors are offered, but in other cases no conversions/equivalents have been proposed (e.g. where tests of light distribution have not been undertaken, direct comparison of efficiency between lamps will be less meaningful). However, consultation with experts suggests there are no viable mechanisms to deal with these issues, and results should be reported and compared as tested, but differences clearly stated.

  Should additional omnidirectional LED tests be undertaken, and in the absence of a finalized CIE/IEC combined methodology, it is proposed that the combined 4E SSL Annex's test method is used given the attempt to combine the various existing test methodologies into a single, coherent test method.

- **For comparisons of omnidirectional CFLs to LEDs:** In general the results of tests on the performance parameters of LEDs and CFLs should be *broadly* similar, irrespective of the test methodology used, although be a degree of variance (e.g. due to spectral differences between CFLs and LEDs). However, within the context of this mapping and benchmarking exercise (as defined by the knowledge requirement), the key issue is whether the products are delivering a service that allows them to form a cost effective replacement for Incandescent lamps, and if so, which might be the better solution. Thus, a small variance (for example 5%) in the measurement of a particular parameter is unlikely to be of critical importance. As long as they are *broadly* comparable, then it should be possible to discern if the available products are similar (i.e. within or near variance value), or one is clearly superior to the other.

---

[30] IESNA LM-79-08 Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products.

[31] See http://ssl.iea-4e.org/ssl-existing-standards, and in particular Annex A of "Solid State Lighting Annex: Interlaboratory Comparison Test Method" available at ssl.iea-4e.org/files/otherfiles/0000/0051/SSL_Annex_2013_IC_Test_Method_v.1.0.pdf.

- **For directional MR16 replacements:** For directional lamps, where luminance distribution is not required, the integrating sphere methods contained in IESNA test methods are considered appropriate (e.g. LM-79 for LEDs). Sphere testing is significantly less expensive than goniophotometer testing, however a goniophotometer is required in order to test for luminance distribution. As tested lamps are all likely to be LEDs, and the cost of goniophotometer testing in order to test luminance distribution is not considered justified, it is suggested that (in the absence of a finalized CIE/IEC methodology) the 4E SSL Annex's *sphere* test method be used.

2.3.1. Proposal

If testing is undertaken, the base test methods to be used for comparison of product performance should be the 2013 Committee Draft Version of IEC 60969 for CFLs; and the IEA 4E "Solid State Lighting Annex: Interlaboratory Comparison Test Method" for LEDs. Checks will be undertaken to ensure actual test results (and manufacturer declarations) follow these procedures, and where not the case, specific deviations should be noted. However, where impact of deviation is considered to result in a variance from the "standard" test of less than 5%, results should be considered comparable both for lamps of the same type, and in comparison of LED and CFL results.

If testing is undertaken for MR16 (LEDs) the *sphere* methods from the IEA 4E "Solid State Lighting Annex: Interlaboratory Comparison Test Method" for LEDs should be used.

2.4. Voluntary and Mandatory Performance Measures (Mapping and Benchmarking)

There has been extensive analysis and comparison of the voluntary and mandatory performance measures in place for both CFLs and LEDs (ECOAsia, IEA 4E Mapping and Benchmarking and SSL Annexes, lites.asia, en.lighten, etc.). Consequently, in general there seems little value in repeating this relatively costly data collection and analysis exercise; either for individual countries (Mappings) or for comparisons between countries (Benchmarking). However, for the Benchmarking of product performance, in-depth investigations of the individual standards, labelling and *compliance* regimes should be undertaken and reported for each of the economies from which product test data is to be analyzed. This will be necessary in order to establish the degree of comparability of results, compliance with national requirements and relative to international benchmark performance levels, and to identify the potential underlying reasons for difference in performance between economies.

Where there appears to have been significantly less study is a comparison of the voluntary and mandatory performance measures for CFLs and LEDs *relative to each other*, i.e. are demands being placed on one type of product that are not being placed on the other, and does this have any impact in terms of development of the products/industries, and balance supply side market competition and consumer acceptance? These appear to be very important issues that are worthy of in-depth study, and should resources allow, CLASP may wish to commission research into these issues in the future.

2.4.1. Proposal

In-depth investigations of the individual standards, labelling and *compliance* regimes (including all associated performance requirements) should be undertaken and reported for each of the economies from which product test data is to be analyzed. Should resources allow, a relative comparison of performance requirements between CFLs and LEDs should be undertaken.

2.5. Mapping and Benchmarking of Product Performance

Referring once more to the knowledge requirements (and analysis in relation to the test and standards labelling and compliance regimes identified in Sections 2.3.1 and 2.4.1), comparison of product performance is required to

- Establish if manufacturer claims align with actual product performance, and whether the degrees of alignment differ between economies, and the potential reasons for this variance.
- Establish if the performance of products within individual economies complies with any national performance requirement (mandatory or voluntary standards and labels), whether this "compliance rate" differs between economies, and the potential reasons for this variance.
- Where a time series of results are available for an individual economy, map the evolution of product performance over time and seek to identify the causes of this evolution.
- Establish the degree of variance between the performance of products *between* economies, and the potential reasons for this variance.
- Establish the levels of performance of products from all economies with respect to international benchmark performance levels (as noted above, provisionally, the international benchmarking standards to be used are the CFL performance tiers recently proposed to the IEC as a technical specification[32], and the 4E SSL performance tiers for LEDs).

The following proposal seeks to define the specific analyses required to obtain this information.

2.5.1. Proposal

Comparisons should be undertaken of the sourced product test results (refer to Section 2.2) and any additional testing commissioned by CLASP. Benchmarking analysis of results should be undertaken against the performance criteria identified in Figure 6 and in wattage/ lumen/shape bins appropriate to the data available (refer to Section 1.2.3). Analysis of performance within and between economies should be undertaken in in relation to the standards labelling and compliance regimes identified in Section 2.4.1.

Comparisons, preferably graphical, should include, at a minimum:

- **For each individual lamp type (i.e. CFL, LED and if available, MR16 replacements):**
    - Most recent test results from individual economies relative to the manufacturer declarations for those products and the extent of variance;
    - Most recent test results from individual economies against any national performance requirement (mandatory or voluntary standards and labels), both for individual performance parameters and against the requirements as a whole, and the degree of national compliance where standards are mandatory;
    - Where a time series of test results are available for an individual economy, the results of tests across the time periods to establish the evolution of product performance over time;
    - Most recent test results for all economies, as direct comparisons, and against international benchmark standards, both for individual performance parameters and against the requirements as a whole. (Provisionally, the international benchmarking standards to be used are the CFL performance tiers recently proposed to the IEC as a technical specification[33], and the 4E SSL performance tiers for LEDs)[34].
    - In each case, efforts should be made to compare the degrees of variance between results in relation to the individual standards, labeling and compliance regimes in place.

[32] 34A/1754/NP PNW 34A-1754: Self-ballasted compact fluorescent lamps for general lighting services - Performance limits
[33] 34A/1754/NP PNW 34A-1754: Self-ballasted compact fluorescent lamps for general lighting services - Performance limits
[34] Note for some regulatory agencies, and some potential funders, comparison of national product performance with non-national performance requirements is sensitive. CLASP, and any contractor undertaking the comparison work, need to be cognizant of such sensitivities and discuss directly with the individual partner concerned.

- **For both CFLs and LEDs:**
    - Most recent test results from individual economies as direct comparisons.

      As noted in previous sections, all analysis should note specific differences in the sampling methodologies, test procedures and performance parameters (both measured and regulated) and other pertinent variables.

Task 3: Key Qualifications to Undertake the Mapping and Benchmarking Project

The recommended *demonstrable* key qualifications and experience of personnel to undertake the mapping and benchmarking study are as follows:

Primary qualifications/experience

- Technical understanding of lamps and lamp testing regimes for incandescent, halogen, CFL and LED.
- Experience in analyzing lamp test results, including mathematical analysis of results, variance analysis and evaluation of potential skew.
- Experience in undertaking energy efficiency mapping and benchmarking activities across a number of economies.

Ideal additional qualifications/experience

- Established network contacts with regulators, trade associations and/or NGOs in key target economies.
- Ability to communicate well with stakeholders from a range of countries/cultures and recognize and respond to politically sensitive issues.

Annex 1: Regional Electrical Consumption, Lighting Electrical Consumption and Lighting Saving Potential

The following information is based on an analysis of the UNEP's On-Grid Country Lighting Assessments[4]. The country lighting assessments provide an estimate of the energy savings potential in 2010 from a switch to efficient-lighting in 150 countries. These country-level savings estimates are calculated from the difference in energy consumption between the installed stock of lamps in 2010, and the complete (overnight) conversion of that same stock to energy-efficient lamps.

Country Name	Electricity Consumption (TWh)	Electricity Consumption by Lighting (TWh)	Lighting Consumption as a Percentage of Electricity Consumption	Lighting Electricity Consumption as a Percentage of Global Lighting Electricity Consumption	National/ Regional Efficient Lighting Saving Potential (TWh)	Lighting Savings Potential as Percentage of Lighting Electricity Consumption	Efficient Lighting Savings Potential as Percentage of Electricity Consumption	Efficient Lighting Saving Potential as Percentage of Global Efficient Lighting Saving Potential
TOTAL ALL REGIONS	**18,621.67**	**2,743.22**	**14.73%**	**100.00%**	**957.616**	**34.91%**	**5.14%**	**100.000%**
Africa Total	**582.961**	**80.040**	**13.73%**	**2.918%**	**27.209**	**33.99%**	**4.67%**	**2.841%**
South Africa	230.891	23.992	10.4%	0.875%	8.53	35.57%	3.70%	0.891%
Egypt	130.654	19.373	14.8%	0.706%	6.40	33.04%	4.90%	0.668%
Libya	27.868	6.077	21.8%	0.222%	2.01	33.04%	7.20%	0.210%
Algeria	34.999	5.250	15.0%	0.191%	2.17	41.33%	6.20%	0.227%
Morocco	25.389	5.088	20.0%	0.185%	1.69	33.13%	6.64%	0.176%
Nigeria	19.743	4.256	21.6%	0.155%	1.38	32.49%	7.00%	0.144%
Tunisia	14.100	2.993	21.2%	0.109%	0.99	33.04%	7.01%	0.103%
Zimbabwe	12.904	1.838	14.2%	0.067%	0.43	23.64%	3.37%	0.045%
Ghana	6.483	1.285	19.8%	0.047%	0.37	29.06%	5.76%	0.039%
DR Congo	7.086	1.004	14.2%	0.037%	0.33	32.49%	4.60%	0.034%
Cameroon	5.865	0.787	13.4%	0.029%	0.26	32.71%	4.39%	0.027%
Cote d'Ivoire	4.183	0.780	18.6%	0.028%	0.25	32.49%	6.06%	0.026%
Zambia	7.765	0.722	9.3%	0.026%	0.25	34.45%	3.21%	0.026%
Angola	4.174	0.715	17.1%	0.026%	0.24	33.04%	5.66%	0.025%
Kenya	6.148	0.685	11.1%	0.025%	0.22	32.49%	3.62%	0.023%
Ethiopia	4.006	0.605	15.1%	0.022%	0.19	32.07%	4.85%	0.020%
Mauritius	2.234	0.580	26.0%	0.021%	0.19	32.27%	8.38%	0.020%
Tanzania	4.081	0.511	12.5%	0.019%	0.17	34.19%	4.28%	0.018%
Namibia	3.891	0.473	12.2%	0.017%	0.17	36.22%	4.40%	0.018%
Botswana	3.154	0.463	14.7%	0.017%	0.18	37.95%	5.57%	0.018%
Senegal	2.402	0.414	17.2%	0.015%	0.13	32.49%	5.60%	0.014%
Uganda	1.958	0.348	17.8%	0.013%	0.09	25.03%	4.45%	0.009%
Gabon	1.483	0.252	17.0%	0.009%	0.08	32.92%	5.59%	0.009%
Madagascar	1.032	0.170	16.5%	0.006%	0.05	27.72%	4.58%	0.005%
Malawi	1.559	0.161	10.3%	0.006%	0.04	27.41%	2.83%	0.005%
Swaziland	1.207	0.147	12.2%	0.005%	0.05	36.21%	4.41%	0.006%
Benin	0.839	0.121	14.5%	0.004%	0.04	29.16%	4.22%	0.004%
Guinea	0.856	0.103	12.1%	0.004%	0.03	32.49%	3.92%	0.004%
Burkina Faso	0.684	0.102	15.0%	0.004%	0.03	29.87%	4.48%	0.003%
Mali	0.456	0.102	22.4%	0.004%	0.03	32.49%	7.29%	0.003%
Mozambique	10.853	0.101	0.9%	0.004%	0.03	31.52%	0.29%	0.003%
Mauritania	0.509	0.082	16.0%	0.003%	0.03	33.43%	5.36%	0.003%
Togo	0.655	0.076	11.7%	0.003%	0.02	32.49%	3.79%	0.003%
Niger (the)	0.626	0.070	11.1%	0.003%	0.02	28.72%	3.19%	0.002%
Eritrea	0.258	0.049	18.9%	0.002%	0.02	32.49%	6.13%	0.002%
Liberia	0.312	0.044	14.2%	0.002%	0.01	32.49%	4.60%	0.001%
Djibouti	0.260	0.034	13.1%	0.001%	0.01	32.49%	4.25%	0.001%
Lesotho	0.236	0.033	13.9%	0.001%	0.01	35.76%	4.97%	0.001%

Country Name	Electricity Consumption (TWh)	Electricity Consumption by Lighting (TWh)	Lighting Consumption as a Percentage of Electricity Consumption	Lighting Electricity Consumption as a Percentage of Global Lighting Electricity Consumption	National/ Regional Efficient Lighting Saving Potential (TWh)	Lighting Savings Potential as Percentage of Lighting Electricity Consumption	Efficient Lighting Savings Potential as Percentage of Electricity Consumption	Efficient Lighting Saving Potential as Percentage of Global Efficient Lighting Saving Potential
Burundi	0.273	0.031	11.2%	0.001%	0.01	28.36%	3.17%	0.001%
Rwanda	0.237	0.030	12.6%	0.001%	0.01	32.49%	4.11%	0.001%
Gambia	0.205	0.023	11.1%	0.001%	0.01	23.83%	2.65%	0.001%
Chad	0.093	0.020	21.6%	0.001%	0.01	32.49%	7.02%	0.001%
Central African Republic	0.149	0.016	10.4%	0.001%	0.01	32.49%	3.39%	0.001%
Sierra Leone	0.054	0.012	22.8%	0.000%	0.00	32.49%	7.40%	0.000%
Equatorial Guinea	0.086	0.012	14.3%	0.000%	0.00	33.04%	4.71%	0.000%
Guinea-Bissau	0.065	0.009	14.5%	0.000%	0.00	32.49%	4.71%	0.000%
Asia/ Australasia Total	**7887.598**	**1150.986**	**14.59%**	**41.958%**	**363.800**	**31.61%**	**4.61%**	**37.990%**
China	3846.231	607.245	15.8%	22.136%	184.80	30.43%	4.80%	19.298%
India	749.061	113.870	15.2%	4.151%	41.28	36.25%	5.51%	4.310%
Japan	1006.318	104.035	10.3%	3.792%	30.60	29.41%	3.04%	3.195%
Republic of Korea	458.534	47.232	10.3%	1.722%	14.32	30.32%	3.12%	1.495%
Australia	248.766	43.873	17.6%	1.599%	11.76	26.81%	4.73%	1.228%
Saudi Arabia	207.725	34.245	16.5%	1.248%	10.90	31.82%	5.25%	1.138%
Iran (Islamic Republic of)	169.593	29.556	17.4%	1.077%	10.72	36.29%	6.32%	1.120%
Indonesia	147.962	22.194	15.0%	0.809%	9.35	42.12%	6.32%	0.976%
Thailand	146.666	18.211	12.4%	0.664%	6.54	35.92%	4.46%	0.683%
Malaysia	105.431	17.550	16.6%	0.640%	5.74	32.72%	5.45%	0.600%
Viet Nam	85.498	12.033	14.1%	0.439%	4.26	35.42%	4.98%	0.445%
Pakistan	74.350	11.560	15.5%	0.421%	4.06	35.10%	5.46%	0.424%
United Arab Emirates	86.928	9.145	10.5%	0.333%	2.91	31.82%	3.35%	0.304%
Kuwait	48.735	8.637	17.7%	0.315%	2.67	30.96%	5.49%	0.279%
Philippines	55.619	8.343	15.0%	0.304%	3.51	42.12%	6.32%	0.367%
Israel	52.741	7.848	14.9%	0.286%	2.27	28.93%	4.30%	0.237%
New Zealand	40.718	7.017	17.2%	0.256%	2.23	31.74%	5.47%	0.233%
Uzbekistan	45.188	5.456	12.1%	0.199%	1.66	30.43%	3.67%	0.173%
Iraq	30.290	5.361	17.7%	0.195%	1.76	32.84%	5.81%	0.184%
Bangladesh	39.542	5.197	13.1%	0.189%	1.87	35.99%	4.73%	0.195%
Syrian Arab Republic	32.702	4.850	14.8%	0.177%	1.59	32.84%	4.87%	0.166%
Singapore	41.069	4.402	10.7%	0.160%	1.55	35.21%	3.77%	0.162%
Qatar	25.153	2.888	11.5%	0.105%	0.87	30.21%	3.47%	0.091%
Lebanon	13.299	2.709	20.4%	0.099%	0.89	33.04%	6.73%	0.093%
Oman	16.212	2.335	14.4%	0.085%	0.76	32.62%	4.70%	0.080%
Jordan	13.638	2.172	15.9%	0.079%	0.64	29.31%	4.67%	0.066%
Turkmenistan	12.796	2.015	15.7%	0.073%	0.62	30.63%	4.82%	0.064%
DPR of Korea	17.995	1.744	9.7%	0.064%	0.53	30.43%	2.95%	0.055%
Bahrain	11.557	1.429	12.4%	0.052%	0.45	31.15%	3.85%	0.046%
Tajikistan	13.467	1.285	9.5%	0.047%	0.39	30.21%	2.88%	0.041%
Sri Lanka	8.380	1.257	15.0%	0.046%	0.56	44.62%	6.69%	0.059%
Yemen	5.624	1.014	18.0%	0.037%	0.28	28.11%	5.07%	0.030%
Kyrgyzstan	6.811	0.761	11.2%	0.028%	0.23	30.21%	3.38%	0.024%
Myanmar	5.185	0.743	14.3%	0.027%	0.26	35.52%	5.09%	0.028%
Nepal	2.705	0.575	21.2%	0.021%	0.19	33.79%	7.18%	0.020%
Mongolia	4.078	0.531	13.0%	0.019%	0.16	30.43%	3.96%	0.017%
Brunei Darussalam	3.419	0.456	13.3%	0.017%	0.20	42.99%	5.73%	0.020%
Papua New Guinea	2.757	0.438	15.9%	0.016%	0.13	30.21%	4.80%	0.014%
Lao PDR	2.230	0.385	17.3%	0.014%	0.13	34.61%	5.97%	0.014%
Cambodia	2.143	0.320	14.9%	0.012%	0.10	32.74%	4.89%	0.011%

Country Name	Electricity Consumption (TWh)	Electricity Consumption by Lighting (TWh)	Lighting Consumption as a Percentage of Electricity Consumption	Lighting Electricity Consumption as a Percentage of Global Lighting Electricity Consumption	National/ Regional Efficient Lighting Saving Potential (TWh)	Lighting Savings Potential as Percentage of Lighting Electricity Consumption	Efficient Lighting Savings Potential as Percentage of Electricity Consumption	Efficient Lighting Saving Potential as Percentage of Global Efficient Lighting Saving Potential
Afghanistan	0.231	0.035	15.0%	0.001%	0.02	50.48%	7.57%	0.002%
Bhutan	0.184	0.024	13.2%	0.001%	0.01	46.44%	6.11%	0.001%
Timor-Leste	0.068	0.013	19.9%	0.000%	0.00	34.03%	6.76%	0.000%
Europe Total	**4453.312**	**660.464**	**14.83%**	**24.076%**	**258.558**	**39.15%**	**5.81%**	**27.000%**
European Union	3100.477	477.263	15.4%	17.398%	178.88	37.48%	5.77%	18.679%
Russian Federation (the)	914.067	115.027	12.6%	4.193%	53.16	46.22%	5.82%	5.552%
Turkey	180.360	25.674	14.2%	0.936%	7.78	30.32%	4.32%	0.813%
Ukraine	155.418	24.820	16.0%	0.905%	12.77	51.45%	8.22%	1.334%
Kazakhstan	77.082	13.411	17.4%	0.489%	4.11	30.63%	5.33%	0.429%
Azerbaijan	13.962	2.193	15.7%	0.080%	1.10	50.25%	7.89%	0.115%
Georgia	6.949	1.152	16.6%	0.042%	0.35	30.43%	5.04%	0.037%
Armenia	4.995	0.924	18.5%	0.034%	0.40	43.51%	8.04%	0.042%
North America Total	**4792.207**	**712.476**	**14.87%**	**25.972%**	**260.342**	**36.54%**	**5.43%**	**27.186%**
United States of America	4044.270	607.856	15.0%	22.159%	222.71	36.64%	5.51%	23.257%
Mexico	223.927	34.865	15.6%	1.271%	12.07	34.63%	5.39%	1.261%
Canada	524.010	69.754	13.3%	2.543%	25.56	36.64%	4.88%	2.669%
South America Total	**905.594**	**139.253**	**15.38%**	**5.076%**	**47.708**	**34.26%**	**5.27%**	**4.982%**
Brazil	448.560	72.773	16.2%	2.653%	25.20	34.62%	5.62%	2.631%
Argentina	117.532	15.257	13.0%	0.556%	5.26	34.48%	4.48%	0.549%
Venezuela	92.416	13.956	15.1%	0.509%	4.68	33.52%	5.06%	0.489%
Chile	58.153	8.128	14.0%	0.296%	2.80	34.44%	4.81%	0.292%
Colombia	49.122	7.980	16.2%	0.291%	2.69	33.76%	5.48%	0.281%
Peru	34.771	5.079	14.6%	0.185%	1.78	35.03%	5.12%	0.186%
Ecuador	17.634	2.740	15.5%	0.100%	0.86	31.55%	4.90%	0.090%
Dominican Republic	14.044	1.965	14.0%	0.072%	0.68	34.63%	4.84%	0.071%
Uruguay	9.692	1.730	17.8%	0.063%	0.58	33.43%	5.97%	0.060%
Guatemala	8.217	1.554	18.9%	0.057%	0.53	34.11%	6.45%	0.055%

Annex 2: Regional Test Procedures

The following listing of test methods, performance standards and labelling requirements is non-comprehensive, and in a number of cases, outdated. However, it is included to act as a first reference point to assist potential contractors to identify relevant sources of information[35].

Country	Type	Scope	Relationship to other standards	Reference/ Policy Name	Test Procedures	Standard/ Policy Type	Mandatory/ Voluntary
Australia	CFL	Self-ballasted compact fluorescent lamps (CFL)		AS/NZS 4847.1:2010	AS/NZS 4847.1:2010	Test method	
Bangladesh	CFL	Self-ballasted lamps. Part of compulsory certification marks scheme	Equivalent to IEC 60969	BDS 1734: 2003	BDS 1734: 2003	Test Method	
Bangladesh	CFL	Energy efficient rating for self-ballasted lamps		BDS 1761:2006	BDS 1761:2006		
Bangladesh	CFL	Specifications for energy efficiency labeling requirements for compact fluorescent lamps	IEC 60969:2001 ed. 1.2	BDS IEC 60969	BDS IEC 60969	Label Unknown Type	Unknown
Bangladesh	CFL			Energy Efficiency and Conservation Rules	BDS 1761:2006, BDS IEC 60969	Label Comparative	Voluntary
Bangladesh	CFL			Energy Efficiency and Conservation Rules	BDS 1761:2006, BDS IEC 60969	Minimum Energy Performance Standard	Voluntary

[35] References for table in Annex 2:

- lites.asia. 2010 (unpublished). Data collected for original country summary exercise.
- Presentation www.lites.asia/files/otherfiles/0000/0165/Day_2_Session_2.2_Bangladesh_national_standards_Sajjadul_Bari.pdf (accessed 30 March 2014)
- Presentation www.lites.asia/files/otherfiles/0000/0217/Day_2_Session_1.3_BRESL_overview_Asep_Suwarna.pdf (accessed 30 March 2014)
- CLASP Global Standards Database http://www.clasponline.org/en/Tools/Tools/SL_Search.aspx (accessed 30 May 2013)
- Presentation www.lites.asia/files otherfiles/0000/0284/Kuala_Lumpur_lites.asia_meeting_1.7_Country_Update_Cambodia.pdf (accessed 30 March 2014)
- APEC Energy Working Group. 1999. Review of Energy Efficiency Test Standards and Regulations in APEC Member Economies.
- Roberto Gonzalez Vale. 2014. Personal communication
- lites.asia country standards and labelling summary
- Presentation Rachman Mustar. 2012. www.lites.asia/files/otherfiles/0000/0176/Hanoi_lites_asia_-_master_presentation_Day_1_PM__final_.pdf (accessed 30 March 2014)
- Presentation Hiroki Nakagawa and Kenji Sugiyama. 2013 (unpublished). Developments in LEDs standards in Japan. Jakarta lites.asia meeting.
- APEC Energy Working Group. 1999. Review of Energy Efficiency Test Standards and Regulations in APEC Member Economies.
- Presentation www.lites.asia/files/otherfiles/0000/0282/Kuala_Lumpur_lites.asia_meeting_1.5_Malaysia_Efficiency_Standards_Zulkiflee_Umar.pdf (accessed 30 March 2014)
- Presentation www.lites.asia/files/otherfiles/0000/0215/Day_2_Session_1.1_Standards_and_labelling_in_Pakistan_Noman_Rafiq.pdf (accessed 30 March 2014)
- Presentation www.lites.asia/files/otherfiles/0000/0222/Sharing_experience_with_Indonesia_Sri_Lanka_Illeperuma_Kithsiri_Namal.pdf (accessed 30 March 2014)

Country	Type	Scope	Relationship to other standards	Reference/ Policy Name	Test Procedures	Standard/ Policy Type	Mandatory/ Voluntary
Brazil	CFL	Compact Fluorescent Lamps		Portaria Interministerial No 1008/2010	as defined by INMETRO	Minimum Energy Performance Standard	Mandatory
Brazil	CFL	Compact fluorescent lamps with integrated ballast		Portaria Interministerial nº 489 de 08/12/10	CIE 84:1989, IEC 60081, IEC 60901, IEC 60969, NBR iv538, NBR iv539, NBR IEC 60061-1, NBR iv671	Label Comparative	Mandatory
Brazil	CFL	Compact fluorescent lamps		Procel - CFL	CIE 84:1989, IEC 60081 IEC 60901, IEC 60969 NBR iv538, NBR iv539 NBR IEC 60061-1, NBR iv671	Label Endorsement	Voluntary
Cambodia	CFL	Safety requirements self-ballasted lamps for general lighting service (CFL)	Established by adopting the relevant IEC test method standards	Prakas No. 1003		Test method	Mandatory

Country	Type	Scope	Relationship to other standards	Reference/ Policy Name	Test Procedures	Standard/ Policy Type	Mandatory/ Voluntary
Canada	CFL	Performance of compact fluorescent lamps and ballasted adaptors (regulated only by selected Canadian Provinces) The standard specifies a range of performance related requirements such as power input (declared versus actual), starting time, run-up time, crest factor and system efficacy (lumens per watt). The system of measuring total power input and light output is used, although a minimum light output requirement is not specified. The standard CAN/CSA-C861-95 is applicable to E26 medium screw-base compact fluorescent lamps and ballasted adaptors for use on 120V and 60Hz. The test temperature is specified as 25oC. Lamps are seasoned for a minimum of 100 hours before testing. Lamp power and light output is to be stable before measurements are undertaken (minimum of 15 minutes, but could be 4 hours or more). Where CFL ballast does not have an integrated lamp, a reference lamp is used. Instrumentation and testing is undertaken in accordance with IES LM66. The harmonic content of the supply shall not exceed 3% of the RMS voltage and voltage shall be regulated to within ±0.5% and the supply impedance shall be such that the voltage at the test unit does not vary by more than 2% when in and out of operation. Requirements of the standard include: • Reference to relevant safety standards • Measured input power < 115% of the rated value • Starting time < 6 seconds • Run-up time less than 3 minutes • Crest factor less than 1.7 • System efficacy is specified for total input powers up to 35 watts It should be noted that at the time of writing, only the provinces of Ontario and British Columbia regulated CFL for energy efficiency (and is under consideration in New Brunswick)	References various IES and ANSI standards	CAN/CSA-C861-95		Test method	
Canada	CFL	An integrally-ballasted compact fluorescent lamp with a medium screw base and a nominal voltage or voltage range that lies at least partially between 100 volts and 130 volts		EnerGuide Program - Compact Fluorescent Lamps (CFL)	CSA C861-06 for power and luminous flux; IES LM65-01 for life	Label Comparative	Mandatory
Canada	Solid State Lighting/LED	These criteria apply to integral LED lamps, defined as a lamp with LED, an integrated LED driver, and an ANSI standardized base designed to connect to the branch circuit via an ANSI standardized lampholder/socket. These criteria include integral LED lamps of non-standard form, and those intended to replace standard general service incandescent lamps, decorative (candelabra style) lamps, and reflector lamps. Other types of replacement lamps may be added in the future as improvements to LED technology make LED use in other replacement lamp types viable.		ENERGY STAR® Qualifying Criteria for Integral LED Lamps Version 1.4		Label Endorsement	Voluntary
Chile	CFL	This protocol provides specifications for energy efficiency labeling for compact fluorescent lamps (CFL) for general lighting, with rated power up to 60W, rated voltage between 100V and 250V, Edison or bayonet screw caps.		PE No 5/06/2	NCh 3020:2006	Label Comparative	Mandatory
Chile	SSL	This protocol provides specifications for certifying efficiency of LED lamps with integrated ballast		PE No 5/17/2	IEC/PAS 62612:2009-06	Label Comparative	Mandatory

Country	Type	Scope	Relationship to other standards	Reference/ Policy Name	Test Procedures	Standard/ Policy Type	Mandatory/ Voluntary
Chile	CFL			unknown		Minimum Energy Performance Standard	Mandatory
China (PRC)	CFL	Applies to CFL of rated voltage of 220V, rated working frequency of 50Hz and rated power lower than 60W, and with caps of screw or bayonet type. These CFL shall be of general service and ignition control parts and stabilization parts are integrated.		China Energy Label - Self-ballasted Fluorescent Lamps	GB/T 17263-2002 GB 19044-2003	Label Comparative	Mandatory
China (PRC)	CFL	Limited values of energy efficiency and rating criteria of self-ballasted fluorescent lamps for general lighting service		GB 19044-2003		Minimum Energy Performance Standard	
China (PRC)	SSL	LED modules for general lighting safety requirements	IEC62031:2008 clone	GB 24819-2009		Safety	
China (PRC)	Solid State Lighting/LED	Apply to self-ballasted LED modules, having: (1) a rated voltage of up to 250 V DC or up to 50/60 Hz 1000 V AC		GB/T 24823-2009: Performance requirements for LED modules for general lighting		Label Endorsement	Voluntary
China (PRC)	Solid State Lighting/LED	Apply to self-ballasted LED lamps used for domestic and similar general lighting purpose, having: (1) a rated wattage up to 60 W; (2) a rated voltage of up to 250 V AC or DC; and (3) lamp cap according to relevant GB standards.		GB/T 24908-2010: Performance requirements for self-ballasted LED lamps for general lighting		Label Endorsement	Voluntary
China (PRC)	CFL	Self-ballasted lamps for general lighting services – Performance requirements	Based on IEC 60969-2001 ed. 1.2 with some differences	GB/T17263:2002			
China (PRC)	LED	LED modules for general lighting - Performance requirements		GB/T24823-2009			
China (PRC)	LED	Measurement methods of LED modules for general lighting		GB/T24824-2009			
Chinese Taipei (Taiwan)	CFL	The applicable product shall meet the definition of compact fluorescent lamps as defined in CNS iv576.		Energy Efficiency Criteria and Labeling Method for Compact Fluorescent Lamps	CNS iv576	Label Endorsement	Voluntary
Chinese Taipei (Taiwan)	CFL			Energy Efficiency Rating for Self-ballasted Fluorescent Lamps		Label Comparative	Mandatory

Country	Type	Scope	Relationship to other standards	Reference/ Policy Name	Test Procedures	Standard/ Policy Type	Mandatory/ Voluntary
Chinese Taipei (Taiwan)	CFL	In August 1992 the Environment Protection Administration (EPA) launched an eco-label program called "Greenmark". The EPA still administers the program via the Greenmark Program Review Committee however implementation of all aspects of the program is contracted to the Environment and Development Foundation (EDF). The program covers a large number of product categories including paper, water-using devices and several energy-using appliances. All energy using appliances must meet energy efficiency criteria to receive the award. **Labelling Requirements:** 1. Category products are meant to be the preheat type of fluorescent lamp tubes. However, the energy-saving compact fluorescent lamps are excluded from this product category. 2. After two thousand (2000) hours of usage, the luminosity of the product shall maintain at no less than 85% of its initial strength. 3. The tube efficacy shall be greater than 80 lumens/watt. Tube must have a color rendering index of no less than 80. 4. The mercury (Hg) content of each tube shall not exceed 15 mg. 5. The average concentration of mercury vapor in the working place shall not exceed 0.23 mg/m3. 6. Then name and address of the Green Mark user must be clearly printed on the product or its package. The name and address of the manufacturer must be marked on the product or package as well, if the logo user is not the manufacturer. 7. The product or the package shall bear a label reading "Energy Conservation and Mercury Pollution Reduction		Greenmark - Fluorescent Lamps	CNS iii839 CNS 3936 CNS 691 CNS iv125 US ENERGY STAR®	Label Endorsement	Voluntary
Costa Rica	CFL	Energy efficiency - compact and circular fluorescent lamps - Performance Ranges		INTE 28-01-07-08			
Costa Rica	CFL	Energy efficiency - compact and circular fluorescent lamps - labeling		INTE 28-01-08-08			
Costa Rica	CFL	Approved method for electrical and photometric measurements of compacted fluorescent single-ended method		INTE 28-01-09-08			
European Union	Solid State Lighting/LED	The product group "light bulbs" shall comprise: "single-ended light bulbs": all light bulbs which provide general purpose lighting and have single-ended, bayonet, screw or pin fittings. The light bulbs shall be connectable to the public electricity supply. "Double-ended light bulbs": all light bulbs which provide general purpose lighting and have fittings at both ends. This includes, principally, all linear fluorescent tubes. The light bulbs shall be connectable to the public electricity supply. The following types of lamps are not included in the product group: compact fluorescent lamps with magnetic ballast, projector lamps, photographic lighting and solarium tubes.		COMMISSION DECISION of 6 June 2011 on establishing the ecological criteria for the award of the EU Ecolabel for light sources	EN 50285	Label Endorsement	Voluntary

Country	Type	Scope	Relationship to other standards	Reference/ Policy Name	Test Procedures	Standard/ Policy Type	Mandatory/ Voluntary
European Union	Solid State Lighting/LED	This Regulation establishes requirements for labelling of and providing supplementary product information on electrical lamps such as: (a) filament lamps; (b) fluorescent lamps; (c) high-intensity discharge lamps; (d) LED lamps and LED modules. This Regulation also establishes requirements for labelling luminaires designed to operate such lamps and marketed to end users, including when they are integrated into other products that are not dependent on energy input in fulfilling their primary purpose during use (such as furniture). 2. The following products shall be excluded from the scope of this Regulation: (a) lamps and LED modules with a luminous flux of less than 30 lumens; (b) lamps and LED modules marketed for operation with batteries; (c) lamps and LED modules marketed for applications where their primary purpose is not lighting, such as: (i) emission of light as an agent in chemical or biological processes (such as polymerization, photodynamic therapy, horticulture, petcare, anti-insect products); (ii) image capture and image projection (such as camera flashlights, photocopiers, video projectors); (iii) heating (such as infrared lamps); (iv) signaling (such as airfield lamps). These lamps and LED modules are not excluded when they are marketed for lighting; (d) lamps and LED modules marketed as part of a luminaire and not intended to be removed by the end-user, except when they are offered for sale, hire or hire purchase or displayed separately to the end user, for example as spare parts; (e) lamps and LED modules marketed as part of a product whose primary purpose is not lighting. However, if they are offered for sale, hire or hire purchase or displayed separately, for example as spare parts, they shall be included within the scope of this Regulation; (f) lamps and LED modules that do not comply with requirements becoming applicable in 2013 and 20iv according to Regulations implementing Directive 2009/125/EC of the European Parliament and of the Council [4]; (g) luminaires that are designed to operate exclusively with the lamps and LED modules listed in points (a) to (c).		Commission Delegated Regulation (EU) No 874/2012 of 12 July 2012 supplementing Directive 20iii/30/EU of the European Parliament and of the Council with regard to energy labelling of electrical lamps and luminaires		Label Comparative	Mandatory
European Union	Solid State Lighting/LED	This Regulation establishes ecodesign requirements for placing on the market the following electrical lighting products: (a) directional lamps; (b) light-emitting diode (LED) lamps; (c) equipment designed for installation between the mains and the lamps, including lamp control gear, control devices and luminaires (other than ballasts and luminaires for fluorescent and high-intensity discharge lamps); including when they are integrated into other products.		Commission Regulation (EU) No 1194/2012 of 12 December 2012 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for directional lamps, light emitting diode lamps and related equipment		Minimum Energy Performance Standard	Mandatory

Country	Type	Scope	Relationship to other standards	Reference/ Policy Name	Test Procedures	Standard/ Policy Type	Mandatory/ Voluntary
Germany	Solid State Lighting/LED	Applies to lamps meeting the following requirements: They § are directly powered from the mains (230 V, 50 Hz) and therefore need no external ballast, power supply pack or the like [8]; § are suitable for indoor use; § have a luminous flux Φ of 60 ≤ Φ ≤ 6'500 lumens (lm). The following lamps do not fall within the scope: § lamps [9]: - having at least 6 % of total radiation of the range 250 -780 nm in the range of 250 and 400 nm, - having the peak of the radiation between 315-400 nm (UVA) or 280-315 nm (UVB); § lamps - for which several operating points may be chosen, i.e. several conditions differing with respect to luminous flux and/or color temperature and/or light color [iii]: - operated by an external circuit or - operated by an internal circuit using, for example, a built-in daylight sensor.		Der Blaue Engel - Schützt das Klima		Label Endorsement	Voluntary
Hong Kong	LED	The provision of this scheme shall apply to directional and non-directional LED lamps, and is intended for general lighting purposes having the following characteristics: (a) those with a rated voltage up to 240 volts AC or DC; (b) those with a rated frequency of 50 Hz for AC; (c) those with a rated lamp wattage up to 60 Watts; and (d) those with a rated CCT value from 2700K to 6500K. The scheme shall apply to LED lamps designed with dimming or non-dimming operations. 3.7 The scheme does not cover (i) LED tubes, and (ii) LED lamps that intentionally produce tinted or colored light neither does it cover organic LED (OLED) lamps.		The Hong Kong Voluntary Energy Efficiency Labelling Scheme for LED Lamp	IES LM-79, IEC/PAS 62612	Label Endorsement	Voluntary
India	CFL	Self-ballasted lamps for general lighting services. Part 2 Performance requirements	Reference Test Standard: IEC 60969	IS 15111		Test method	
India	Solid State Lighting/LED	Self-ballasted LED lamps with a d.c. supplies up to 250 V or a.c. supplies up to iii00 V at 50 Hz, intended for domestic and similar general lighting purposes, having, (1) a rated wattage up to 60 W; (2) a rated d.c. supplies up to 250 V or a.c. supplies up to iii00 V at 50 Hz; and (3) a lmap cap according to IS 16iii2 (Part 1): 2012 “Self-ballasted LED lamps for general lighting services: Part 1 Safety requirements”. This standard does not cover self-ballasted LED-lamps that intentionally produce tinted or colored light neither does it cover OLED.		IS 16iii2 (Part 2): Performance Requirements for Self-Ballasted LED Lamps for General Lighting Services		Label Endorsement	Voluntary
Indonesia	CFL	Energy Efficiency Labeling on CFL		Ministerial Regulation No 6/2011		Labelling	Mandatory
Indonesia	CFL	Self-ballasted lamps for general lighting services- Safety requirement	IEC 60968:1998 61347.1	SNI 04-6504-2001			
Indonesia	CFL	Self-ballasted lamps for general lighting services - Performance requirements	IEC 60969	SNI IEC 60969:2009			

Country	Type	Scope	Relationship to other standards	Reference/ Policy Name	Test Procedures	Standard/ Policy Type	Mandatory/ Voluntary
Japan	LED	Photometry of white light emitting diode for general lighting. Part 1: LED packages		C8152.1		Test method	
Japan	LED	Photometry of white light emitting diode for general lighting. Part 2: LED modules and LED light engines	To be proposed	C8152.2		Test method	
Japan	LED	Method of lumen maintenance measurement for LED lamps (including packages)		C8152.3		Test method	
Japan	LED	Types and forms in Annex B (Normative) in JIS C 8157 "Self-ballasted LED - lamp s for general lighting services > 50 V -- Performance requirements" and have a bayonet cap of E17 or E26 and emit light according to the light - source colors defined in the JIS Z 9112 "Classification of fluorescent lamps based on light - source colors and color rending properties." 3. Terminology		Japan Environment Association (JEA) Eco Mark - LED Bulb Lamp (Type A) Version1.0 Certification Criteria		Label Endorsement	Voluntary
Jordan	LED	This Regulation establishes ecodesign requirements for the placing on the market of non-directional household lamps, including when they are marketed for non-household use or when they are integrated into other products. It also establishes product information requirements for special purpose lamps. Exclusions: (a) lamps having the following chromaticity coordinates x and y: — x < 0,200 or x > 0,600 — y < – 2,3172 x2 + 2,3653 x – 0,2800 or y > – 2,3172 x2 + 2,3653 x – 0,iii00; (b) directional lamps; (c) lamps having a luminous flux below 60 lumens or above 12 000 lumens; (d) 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); (e) fluorescent lamps without integrated ballast; (f) high-intensity discharge lamps; (g) incandescent lamps with Eiv/E27/B22/B15 caps, with a voltage equal to or below 60 volts and without integrated transformer in Stages 1-5 according to Article 3 of the Regulation.		Technical Regulation on Eco-design requirements for non-directional household lamps (transposition of 244/2009/EC)	244/2009/EC	Minimum Energy Performance Standard	Mandatory
Jordan	Solid State Lighting/LED	Household electric lamps supplied directly from the mains (filament and integral compact fluorescent lamps), and to household fluorescent lamps (including linear, and non-integral compact fluorescent lamps), even when marketed for non-household use. Where an appliance can be taken apart by end users, for the purposes of this Directive the 'lamp' shall be the part(s) which emit(s) the light. The following lamps shall be excluded from the scope of this Directive: (a) those with a luminous flux of more than 6 500 lumens; (b) those with an input power of less than 4 watts; (c) reflector lamps; (d) those marketed or commercialized primarily for use with other energy sources, such as batteries; (e) those not marketed or commercialized primarily for the production of light in the visible range (400 to 800 nm); (f) those marketed or commercialized as part of a product, the primary purpose of which is not illuminative. However, where the lamp is offered for sale, hire or hire purchase or displayed separately, for example as a spare part, it shall be included. For lamps referred to in paragraph 2, labels and fiches may be provided in accordance with this Directive, provided that harmonized measurement standards applicable to such lamps have been adopted and published in accordance with Article 1 paragraph 4 of the Regulation.		Technical Regulation on energy labelling of household electric lamps (transposition of No. 98/11/EC)	EN 50285	Label Comparative	Mandatory

Country	Type	Scope	Relationship to other standards	Reference/ Policy Name	Test Procedures	Standard/ Policy Type	Mandatory/ Voluntary
Korea (ROK)	CFL	Self-ballasted lamps (screw base CFL)	Based on KS C8iii0 and KS C7601, as well as parts of IEC60969	KS C7621-1997		Test method	
Malaysia	CFL	MEPS for *CFL (Non integrated lamps)* *Specifies lm/W limit for <iiiW, 11-26W, ≥ 26W lamps*		P.U. (A) 151, Electricity (Amendment) Regulations 2013		Performance	
Malaysia	CFL	MEPS for CFLi (Self ballasted). Specifies lm/W limit for <9W, 9-15W, 16-24W and ≥ 25W lamps		P.U. (A) 151, Electricity (Amendment) Regulations 2013[2]		Performance	
Malaysia	Solid State Lighting/LED			Performance indicator and testing standard for electric lamps	IES LM 79-08 Electrical and photometric measurement of solid state lighting products, MS IEC 62612 (P) (Self-ballasted LED-lamps for general lighting services – performance requirement)	Minimum Energy Performance Standard	Mandatory
MEXICO	CFL	NOM-017-ENER-1997	Equivalent to IEC60901 contains energy efficiency requirements as well	NOM-017-ENER-1997		Test method	
Mexico	Solid State Lighting/LED	Integrated LED lamps		NOM-30-ENER-2012	NOM-30-ENER-12	Minimum Energy Performance Standard	Mandatory
Mexico	Solid State Lighting/LED	This endorsement label establishes specifications for interior fixtures and lamps with integrated LED, with control device, with nominal operating voltage of 120, 127, 220, 240, 254 or 277 volts, or multi-voltage with a ±iii% variation, at a frequency of 60 Hertz.		Sello FIDE No. 4171	IES LM-79	Label Endorsement	Voluntary
Nigeria	Solid State Lighting/LED	LED and solid state lighting. As part of the UNDP/GEF funded project, MEPS will be implemented for lighting.		unknown		Minimum Energy Performance Standard	Mandatory
Nigeria	Solid State Lighting/LED	LED and solid state lighting. As part of the UNDP/GEF funded project, MEPS will be implemented for lighting.		unknown		Label Comparative	Mandatory

Country	Type	Scope	Relationship to other standards	Reference/ Policy Name	Test Procedures	Standard/ Policy Type	Mandatory/ Voluntary
Pakistan	CFL	Self-Ballasted Lamps for General Lighting Services – Safety Requirements		PS- IEC : 60968			
Pakistan	CFL	Self-Ballasted Lamps for General Lighting Services – Performance Requirements		PS- IEC: 60969			
Philippines	CFL	Lamps and related equipment- Energy labelling requirements- Part 2: Self-ballasted lamps for general lighting services	Reference Test Standard: IEC 969	PNS 2050-2: 2007		Labelling	
Philippines	CFL	Compact fluorescent lamps	Based on IEC60969	PNS 603-2:1993		Test method	
Philippines	CFL	Self-ballasted lamps for general lighting services - Safety requirements	Reference Test Standard: IEC 968	PNS IEC 968:2006		Test method	
Philippines	CFL	Self-Ballasted Lamps for General Lighting Service - Performance Requirements	Reference Test Standard: IEC 969	PNS IEC 969:2006		Test method	
Philippines	CFL	Self-Ballasted Lamps for General Lighting Service - Performance Requirements		PNS IEC 969:2006		Performance	
Sri Lanka	CFL	Specification for Self ballasted lamps for General Lighting Services (Integral type compact fluorescent lamps)		SLS 1231:2002		Performance	
Sri Lanka	CFL	Energy efficiency rating for Self ballasted lamps (Integral type compact fluorescent lamps)		SLS1225:2002		Labelling	
Switzerland	Solid State Lighting/LED	The Commission Directive 98/11/EC of 27 January 1998 implementing Council Directive 92/75/EEC with regard to energy labelling of household lamps shall apply to household electric lamps supplied directly from the mains (filament and integral compact fluorescent lamps), and to household fluorescent lamps (including linear, and non-integral compact fluorescent lamps), even when marketed for non-household use. Where an appliance can be taken apart by end users, for the purposes of this Directive the 'lamp' shall be the part(s) which emit(s) the light. The following lamps shall be excluded from the scope of this Directive: (a) those with a luminous flux of more than 6 500 lumens; (b) those with an input power of less than 4 watts; (c) reflector lamps; (d) those marketed or commercialized primarily for use with other energy sources, such as batteries; (e) those not marketed or commercialized primarily for the production of light in the visible range (400 to 800 nm); (f) those marketed or commercialized as part of a product, the primary purpose of which is not illuminative. However, where the lamp is offered for sale, hire or hire purchase or displayed separately, for example as a spare part, it shall be included. For lamps referred to in paragraph 2, labels and fiches may be provided in accordance with this Directive, provided that harmonized measurement standards applicable to such lamps have been adopted and published in accordance with Article 1 paragraph 4 of the Regulation.		98/11/EC		Label Comparative	Mandatory

Country	Type	Scope	Relationship to other standards	Reference/ Policy Name	Test Procedures	Standard/ Policy Type	Mandatory/ Voluntary
Switzerland	Solid State Lighting/LED	The product group 'light sources' shall comprise all light sources of a luminous flux = 60 and = 12 000 lumens for general lighting applications with direct or indirect connection to the public electricity supply equipped with a lamp cap listed in EN 60061 and made in order to produce a visible radiation. The following types of light sources are not included in the product group: directional lamps, high-intensity discharge lamps, colored lamps, projector lamps, photographic lighting, solarium tubes, battery driven systems and other light sources that are not intended for general lighting applications. The following types of light sources are not included in the product group if they are not supplied directly from the mains: integral compact fluorescent lamps, filament lamps, LED lamps.		COMMISSION DECISION of 6 June 2011 on establishing the ecological criteria for the award of the EU Ecolabel for light sources	EN 50285	Label Endorsement	Voluntary
Switzerland	Solid State Lighting/LED	This Regulation establishes ecodesign requirements for the placing on the market of non-directional household lamps, including when they are marketed for non-household use or when they are integrated into other products. It also establishes product information requirements for special purpose lamps. Exclusions: (a) lamps having the following chromaticity coordinates x and y: — x < 0,200 or x > 0,600 — y < – 2,3172 x2 + 2,3653 x – 0,2800 or y > – 2,3172 x2 + 2,3653 x – 0,iii00; (b) directional lamps; (c) lamps having a luminous flux below 60 lumens or above 12 000 lumens; (d) 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); (e) fluorescent lamps without integrated ballast; (f) high-intensity discharge lamps; (g) incandescent lamps with Eiv/E27/B22/B15 caps, with a voltage equal to or below 60 volts and without integrated transformer in Stages 1-5 according to Article 3 of the Regulation.		EC 244/2009		Minimum Energy Performance Standard	Mandatory
Thailand	CFL	Green Label Scheme – CFL		*Reference number not known*		Labelling	Voluntary
Thailand	CFL	Energy Efficient Compact Fluorescent Lamps Program		*Reference number not known*		Labelling	Voluntary
Thailand	CFL	Self-ballasted lamps for general lighting services		TIS 2233-2548		Test method	
Thailand	CFL	Self-ballast lamps for general lighting services: Safety Requirements		TIS 2234-2548 (2005)		Test method	
Thailand	CFL	Self-Ballasted Lamps for General Lighting Services: Energy Efficiency Requirements	Reference standard: National Appliance and Equipment Energy Efficiency Committee (Australia) Report no.: 2005/12 Minimum Energy Performance Standards – Compact Fluorescent lamps	TIS 23iii-2549 (2006)		Test method	
Thailand	CFL			TIS 23iii-2549 (2006)		Minimum Energy Performance Standard	

Country	Type	Scope	Relationship to other standards	Reference/ Policy Name	Test Procedures	Standard/ Policy Type	Mandatory/ Voluntary
Turkey	Solid State Lighting/LED	The product group 'light sources' shall comprise all light sources of a luminous flux = 60 and = 12 000 lumens for general lighting applications with direct or indirect connection to the public electricity supply equipped with a lamp cap listed in EN 60061 and made in order to produce a visible radiation. The following types of light sources are not included in the product group: directional lamps, high-intensity discharge lamps, colored lamps, projector lamps, photographic lighting, solarium tubes, battery driven systems and other light sources that are not intended for general lighting applications. The following types of light sources are not included in the product group if they are not supplied directly from the mains: integral compact fluorescent lamps, filament lamps, LED lamps.		COMMISSION DECISION of 6 June 2011 on establishing the ecological criteria for the award of the EU Ecolabel for light sources (2011/331/EU) - to be transposed	EN 50285	Label Endorsement	Voluntary
Turkey	Solid State Lighting/LED	The Commission Directive 98/11/EC of 27 January 1998 implementing Council Directive 92/75/EEC with regard to energy labelling of household lamps shall apply to household electric lamps supplied directly from the mains (filament and integral compact fluorescent lamps), and to household fluorescent lamps (including linear, and non-integral compact fluorescent lamps), even when marketed for non-household use. Where an appliance can be taken apart by end users, for the purposes of this Directive the 'lamp' shall be the part(s) which emit(s) the light. The following lamps shall be excluded from the scope of this Directive: (a) those with a luminous flux of more than 6 500 lumens; (b) those with an input power of less than 4 watts; (c) reflector lamps; (d) those marketed or commercialized primarily for use with other energy sources, such as batteries; (e) those not marketed or commercialized primarily for the production of light in the visible range (400 to 800 nm); (f) those marketed or commercialized as part of a product, the primary purpose of which is not illuminative. However, where the lamp is offered for sale, hire or hire purchase or displayed separately, for example as a spare part, it shall be included. For lamps referred to in paragraph 2, labels and fiches may be provided in accordance with this Directive, provided that harmonized measurement standards applicable to such lamps have been adopted and published in accordance with Article 1 paragraph 4 of the Regulation.		Turkish Official Gazette No. 24852 (transposition of 98/11/EC)	EN 50285	Label Comparative	Mandatory
Turkey	Solid State Lighting/LED	This Regulation establishes ecodesign requirements for the placing on the market of non-directional household lamps, including when they are marketed for non-household use or when they are integrated into other products. It also establishes product information requirements for special purpose lamps. Exclusions: (a) lamps having the following chromaticity coordinates x and y: — x < 0,200 or x > 0,600 — y < – 2,3172 x2 + 2,3653 x – 0,2800 or y > – 2,3172 x2 + 2,3653 x – 0,iii00; (b) directional lamps; (c) lamps having a luminous flux below 60 lumens or above 12 000 lumens; (d) 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); (e) fluorescent lamps without integrated ballast; (f) high-intensity discharge lamps; (g) incandescent lamps with Eiv/E27/B22/B15 caps, with a voltage equal to or below 60 volts and without integrated transformer in Stages 1-5 according to Article 3 of the Regulation.		Turkish Official Gazette No. 28038 (transposition of EC 244/2009)	EC 244/2009	Minimum Energy Performance Standard	Mandatory

Country	Type	Scope	Relationship to other standards	Reference/ Policy Name	Test Procedures	Standard/ Policy Type	Mandatory/ Voluntary
United Arab Emirates	Solid State Lighting/LED	Non-directional LED lamps		Technical Regulation: Requirements for Approval and Registration of Lighting Products (draft)		Label Comparative	Mandatory
United Kingdom	Solid State Lighting/LED	LED lamps and Modules		Energy Saving Trust Recommended scheme		Label Endorsement	Voluntary
USA	CFL	US Code of Federal Regulations: Energy Conservation Program for Consumer Products Energy labelling applies to compact fluorescent lamps. All set up and test conditions are specified in the standard prepared by the Illumination Engineering Society of North America IES LM66. Lamp electrical power input in watts and light output shall be measured and recorded. Lamp efficacy shall be determined by computing the ratio of the measured lamp lumen output and lamp electrical power input at equilibrium for the reference condition	All of the test conditions are externally referenced to an IES standard. The test procedures are broadly in line with the requirements for Canada, which reference the same IES standard, which involves determining the total input power and light output for the CFL. Note that no minimum light output is required.	iiiCFR430 Sub Part B, Appendix R		Test method	
USA	Solid State Lighting/LED	The Federal Trade Commission requires energy and other performance labeling of appliance and energy consuming products, across many product categories. For lighting products, the label includes fluorescent lamps and ballasts, CFL, incandescent, halogen, metal halide, and LED lamps. It excludes many types of specialty lamps, such as infrared lamps, colored lamps, plant lights, marine lamps and traffic signals, among others. A full description of the scope of the FTC label is available at http://www.ecfr.gov/cgi-bin/text-idx?c=ecfr&SID=b8524civb9fba95a12dcfdbc215eac9e&rgn=div8&view=text&node=16:1.0.1.3.29.0.13.3&idno=16 The revised FTC label, introduced in 2011, focuses on lumen output rather than wattage. More information about the change is available at http://www.ftc.gov/opa/20iii/06/lightbulbs.shtm		16 CFR Part 305	iii CFR Part 430 Appendix R to Subpart B	Label Comparative	Mandatory
USA	Solid State Lighting/LED	Voluntary label with light quality and energy information for labeling LED products.		DOE LED Lighting Facts Label		Label Endorsement	Voluntary

Country	Type	Scope	Relationship to other standards	Reference/ Policy Name	Test Procedures	Standard/ Policy Type	Mandatory/ Voluntary
USA	Solid State Lighting/LED	These criteria apply to integral LED lamps, defined as a lamp with LED, an integrated LED driver, and an ANSI standardized base designed to connect to the branch circuit via an ANSI standardized lampholder/socket. These criteria include integral LED lamps of non-standard form, and those intended to replace standard general service incandescent lamps, decorative (candelabra style) lamps, and reflector lamps. Other types of replacement lamps may be added in the future as improvements to LED technology make LED use in other replacement lamp types viable.		Integral LED Lamps Program Requirements Version 1.4	Integral LED Lamps Program Requirements Version 1.4	Label Endorsement	Voluntary
Vietnam	CFL	High energy lighting products – Part 2: Methods for determination of energy Performance		TCVN 7541-2: 2005		Test method	
Vietnam	CFL	Self-ballasted for general lighting services – Safety requirements	Reference standard: IEC 60968	TCVN 7672:2007		Test method	
Vietnam	CFL	Self-ballasted lamps for general lighting services – Performance requirements	Reference standard: IEC 60969	TCVN 7673:2007		Test method	
Vietnam	CFL	Compact fluorescent lamps – Energy efficiency		TCVN 7896:2008		Performance	