UNEP

EFFICIENT LIGHTING MARKET BASELINES AND ASSESSMENT

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FOREWORD

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

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

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

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

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

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

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

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

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

ABOUT THE UNEP–GEF EN.LIGHTEN INITIATIVE

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

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

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

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

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

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

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

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

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

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ABBREVIATIONS AND DEFINITIONS

CFL	compact fluorescent lamp
CIE	International Commission on Illumination
CLASP	Collaborative Labeling and Appliance Standards Program
GELC	Global Efficient Lighting Centre
HEPS	high energy performance standard
IEA	International Energy Agency
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
kWh	kilowatt-hour
LED	light emitting diode
MEPS	minimum energy performance standard
MVE	monitoring, verification and enforcement
SEAD	Super-efficient Equipment and Appliance Deployment Initiative
UNEP	United Nations Environment Programme

GLOSSARY

B

(light) bulb: transparent or translucent gas-tight envelope enclosing the luminous element(s). (IEC)

C

colour rendering index: measure of the degree to which the psychophysical colour of an object illuminated by the test illuminant conforms to that of the same object illuminated by the reference illuminant, suitable allowance having been made for the state of chromatic adaptation. (IEC)

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

E

efficacy: see luminous efficacy.

F

fluorescent lamp: a discharge lamp of the low pressure mercury type in which most of the light is emitted by one or several layers of phosphors excited by the ultraviolet radiation from the discharge. Note: These lamps are frequently tubular and, in the UK, are then usually called fluorescent tubes. (IEC)

H

high efficiency performance standard (HEPS): term generally used to describe regulatory strategy or measures specifying 'reach' or challenge efficiency levels for products sold in a market, or region, or at the international level.

L

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

L

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

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

lumen depreciation: luminous flux lost at any selected, elapsed operating time, expressed as a percentage of the initial output. Converse of lumen maintenance.

lumen maintenance (luminous flux maintenance factor): ratio of the luminous flux of a lamp at a given time in its life to its initial luminous flux, the lamp being operated under specified conditions. Note: This ratio is generally expressed in per cent. (IEC)

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

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

luminous intensity (of a source, in a given direction): quotient of the luminous flux $d\Phi_v$ leaving the source and propagated in the element of solid angle $d\Omega$ containing the given direction, by the element of solid angle: $I_v = d\Phi_v / d\Omega$. Unit: cd = lm/sr. (IEC)

M

mean: in statistics, an average is defined as the number that measures the central tendency of a given set of numbers (or a number that the number set is close to). There are a number of different averages including but not limited to: mean, median, mode and range.

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

M

minimum energy performance standard (MEPS): regulatory measure specifying minimum efficiency levels acceptable for products sold in a particular country, or region or at the international level. MEPS define what products can be marketed and which ones should be eliminated.

model: manufacturer's particular lamp design.

O

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

P

power factor: under periodic conditions, ratio of the absolute value of the active power P to the apparent power: $\lambda = P / S$.
Note: Under sinusoidal conditions, the power factor is the absolute value of the active factor. (IEC)

product life: see rated lifetime

R

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

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

S

sample: a test sample may refer to a single lamp collected for testing, or a set of lamps of the same make and model. It may also refer to a statistical sample, or a datum from a data set.

S

standard deviation: in mathematics and statistics, deviation is a measure of difference between the observed value of a variable and some other value, often that variable's mean.

T

type of lamp: category of lamp based on the mechanism of producing light. For example, incandescent, tungsten halogen incandescent, fluorescent or light emitting diode.

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

V

verification test: a product test conducted by, or on behalf of, an enforcement authority to prove the performance of a product with regard to its energy consumption, in accordance with the specified test methodology. This process is used to determine whether a sample of units of a particular product model meet the requirements of a regulation or programme.

EXECUTIVE SUMMARY

This guidance note focuses on the development and maintenance of market baselines and market monitoring activities as tools to inform minimum energy performance standards (MEPS), labelling, and supporting policies for energy efficient lighting. It is primarily aimed at policymakers that wish to establish, or update, policies to facilitate the transition to efficient lighting and provides a practical resource for those developing a market baseline for the first time, or those who are looking to update existing baselines for market monitoring purposes.

A market baseline provides a detailed snapshot of the products available in a market at a given point in time, and provides a sound technical foundation for the development of new, or revised, policies for efficient lighting. Market baselines enable policymakers to gain a thorough understanding of product availability, performance, pricing, and other important factors that influence policy development. As market baselines are refreshed over time, they enable policymakers to identify, and understand, market trends and responses to government policies and programmes, and this in turn supports the development of more effective MEPS and supporting policies in the future.

Market baselines and market monitoring are typically the responsibility of government agencies that have the legal mandate to establish MEPS and other product regulations or energy efficiency programmes for an economy, such as mandatory and voluntary labelling programmes. Governments may also establish a series of energy efficiency levels. For example, to include high efficiency performance standards (HEPS) to recognise high-performance products in addition to MEPS to eliminate low-performing products.

Best practice suggests that policymakers should allocate adequate financial and human resources to data collection and analysis efforts, and support these efforts with robust planning in order to ensure high quality outcomes,

In terms of resources, market baselines are typically funded directly by a government and/or donor agencies, and staffed with a combination of government and contractor personnel. Third-party stakeholders, including industry associations, manufacturers and research institutions, often support the process by supplying data and assisting with its analysis.

In terms of planning, it is recommended that governments clearly define the roles, responsibilities, resource needs, and key performance indicators at the outset of any new market baseline development and market monitoring activity. Once resources are identified, market baseline and monitoring planning may commence. The plan typically addresses the following key questions:

1. What policy and regulatory objectives are being served?
2. What is the status of existing market baselines?
3. What data sources are available, and what gaps must be filled?
4. How will data be collected to fill in the gaps?
5. How will data quality and integrity be ensured?
6. How will the data be analysed and evaluated?
7. Who will be the audience for the data?
8. How should the results be presented to the target audience?
9. Will the data be kept confidential or shared publically?
10. How will progress towards completion of the baseline be measured?

Depending on the answers to these questions, the resources and effort needed to collect the data and perform the analysis will vary. For example, as energy efficiency programmes mature, the process of developing baselines to inform policy decisions and set performance or labelling requirements will be able to leverage data collected through monitoring, verification and enforcement (MVE) activities and product registration databases, or in support of incentives programmes. Cross-border or

regional cooperation among economies can also reduce the cost and effort required to collect data, especially in cases where product markets are similar. Analysis efforts can be streamlined by leveraging the work of a range of bilateral and multilateral energy efficiency initiatives; for example, by reviewing and incorporating the results of benchmarking studies that evaluate the performance of different lamp types across major world economies.

In order to be most effective and to avoid distorting a market, policy decisions must be grounded in data that is at once timely, comprehensive and representative of the market as a whole. It is recommended that countries follow the principles and steps outlined in this guide in the planning and execution of market baselines and market monitoring in order to maximise the impact of policies, and achieve the greatest possible benefits for households and national economies.

The basic steps that comprise a market baseline and market monitoring process are outlined below.[2]

1. **Establish goals and objectives.** Goals and objectives are the only way to meaningfully interpret measurements and gauge the degree of success of a market baseline. A baseline and market monitoring exercise should be tied to predefined goals or objectives, even if the goals are at first somewhat subjective.

2. **Identify the critical indicators to be measured.** Critical indicators (key performance metrics) are the means of tracking progress towards achieving the objectives of the baseline. Policymakers are encouraged to seek out international or regional expertise at this stage of the market baseline process – there is a wealth of institutional experience and data available to be leveraged to ensure that selected critical indicators and referenced test methods are fit for purpose.

3. **Identify data needs and possible data sources, then collect data.** Each identified indicator or metric will require specific data sets, that must often be gathered from different sources. It is important to identify key stakeholders such as non-governmental organisations and other institutions that can assist with identification of key performance metrics and data sources. It is often useful to identify opportunities for regional or international collaboration to take advantage of existing data and experience. Collected data will need to be reviewed to identify any issues and confirm its adequacy.

4. **Establish analysis approach or methodology and perform analysis.** The approach or methodology describes how the baseline will be assembled from the indicators or metrics. The established approach should then be used to convert the collected data into the actual baseline.

Following the baseline development exercise, policymakers can compare the results of the baseline analysis to the original goal or objectives, or to a previous market baseline, if one is available. Depending on the magnitude of variation between the market baseline and policy objectives, some corrective action (in the form of new or amended policies or programmes) may be called for to better address market conditions.

2 United States Environmental Protection Agency 2007

1 INTRODUCTION

Successful market transformation to energy efficient lighting depends on the implementation of thoughtful and effective policies including MEPS, energy labelling, and supporting policies. The most effective policies are underpinned by technically-sound, up-to-date information about the markets they are intended to address. Market baselines (whether conducted just once or repeated over time as part of a market monitoring scheme) provide just such a foundation for policy. This guidance note defines the necessary components of a market baseline for lighting products and outlines a step by step approach to their development and to carrying out market monitoring.

Policymakers who wish to establish the most effective and impactful market transformation programmes benefit from a thorough understanding of the markets they aim to influence. Market baselines provide the necessary level of detail about a given market at a specific point in time, and can be invaluable in the establishment of MEPS, energy labelling or supporting policy measures.

Market baselines provide insights into:

- **PRODUCT AVAILABILITY:** the availability (percentage) and range (technologies and/or service types) of efficient lighting products compared to other lighting products in a defined category or segment (general service, residential, or retail/commercial/industrial);
- **PRODUCT PERFORMANCE:** the types of products or technologies available, and how these products perform relative to each other (in terms of luminous efficacy, light output, lifetime or other performance parameters);
- **OTHER MARKET CONDITIONS:** including, product pricing, types of sales outlets and sales volumes. A comprehensive market survey can also provide specific information, such as the level of product conformance to national or international requirements, consumer behaviour, usage and other lighting sector characteristics such as performance and improvement potential.

If a market baseline is then revisited over the course of several years as part of a market monitoring process, complex trends and market dynamics may become apparent that will further enhance a policymaker's ability to make informed decisions. For example, effective monitoring will demonstrate the impacts of policy actions and related energy efficiency programmes on the market share of efficient products. Even in the absence of market transformation activities, monitoring can offer valuable insights into market dynamics. In many cases, these trends can be verified by interviewing industry participants and other stakeholders.

This guidance note describes the role of market baselines and market monitoring in supporting market transformation strategies for efficient lighting. It outlines the process for establishing and updating baselines through market monitoring activities, looking in particular at the types of data required, the data collection process and how to analyse data to most effectively inform policy development. The key steps in this process are illustrated diagrammatically in Figure 1 and a more detailed plan and checklist are included in Annex A to support implementation of this process.

CHAPTER 2 outlines a plan for developing a market baseline and market monitoring, including goal-setting, administrative frameworks, and resource requirements. This chapter also introduces data collection and analysis considerations.

CHAPTER 3 describes in detail the data collection process, data types, and quality assurance considerations. This chapter also addresses situations in which there is no data available.

CHAPTER 4 provides an overview of data analysis methods and introduces the energy efficiency distribution and its relationship to other parameters.

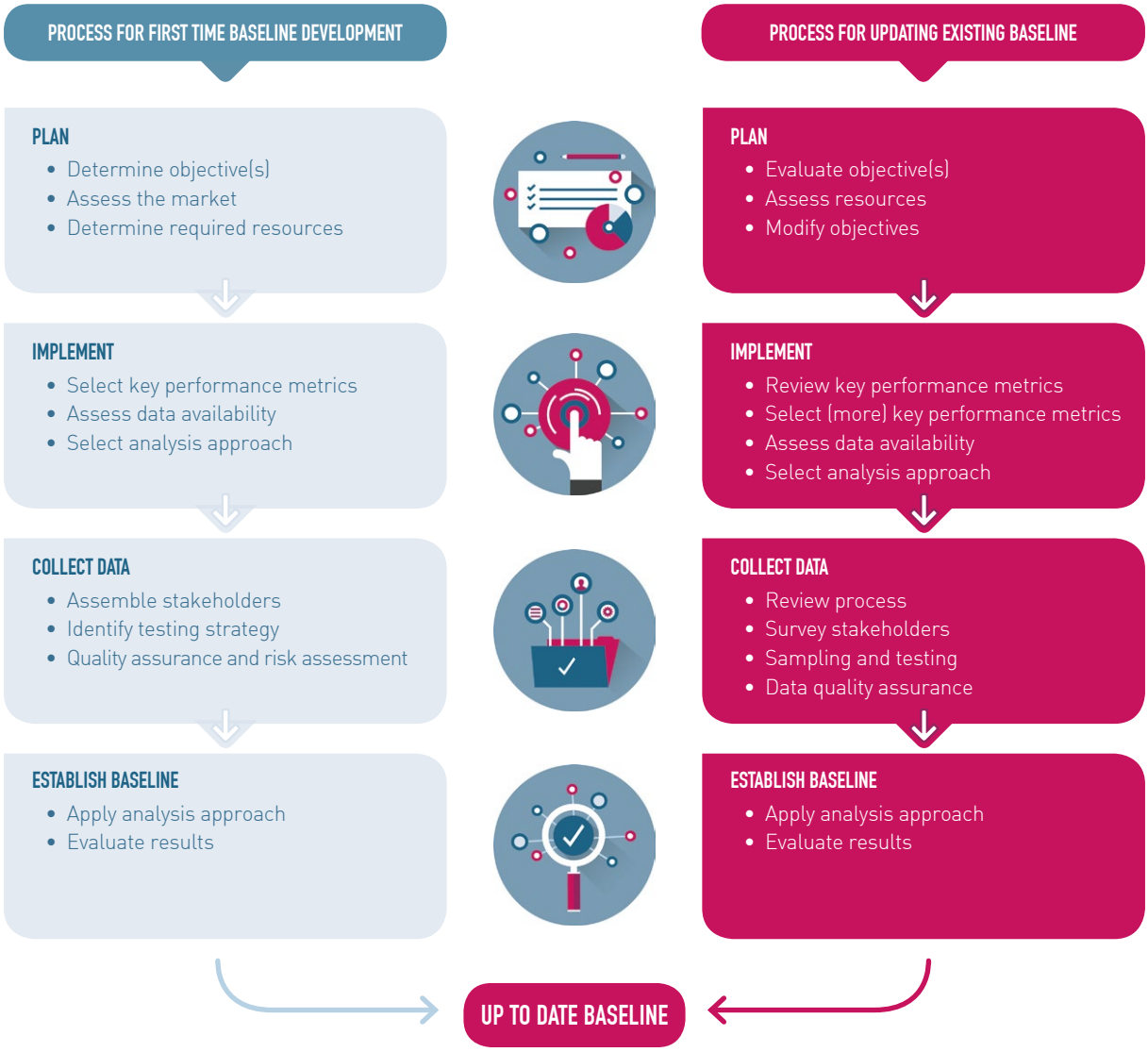
CHAPTER 5 best practices for establishing market baselines and monitoring the market.

CHAPTER 6 provides information on additional resources.

An example of a work plan for establishing market baselines for lighting products is included as an annex to help guide efficient lighting policymakers, programme managers, and other practitioners through the process.

Figure 1

Key steps in the process for establishing a market baseline



2 INITIATING MARKET BASELINE AND MONITORING ACTIVITIES

The development of market baselines and associated market monitoring schemes benefits from careful planning. It is recommended that policymakers start by: establishing clear and achievable goals for the baseline; preparing a comprehensive project plan; identifying performance metrics for tracking progress; and putting in place sound strategies for data collection and analysis. This chapter outlines a plan for developing a market baseline and carrying out monitoring, including goal-setting, administrative frameworks, and resource requirements. It also introduces some important data collection and analysis considerations.

2.1 ESTABLISH GOALS OR OBJECTIVES

Establishing a single, or set, of goals and objectives should be the first step in any baseline and market monitoring exercise. Goals and objectives provide a means to meaningfully interpret the results of the baseline and gauge the degree of success of an energy efficiency policy or programme.

2.1.1 DEFINE GOALS AND OBJECTIVES FOR MARKET BASELINES

It is important to define clear, policy-driven objectives for the market baseline at the outset of the project. Only if the analysis delivers the right information, in the right format, can it effectively further the specific market transformation goals that it is intended to inform. For example, a market baseline that demonstrates high levels of compliance for one product type may lead the enforcement agency to prioritise other product types for future compliance checks, but only if the enforcement agency is made aware of the results in a timely fashion and has sufficient confidence in the integrity of the data and the results of the analysis.

Generally speaking, market baselines for energy efficient lighting may be designed to serve some, or all, of the following purposes:

- Assess the need for MEPS, HEPS and/or labelling programmes, and supporting policies as mechanisms to further market transformation objectives;
- Identify and prioritise the scope of products and the performance parameters and levels to be addressed by performance requirements and supporting policies;
- Inform the timing and design of policies and programmes to suit market conditions;
- Define a reference point from which policy and programme impacts can be measured over time;
- Inform projections of energy and economic benefits that may be achieved through MEPS and other policies;
- Assess the degree of product compliance with any existing regulations and the need for any adjustment to the regulations.

Market baseline data and analysis may be refreshed over time and analysis of market trends can then be used by policymakers to inform MVE programmes.

Examples of market baseline outputs and their practical applications in support of policy are provided in Table 1 and in Figure 2 and Figure 3.

Table 1

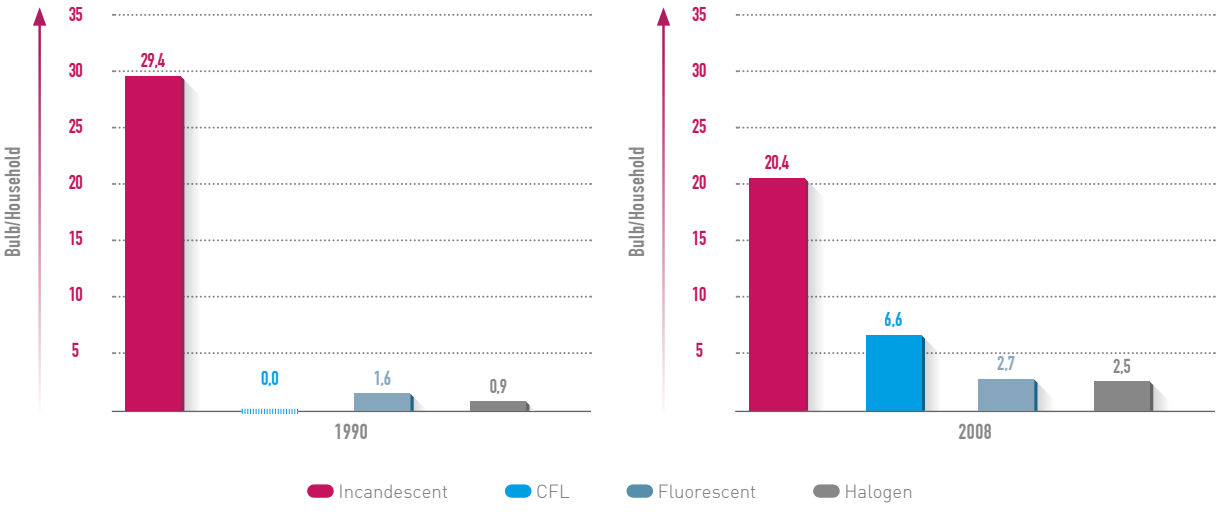
Examples of market baseline outputs and their application to policy

Example Output from Market Baseline	Policy Application	Example Policy Objectives
Average luminous efficacy of products on a market	MEPS HEPS Labelling	• Set appropriate minimum efficacy levels for each technology type. • Project the benefits of MEPS and supporting policies.
Average price of different product types that provide similar lighting service	MEPS Supporting policies	• Determine incentive levels necessary to drive purchase of more efficient products.
Percentage of products on the market that meet regulatory requirements[3]	MEPS Enforcement	• Determine compliance levels to allocate resources for future enforcement. • Assess actual versus projected impacts of policy measures.

Figure 2 illustrates the use of market baseline data to monitor changes in a market in the absence of policy (number of lamps per household in Canada between 1990 and 2008), while Figure 3 illustrates the use of baseline data to estimate the impact of a proposed policy measure, in this case the projected mix of lamp types in Lao PDR following a policy to phase-out incandescent lamps.

Figure 2

Number of lamps (by type) per Canadian household, 1990 and 2008

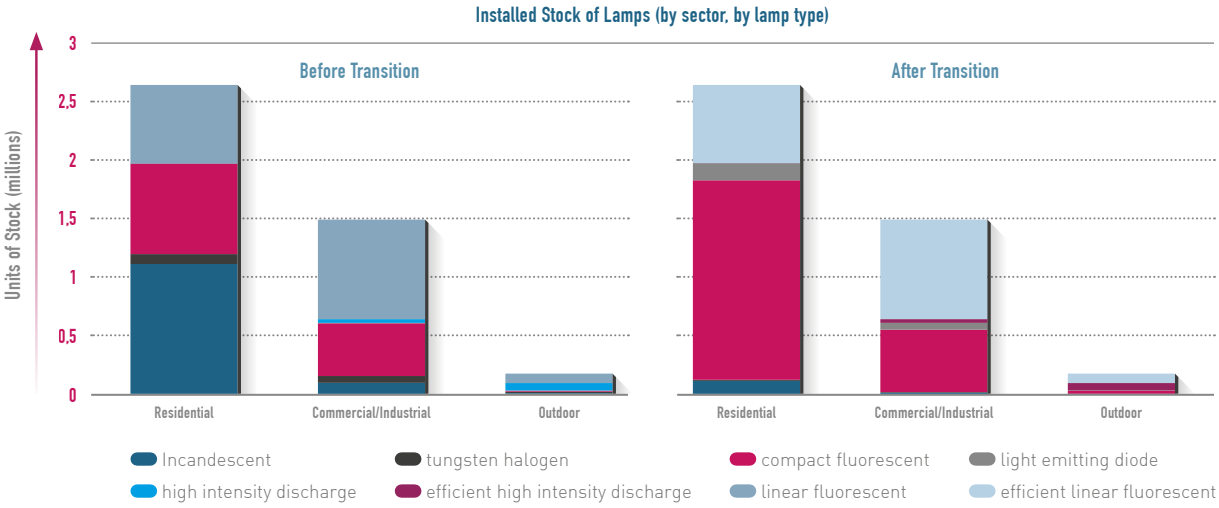


Source: Natural Resources Canada 2010

3 This requires that tested samples are selected randomly in the market across the whole country. When tested samples are selectively chosen for market monitoring, the results often serve a certain purpose, such as identification of non-compliant products, addressing complaints, or a follow up to previous non-compliance record.

Figure 3

Installed and projected stock of lamps in Lao PDR used in an incandescent lamp phase-out scenario (as represented by en.lighten's Country Lighting Assessment Tool)



Source: UNEP 2014

Box 1

Case study: Use of baselines to inform energy efficiency programmes in Asia

In 2007, as a part of its efforts to report on the state of the compact fluorescent lamp (CFL) market, the United States Agency for International Development Environmental Cooperation-Asia Clean Development and Climate Programme (ECO-Asia) conducted a baseline study of CFL quality in six countries in Asia (China, India, Indonesia, Philippines, Thailand, and Vietnam). A key objective of this research was to gauge the quality of CFLs available in the market at that time. This research effort defined indicators for lamp quality in terms of product lifetime, actual lumen output, as compared to claimed lumen output, and evidence of testing or registration.

The market review found that that up to 50% of the CFLs on the market at that time had no evidence of testing or registration, and shorter lifetime and lower lumen output than claimed. It showed clear indications that these products were of lower-than-expected quality, thereby forming a baseline for energy efficiency programme actions or activities. The baseline of product quality established by this study helped to launch a regional discussion on CFL quality standards and served as one of the drivers for the Bureau of Indian Standards to require mandatory certification for all CFLs on the Indian market.

Source: United States Agency for International Development 2007

2.1.2 DEFINE GOALS AND OBJECTIVES FOR MARKET MONITORING

Markets can change quickly as economic conditions change, consumer preferences evolve, environmental priorities shift and new technologies are introduced that lower the cost of efficient products. On-going market monitoring (accomplished by refreshing the baselines described previously) provides policymakers with the information they need to keep abreast of market trends. Market monitoring can serve a variety of purposes, some of which are detailed in Table 2. For example, managers of financial incentive programmes require near real-time market data to ensure that incentives are made available for the newest and most efficient products on the market, and that incentive levels keep pace with changes in product pricing.

Table 2

Typical purposes of market monitoring by programme type

Programme Type	Typical Monitoring Objectives
MEPS and Energy Labelling	• To ensure the accuracy and quality of registered product performance data, label information and other relevant parameters for products under voluntary or mandatory MEPS and labelling programmes.[4] • To establish frequency of regular market surveillance activities, and identify implementing partners. • To establish consequences for different types and levels of non-compliance (in support of MVE activities). • To understand and follow up the impacts of market surveillance or compliance actions and activities. • To inform the need for any adjustments to current programmes.
Supporting Policies	• To establish criteria for products to qualify for incentives. • To establish incentive levels. • To make sure that products targeted by incentives are well qualified.
Consumer Response	• To respond to consumer complaints. • To establish or develop consumer education/outreach materials or campaigns.

Market monitoring typically requires evaluation of many of the same data points as the market baseline process, including product performance, quality, production and sales data for popular models. As countries gain experience with market monitoring, data collection may be expanded to include additional indicators and advanced analytics in order to better characterise market segments to suit specific needs. These updates can help programmes maximise their market intelligence and relevance.

Market monitoring can be a costly undertaking, depending on the approach used – either on-site or web-based. In order to gather accurate and representative market data such as product pricing or labelling, it is necessary to carry out on-site monitoring in a number of diverse retail locations (as described in Section 3.4). Although on-line data gathering can help to pinpoint certain trends in the market, comprehensive data collection typically requires on-site monitoring. For this reason, it is important to regularly evaluate the data collection and analysis requirements to avoid the gathering of extraneous information. For example, whereas it is important to track changes in the luminous efficacy of rapidly evolving technologies such as light emitting diode (LED) lamps, tracking the same trends for stable, mature technologies (such as high pressure sodium or metal halide lamps) are unlikely to yield significant insights.[5] However, monitoring of these products may still be useful for compliance purposes if regulations are in place. A brief description of these market monitoring approaches is given below to inform the decision on which approach may be most relevant in individual situations.

4 Note that independent verification of manufacturer claims and label information is an important part of market monitoring.
5 Natural Resources Canada 2010

Box 2 Policymaker tip: Frequency of baseline updates

Depending on programme needs and available resources, baselines can be updated on a regular basis, or on an as-needed basis, using results and data from market monitoring activities. MEPS, energy labelling and MVE programmes often require frequent updates of some types of product and market information (such as, product performance and price trends and compliance rates) that can change rapidly with changes in product availability or technology advancements. Further, many MEPS and energy labelling programmes tend to review their requirements on a 24 to 36 month cycle (this period can be longer for a more mature market) to closely reflect market conditions. The frequency of market baseline analysis should reflect these cycles.

With respect to LED lamps, it should be noted that, although product changes may be accelerating with the rapid advancement in electronic control gear, actual energy performance of lighting products may not follow as rapidly. The tracking of this information is therefore an important role for market monitoring activities.

Thus, the decision on how often to update a baseline (and MEPS levels) is a balance between programmatic needs, available resources and the pace of change. This is discussed further in the UNEP-GEF en.lighten initiative guidance note, *Developing Minimum Energy Performance Standards for Lighting Products.*

ON-SITE MONITORING

On-site monitoring refers to in-person site visits to retail outlets to visually confirm compliance status, pricing, or other characteristics of products on sale. If regulations require display of a label and/or energy related information on a product or its package, inspectors should also check the presence of such information.[6] Other product data may also be collected to check for accuracy with information that is self-reported by manufacturers in product registration systems.

On-site monitoring requires the use of trained field personnel, and sometimes involves travel and other expenses that can make the cost of data collection far greater than if the data were collected via secondary methods. On-site monitoring may also involve the purchase and collection of product samples for testing. It is recommended that policymakers allocate sufficient budgetary resources to the baseline project to meet these needs. For more information on on-site monitoring see the UNEP-GEF en.lighten initiative guidance note, *Product Selection and Procurement for Lamp Performance Testing*. For a practical example of a recent on-site monitoring exercise undertaken in Southeast Asia, see the UNEP-GEF en.lighten initiative report, *Lamp Sampling in Cambodia, Indonesia, Lao PDR, the Philippines, Thailand and Viet Nam*.[7]

In addition to in-store surveys, it is also useful to survey the use of lighting products in homes. This provides additional information on how products are being used and how a transition to more efficient lighting is being taken up. For example, information about the types of lamps found in high use areas of the house (such as living areas and kitchens) compared to low traffic areas (such as storage rooms and garages) provides a clearer idea of how much energy can be saved from an efficient lighting policy. Surveys may be conducted in person, with inspection of installed lighting, or via paper, telephone or online surveys. Remote surveys are less reliable but are cheaper and allow larger sample sizes.[8]

Box 3 Case study: Southeast Asia on-site market monitoring

As a part of the UNEP-GEF en.lighten initiative Southeast Asia and Pacific Monitoring, Verification and Enforcement Project, the International Institute for Energy Conservation (IIEC), in association with countries agencies, conducted a retailer survey on behalf of UNEP to identify popular models of CFLs and LED lamps and to characterise the retailers in the individual markets. IIEC used the results from this retailer survey to develop a list of lamps in each country to be purchased for performance testing. The surveys covered more than 90 retailers in the target countries. Some of the lessons learned from this process included:

- Small retailers (and some large ones) do not carry sufficient numbers of lamps to allow purchase of the required number of lamps to make up the necessary testing sample size;
- Collection/sampling protocols may need to be adjusted to match market conditions (such as, adding alternative models to be collected, or additional retail locations to be visited).

Source: UNEP 2015b

6 CLASP and Topten China 2013
7 UNEP 2015b
8 As an example, information on a survey of the Vietnamese market can be found at: http://industry.gov.au/Energy/InternationalEngagement/Pages/Vietnam-Energy-Efficiency-Standards-and-Labeling-Programme.aspx

WEB-BASED MONITORING

Web-based monitoring refers to the regular collection and monitoring of information from product manufacturer and retailer websites. In many markets, a wide range of information is available online, including product specifications and performance characteristics, often with explanations of terminology, product photographs and pricing details. In markets where e-commerce is prevalent, it is important that market monitoring activities address this important and expanding sales channel. Web-based monitoring typically relies upon automated computer processes (or in some cases manual web searches) to collect data from the internet and compare it with policy requirements.[9]

Compared with on-site monitoring, which can involve employing a data collection team, web-based monitoring typically requires fewer resources and can therefore be conducted more frequently if changes in products or markets are anticipated. However, depending on the scope of the monitoring effort, web-based monitoring may require up-front investments to develop data collection tools and purchase information technology equipment, and ongoing expenses for tool updates and equipment maintenance.[10] There is also the need have a process to verify the online data against other data sources, such as product registration systems or actual test results, before using the data in the market baseline process.

2.2 SELECT KEY PERFORMANCE METRICS

In order to meet market baseline and market monitoring objectives, a set of initial key performance metrics should be defined, based on baseline objectives, availability of data and resources, as well as experience in data collection and conducting analyses. It is important that countries consider regional or international collaboration and alignment of metrics, in order to fully take advantage of existing domestic and international experience where available. As a country gains experience (and resources) in this process, the number of key performance metrics can expand and the data gathering effort can be better adapted to suit programme needs.

These metrics should represent specific, measureable and traceable product characteristics. For lighting products, these typically include:

- Technology type (such as, compact fluorescent or LED);
- Service type (such as, omnidirectional, reflector, linear);
- Light output (both that stated by the manufacturer and that obtained by testing);
- Efficacy (both that stated by the manufacturer and that obtained by testing);
- Lifetime;
- Colour rendering index;
- Power factor;
- Price;
- Market share;
- Compliance testing rate;
- Registration rate;
- Labelling;
- Packaging details.

Box 4 Policymaker tip: The Importance of test data

Test data can be a key input to baseline development, especially data regarding product lifetime or depreciation. Obtaining this data can be a lengthy process, as lifetime testing can take a substantial amount of time.

Product testing provides a foolproof way of verifying the performance of products available on the market, as there can be performance differences between products under laboratory development and those actually in production and on the market. In most cases, test data from independent third-party laboratories is preferable to manufacturer-sourced data, since there is less potential for bias in the results. One way to improve confidence in manufacturer test data is to require laboratories to be independently accredited by a third-party organisation.

When conducting tests, it is important to use the most transparent and repeatable methodologies, and with the full application of the testing standards. Testing may be conducted in a Government laboratory or, in the absence of a national testing facility, contracted to an independent, appropriately accredited commercial laboratory.

Policymakers with few resources at their disposal will greatly benefit from formal or informal data sharing arrangements with peer governments, since products are often common across regional markets.

For more information on the key considerations associated with product testing, see the UNEP-GEF en.lighten initiative guidance note, *Performance Testing of Lighting Products*.

9 SEAD 2013
10 UNEP 2015c

2

It is recommended that key performance metrics be selected in consultation with a diverse group of stakeholders, including industry representatives, rather than in isolation. These stakeholders can often provide important insights into market dynamics that may be obscure to the policymaker. Therefore, their input is critical, not only to the identification of meaningful key performance metrics, but also to the data collection and analysis methods that will support them, as further elaborated in Chapter 3.[11]

A mix of qualitative and quantitative key performance metrics are frequently selected to provide a thorough understanding of market conditions. It is important to include key performance metrics that allow for measurement of the impacts of a resulting policy measure over time, as part of a market monitoring scheme.[12] Product registration systems (where they exist) are a good source for first-order lists of key performance metrics and indicators of available data.

Policymakers looking to set MEPS may require product performance metrics to describe the overall efficacy level of products on the market. Those seeking to establish energy labelling programmes may want more market and consumer-related key performance metrics to describe retail conditions and consumer awareness. Where the policy or regulation aims to effect a market transition to newer more efficient technology, information may be required on a broader range of parameters to determine whether the efficient lighting products available in the market can provide a sufficient, cost-effective, and acceptable level of lighting service to replace the less efficient technology to be phased out. In turn, MVE programme officers will require key performance metrics related to compliance levels by manufacturers to various established regulatory requirements (not necessarily just energy-related). Examples of some key objectives and the suggested performance metrics to inform them are given in Table 3.

Table 3

Examples of key objectives and applicable key performance metrics

Key Objective	Example Key Performance Metrics
To quantify the emissions or energy use footprint of the existing lighting market. To determine where the minimum level(s) should be set with respect to performance of available products on the market, taking into consideration: the costs to consumers; the benefit of increased energy savings; a technology transition pathway and possible technology development trends; and reduction in emissions.	• Technology market share. • Range of product efficacies.[13] • Other performance parameters (lifetime, lumen maintenance, colour quality, etc.). • Average production costs. • Average market price and price range. • Electricity or energy use. • Market size/socket count. • Emission factors per kWh generated. • Hours of use.
To determine the levels of product or manufacturers' compliance against established requirements, such as testing to specific standards, meeting mandated labelling or registration rules To ascertain the accuracy level of product performance represented by manufacturers (known as 'truth in claim').	• Average, or tested, efficacy levels (and other performance parameters). • Tested efficacy (and other performance parameters) versus claimed levels. • Standards used. • Performance reporting practices. • Evidence of third-party testing. • Compliance with registration requirements, etc. • Presence of required and/or approved compliant product labelling on packaging. • Available products are registered (if up-front registration required).

11 It is important to keep in mind that there is often difficulty in establishing a 'control' group of baseline key performance metrics against which to measure market changes, especially for the first time. Importantly, some key performance metrics may be affected by other market forces, and this can limit the accuracy of any baseline. For example, changes in the performance of some energy efficient lamps, which are an internationally traded product, may be the result of actions or policies in other markets.

12 United States Environmental Protection Agency

13 Note that this can be a range of the average efficacies of each sample set.

Box 5 Policymaker tip: Practice makes perfect

Regardless of the key performance metrics chosen, if the process is being used for the first time, it may be useful to consider piloting the process. For example, if a consumer survey is needed, it may be useful to pilot both the actual survey delivery, or collection method, as well as the survey questions with a sample audience. This will make it possible to assess the effectiveness of the data gathering methodology, and the clarity of the questions and their ability to elicit useful responses. The time and costs needed to implement these pilot efforts also need to be accounted for in the work plan.

Countries and regions may also wish to consider additional metrics and data as appropriate to their needs. For example, data may be needed on compliance with regulations on the use of hazardous substances[14] or mercury content where handling and disposal of products at end-of-life are a particular issue.[15] Policymakers are encouraged to seek out international or regional expertise at this stage of the market baseline process - there is a wealth of institutional experience and data available to be leveraged to ensure that selected indicators and referenced test methods are fit for purpose.

2.3 PREPARE AN IMPLEMENTATION PLAN

Once the goals for the market baseline effort are defined, a project manager must develop a comprehensive implementation plan to document the objectives of the market baseline and define project timelines, resource needs, roles and responsibilities, data sources and other factors. The implementation plan should encompass both the initial market baseline preparation, as well as ongoing market monitoring, and should include all the steps in the baseline development process (as illustrated in Figure 1 in Chapter 1). An implementation plan is especially important in cases where market baseline development requires coordination among multiple government agencies and private sector organisations.

Clear priorities are needed to determine the sequence with which stated baseline objectives and metrics can be met. For example, if the priority is to characterise the performance levels of products on the market for setting MEPS, the objectives and metrics will need to focus on technical and energy performance parameters. On the other hand, if the priority is to increase the market penetration of efficient products, the objectives and metric may need to focus on market shares and other market-related parameters. Objectives and metrics may be expanded as countries gain experience or additional resources, or both.

Once a starting point is set, other analyses using the same approach and indicators can follow periodically, and can be evaluated in comparison with the indicator values that were established at the beginning of the project. An analysis may be performed halfway through the project timeline as a mid-term review. At a minimum, a second analysis should be carried out at the completion of the project or programme to determine the impacts on the market.

It is recommended that the implementation plan specifically address the points set out below.

2.3.1 EVALUATE ADMINISTRATIVE AND LEGAL FRAMEWORKS

At the outset of project planning, it is recommended that the project manager first evaluate the existing legal and administrative frameworks within which their baseline will be developed. For nascent programmes that are conducting their first baseline activities, a legal framework that gives authority to the responsible government agency (or other institutions) may need to be established or modified to fully support the baseline and monitoring process. [16] Legal frameworks may require significant time to establish, so policymakers may consider how to begin market baseline research in their absence, provided that the collected data are used with caution.

2.3.2 DEFINE ROLES AND RESPONSIBILITIES

The project manager must next determine the roles and responsibilities for participating agencies and contributors. The authority developing efficient lighting policies may seek to maintain full responsibility for the market baseline exercise and market monitoring

14 Such as the European Union, *Restriction of the Use of Certain Hazardous Substances (RoHS) in Electrical and Electronic Equipment (EEE) Directive* (2011/65/EU). http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:174:0088:0110:EN:PDF

15 For more information on the development of legal frameworks for environmentally sound, end-of-life activities see UNEP-GEF en.lighten reference manual, *Achieving the Global Transition to Energy Efficient Lighting Toolkit*, Section 5.

16 For more details on planning a legal and administrative framework, see the CLASP guidebook, *Energy Efficiency Labels and Standards: A Guidebook for Appliances, Equipment and Lighting.*

programmes, or they may seek to assign authority over aspects of the project plan to different agencies or consultants. In any case, setting clear expectations for each participant in the process is vital to the success of the market baseline effort, especially if the process is to be formalised and repeated over the long term.

To the extent possible, it is recommended that roles and responsibilities be well-documented, and be assigned to agencies and institutions rather than individuals, in order to mitigate the impacts of staff turnover within organisations over the course of time.

For a project manager, there are distinct advantages and disadvantages to consider in the approach to assigning roles and responsibilities. These are explained below and summarised in Table 4.

USING GOVERNMENT PERSONNEL

Market baseline and monitoring activities are likely to require the expertise of several government agencies, and departments within an agency (such as statistical, energy and standards agencies). Inter- and intra-agency coordination may be challenging, so it is important for the project manager to agree upon responsibilities and gain commitments from the outset, as these can be seen as additional burdens for government personnel (unless provided for by legislation or other legal framework). For governments that are conducting their first baseline or monitoring activity, the process may be slow and inefficient without the help of external experts. However, by conducting activities in-house, the participating agencies will build technical expertise over time, and these in-house capacities can be utilised during the implementation phase for MEPS, labelling and supporting policies.

USING EXTERNAL CONSULTANTS

There are many consultants around the world that specialise in preparing market baselines, and can often be engaged quickly through a tendering process. While this may offer a more expedient approach, especially when there is no expertise within the government to build upon, there are also drawbacks, including higher costs and the missed opportunity to establish internal processes and expertise. In addition, a government project manager is still required to facilitate interactions among various agencies, stakeholders, and external consultants.

In most cases, the optimal solution will involve a blend of in-house and outside experts to best suit the needs of the situation. In cases where data collection is being carried out within a legal framework and may be used for compliance and enforcement, there may be particular requirements as to who has the authority to collect data or samples, and it is important to ensure that those involved qualify under any legislative requirements.

Table 4

Overview of advantages and disadvantages of using different resources for baseline work

Resource Option	Likely Advantages	Likely Disadvantages
Government Resources	• Capacity building opportunity. • Lower costs.	• Requires inter-agency coordination. • Slower to complete. • May require a lot of staff capacity.
External Consultants	• Established and experienced. • More expedient.	• Higher costs. • No in-house capacity building, unless specifically built into process. • Ensure authority can be granted under any regulatory requirements.
Hybrid Approach	• Leverages existing expertise. • Establish internal processes.	• Requires external resources. • May not address internal knowledge gaps.

2.3.3 SECURE ADEQUATE RESOURCES

The costs of developing a market baseline and conducting market monitoring will vary depending on the objectives and scope of the effort, and whether there are already processes and systems in place for data collection. A project manager should plan for expenses associated with data collection, analysis and storage. Data collection in particular may require field sampling (i.e. sending teams to randomly select products from retail store shelves), the purchase of market data from aggregation services, product performance testing and surveys of end-users.

Box 6 Policymaker tip: Justifying the cost of baselines

A clear and accurate baseline is a key component of any efficient lighting market transformation strategy. It represents an important investment of programme resources, but it also has the potential to pay back in many significant areas. Most governments are required to justify a cost/benefit of any proposed new regulation. An accurate baseline will assist in providing this evidence. For example, a baseline of lamp efficacy can help a MEPS programme determine the most appropriate cut-off points for inefficient lamps, and can result in more energy and emissions savings than a level that is set too low. Conversely, a MEPS level that is set too high may result in: manufacturers not being able to produce compliant products; some monopolies in market segments; or products that can have significantly higher costs relative to inefficient counterparts, potentially creating a barrier to adoption and energy savings.

Source: UNEP 2015a

3 COLLECTING DATA

Market baseline and market monitoring processes often require the collection of large and diverse data sets. In order to generate high quality results, this data must be representative of the market segment under investigation and of sufficient quality. This chapter explains the data collection process, as well as challenges that might be encountered throughout.

3.1 DATA TYPES

Each of the key performance metrics identified for a market baseline or market monitoring exercise is calculated from one or more data points which may be collected using a variety of methods, and from a wide range of sources. The three principal types of data used in market baseline and market monitoring activities are:

- **PRODUCT TECHNICAL AND PERFORMANCE DATA,** including energy performance and light quality parameters;
- **MARKET AND SUPPLY CHAIN DATA,** including product sales volumes, information about retailers and distribution channels, import duties, stocking practices, product pricing, energy prices, etc.;
- **USAGE AND BEHAVIOUR DATA,** including consumer usage patterns, preferences and their awareness of efficiency labelling programs and the impact of energy efficiency, etc.

Table 5 lists some examples of the data types typically used to inform market baselines and market monitoring for efficient lighting products. As noted earlier, countries and regions may wish to consider additional metrics and data specific to their environmental priorities, such as where handling and disposing of products at end-of-life are a particular issue.

Data types should be chosen depending on the objectives and key indicators as established for the baseline process. In addition, each data type may require a different resource level and timeframe for collection. Therefore, it is recommended that decisions regarding these data types are made in collaboration with, and with input from, stakeholders, as well as based on international experiences from the outset.

Table 5

Data types frequently referenced in efficient lighting market baselines and market monitoring

Technical and Performance Data	Market Data	Supply Chain Data	Usage and Behaviour Data
• Light source technology (LED, CFL, etc.). • Service type (general service, directional, etc.). • Range of light output levels (lumens). • Typical lamp efficacy values (lumens/watt). • Technical and physical attributes of products (for example: size, wattage, lifetime, light quality) etc. • Lamp quality parameters such as CRI, lifetime, lumen depreciation. • Product information included on packaging.	• Range of domestic wholesale and retail prices of products. • Prices of equivalent lamps in other markets. • Average domestic manufacturing cost of lamps. • Consumer price index or similar indicator of consumer prices. • Highest and lowest efficiencies of products available on the market (and in the region or globally).	• Product distribution/ availability at retail. • Retail network/ stocking practices. • Import and domestic production. • Number of available sockets/use conditions.	• Awareness of efficiency benefits. • Perception of technology characteristics/ product quality. • Penetration rates of energy efficient lamps in homes and other institutions. • Usage characteristics (hours of use, application type/location, user preference, energy prices paid, etc.).

3.2 DATA COLLECTION METHODS

Data for market baselines and market monitoring are generally obtained directly or through secondary sources. These principle methods of data collection are described below and summarised in Table 6.

- **PRIMARY DATA COLLECTION,** involves direct measurement or observation, such as obtaining and testing product samples from retail stores, collecting product pricing data directly through store surveys, or conducting consumer interviews or focus group studies to understand consumer preferences, awareness or product usage patterns.[17] Examples of surveys for collecting data on lighting are included in Annex B and Annex C.

- **SECONDARY DATA COLLECTION,** the acquisition of data that has been collected and aggregated by third-party organisations, possibly for purposes unrelated to market baselines or market monitoring. Examples of secondary data collection include the compilation of product performance data from product registration systems or requests for product sales data from industry associations. Secondary approaches are preferable to primary approaches in many cases, as they require fewer resources and less time to collect. However, the collected data may not be as current and there will be less choices or control over the data available.

Quantitative market data such as annual sales and imports may be readily sourced from public-sector institutions that track international trade and manufacturing information.[18] Additional data may be sourced from international development banks and aid agencies. Product data such as specifications, performance and quality parameters may be sourced from industry and manufacturers in the form of product data sheets or catalogues. However caution must be observed when relying upon manufacturer-published marketing data; experience has shown that products may be marketed with exaggerated or unverified performance claims.

It is important to note that primary data collection usually requires more time and labour resources (such as resources for training of data collectors), while secondary data collection may require governments to enter into non-disclosure or other end-use agreements that restrict the use and re-distribution of data. Secondary data collection sometimes involves private sector firms that specialise in data aggregation and who may be able to supply reports that are customised to suit the policymaker's specific needs. If long-term market monitoring is anticipated, it is often more cost-effective for governments to enter into a long term data use agreement with vendors.

In cases when market baselines are being produced for the first time, some types of data (such as independently verified product performance metrics, consumer behaviour and awareness statistics) may not be readily available. Primary data collection efforts will therefore be required to complete the picture. Even countries with well-developed markets and a long history of market monitoring may have to conduct primary data collection to capture details about consumer awareness of energy efficiency, since this factor is changeable and the market for, and hence availability of, such data may be limited.

Box 7 Policymaker tip: Allow sufficient time for product testing

The collection of primary technical data can be challenging. In a developing market, such data may not be readily available, and product testing may be the only option to obtain product-related performance data. If this is the case, a plan will be needed to identify testing capability and resources, product selection, sampling and collection strategy, and testing methodologies and processes, as well as the interpretation of results. It is important to note that product testing data can be time consuming to obtain (for example, lifetime testing can take months or even years).

For more information on the key considerations when planning a performance testing programme, see the UNEP-GEF en.lighten initiative guidance note, *Performance Testing of Lighting Products*. Note that testing may be conducted in a Government laboratory or, in the absence of a national testing facility, contracted to an independent, appropriately accredited commercial laboratory.

17 For an example of a data collection project undertaken in Asia, see the UNEP-GEF en.lighten initiative report, *Lamp Sampling in Cambodia, Indonesia, Lao PDR, the Philippines, Thailand and Viet Nam.*

18 The use of World Customs Organisation's International Convention on the Harmonised Commodity Description and Coding System (commonly known as the Harmonised System or HS codes) for products should be investigated. However, it should be noted that the extent of their adoption can vary among countries.

Table 6

Some examples of data collection methods and details

Resource Option	Examples	Typical Resources Required	Data Collection Notes
Primary	Consumer surveys (interviews)	• Development of survey instrument and tools. • Survey team. • Training and deployment. • Time to conduct survey. • Analysis of survey results.	• Need to survey a representative cross-section of the population.
	Product sample collection (in-store purchases)	• Training and deployment of field collection team. • Travel expenses. • Purchase budget. • Testing budget. • Time to collect samples.	• Need to collect from a variety of retail locations and retail types. • Additional time on top of testing.
Secondary	Sales data	• Budget for data purchases or other means such as agreements or legislation.	• May require data sharing agreement and ways to mask data from individual manufacturers.
	Product characteristics (from catalogues or registries)	• Familiarity with product categories (training for data collectors). • Automated data collection software (netbot).	• Performance data will need to be verified as appropriate.

3.3 DATA SOURCES

Market baseline and market monitoring data is often sourced from external parties such as manufacturers, industry associations, and independent test laboratories. It is important that policymakers maintain good relationships with these stakeholders to most effectively leverage their goodwill and knowledge in the data collection process. It is good practice to build trust with stakeholders by involving them as partners in the data collection process from the outset and by putting controls in place to ensure that sensitive market data is kept confidential and anonymous when necessary. Depending on the data available and sources, governments may need to institutionalise the data reporting process through legislation or other administrative means, including the development of a product registration system. The following sections contain additional information about data sources that are commonly referenced in efficient lighting market baseline and market monitoring projects.

3.2.1 GOVERNMENT PRODUCT REGISTRATION SYSTEMS

Policymakers can often source product information and performance data from sources in the public domain, particularly government product registration systems such as the United States Environmental Protection Agency's ENERGY STAR product registration system[19] or the Government of Australia's Energy Rating database.[20] These product registration systems contain information about product characteristics and energy performance that will be useful to most market baseline and market monitoring efforts. Some regulatory programmes also require the submission of product sales data for registered products. While this imposes an additional burden upon suppliers, the combined product registration and sales data can provide a quite comprehensive database of product performance and stock in the market.

Note that for some programmes, being able to set baselines and track market transformation is a key design function of registration systems. For these programmes, data from the registration system can offer

19 Available at: http://www.energystar.gov/products/certified-products?s=mega
20 Available at: http://reg.energyrating.gov.au/comparator/product_types/

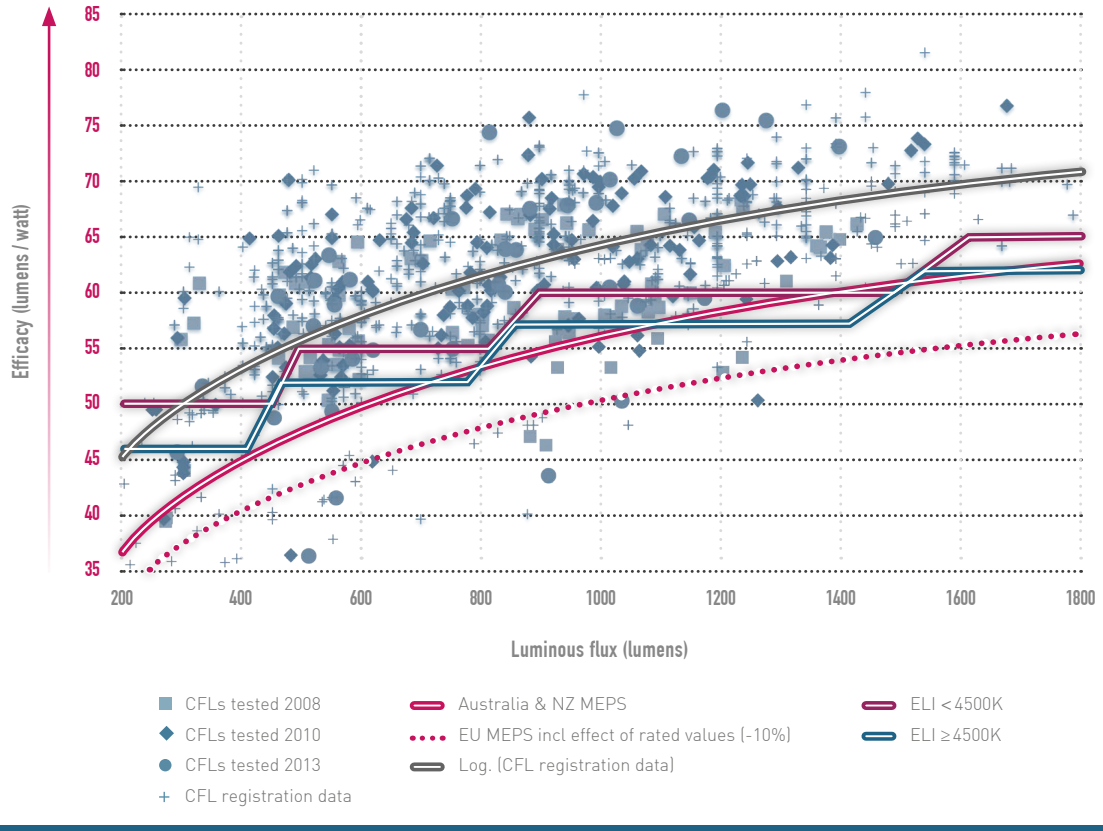
a primary source for establishing baselines, depending on the parameters being collected. As with the use of data from any source, it is important for the policymaker to understand and decide whether the underlying data should be self-reported by manufacturers or independently verified, and how this data can be used in the baseline development process.

For more information on developing a product registration system, see the UNEP-GEF en.lighten initiative guidance note, *Developing Lighting Product Registration Systems.*

Box 8 Policymaker tip: Leverage the knowledge of local partners

The graph below shows a comparison of test data and registered data of CFLs on the Australian market. Although the test data and registered data do not necessarily represent the same models, there is a great overlap in terms of efficacy level. Although the plot of the registered data shows compliance with the Australia and New Zealand MEPS requirement, the test data tells a different story - there are a number of tested models that fall into the non-compliant zone. This shows that while policymakers can use registered data to develop a basic market baseline, it is important to also look at test data for a more comprehensive understanding of the market.

Average efficacy of bare CFLs from lamps tested by the Australian Government in 2008, 2010 and 2013



Source: Equipment Energy Efficiency Program 2014

Box 9 Policymaker tip: Leverage the knowledge of local partners

Collection of market data such as pricing, stocking/distribution, market penetration rates,etc., tends to be done through field surveys. Surveys are resource intensive, so a strategic approach will need to be developed to leverage the resources available. For example, a price survey might be combined with an exercise to procure samples for verification testing to fully leverage the use of field personnel. In these cases, it is also important to involve local stakeholders, who can provide input into survey locations or content. Retailers, associations or local industry representatives tend to be the best sources for these data types.

3.3.2 INDUSTRY GROUPS

Industry groups can be approached to provide product and sales volume data. This often requires arrangements to be put in place to protect confidential commercial information. Confidentiality is typically achieved through amalgamation of industry data and masking or removal of specific supplier details. In some cases, industry participants may wish to establish memoranda of understanding, or other formal partnership terms, regarding the sharing and use of sensitive data before such sharing can take place.

3.3.3 MANUFACTURER AND RETAILER WEBSITES

With increased access to the Internet by the general population, many retailers and other suppliers have made their information available online, some even sell exclusively online. The retrieval of such online product and pricing information can be done quickly through the use of automated data collection tools often referred to as web crawlers). These tools typically do not require significant investment in resources, but they do need to be strategically deployed and managed. In many cases, these tools tend to be available on a proprietary basis from vendors, and do require customisation to suit a particular market, as along with ongoing quality checks. If the appropriate information technology equipment is not available, there may be some upfront financial investment required, such as for servers, storage, etc. However, it is important to note that in less developed markets and regions, online product offerings may not be representative of the overall market (see data representativeness in section 3.4, below) and products and pricing listed by online retailers may, or may not, be available to the general population. Online prices also typically do not include handling and shipping charges.

3.3.4 NATIONAL STATISTICAL DATABASES

Product import and export data may be useful for determining the overall product volume in the market. This data can be combined with smaller, more detailed information samples from sources such as in-store surveys. Where overall sales volume and pricing information is not otherwise available, some third party data suppliers may be able to provide sales data for a range of retail outlets.

3.3.5 REGIONAL COLLABORATION INITIATIVES

Regional collaboration, especially the coordinated collection and exchange of market baseline data and alignment of key performance indicators and objectives, can greatly benefit countries that are in the early stages of assessing their markets for energy efficient lighting. Markets for lighting products are often found to be quite similar in neighbouring countries, particularly when those countries have pre-existing political or trade cooperation agreements.

Coordinated data collection and information sharing efforts can extend scarce resources and maximise the value of a market baseline by providing insights into regional market conditions. It is important to note that data sharing and cooperation between sovereign governments often requires official agreement or approval, and thus should be included in project planning efforts.[21]

Several regional initiatives are working towards aligning standards for lighting and are working collaboratively to collate data to inform these standards, including *lites.asia* (see Box 10), en.lighten[22] Proyecto Mesoamerica in Central America[23] and ECO-Asia[24].

3.4 STATISTICAL DATA SAMPLING AND QUALITY ASSURANCE

As noted previously, data collection for market baselines is often time consuming and resource intensive. Few countries have the resources that would be needed to evaluate a domestic efficient lighting market in its entirety, so statistical practices are often employed to maximise the scope of the data collection process. The information below sets out these common statistical practices used for collecting samples to inform baseline development.

21 UNEP 2012

22 The en.lighten initiative supports efficient lighting in developing and emerging economies. More information available at http://www.enlighten-initiative.org/

23 The Proyecto Mesoamerica is intended to strengthen regional integration and to promote economic and social development of the participating countries, with some focus on transitioning to efficient lighting. More information is available at (http://www.proyectomesoamerica.org/joomla/index.php?option=com_content&view=article&id=229&Itemid=57).

24 The ECO-Asia Clean Development and Climate Program, funded by the United States Agency for International Development, operated from 2006 – 2010 to promote market transformation toward clean energy development in Asia, with a focus on lighting. The reports from the program can be accessed through the *lites.asia* Communications Materials Library at http://www.lites.asia/library.

Box 10 Case study: lites.asia regional collaboration network

An excellent example of regional collaboration can be seen in the activities of *lites.asia* (www.lites.asia), which arose out of a meeting in October 2009, when representatives from Australia, China, India, Indonesia, Philippines, Sri Lanka, Thailand, United States and Viet Nam met to discuss the potential benefits of regional cooperation on the development of lighting standards and the importance of improving product quality for the whole region. The forum resulted in participants proposing a ten-point plan for:

- Improving knowledge of the standards in force and under development across the region;
- Increasing participation of regional economies in the International Electrotechnical Commission (IEC) standards development process to ensure resulting test methods and performance standards are appropriate to the region;
- The development of national and regional capacity for compliance in standards and labelling processes.

Since the meeting in October 2009, membership of the *lites.asia* network has increased to over 700 participants from more than 30 economies, with delegates actively participating in IEC meetings, sharing knowledge on local standards and labelling electronically and in regional meetings, plus a number of other cooperative actions.

When compiling a market baseline, a representative sample of the population, or of the whole market – known as a 'population sample' – should first be identified. For example, when data is collected that is related to households or consumers, it is important to obtain a sample that reflects demographics and income distribution, as well as geographic distribution. Similarly, data on lamp pricing will need to be collected from different market channels, retailer types, and geographic regions, etc. (as illustrated in the data collection form example in Annex B). The data 'mean' and 'standard deviation' (denoted as M and SD in statistics) used to inform the baseline are therefore calculated from the 'population sample' and not the actual population. Several factors can affect the statistical precision of a parameter estimate, however sample size is always an important factor.[25]

The statistical precision of a data sample is defined as "*the closeness with which such a sample can be expected to approximate the relevant population value.*"[26] The statistical precision of the data sample is an estimated value, as the actual population value is generally unknown. The statistical precision is usually estimated using a standard error, which specifies the amount of chance fluctuation, or lack of precision, that can be expected in sample estimates. If all other factors are held constant, the standard error decreases as sample size increases.[27]

As population sample sizes increase, parameter estimates become more precise. Therefore, differences between or among parameter estimates may be small but may still generate statistically significant errors.

Since resources are often limited, it is essential to determine the sample size requirements of a study before collecting data to ensure that the results will be neither insufficiently precise (not enough data) or overly precise (too much data) – both of which are wasteful.[28] Consultation with national statistical agencies or experts will be helpful to make sure this phase of work is carried out in a cost-effective and correct manner.

3.5 DATA INTEGRITY

As volumes of data are continually collected and processed for market baselines and market monitoring, maintaining data integrity (the accuracy and consistency of stored data) becomes an increasingly important concern to the policymaker, regardless of the quality of the original sources. Below is a four-step process that may be followed to ensure that source data is appropriately collected and maintained.[29] It is important to note that this process can only improve the quality of the data that already exists, and cannot address the root causes of fundamental data collection problems.

⇨ **DATA PROFILING** involves the regular review of source data to ensure it meets quality expectations for completeness and accuracy (this step is sometimes called 'source system analysis'). Data completeness refers to the degree to which all products are represented in the data, and the degree to which all necessary information about each product is included. Data accuracy refers to the degree to which data values are free from anomalies or inconsistencies.

25 Note that this discussion is about statistical data sampling. For information on product sampling, please refer to the UNEP-GEF en.lighten initiative guidance notes, *Performance Testing of Lighting Products* and *Product Selection and Procurement for Lamp Performance Testing*.

26 Cohen 1988

27 Australia's National Statistic Service has developed an online Sample Size Calculator that can be used to calculate the required responding sample size, standard error, relative standard error, and a confidence interval (95% or 99%) for a proportion estimate, using just one of these criteria as an input. For example, if you know the standard error you need to meet precision requirements of your estimate, you can find out the responding sample size required to achieve that; if you know the likely size of the responding sample you can estimate the standard error of your estimate, and a confidence interval for it. It is available at: http://www.nss.gov.au/nss/home.nsf/pages/Sample+size+calculator

28 United States Census Bureau 2013

29 ibid

⇨ **DATA QUALITY IMPROVEMENT** involves a review of the anomalies found during data profiling to identify the source of each problem. Once specific data problems are identified, four options are available for improving the data set:

- **Exclude the data:** If problems with the data are deemed to be severe and irreparable they should not be used;
- **Accept the data:** If suspected errors are tolerable, it may possible to accept the data as-is, with known errors;
- **Correct the data:** In some cases, a known value can be substituted for problematic data points;
- **Insert a default value:** In cases where empty data fields would cause problems, it may be preferable to insert a default value even if it is known to be inaccurate.

⇨ **DATA INTEGRATION** entails the identification and consolidation of duplicate data for a single product entry.

⇨ **DATA AUGMENTATION** involves the incorporation of additional information into a data set (such as qualitative assessments by topic experts) that has not been collected from a primary or secondary data source.[30]

30 The Australia/New Zealand Residential Lighting Baseline study demonstrates a good example of data augmentation. In this case, a range of data sources from the two countries was brought together to deliver a lighting market model (Equipment Energy Efficiency Program 2014).

4 ANALYSING DATA

A number of analytical techniques are typically applied to market baseline data to illustrate the distribution of products in a market in terms of energy efficiency, pricing, and other factors. This chapter includes a review of these techniques and a discussion of interpretation and modelling approaches that can be used when data are insufficient.

Once data collection has been completed and the integrity of the data has been validated, policymakers must determine how to analyse the data. It is often useful to start this process by thinking through the format and content of the final presentation of results, particularly in light of the objectives that were initially defined in the project plan, the audiences to whom the results will be presented, and the decisions that are to be influenced. This step also provides the policymaker with a means for evaluating the effectiveness of the market baseline or market monitoring process and identifying areas for future improvement.

Market baselines for efficient lighting typically characterise products and technologies as well as their end uses. The analysis approaches can be further categorised as follows:

- **Technology characterisation**, such as energy efficiency distribution, often requires statistical analysis of individual product types and their energy performance, lifetimes, and light quality characteristics, among other attributes to support the setting of MEPS levels.
- **Market or end use characterisation** often includes estimates of national market size and trends, electricity use, compliance rates, and distribution chains of major market segments.[31]
- **Economic characterisations** often use a combination of technical and market data such as product energy performance, lifetime, pricing, electricity tariffs, market size, emissions and other environmental factors to support cost and benefit analyses or programme impacts.

It is recommended that the selected performance metrics to be analysed by policymakers are sufficiently intuitive for stakeholders to comprehend and that the intention is to reference them in the regulatory process. Several example analyses are discussed in more detail in the sections that follow.

4.1 ENERGY EFFICIENCY (OR ENERGY PERFORMANCE) DISTRIBUTIONS

An analysis of the energy efficiency distribution of lighting products that provide an equivalent service is an essential input to an energy efficiency programme development process, particularly for MEPS development. This analysis includes developing trend lines that represent the performance of all products for which data has been collected. Energy efficiency distributions are often characterised in terms of:

- Luminous flux versus power consumption;
- Luminous efficacy versus power consumption;
- Luminous efficacy versus luminous flux.

Generally, the approach uses data collected from the market, such as performance test results or efficacy levels, to infer performance trend lines and determine product performance threshold levels which form the basis of energy efficiency policy requirements. The precise level at which thresholds are set, and their shape, will be determined based on the objectives of the energy efficiency policy[32] and the characteristics of the individual market.

Two examples of these energy efficiency distribution plots of lighting products are included below, which help to demonstrate how the analysis of these distributions can be used to inform policy decisions.

Figure 4 shows an example plot of luminous efficacy (measured in lumens per watt) versus luminous flux

31 United States Census Bureau, 2013.
32 For example, to remove the worst performing products from the market or to highlight those with the best performance

(measured in lumens) for all products in a hypothetical market. Each blue dot represents a single product, and the superimposed lines represent thresholds that may be used for policy actions. In this example, the line for Level 1 could represent a proposed minimum efficiency standard that would eliminate lower-performing products (dots below the red line) from the market. The three other levels illustrated could represent performance levels for supporting policies, such as incentives or labelling, which would accelerate the transition to efficient lighting. In this example, the proposed thresholds are all curves which mirror the trend line for the distribution of the products currently in the market.

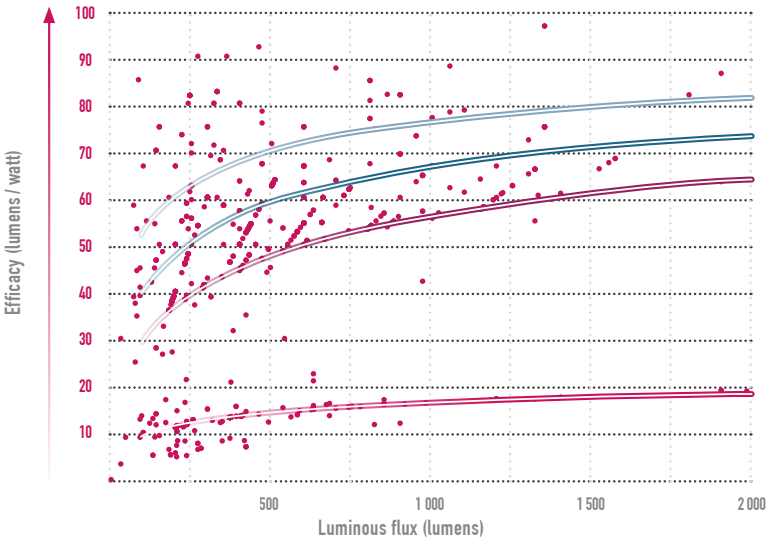


Figure 4
A hypothetical example of analysis of market data for energy efficiency policies

- Threshold Level 4
- Threshold Level 3
- Threshold Level 2
- Threshold Level 1

Figure 5, shows an energy efficiency distribution baseline analysis of LED directional lamps products available in the North American market.[33] This figure shows the distribution of individual products and threshold levels that could be applied. In this example, these levels are flat lines rather than curves, so they would establish a single efficacy value that applies across all the light output (i.e. luminous flux) range. Again here, the line for Level 1 could represent a proposed minimum efficiency standard that would eliminate lower-performing products (dots below the red line) from the market.

Figure 5
Example of analysis of directional lamp performance data for energy efficiency policies

- Threshold Level 3
- Threshold Level 2
- Threshold Level 1

33 Based on data from the United States LED Lighting Facts programme (LED Lighting Facts 2015)

4.2 RELATIONSHIP BETWEEN ENERGY EFFICIENCY AND OTHER PARAMETERS

The extensive data collected through a market baseline process facilitates the analysis of a wide variety of market and consumption factors of interest to policymakers. Often it is useful to examine the supply chain for energy efficient lighting products, including manufacturers, retailers, and other market influencers (such as designers and installers). It is also useful to examine user or demand-side factors such as energy use, penetration or distribution of different lighting technologies or hours of operation. The results of these analyses are often used to estimate costs and benefits of proposed policy actions. Figures 6, 7 and 8 illustrate other examples of market baseline analyses that are used to support energy efficiency programme development, and specifically MEPS development, including determinations of market share and projections of energy savings.

Figure 6 shows the 1993 and 2009 baselines for energy consumption in homes in the United States. This type of analysis can provide information about the mix of residential appliances (such as lighting) and energy usage over time.

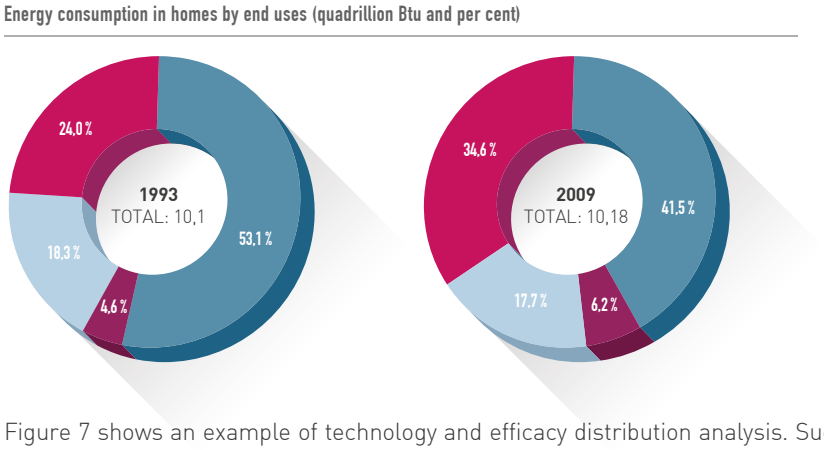
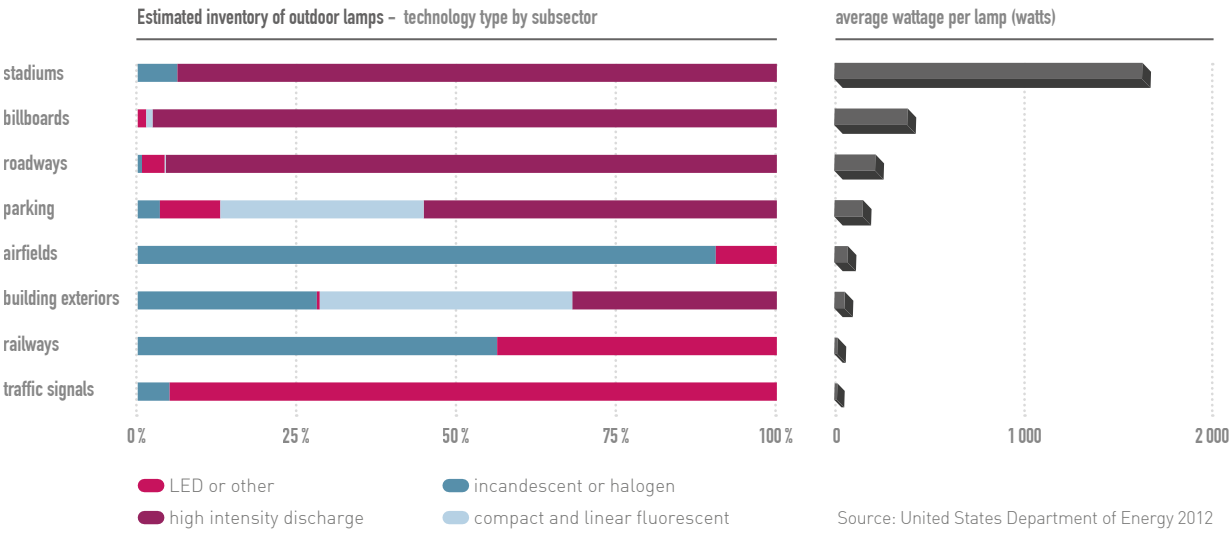


Figure 6
Baseline example of energy consumption in homes in the United States

Source: United States Energy Information Administration 2015

Figure 7 shows an example of technology and efficacy distribution analysis. Successive analyses over time provide a clear trend of technology and applications.

Figure 7
Example of technology and efficacy distribution analysis



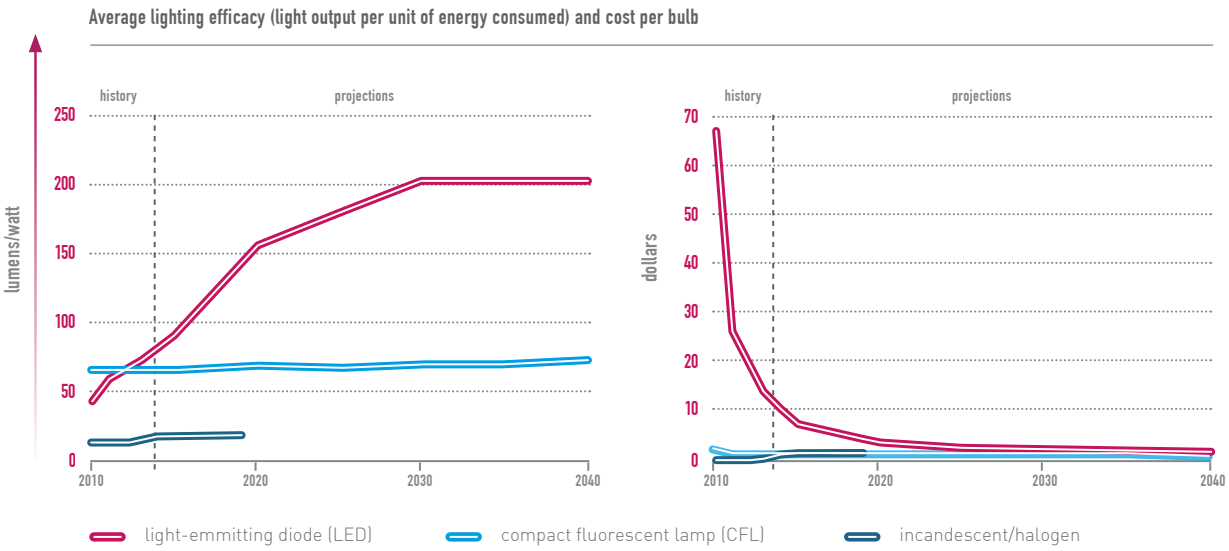
Source: United States Department of Energy 2012

4

Figure 8 demonstrates an example of efficacy and unit cost analysis that can be used to support cost-benefit projections.

Figure 8

Example of efficacy and unit cost analysis



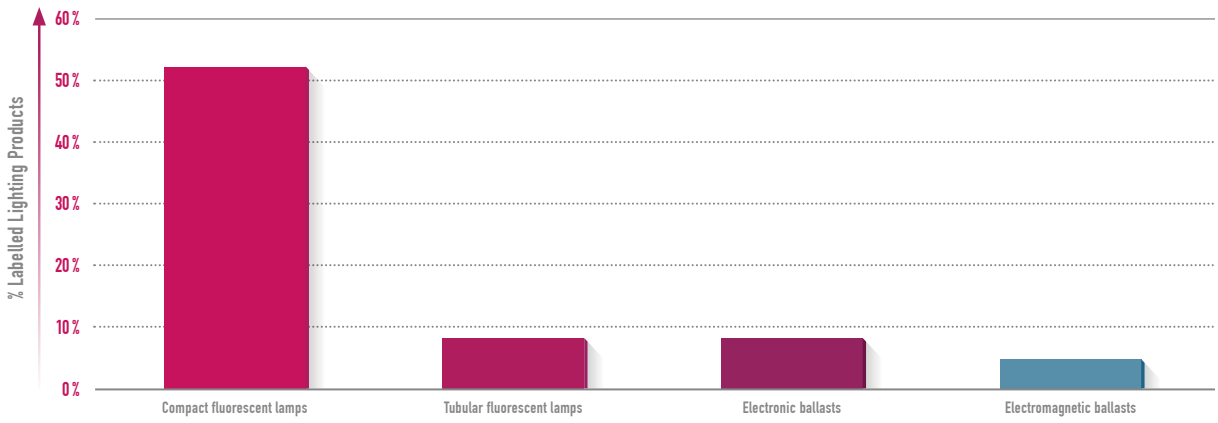
Source: United States Energy Information Administration 2014

Analyses of market baseline and market monitoring data can also be used in support of MVE programmes by characterising the degree of product compliance with existing regulations in the market. The graphs in Figures 9, 10 and 11 provide examples of these types of analyses.

The analysis depicted in Figure 9 shows the various compliance rates for labelling of lighting products at a given point in time in Vietnam in 2013.

Figure 9

Compliance rates for labelling of lighting products in Vietnam in 2013

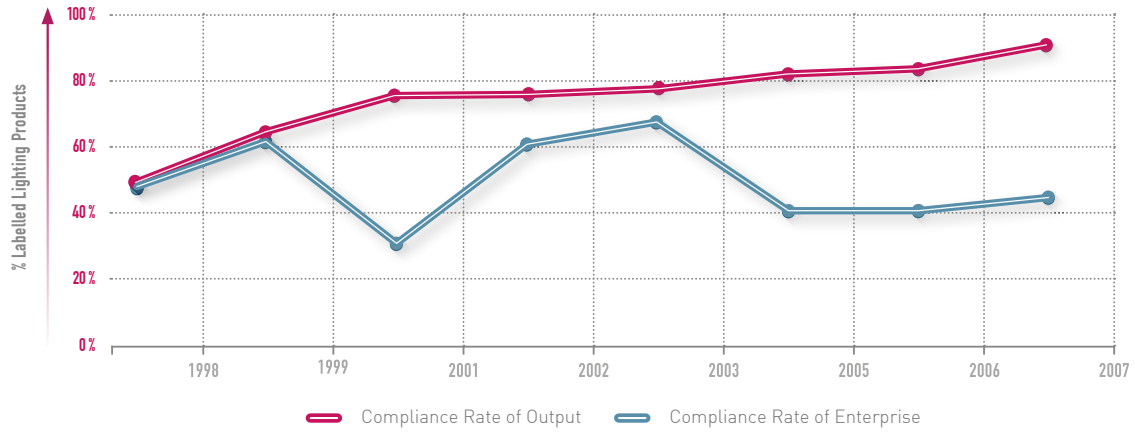


Source: *lites.asia* 2014

Figure 10 shows analysis that tracks the overall compliance rates for CFLs manufactured in China (some of which are for the export market) and the overall compliance rates of products available in the market over time, based on successive baselines.

Figure 10

Example of Chinese compliance rates for CFLs manufactured and available in the market

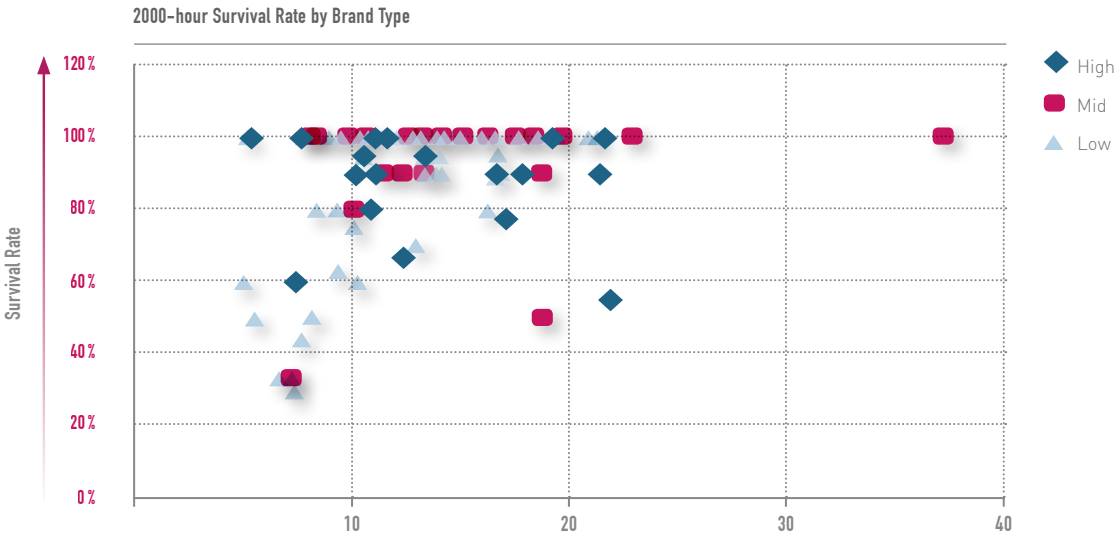


Source: United States Agency for International Development 2010a

The data in Figure 11 shows the different failure rates by lamps of different brand types, based on price range. The legend identifies models with one of three 'manufacturer' or 'brand' type identifiers to facilitate sub-group analysis. These are: High - major international brands; Mid -known local or regional brands; Low - unknown or low-cost brands.

Figure 11

Failure rates by lamps of different brand types based on price range



Source: United States Agency for International Development 2010b

4.3 INTERPRETATION AND MODELLING

When preparing a market baseline, it is possible that despite every effort at robust data collection, some critical data points will be missing at the time the analysis is performed.

⇨ **IN CASES WHERE REQUIRED DATA IS PARTIALLY AVAILABLE,** it may be possible to incorporate interpolated or augmented data as noted in Chapter 3. In these cases, the output of the analysis is not a complete market baseline, but rather a baseline projection.[34]

⇨ **IN CASES WHERE REQUIRED DATA IS MISSING ENTIRELY,** it may be possible to conduct an analysis using proxy data from other markets, using factors such as similar size, or broader international market projections or other key factors. In these cases, the output of the analysis will not be a true market baseline, but rather a baseline model.

For each of these cases, it is suggested that policymakers consult with industry representatives and other technical experts about data augmentation plans. It is also recommended that baseline models and projections be revisited and refined as new data is collected to confirm the original analysis results.

4.4 INTERNATIONAL BENCHMARKING

Organisations such as the International Energy Agency's (IEA) Energy Efficient End-use Equipment (4E) Implementing Agreement, the Super-efficient Equipment and Appliance Deployment (SEAD) Initiative of the Clean Energy Ministerial, and CLASP regularly prepare 'mapping and benchmarking' studies that compare policies and products across major world markets. These studies and their underlying data may prove very useful to policymakers seeking to develop a market baseline for the first time.

The IEA 4E mapping and benchmarking process, for example, is undertaken in three stages:

1. **Product definition:** The exact characteristics of the product are described in the product definition. Details include: the energy metrics that will be calculated; the technological, usage and other characteristics that will be considered; and any other policy or cultural information that will be collected and analysed.
2. **Mapping report:** A document is created that describes the energy performance of the product in selected markets over time. Where possible analysis of the energy consumption in the installed stock is also presented along with details of the local policies and cultural issues.
3. **Benchmarking report:** This report draws together the results from each of the participating countries. Data used for the report usually has to be normalised to ensure that it is comparable because test methodologies can vary between different regions and countries. The results are consolidated to show how performance varies between countries. Any lessons that can be learned from the data alone, or in conjunction with policy and cultural information, are presented in this benchmarking output.[35]

Figure 12 is an example of the IEA 4E benchmarking of various countries' phase-out requirements for incandescent lamps

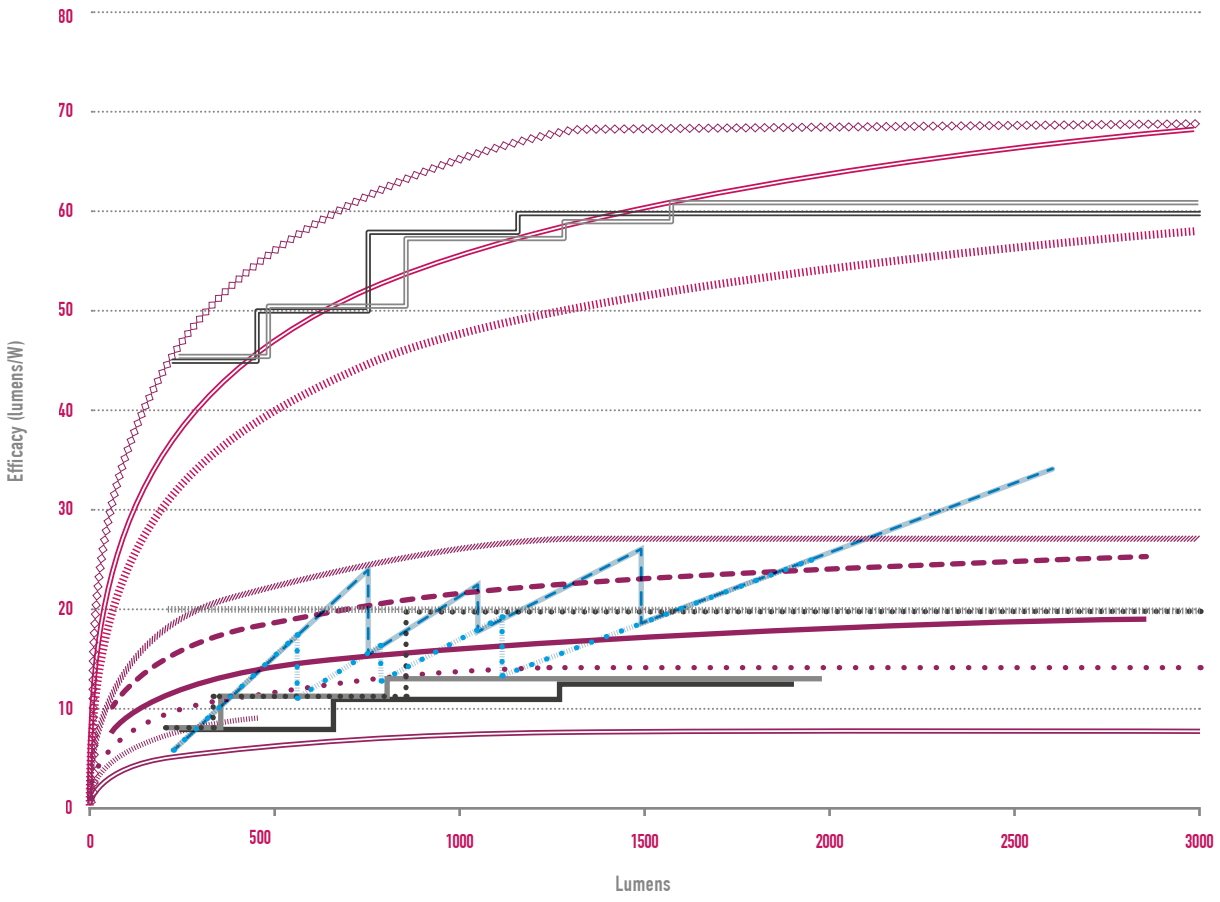
Mapping and benchmarking analyses are designed to help policymakers understand differences in product performance and energy consumption, and the resulting opportunities that may exist to improve the performance of products. Lessons learned from the best performing countries are highlighted by these studies, which can help to guide decisions of policymakers elsewhere. These findings, particularly when they include data from similar markets, can directly support another country's market baseline analysis process. Even if the analyses are not available with locally obtained data, they can be used for comparison, or even as a proxy for models as applicable. Further, this type of analysis can help identify common areas for regional data needs or potential areas for regional coordination or cooperation.

34 For example a 'stock and sale' model can be used to estimate stock, based on sales data, and vice versa. For any modelling undertaken, it is likely that a range of assumptions will be required, and these should be discussed with stakeholders and disclosed.

35 IEA 4E Mapping and Benchmarking Annex 2015

Figure 12

Benchmarking of countries phase-out requirements for incandescent lamps



- Australia MEPS (staged 2009-2016)
- Australia MV Halogen relaxed requirement (staged 2011-16, final date under review)
- Australia Bare CFL (2009)
- Australia Covered CFL (2009)
- Canada Standard Spectrum MEPs (phased during 2014)
- Canada Modified Spectrum MEPs (phased during 2014)
- EU Clear Lamp MEPs (staged 2009-2012)
- EU Clear Lamp MEPs (2016)
- EU MV directional filament lamps (Staged: 2013:flux >450 lm, 2014:all lamps)
- EU Other directional filament lamps (Staged: 2013/14)/MV directional filament lamps (2016)
- EU Other directional filament lamps (2013 - flux ≤450 lm)
- EU Other directional lamps (2013)
- EU Other directional lamps (2016)
- Korean Original GLS MEPS (2003-2008)
- Korean Revised GLS MEPS (2009-2012)
- Korean Revised GLS MEPS (2012)
- Korean Revised GLS MEPS (2014)
- Korean CFL MEPs (2006-2008)
- Korean CFL MEPs (2009)
- Korea LED MEPS
- USA General Service MEPS (staged 2012-2014 - normalised)
- USA Modified Spectrum MEPS (staged 2012-2014 - normalised)

Box 11 Case study: Market assessment of China's energy efficiency programme

The Market Analysis of China Energy Efficient Products (MACEEP) was initiated as a project to review the impacts of China's appliances standards. It was a collaboration between CLASP and Top Ten China, supported by the Energy Foundation China, and has now grown into a regular and ongoing process.

Although lighting products were not included in the MACEEP, it represents a unique and low-cost approach to baseline data collection that can be replicated for lighting and other products. The methodology used collects data from online retailers through an automated process. Online data can represent the whole market, including the offline market, for the following reasons:

- Online retail represents about 18% of total sales of household appliances across China - this number has been rising rapidly;
- Major online retailers are also the biggest chain stores. Therefore, an online product model can often also fully represent the bricks and mortar market;
- Many consumers who purchase appliances in stores may compare prices with online stores, as well as seeking out information on websites that usually contain more information than physical flyers.

Using the automatically generated data, MACEEP studies the following aspects and makes recommendations to policymakers based on the analyses:

- Availability and popularity of different product technologies, e.g. which technologies are available for water heaters and how popular each of them are: electrical water heater, gas water heater, heat pump water heater, and solar water heater;
- Overall energy performance, i.e. distribution of energy efficiency/consumption;
- Relationship between energy performance/efficiency and other parameters, i.e. energy efficiency versus price, energy efficiency versus size or volume, and energy efficiency changes and improvements over time, etc.;
- Impacts of policy interventions. For example, how the market would react if a subsidy programme were introduced to the Chinese appliance market;
- Gap between current MEPS or energy labelling programmes and the actual market. For example, is 80% of the market classified as Tier 1 (the most efficient tier) or 10%?

Two years of completed MACEEP studies show that the Chinese market can change significantly for certain products. Therefore, it is very important to conduct market research in regular and frequent intervals (annually is recommended) to obtain up-to-date market baselines to inform policy development and updates.

China's Energy Label product registration system offers another valuable data source for MACEEP. It contains information on every product model covered by the China Energy Label and, because the data in the China National Institute of Standardization system has been validated through product document inspections as part of the registration process, it can be used to verify and supplement other data sources for certain types of analysis.

Source: CLASP and TopTen China, 2013 CLASP 2014

5 RECOMMENDATIONS

Policy tools and actions, including MEPS and energy labelling, are key to success in the transition to energy efficient lighting. To be effective, these policies must be reflective of, and respond to, the market and must therefore rely on representative market baselines supported by market monitoring activities. The key recommendations for achieving this are outlined in this chapter.

FOLLOW A STRUCTURED APPROACH

A structured, multi-step work plan should be followed when developing baselines. The key recommendations are:

1. **Establish an administrative and legal framework:** A well-defined administrative framework forms the foundation for developing baselines and monitoring the market, setting out clearly defined roles and responsibilities and adequate allocation of resources and funding to successfully implement the project. An appropriate legal framework gives authority to the responsible government agency (or other institutions) for the activities in the baseline and monitoring process.

2. **Define baseline and monitoring objectives and applications:** Clear objectives are required from the outset to inform the baseline and monitoring strategy. Key performance metrics should be identified and the data analysis approach selected. Regional collaboration or leveraging opportunities, as well as available international best practices and experiences should be explored.

3. **Use a collaborative approach:** When developing the data collection and analysis work plan, key stakeholders should be involved to encourage a collaborative approach to sourcing quality data.

4. **Use a structured approach for data collection:** A step-by-step work plan is needed for the development of a baseline. This plan should include:
    - An assessment of the state of the market;
    - Consideration of data availability, representativeness, potential sources and collection methods;
    - A regular review and update of strategies, including market monitoring strategies, and ways to deal with market changes.

5. **Ensure that analysis objectives are met:** Upon completion of the process, it is necessary to determine whether or not the collected data and analysis results have met the established objectives. This can be a useful measuring tool to gauge the effectiveness of the process, and identify areas for future improvement.

6. **Formulate recommendations:** After all of the preceding steps are completed, a final report with data, analysis and recommendations should be developed and discussed with relevant stakeholders to help develop and/or revise regulatory decisions.

If these steps are followed, an accurate baseline can be established to support the development of ambitious yet realistic MEPS, as well as other cost-effective energy efficiency policies and actions that should yield significant benefits for households and the national economy.

CONSULT AND REVIEW

Baselines and market monitoring approaches should be developed with stakeholders' input to obtain maximum participation and support to minimise costs and to ensure the highest data quality. Governments should also plan to periodically review and update the baseline every few years to ensure that the results and process remain appropriate and relevant.

5

CONSIDER COLLABORATION AND TAKE ADVANTAGE OF INTERNATIONAL EXPERIENCE

Baseline development and market monitoring should take into account similar activities in neighbouring countries, or the availability of data and expertise from international MVE or benchmarking activities. Lamps are a commonly traded commodity, so it may be practical to align market monitoring activities, or baseline development processes, with those of trading partners or to work towards regional collaboration.

Governments in developing countries may consider the experiences of the UNEP-GEF en.lighten partner countries and regional initiatives to help accelerate the phasing out of inefficient lamps.

6 RESOURCES

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

UNEP-GEF EN.LIGHTEN INITIATIVE PUBLICATIONS

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

CLASP PUBLICATIONS

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

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

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

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

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

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

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

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

EXPERTISE AND COLLABORATIVE PROGRAMMES

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

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

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

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

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

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

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

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

http://www.lites.asia/

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

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

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

http://www.clasponline.org/en

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

https://cleanenergysolutions.org/

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

http://www.iea.org/

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

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

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

http://www.lightingfacts.com/

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

www.superefficient.org.

DATA COLLECTION AND ANALYSIS TOOLS

Although developed for their national markets, the following websites provide extensive resources and information on methodologies and approaches that anyone can replicate and reference; in particular with reference to data collection and analysis.

Natural Resources Canada, Office of Energy Efficiency – Natural Resources Canada (NRCan) works in the fields of housing, building, communities, industry, and transportation to help Canadians take advantage of the benefits of energy efficiency, such as lower energy costs, cutting emissions, improving operating performance, and increasing asset values.

http://www.nrcan.gc.ca

United States Census Bureau – The United States Census Bureau's mission is to serve as the leading source of quality data about the nation's people and economy.

http://www.census.gov

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ANNEX A

RECOMMENDED WORK PLAN FOR ESTABLISHING A NATIONAL OR REGIONAL MARKET BASELINE

The required steps for establishing a market baseline are similar for a market with little penetration of energy efficient products or a market that has significant penetration. However, the objectives of the exercise may differ, as may the data available for collection and the analysis that can be carried out. The work plan outlined in this Annex is primarily targeted at those regions with an undeveloped market, and no existing baselines, however it can be applied and slightly modified to inform a work plan for the following market types:

- For **an undeveloped market**, with no existing baseline and unknown data availability, the baseline may aim to achieve very clear, simple objectives, such as to determine the product mix, pricing, overall efficacy and/or compliance levels, in order to inform and initiate effective energy efficiency policies or programmes.
- For **a market in transition**, where product energy efficiency is evolving and a baseline has previously been established, the baseline may aim to identify trends in product mix, efficacy, pricing, or compliance levels in order to identify policy changes necessary to accelerate the transition to energy efficient lighting.
- For **a developed market**, where there is significant penetration of efficient products and established baseline processes and data sources, the baseline may aim to identify areas or product types that have not been impacted by policies or programmes (i.e. expanding the scope) or to focus on behavioural trends and usage patterns, such as consumer response to products, awareness of products or programmes, or attitudes regarding different efficient lighting technologies or characteristics, all of which have the potential to assist in the design of more impactful supporting policy actions.

HYPOTHETICAL BASELINE SCENARIO

Table 7 presents a scenario where market conditions are not developed, there are no policies in place, but there may be some energy efficient product alternatives available. No previous baseline exists.

Note: the UNEP-GEF en.lighten initiative *Country Lighting Assessments* can provide some of this information.[36]

36 UNEP's *Country Lighting Assessments* highlight the potential savings in electricity consumption, CO_2 emissions and financial costs by replacing all inefficient on-grid lighting technologies in all lighting sectors. These are available at http://www.enlighten-initiative.org/ResourcesTools.aspx

Table 7

Plan for establishing baseline for an undeveloped market

Step	Description of Activity or Required Item	Time Required	Budget Required
1. Establish baseline objectives	• Evaluate different possibilities for MEPS. • Estimate savings potentials. • Determine cost-benefit.	Short	Small
2. Establish key performance metrics	**Average efficacy of the market:** • Inventory of technology (light source) types; • Technology distribution (market); • Average efficacy levels of each technology and service type **Energy Savings Potentials:** • Estimated total lamp population (or number of sockets) and rate of increase; • Estimated average hours of use (or per application if available). **Cost-Benefit:** • Cost of electricity; • Product lifetimes.	Short	Small
3. Establish data needs and identify possible data sources	**Range of product efficacies on the market:** • Inventory of light source types - lighting associations, manufacturers, importers, retailers, market or retail surveys, sales or import data; • Technology distribution - market/retail surveys (available products on market), retailer surveys, manufacturers or distributor data, lighting association data, sales or import data; customs data; • Average efficacy levels of each technology - claimed (from registration, retail surveys), manufacturer data; test results (from sampling and testing at accredited, independent laboratory/ies). Confirm with international or regional data. **Energy savings potentials:** • Total installed sockets and rate of increase - housing and commercial building stock data, surveys, previous baselines, proxy from international studies; • Average hours of use - surveys, previous baselines, proxy from international or regional data. **Cost-benefit impacts:** • Cost of electricity - utilities and/or power reseller data; • Product lifetimes - manufacturer claims, industry associations, other international or regional data sources; actual test results; • Product pricing.	Medium	Small

Step	Description of Activity or Required Item	Time Required	Budget Required
4. Data collection and cleaning	• Development of surveys and methods, training of data collection staff. • Carry out actual surveys (primary data collection) where needed for technology types, market distribution, use hours, etc.; • Survey possible sources for data (secondary data collection), purchase data; • Acquire samples and conduct tests for lamp performance, lifetime, and other parameters (note associated time required); • Identify and obtain proxy data where needed; • Perform data quality assurance checks and merge datasets.	Long	Large
5. Establish analysis approach or methodology	• MEPS - map efficacy data (lumen/watt vs. lumen package or rated watts) to identify trends and determine 'efficacy curves'; • Estimate savings potentials - use estimates of total lamp population to calculate differential in energy consumption for the inefficient case and the efficient case, integrated over the time period of interest; • Cost-benefit - Estimate the total costs of replacement using product pricing, and total benefits using estimated energy savings and costs of electricity over the time period of interest.	Medium	Medium
6. Perform analysis	• Use the established approach to convert the collected data into the actual baselines.	Medium	Small
7. Formulate recommendations	• Report data, analysis and recommendations and discuss with relevant stakeholders to support the development and/or revisions to policies.	Medium	Small

ANNEX B

EXAMPLE OF A LAMP SAMPLING FORM (FOR SAMPLE COLLECTION)

Compact Fluorescent Lamp Sampling Sheet										**Ref. No.:**_____
IIEC is conducting lamp sampling on behalf of the United Nations Environment Programme's *en.lighten initiative* in order to strengthen the national and regional resources for efficient lighting monitoring, verification and enforcement (MVE). The lamp sampling will be conducted in six Southeast Asian countries. Website: *http://www.enlighten-initiative.org*										
Country		City				Date				
Sampler's name			phone			email				
Name of retailer		Address and telephone of retailer								□ Shopping mall □ Specialized lighting shop □ Electrical/Hardware shop □ Others_____
1. Lamp Wattage, Model Number and Color (specify lamp wattage, note model number,color description and/or color temperature in Kelvin, such as 2700K, "warm white")										
	DL									
	CW									
	WW									
Note: 1) Use one sampling sheet for only one lamp model 2) Lamp wattage equal to or greater than five watts and equal to or less than thirty watts (≥5W and ≤30W) 3) Sampling quantity = 30 samples per model 4) DL="daylight" CW="cool white" WW="warm white"										
2. Manufacturer and/or Brand Information										
A	GE		**E**	Sylvania		**I**				
B	OSRAM		**F**	Toshiba		**J**				
C	Panasonic		**G**			**K**				
D	Philips		**H**			**L**				
3. Lamps: Bulb and Base Types										
Lamp	**Bulb type** (circle if available)	bare, spiral			bare, U-bend			covered		
	Base type (circle if available)	E26 or E27		G23		B22		GU10		Other
4. Average Price, per Wattage of Lamp										
Local currency: _____		5W-8W		9W-12W		13W-20W		21W-28W		greater than 28W
5. Qualitative Comments										
Retailer	Best selling brand		Best selling color (white)		Best selling lamp type		Customers' common questions about compact fluorescent lamps			
Sampler										
6. Signatures										
Samplers and Witnesses	1	Signature		Name		Title		Organization		
	2	Signature		Name		Title		Organization		
	3	Signature		Name		Title		Organization		
	4	Signature		Name		Title		Organization		

ANNEX C

SAMPLE END-USE SURVEY FORM (FOR DATA COLLECTION)

This example is drawn from the Australian Residential Lighting Survey

Introduction

This study of how lights are used at home is being conducted on behalf of [insert Name of Government Department]

Please be assured that all your responses are confidential. However, if you do not wish to answer a question or do not know the answer to a question please circle the question number and leave blank.

Thank you for taking the time to respond to this survey. Your participation in this study is very much appreciated.

The first questions are about the lights that are used in your home at different times of the day during the week.

Morning (before typical office hours) Lighting Use

1. During the week, are lights typically turned ON during the morning?
   - ☐ No [go to question 6]
   - ☐ Yes

2. During the week, what time does the first person typically get up?
   Enter time _____ am

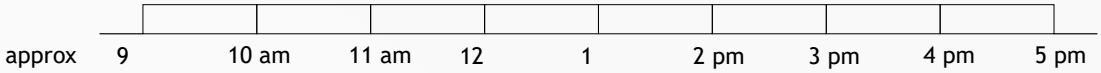
3. When do they turn the lights ON? (Select one answer only)
   - ☐ when they get up
   - ☐ typically at _____ am
   - ☐ other (please complete)

   _____

4. What lights are used at this time of the day? - Please complete the table below to indicate in which rooms lights are used at this time of day and how they are used. **Indicate up to three rooms that are <u>used the most</u> at this time of day.**

Enter name of room lights are used in	*Type of lights used [Tick all that apply]*	*Type of use at this time of day [Tick one type of use per light]*
Room 1 - name	☐ Fixed lights (e.g. light fixture(s) with wall switch)	100% ☐ ON all of the time during the morning 75% ☐ ON most of the time during the morning 50% ☐ Switched ON and OFF frequently during the morning 25% ☐ Used once or twice during the morning
	☐ Plug-in lights (e.g. table lamps plugged into power point etc)	100% ☐ ON all of the time during the morning 75% ☐ ON most of the time during the morning 50% ☐ Switched ON and OFF frequently during the morning 25% ☐ Used once or twice during the morning
Room 2 - name	☐ Fixed lights (e.g. light fixture(s) with wall switch)	100% ☐ ON all of the time during the morning 75% ☐ ON most of the time during the morning 50% ☐ Switched ON and OFF frequently during the morning 25% ☐ Used once or twice during the morning
	☐ Plug in (e.g. table lamps plugged into power point etc)	100% ☐ ON all of the time during the morning 75% ☐ ON most of the time during the morning 50% ☐ Switched ON and OFF frequently during the morning 25% ☐ Used once or twice during the morning
Room 3 -	☐ Fixed	100% ☐ ON all of the time during the morning

name	(e.g. light	75% ☐	ON most of the time during the morning



		50% ☐	Switched ON and OFF frequently during the morning
		25% ☐	Used once or twice during the morning
	☐ Plug in (e.g. table lamps plugged into power point etc)	100% ☐	ON all of the time during the morning
		75% ☐	ON most of the time during the morning
		50% ☐	Switched ON and OFF frequently during the morning
		25% ☐	Used once or twice during the morning

5. On a typical weekday, after the morning breakfast period, is the house vacated by all householders who only then return in the evening?

☐ No [Go to question 6]		
☐ Yes	What time in the morning does the last person typically leave?	Enter Time _____ am [Go to Question 9]

Daytime (typical office hours) Lighting Use

6. On a typical week day, mark the boxes with a cross for those hours for which the house is occupied.

7. Are lights used during the day?

☐ No [Go to Question 9]

☐ Yes

8. What lights are used during the day? - please complete the table below to indicate in which rooms lights are used during the day and how they are used. **Indicate up to three rooms that are <u>used the most</u> at this time of day.**

Enter name of room lights are used in	*Type of lights used [Tick all that apply]*	*Type of use at this time of day [Tick one type of use per light]*	
Room 1 - name	☐ Fixed lights (e.g. light fixture(s) with wall switch)	100% ☐	ON all of the time during the day
		75% ☐	ON most of the time during the day
		50% ☐	Switched ON and OFF frequently during the day
		25% ☐	Used once or twice during the day
	☐ Plug-in lights (e.g. table lamps plugged into power point etc)	100% ☐	ON all of the time during the day
		75% ☐	ON most of the time during the day
		50% ☐	Switched ON and OFF frequently during the day
		25% ☐	Used once or twice during the day
Room 2 - name	☐ Fixed lights (e.g. light fixture(s) with wall switch)	100% ☐	ON all of the time during the day
		75% ☐	ON most of the time during the day
		50% ☐	Switched ON and OFF frequently during the day
		25% ☐	Used once or twice during the day
	☐ Plug in (e.g. table lamps plugged into power point etc)	100% ☐	ON all of the time during the day
		75% ☐	ON most of the time during the day
		50% ☐	Switched ON and OFF frequently during the day
		25% ☐	Used once or twice during the day
Room 3 - name	☐ Fixed	100% ☐	ON all of the time during the day
		75% ☐	ON most of the time during the day

	(e.g. light fixture(s) with wall switch)	50% ☐ Switched ON and OFF frequently during the day 25% ☐ Used once or twice during the day
	☐ Plug in (e.g. table lamps plugged into power point etc)	100% ☐ ON all of the time during the day 75% ☐ ON most of the time during the day 50% ☐ Switched ON and OFF frequently during the day 25% ☐ Used once or twice during the day

9. When leaving the house to go out, are any lights left ON?
   - ☐ Always
   - ☐ Mostly
   - ☐ Sometimes
   - ☐ Never – [Go to Question 12]

10. How many lights are left ON?

    ____ Fixed lights
    ____ Plug-in lights

11. Why are some lights left ON during the day?
    - ☐ Forget or don't get around to turning them off
    - ☐ Get home after dark – want lights to be on
    - ☐ Security
    - ☐ For pets
    - ☐ Other – please explain below.

    _____

Evening (after typical office hours) Lighting Use

12. What time does the first person typically get home in the evening?
    - ☐ Enter time _____
    - ☐ Someone is typically home during the day through till the evening

13. What lights are used in the evening? – Please complete the table below to indicate in which rooms lights are used at this time of day and how they are used. **Indicate up to four rooms that are <u>used the most</u> at this time of day.**

Enter name of room lights are used in	*Type of lights used [Tick all that apply]*	*Type of use at this time of day [Tick one type of use per light]*	
Room 1 – name	☐ Fixed lights (e.g. light fixture(s) with wall switch)	Turned ON: ☐ When going to bed ☐ After evening meal ☐ Typically at _____pm Other _____	Turned OFF: ☐ When going to bed ☐ After evening meal ☐ Typically at _____pm Other _____
	☐ Plug-in lights (e.g. table lamps plugged into power point etc)	Turned ON: ☐ When arrive home ☐ When dark (sunset) ☐ Typically at _____pm ☐ Other _____	Turned OFF: ☐ When going to bed ☐ After evening meal ☐ Typically at _____pm ☐ Other _____

Room 2 - name	☐ Fixed lights (e.g. light fixture(s) with wall switch)	Turned ON: ☐ When arrive home ☐ When dark (sunset) ☐ Typically at _____pm ☐ Other _____	Turned OFF: ☐ When going to bed ☐ After evening meal ☐ Typically at _____pm ☐ Other _____
	☐ Plug in (e.g. table lamps plugged into power point etc)	Turned ON: ☐ When arrive home ☐ When dark (sunset) ☐ Typically at _____pm ☐ Other _____	Turned OFF: ☐ When going to bed ☐ After evening meal ☐ Typically at _____pm ☐ Other _____
Room 3 - name	☐ Fixed lights (e.g. light fixture(s) with wall switch)	Turned ON: ☐ When arrive home ☐ When dark (sunset) ☐ Typically at _____pm ☐ Other _____	Turned OFF: ☐ When going to bed ☐ After evening meal ☐ Typically at _____pm ☐ Other _____
	☐ Plug in (e.g. table lamps plugged into power point etc)	Turned ON: ☐ When arrive home ☐ When dark (sunset) ☐ Typically at _____pm ☐ Other _____	Turned OFF: ☐ When going to bed ☐ After evening meal ☐ Typically at _____pm ☐ Other _____

14. What time does the last person typically go to bed?
Enter time _____

15. Are lights regularly left ON over night?
☐ No [Go to question 18]
☐ Yes

16. Which lights are left ON most often over night? - Please complete the table below to indicate in which rooms lights are left ON overnight and how often. **Indicate up to three rooms where the lights are <u>most often</u> left on overnight.**

Enter name of room lights are used in during the night	*Type of lights left on [Tick all that apply]*	*Frequency light left ON [Tick one frequency per light]*
Room 1 - name	☐ Fixed	☐ Always (>80% of nights) ☐ Mostly (~50% of nights) ☐ Sometimes (~25% of nights)
	☐ Plug in	☐ Always (>80% of nights) ☐ Mostly (~50% of nights) ☐ Sometimes (~25% of nights)
Room 2 - name	☐ Fixed	☐ Always (>80% of nights) ☐ Mostly (~50% of nights) ☐ Sometimes (~25% of nights)
	☐ Plug in	☐ Always (>80% of nights) ☐ Mostly (~50% of nights) ☐ Sometimes (~25% of nights)

Room 3 – name	☐ Fixed	☐ Always (>80% of nights) ☐ Mostly (~50% of nights) ☐ Sometimes (~25% of nights)
	☐ Plug in	☐ Always (>80% of nights) ☐ Mostly (~50% of nights) ☐ Sometimes (~25% of nights)

17. Why are lights left on at night?

- ☐ Forget/don't get around to turning them off
- ☐ Security
- ☐ So we can see when we get up in the night
- ☐ Pets
- ☐ Other – please explain below.

General Lighting Use

18. Are there any lights in the home or garden that are left switched on constantly?

☐ No				
☐ Yes	Which room(s)/space(s) are these in?	Room/space 1 – name _____	Are these fixed lights or plug in lamps?	☐ Fixed ☐ Plug in
		Room/space 2 - name _____	Are these fixed lights or plug in lamps?	☐ Fixed ☐ Plug in
		Room/space 3 - name _____	Are these fixed lights or plug in lamps?	☐ Fixed ☐ Plug in
	[Tick all that apply] Why are they left on?		☐ Has sensor (so only comes on with movement when dark) ☐ For safety ☐ For pets ☐ Other, please specify_____	

19. Are there any lights in the home or garden that are rarely used?

☐ No				
☐ Yes	Which room (s) are these in?	Room 1 – name _____	Are these fixed lights or plug in lamps?	☐ Fixed ☐ Plug in
		Room 2 - name _____	Are these fixed lights or plug in lamps?	☐ Fixed ☐ Plug in
		Room 3 - name	Are these fixed lights or plug in lamps?	☐ Fixed ☐ Plug in

	[Tick all that apply] Why don't you use them?		☐ No need ☐ Need to change the bulb ☐ Light is broken ☐ Other, please specify_____ _____	

20. Are there dimmers on any of your lights?

☐ No			
☐ Yes	Which room (s) are these in?	Room names:	
	How do you use them?	☐ Set to same level of brightness all the time	☐ Set on maximum ☐ Set below max
		☐ Different levels of brightness at different times	Under what circumstances do you change? _____ _____ _____

21. (Tick all that apply) Given the opportunity, how would you change the way your light switches are setup?

☐ No change
☐ Move switches to better positions
☐ Have ☐ more ☐ less switches for some rooms
☐ Have ☐ more ☐ less dimmers for lights
☐ Other, please specify? _____

General Lighting Preferences

The following questions (Q22 to Q30) are about what sort of lighting you prefer in the room you nominate in Q22 below:

22. Which room in the house is used most often as your living space? _____

23. Thinking about the lighting in that room, are you happy with the lighting you currently have in terms of:

	Yes	*No*
Brightness	☐	☐
Colour	☐	☐
Warm up time	☐	☐
Dimmability	☐	☐

24. Have you changed any of the light fittings in this room? (some may have already been installed when you moved into the house)

☐ No [Go to question 28]			
☐ Yes		*Total number in room*	*Number changed / added*
	Fixed lights		
	Plug in lamps		

Answer if you changed the lights in the nominated room (i.e. the room used most often as living room)

25. [Tick all that apply] Why did you change the light fittings?

☐ Part of a refurbishment
☐ Changed the location of the light fitting
☐ The light didn't work

- ☐ Didn't like style / design.
- ☐ Wanted a different type of light
- ☐ Wanted more light
- ☐ For energy efficiency reasons
- ☐ Other, please specify _____

26. [Tick all that apply] Thinking about the light fittings that you have now installed in this room what is it about those fittings that made you select them?
    - ☐ Price
    - ☐ Design/style
    - ☐ Brighter light
    - ☐ Softer light
    - ☐ Energy efficiency
    - ☐ Other, please specify_____

27. [Tick all that apply] Other than your own preferences, what influenced your choices?
    - ☐ Friends / family homes
    - ☐ Advice from an electrician
    - ☐ Advice from builder / renovator
    - ☐ TV Shows
    - ☐ Magazines
    - ☐ Lighting Store (suggested addition)
    - ☐ Display home
    - ☐ Government energy efficiency information
    - ☐ Other, please specify _____

28. Are there any (other) light fittings that you would like to change?

☐ No [Go to question 31]		
☐ Yes		*Number you would like to change*
	Fixed lights	
	Plug in lamps	

Answer if you would like to change the lights in the nominated room (i.e. the room used most often as living room)

29. [Tick all that apply] Why would you like to change these light fittings?
    - ☐ Part of a refurbishment
    - ☐ Changed the location of the light fitting
    - ☐ The light didn't work
    - ☐ Didn't like style / design.
    - ☐ Wanted a different type of light
    - ☐ Wanted more light
    - ☐ For energy efficiency reasons
    - ☐ Other, please specify_____

30. [Tick all that apply] If you would like to change the light fittings but haven't done this yet, why is that?
    - ☐ The effort of finding an installer and sorting out a time for them to visit
    - ☐ Can't decide what to change it to
    - ☐ Other areas of refurbishment required first
    - ☐ Other priorities for spending money on
    - ☐ Can't get advice/ information on options

- ☐ I'm not able to change the fixed lights as it's a rental property
- ☐ Other, please specify _____

All to answer

31. [Tick all that apply] Other than your own preferences, what influences you in terms of how you would like lighting in your home to look and work?
    - ☐ Friends / family homes
    - ☐ Advice from lighting retail store
    - ☐ Advice from an electrician
    - ☐ Advice from builder / renovator
    - ☐ TV Shows
    - ☐ Magazines
    - ☐ Websites
    - ☐ Display home
    - ☐ Government energy efficiency information
    - ☐ Other, please specify _____

General Light Bulb Preferences

The final questions are about the light bulbs or globes you use

32. As far as you are aware, are you currently using any of the following types of light bulb in your home? (Please provide a response for each type of light bulb.)

Incandescent	☐ No ☐ Yes ☐ Not sure
Halogen	☐ No ☐ Yes ☐ Not sure
Compact Fluorescent	☐ No ☐ Yes ☐ Not sure
LED	☐ No ☐ Yes ☐ Not sure

33. [Tick all that apply] How are light bulbs for your house purchased?
    - ☐ As required
    - ☐ Bulk buy in advance
    - ☐ When they are reduced in price / on offer
    - ☐ Don't know
    - ☐ Other, please specify_____

34. Do you have any spare light bulbs in a drawer or cupboard that you can no longer use because you have changed your light fittings and they no longer fit?
    - ☐ No
    - ☐ Yes

35. Where do you tend to buy your light bulbs from?
    - ☐ Grocery store / supermarket
    - ☐ Hardware store / home improvement store
    - ☐ Specialty lighting store

☐ Online (web)

☐ Other, please specify _____

36. When you purchase new light bulbs, what factors influence your choice? Tick all that apply and then number in order of influence starting with 1 for the most influential factor. Don't number those that you don't consider an influence (egg you may only consider 5 factors to influence your choice so number them from 1 to 5 and leave the remainder blank).

	Factors that influence your choice [Tick all that apply]	*Factors that influence your choice [Number in order of influence all that apply - start with 1 for the most influential factor]*
Purchase price		
Brand		
Wattage		
Brightness		
Colour		
Energy cost / energy efficiency		
Lifetime / how long it lasts		
Warm up times		
The lamp type that was used previously		

37. Do you have any further comments on your use of lights, choice of lights or choice of light bulbs?

_____

_____

Thank you for your help.

Source: Australian Residential Lighting Survey 2013

ABOUT THE UNEP DIVISION OF TECHNOLOGY, INDUSTRY AND ECONOMICS

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

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

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

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

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

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

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This guidance note focuses on the development and maintenance of market baselines and market monitoring activities as tools to inform minimum energy performance standards, labelling, and supporting policies for energy efficient lighting. It is primarily aimed at policymakers that wish to establish, or update, policies to facilitate the transition to efficient lighting and provides a practical resource for those developing a market baseline for the first time, or those who are looking to update existing baselines for market monitoring purposes. It defines the necessary components of a market baseline for lighting products and outlines a step by step approach to their development and to carrying out market monitoring.

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