PROTOCOLS TO CONDUCT MARKET AND IMPACT ASSESSMENTS

United Nations Environment Programme – United for Efficiency (U4E)

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Acronyms

AEC	Annual energy consumption
APF	Annual performance factor (for air conditioners)
B2B	Business to business
B2C	Business to consumer
BAT	Best available technology
BAU	Business as usual
BNAT	Best not- available technology
COP	Coefficient of performance (for air conditioners)
CSPF	Cooling seasonal performance factor (for air conditioners)
EEI	Energy efficiency index
EER	Energy efficiency ratio (for air conditioners)
GHG	Greenhouse gas
GWP	Global warming potential
HFC	Hydrofluorocarbon
HCFC	Hydrochlorofluorocarbon
IBAT	Internationally best available technology
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
kWh	Kilowatt-hour
LCC	Life cycle cost
LLCC	Least life cycle cost
MEPS	Minimum energy performance standard
ODP	Ozone depletion potential
PP	Peak power
PRS	Product registration system
RBAT	Regionally best available technology
SCOP	Seasonal coefficient of performance (for air conditioners)
SEER	Seasonal energy efficiency ratio (for air conditioners)
ToR	Terms of Reference
TOU	Time of use
U4E	United for Efficiency
UEC	Unit energy consumption (kWh/year)
Wh	Watt-hour

1. Introduction

At least 127 countries have adopted, or are in the process of adopting, minimum energy performance standards (MEPS) in combination with energy labelling to indicate the energy efficiency of new products to prospective purchasers, and many more are considering such schemes. Experience shows that the approaches which stimulate the greatest shift towards higher efficiency products are those that follow good practices in the development and review of programmes. Market assessments and impact analyses are critical components that provide the necessary evidence-base to design, review and optimize MEPS and labelling policies and programmes.

While MEPS and labelling can be extremely cost-effective means of delivering energy savings, it is less well known that the savings are highly sensitive to the investment in the knowledge base that underpins them. Programmes are designed to save energy cost-effectively. However, underinvesting in knowledge inputs is akin to planning new power plants but failing to invest in the infrastructure necessary to connect them to the electricity grid.

Regulatory assessments are essential to achieve cost-effective energy savings. This document aims to support the adoption and implementation of the U4E Model Regulation Guidelines (Model Regulations)[1] by indicating how market and impact assessments help with selecting appropriate energy efficiency tiers for MEPS and labels (with the Model Regulations as a basis), when to revise these levels, and ways to reference the U4E Product Registration System (PRS) guides[2] to inform such assessments. The Model Regulations and this supplemental guidance are intended to simplify and expedite the policy development process based on what is often practicable in markets where there is limited to no existing experience and protocols for MEPS and labels.

For those with further resources, time, experience, and capacity that wish to undertake a comprehensive approach akin to those used in well-established market transformation programmes, this document also sets out more in-depth protocols for **market assessments**, and **consumer**, **utility, manufacturer** and **societal impact analyses**. It distils experience that has been accrued about how to conduct and use such analyses to inform policymakers and programme managers. It distinguishes between **ex-ante** assessments that are necessary to design effective MEPS and labelling programmes and **ex-post**[3] impact assessments that determine whether impacts are in line with expectations[4]. The focus of this guide is not on assembling the level of

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[1] UNEP U4E (2019) *Model Regulation Guidelines: Energy-Efficient and Climate-Friendly Air Conditioners* and *Model Regulation Guidelines: Energy-Efficient and Climate-Friendly Refrigerators*, both available at: https://united4efficiency.org/resources/model-regulation-guidelines/

[2] UNEP U4E (2019) *Guidance Notes on: 1) What is a Product Registration System and Why Use One; 2) Planning to Build - Foundational Considerations; 3) Planning to Build – Detailed Considerations; 4) Implementing a Product Registration System.* Available at*:* https://united4efficiency.org/resources/publications/

[3] *Ex-ante* means from before the intervention, based on forecasts rather than actual results, while *ex-post* means after the intervention, based on actual results.

[4] In general, ex-post assessments should include both an impact evaluation and a so-called “process assessment”,

evidence necessary to decide whether or not to develop a MEPS and labelling programme (for which more aggregate macro-economic data can often be used). Rather, the focus is on analysing evidence necessary to design and evaluate effective MEPS and labelling once such a decision has been taken.

This guidance covers the principal information needs, and data collection and analysis techniques. The document is structured to provide information relevant to policymakers and programme managers in the main body of the text. More detailed practical guidance to support data collection can be found in Annex 1, analysis and process management in Annex 2, and sample terms of reference for securing expert services in Annex 3.

2. Overview of Assessments

Market and impact assessments have long been recognised as a key aspect of good policy development and governance. In a comparatively technical area such as MEPS and energy labelling, market and impact assessments built on reliable market analysis are essential and need to be planned from the outset. They are required to design the programme in a manner that will lead to cost-effective energy savings that balance the interests of the different sectors of society. Within a few years of implementation,[5] they need to prove that the programme is having the desired effect, to help fine-tune it if necessary, and to inform future revisions to yield additional cost-effective energy savings.

Initial assessments conducted at the outset are described as ex-ante, as they entail gathering and processing information to create forecasts of projected impacts due to the implementation of prospective MEPS and labels. They provide the foundations to enable the economic and environmental case to be made for policy and help quantify the costs and benefits of different options to various market stakeholders. Ex-post assessments look back at what has happened during the implementation of these policies and aim to establish their outcomes and effectiveness.

Effective MEPS and labelling design can only be built upon reliable information. MEPS and labels must demonstrate their value as effective policy tools as they require sustained government and commercial engagement. Much of the information needed for ex-ante programme design is also necessary for ex-post evaluation. An evaluation of compliance is an important added element for an ex-post evaluation.[6] Investing adequate resources in gathering quality information at the inception, and progressively thereafter, will create synergistic benefits; this needs to be anticipated in the initial programme design.

which examines how well different implementation aspects are functioning. This guide is not focused on process evaluations, however, it worth noting that these will often draw on many of the same data sets needed to conduct impact evaluations.

[5] The UNEP U4E Model Regulations (see footnote on Page 1) recommend a minimum of every five years.

[6] LBNL (2012*) International Review of Frameworks for Impact Evaluation of Appliance Standards, Labeling, and Incentives*: https://eta-publications.lbl.gov/sites/default/files/lbl-6003e-sli-evaluation-dec-2012.pdf

Historically, inadequate assessments have been a weak spot in many MEPS and labelling programmes. This occurs because, during the inception phase, programmes have yet to prove their value and resources for their development are constrained. Also, those who design and implement MEPS and labelling programmes are sometimes new to the topic and hence are unaware of future information needs and benefits. Up-front acquisition of this information results in better programmatic design, fewer problems during implementation and more cost-optimized energy savings. It is also essential if the benefits of the programme are to be demonstrable in the future, in a manner that is persuasive for those responsible for resource and budgetary allocations.

The most helpful assessments are market assessments, along with impact assessments for consumers, industry, utilities and society. While the examples that follow are on refrigerating appliances and air conditioners, most aspects can apply to other product types as well.

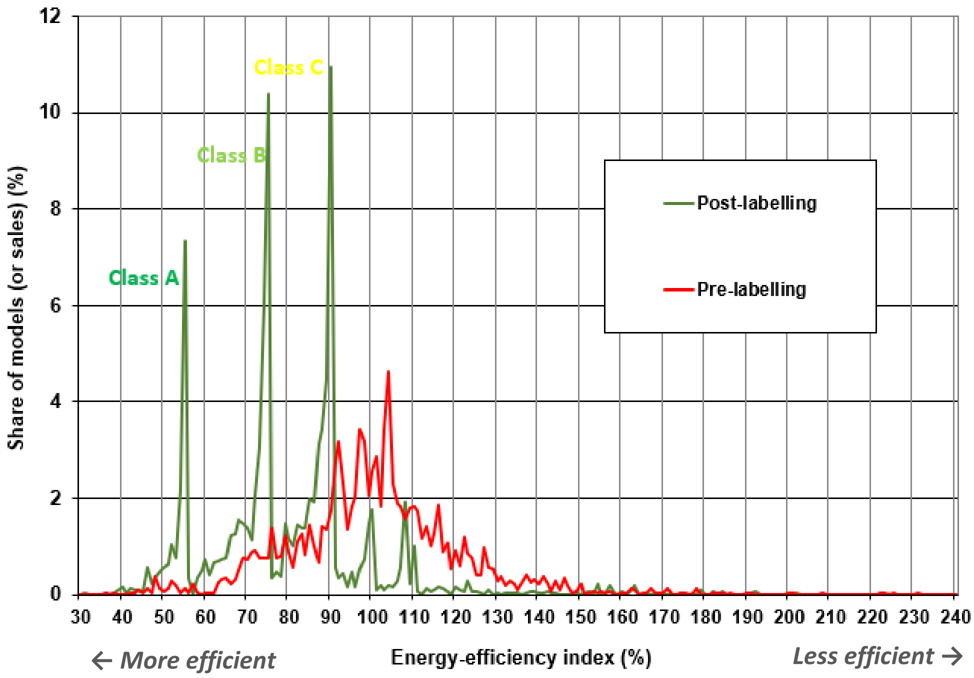
3. Market Assessments

Market assessments involve gathering information on the market for targeted products, which may be unavailable if there is not an existing, adequate PRS. Such market insights are needed at the programme's inception and throughout its implementation. Market assessments characterise the market and capture technical characteristics of products and their usage. In general, they are conducted for a specific product in response to a decision to develop MEPS and labelling for that product. However, they can also be conducted in a more general and rudimentary way in the early stages of consideration for MEPS and labelling to help decide which products are the most promising candidates for energy efficiency regulations.

3.1 How do market assessments help deliver cost-effective energy savings?

Market assessments provide the technical and market data necessary to design and implement effective MEPS and labelling programmes. Assessments help regulators understand the technical and commercial characteristics of the market, so they can set the efficiency thresholds at levels to deliver the most cost-effective energy savings. The aim is to balance energy savings and other policy drivers, most often maintaining product affordability and a stable, profitable supply chain. The confidence with which such policies can be developed depends on the quality of the analysis, which in turn is a function of the completeness and reliability of the data. Failing to adequately invest in these activities will likely dissipate cost-effective savings. The benefits from optimal regulatory design usually hugely outweigh the costs for competent design and implementation.

Figure 1: Distribution of sales by product energy efficiency index sold in the EU for different years: pre-energy labelling (1990-92) and post-energy labelling (from 1994)

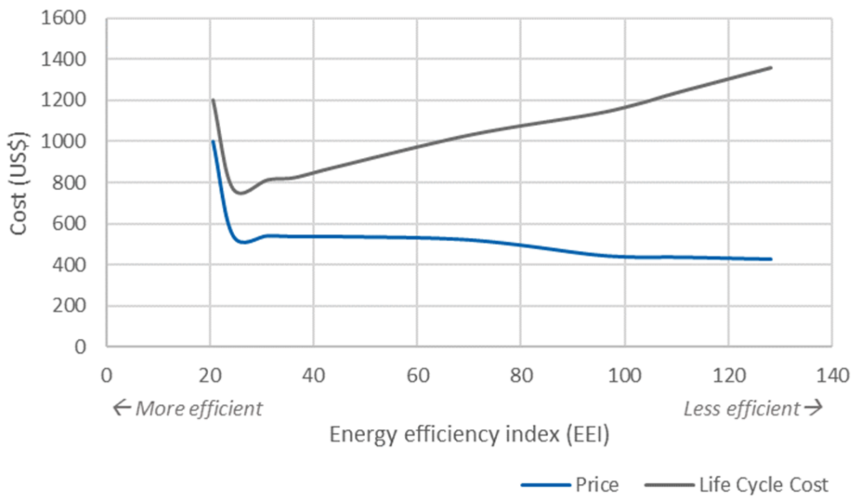


A key piece of information is the energy efficiency distribution of products. It helps policymakers know how efficient products are at the outset, and to estimate how much the efficiency will improve once MEPS and labels are introduced. Figure 1 shows an example from the European Union (EU) of refrigerators' energy efficiency pre- and post-energy labelling. Pre-labelling (1990-92), product sales are randomly distributed, and many inefficient products are offered for sale. Post-labelling (from 1994), the average energy efficiency index is lower (energy efficiency has improved) and almost all products are designed to meet one of the top three label thresholds (A, B and C for this example). The spikes are due to the energy label's distinct energy classes. Producers chose to design and declare products at the borders of the energy label classes. An ex-ante market assessment was needed to establish the pre-labelling distribution and to inform the design of the thresholds, while an ex-post market assessment conducted four years after labelling indicated the actual impact.

Knowing the distribution of product energy efficiency is essential to design policy and evaluate its impacts. It is also critical to understand how product price and lifecycle cost (LCC) - the cost of purchasing and operating a product over its lifetime - vary with energy efficiency when the policy is introduced and after it goes into effect. These insights are key to setting MEPS and labelling thresholds that enhance efficiency and minimise the LCC for the consumer. Many programmes explicitly follow this objective within the regulatory design. The legislation empowering MEPS in the EU requires MEPS thresholds consistent with the least life cycle cost (LLCC) for end-users. Other programmes, even if they do not mandate MEPS in this way, still aim to achieve it. In the United States, any new or amended energy conservation standard must be designed to achieve the maximum improvement in energy efficiency that the Department of Energy determines is technologically feasible and economically justified.

Thorough LCC-versus-efficiency analysis involves examining how the purchase price and operating costs of existing products and potential new technologies are expected to vary with their efficiency. Shortcuts exist that allow analysts to derive working estimates with less intensive data collection and analysis than is required for more reliable analysis. Figure 2 provides an illustration of how the LCC of refrigerators might vary with efficiency, which could be categorised in three stages. A) At low efficiencies, the product price is lower, but the LCC is higher due to high energy consumption. B) As energy efficiency increases, the energy savings are greater than the increase in product price, hence decreasing the LCC. C) At some point, the increase in price is greater than the energy savings, increasing the LCC. In this example, the LLCC is around an energy efficiency index of 25. Knowledge of local market factors - types and efficiency of appliances, usage and ambient temperature conditions, electricity tariffs, product prices accounting for supply chain costs and mark-ups - are needed to derive locally valid LCC-versus-efficiency curves.

Figure 2: Refrigerator price and LCC as a function of the product's energy efficiency



A related, but different, objective is to ensure that while products become more energy-efficient, they are still sufficiently affordable for target users. The upfront cost should not be so high as to put products out of the purchasing reach of key segments of the community, even if the LCC is favourable. Market assessments provide inputs to characterize product price-efficiency relationships and other information to understand the willingness and ability of consumers to pay for higher efficiency.[7]

Market assessments also provide the data needed to develop forecasts of the potential for energy savings across the whole economy at different MEPS and labelling levels. By incorporating forecasts of future demand, these models can project energy savings over longer time periods, helping to quantify other benefits, such as reducing CO_2 emissions and the need for additional generation capacity. The economic value of these benefits can in turn be used in

[7] For further insights, see: LBNL (2017) *Assessment of Commercially Available Energy-efficient Room Air Conditioners Including Models with low Global Warming Potential Refrigerants:* https://eta.lbl.gov/publications/assessment-commercially-available; and LBNL (2013) *Incorporating Experience Curves in Appliance Standards Analysis:* https://eta.lbl.gov/publications/incorporating-experience-curves-0

a wider cost-benefit analysis of potential MEPS/labelling levels, incorporating other policies such as financial incentives for consumers and/or the supply chain. With these, an optimum mix of policies can be developed to ensure the most cost-effective regulation development in the broadest sense.

Market assessments provide the information needed to derive the expected (ex-ante) and actual (ex-post) impacts of the policy on energy savings, costs and benefits; electricity generation, transmission and distribution; and direct and indirect greenhouse gas (GHG) emissions. Macro-level societal and utility impacts need to be favourable and maximised to achieve the policy objectives. They take into account micro-level inputs and a variety of analyses are conducted, from individual products to the mass market level. Forecasting assessment tools derive the energy, economic, electricity sector and environmental impacts attributable to the policy scenarios.

Projected energy consumption and related GHG emissions data, information on the product purchase price, LCC and affordability, impacts on manufacturers and suppliers, as well as impacts from the used refrigerants, are needed to optimise policy design.

Beyond the core policy aims, many programmes are also concerned with:

- Reducing peak power demand and improving security of energy supply.
- Reducing the cost of energy subsidies.
- Providing environmental benefits.
- Improving public health and well-being.
- Ensuring industry (especially local industry), distribution and retail are not unduly affected.
- Ensuring an adequate supply of products and that service levels or other factors (such as usability and safety) are not adversely affected.

The market assessments can be structured to answer these concerns.

3.2 Conducting a market assessment

This section discusses types and sources of data, stakeholder consultations, data collection methodologies and analysis, and the steps and resources needed to conduct an assessment.

3.2.1 Types of market data

The data necessary for MEPS and labelling market assessments cover a number of areas that together provide insight into the characteristics of a market as follows.

Product data

Gathering data on the products available in a market, and how sales are split between sub-types, energy use and price, is necessary to understand the current situation, what opportunity there is for energy savings and the potential costs of intervention for the market.

Sales channel data

Understanding the sales channels, including the market share of different manufacturers and retailers and mark-ups throughout the supply chain, helps ensure that the full market is considered, identifies stakeholders to engage, and supports implementation and surveillance. This includes:

- How product prices, affordability and duty/tax revenues are likely to change.
- Implications for the operations of suppliers, especially the local industry.
- How the market operates, so actors can be adequately informed of the requirements and their responses to the requirements monitored to maximise compliance.
- How to devise and subsequently revise the regulations.
- Key channels by which products enter the market so border controls can be established.
- Indirect[8] impacts on the second-hand market and product repair practices.

Usage data

Establishing how the product is used helps explain current energy use and potential savings, particularly for air conditioners, where usage can vary significantly by sector, season, climate and household income.

Utility data

A clear picture of the utility situation (tariffs, load profiles, peak loads, capacity planning and costs) provides a wider view of the impacts of regulation, including:

- Energy, operating cost, peak power demand and GHG savings that can be expected.
- Appropriate efficiency thresholds to be applied for MEPS and energy labelling.

See Annex 1 for the types of data to collect for each product (refrigerators and air conditioners) based on the analysis being undertaken. Table 1 relates the types of analyses to the data that are required.

Table 1: Types of analysis matched to types of data

	Product technical data e.g. efficiency	Product price	Market share/unit sales by product type	Product usage	Energy cost	Macro socio-economic data	Enviro. data - emissions factors and refrigerants	Other analysis specific data
Product efficiency distribution	✓		✓					
LCC versus efficiency[1]	✓	✓		✓	✓			
Economy level energy impacts[2]	✓	✓	✓	✓				
Economy level economic impacts[2]	✓	✓	✓	✓	✓	✓		
Economy level environmental impacts[2]	✓	✓	✓	✓			✓	
Manufacturer impacts	✓	✓	✓			✓		✓
Utility impacts	✓	✓	✓	✓	✓	✓		✓

[1] Part of a consumer impact assessment. [2] Aspects of a societal impact assessment.

[8] MEPS and energy labelling only apply to new products, so any impacts on the second-hand market will be indirect.

3.2.2 Sources of data and collection methodology

Sources of data vary by product and market. There is often regional and international data on products and their energy performance, which offer useful inputs.[9] See Annex 1 for a more detailed discussion of data sources. Table 2 lists some common data sources and the types of data that they provide. The terms of reference of market assessments, timing and budget are critical to their success, as is ensuring that the team has the necessary experience. See Annex 3 for a sample terms of reference and discussion of options, including data that could be supplied via a product registration scheme. Generally, some data are in the public domain and can be gathered rapidly, such as customs data (if data exchanges between the line ministry and customs are well established and customs has a good protocol for extracting useful insights) and product data available on the internet. Other data are harder to come by and require dedicated surveys or other approaches, as discussed in the rest of this section. Customs data alone cannot provide sufficient insights for a market assessment in a country with significant product manufacturing.

Table 2: Sources of data matched to types of data

	Product technical data e.g. efficiency	Product price data	Market share /unit sales by product	Product usage data	Energy cost data	Macro socio-economic data	Enviro. data - emissions factors and refrigerants	Other analysis specific data
Product registration systems	✓		✓				✓	
Customs		✓	✓					
Internet sales	✓	✓	✓				✓	
Market research	✓	✓	✓				✓	✓
Surveys, questionnaires	✓	✓	✓	✓	✓			
Utilities*				✓	✓			
Census data						✓		✓

* Other sources may be needed if the utility is not already operating an efficiency scheme that gathers such data.

Customs data

Customs data are relatively simple to gather via a range of national, regional and international databases that provide details on the imports and exports of products to a country. They are a good starting point and can be very useful if they are of high quality, rich in detail and available over many years. Normally, additional data from other sources are needed. Considerations regarding customs data collection include:

- Product classification (product type) is only distinguished per the classifications used in customs codes, which are internationally harmonized but vary from a basic 6-digit level to a 10-digit level, which gives a far greater insight into the types of products. (see Annex 1.4).
- Data are often limited to value and weight information but can include unit quantities.

[9] See UNEP U4E (2019) *Model Regulation Guidelines Supporting Information: Energy-Efficient and Climate-Friendly Air Conditioners* and for *Energy-Efficient and Climate-Friendly Refrigerators*, both are available at https://united4efficiency.org/resources/model-regulation-guidelines/

- Data are typically available as a time series. Gathering the longest time series possible is important to see market trends and to anticipate future trends. Longer time series can be used as inputs to models on the installed stock in a country. Data are only as reliable as the customs process.
- There may be a sizeable informal market that is not accounted for in customs data.
- Energy performance and price of individual products are rarely captured. Customs data can provide an estimate of the average import price of finished products, which, if compared with other data on the average final price of products, will indicate how much additional costs and mark-ups are due to distribution and retail.

Internet product data

Many products are sold or promoted on the internet and trawling these data are useful to gather data on prices, technical characteristics and sometimes energy efficiency. Sellers who are promoting products provide this information. In some economies, all products are promoted on the internet, meaning that the information available online covers the whole retail spectrum. In most economies there is a blend of larger retailers who promote products online and smaller ones who do not. Original manufacturers often promote products online and include technical details, though pricing may not be listed. A disadvantage compared to customs data is that internet data are scattered across many web pages with content that is regularly changed, making the data collection process more complex. See Annex 1.4 for more information on this data collection approach.

Once MEPS and labels are adopted, vendors are usually required to provide standardized technical information on their products (when such regulations are not in place, it is at the suppliers' discretion). Figure 3 provides an illustration of this. The type of data and reporting methods are presented below. Technical data, when provided, are based on measurements reported by the manufacturer carried out in accordance with the adopted test procedure.[10]

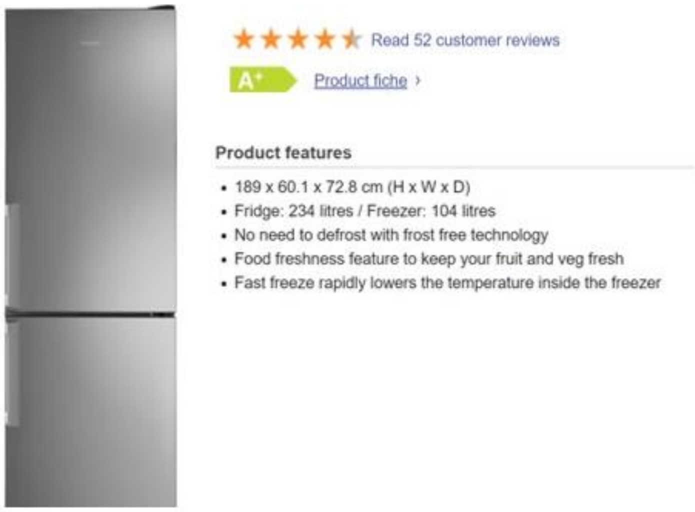
By compiling the available product data from the internet, it is possible to get an insight into the formal[11] part of the market. When energy performance information is included, it can be used to understand the mix of products in the market by, for example, creating a scatter plot or frequency distribution graph of the number of products offered for sale as a function of their efficiency (see Figure 1). This type of product mapping analysis is essential to estimate the impact of MEPS and labels both ex-ante and ex-post[12] and hence is vital for policy design and evaluation.

[10]Ordinarily aligned with the nationally adopted test procedure approved by the national standards body.
[11] Formal in this sense means new and legal for sale in the market, for those that follow the Model Regulations recommendation of banning the importation of used products and ensuring that new products meet regulatory requirements. Informal refers to second-hand imports or new products that fail to meet regulatory requirements. Second-hand sales are not affected by MEPS or labelling. Markets with significant informal sales can dramatically reduce the impacts of MEPS and labelling.
[12] UNEP U4E (2021) *Energy Labelling Guidance for Lighting and Appliances*, see Figure 3, https://united4efficiency.org/resources/publications/

Considerations regarding internet data collection:

- There might be a lack of sales volumes for each product. If a small subset of products dominates sales, the proportion of the market affected by the introduction of MEPS is hard to establish. Linking internet data to other sources on sales distributions may be necessary to minimise this risk.
- While online data are helpful in most markets, information from customs and the internet alone are insufficient to characterize the market and additional approaches are required.
- Without national MEPS and labels, retailers sometimes report energy efficiency classifications from a major economy elsewhere: this can provide some useful insights, even if the claims are not verifiable and the system to define efficiency differs from the anticipated local one.

Figure 3: Internet sales data for an economy without MEPS and labels (left) and for one with MEPS and labels (right) where standardized technical product technical information must be provided by law



Product fiche pursuant to Delegated Regulation (EU) no. 1060/2010

Refrigeration	Answer
Supplier's Name or Trade Mark	
Model	
Category of the household refrigerating model	Refrigerator-freezer
Energy efficiency class	A+
EU Ecolabel (If applicable)	
Annual Energy Consumption in kWh per year. Energy consumption XYZ kWh	346
Storage Volume Compartment 1	234
Storage Volume all other compartments	104
Star Rating Compartment 1	N/A
Star rating all other compartments	****
Design temperature of fridge compartment	2 - 8 °C
Design temperature of freezer compartment	-18 °C
Design temperature of "other compartments" e.g. For Wine storage	
"Frost Free" for any relevant compartments	Yes
Power cut safe "X" H defined as "temperature rise time"	17
"Freezing capacity" in kg/24h	10
Climate Class	SN-T
Noise Level (dB(A))	40
Built-In	Freestanding
For wine storage appliances add the following information "This appliance is	N/a

Market research data

In some locations, market research companies gather intelligence in support of the private sector, and regulators can seek to acquire these data. Typically, commercial market research data determine the size and value of the market, segment the market channels and determine market shares by the main actors. The quality and detail of the data can vary considerably. It is worthwhile determining if such market research has been conducted, what it addresses, and how much it would cost to acquire.

Surveys and questionnaires

Aside from accessing customs and internet data, the most universally applied market assessment method is surveying product suppliers, distributors and retailers. Designing the optimal survey strategy requires intelligence on the structure of the market.

For example, if the retail market has a proportion of sales via only a few leading retailers and the rest via a much larger number of small retailers, it usually suffices to survey leading retailers and a sample of smaller retailers. Leading retailers tend to operate nationally and stock the same product range across the country, but smaller retailers may exhibit more local variation related to who is importing and distributing their products and the point of entry or local manufacture. When a few distributors serve most of a small retail sector, it is often more effective to survey distributors.

Once the survey sample is selected, an appropriate questionnaire should be devised. Overly thorough questions can be counterproductive because market actors may not feel sufficiently motivated or willing to put in the time required to complete all data fields. There is a risk that they provide no response, while a more modest request only covering essential information might have stimulated one. The level of influence government has over the market and the extent to which market actors feel that it is in their interests to support the integrity of the programme are key factors which influence the engagement level and quality. The Government is also key to coordinating data gathering to ensure that market actors are approached by dedicated points of contact with proper authorization for their work and use an approved information gathering template.

If consultants can visit retail outlets and gather information directly, it may partially circumvent this problem, but required data may not be fully available.[13] Occasionally, it is possible for surveys to gather data on either the actual sales or the shipments of models, but this type of data is frequently not available. In this eventuality, an assumption can be made that each model has an equal sales presence in the market.

[13] Prior to mandatory labelling, retailers may not have energy efficiency information of their products or only report it at a basic level.

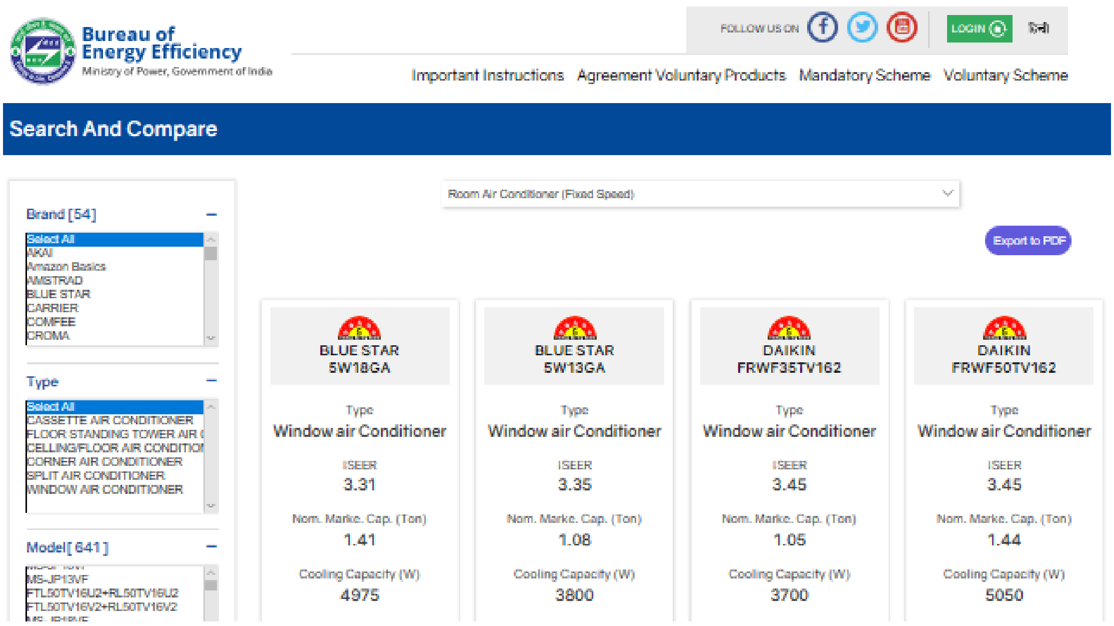
Annex 1 provides sample surveys for different parts of the distribution chain. While these questions should be posed, one should consider information needs for bespoke surveys in conjunction with other data gathering options.

Product registration system (PRS) data[14]

In many cases, the best combination of data available from the above methods still does not provide a full picture of the products bought in a market. There is likely to be information missing that reduces the confidence with which decisions on efficiency levels can be reached. Missing data reduce the robustness of monitoring, verification and enforcement activities, so many countries establish a PRS to help obviate this problem. Under a PRS, manufacturers or suppliers register details on products they wish to sell into a government-managed database (see an example in Figure 4).

When a PRS is available, all relevant technical characteristics of the product should be gathered to adequately analyse the products as a function of when they are first registered. If the system tracks how many products are being imported, and when, it provides an excellent source of statistical data. If it is available prior to MEPS and labelling coming into effect, it helps establish the efficiency baseline. However, this is rarely the case and other data are needed.

Figure 4: Example of the information available in the PRS – the public interface for air conditioners (fixed speed) in the Indian PRS[15]



[14] UNEP U4E (2020) *Product Registration System Guidance*, https://united4efficiency.org/product-registration-systems/

[15] India Bureau of Energy Efficiency (2020), Star Label Database, https://www.beestarlabel.com/SearchCompare, accessed on 31 August 2020.

International data

In parallel with domestic data collection, accessing international market data from other economies is useful to inform programme design. Most economies are net importers of products and obtaining information about how efficient products are elsewhere, what the price-efficiency relationships are, and other market-related data is helpful because local importers are usually able to adjust their source of supply in response to demand. It is challenging to obtain comprehensive price data that matches efficiency data, but there are methods and examples that can be used to derive price-efficiency relationships.[16] Even when local manufacturers have a significant share of the market, knowledge of how others are attaining a given efficiency level at a given cost offers important context on challenges for local industry to do likewise. International data provide a useful benchmark to inform local decision making.

There is a lot of relevant data in the public domain. All economies publish their regulatory requirements, and these are usually accessible online and provide insights into what they consider to be reasonable levels of ambition. Many countries with mature MEPS and labelling, such as the EU members, USA and Japan, publish technical and market assessments used to inform their regulatory processes.[17] These often include market data on the proportion of the market that attained given efficiency levels, product technical characteristics, and so forth. These data may provide a useful starting point to compare with the local market in order to explore the potential to improve efficiency and the likely costs. The supporting documents to the U4E Model Regulation Guidelines for refrigerating appliances and air conditioners[18] recommend MEPS and labelling levels based on international best practices and include relevant insights on some of the major markets.

[16] LBNL (2017) *Assessment of commercially available energy-efficient room air conditioners including models with low global warming potential (GWP) refrigerants*: https://eta-publications.lbl.gov/sites/default/files/assessment_of_racs_lbnl-_2001047.pdf; and LBNL (2017) *The International Database of Efficient Appliances (IDEA): A new tool to support appliance energy-efficiency deployment:* https://www.sciencedirect.com/science/article/abs/pii/S0306261917309650?via%3Dihub

[17] European Commission (2005) *Preparatory Studies for Ecodesign for Refrigerators*, https://www.eceee.org/static/media/uploads/site-2/ecodesign/products/domestic-fridges-and-freezers/final-report-lot13.zip and for air conditioners, http://www.eco-airconditioners.eu/
U.S. Department of Energy, technical support documents accessed on 18 August 2020 for refrigerators at: https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=37&action=viewlive; and for air conditioners at: https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=52&action=viewlive
Japanese reports accessed on 18 August 2020 at: https://www.asiaeec-col.eccj.or.jp/top-runner-target-standards/

[18] UNEP U4E (2019) *Model Regulation Guidelines: Energy-Efficient and Climate-Friendly Air Conditioners* and *Model Regulation Guidelines: Energy-Efficient and Climate-Friendly Refrigerators*, both available at: https://united4efficiency.org/resources/model-regulation-guidelines/

To make full use of these data, it is necessary to understand their technical basis, including the test procedures and efficiency metrics, product features and characteristics, to see how comparable it is with the local market. Benchmarking studies should convert results from one system to another when test standards and metrics differ.[19]

Stakeholder identification, consultation and engagement

Reliable information is essential to a robust process; therefore regulators need to engage stakeholders who have access to this information. Private sector actors such as manufacturers, importers, distributors and retailers, are best placed to provide data. At the inception of a programme, one needs to establish a stakeholder consultation process and identify relevant stakeholders in dialogue with the chamber of commerce and industry associations. Generally, the ministry responsible for industry already knows if there are any local manufacturers or assemblers, while the ministry responsible for trade and commerce is likely to have information on importers and possibly distributors and retailers. Retailers can provide information on distribution networks.

The stakeholders to be engaged should be closely linked to specific products once the policy preparation process begins. At a minimum, stakeholders should be introduced to the goals and methods at the beginning and then reassembled to review provisional findings. The first stakeholder meeting announces the intention to conduct a market survey and invite engagement. Letters of support should be provided by the lead government agency to those conducting surveys to confirm the legitimacy of the request and encourage participation. Often, suppliers and retailers have close connections with the lead government agency and reason to engage, while manufacturers have close ties with industrial ministries. Ministries should coordinate to share available data and engage stakeholders. Relevant agencies and the types of data they may own are shown in Table 3.

Table 3: Government agencies and the types of information they are likely to have

Ministry/Agency	Type of data
Trade and Commerce	Lists of market actors and potentially market share data
Industry	Lists of industrial actors
Energy	Energy sector data
Environment	Refrigerants and other chemicals
Finance	Taxation data
Economy	Economic data
Statistics (if standalone from those above)	Demographics, economic trends, and other

This stakeholder engagement process is in the interest of the private sector and therefore they should be encouraged to participate. Non-disclosure agreements can be used to ensure confidentiality of business-sensitive information, so that it is masked when used in public reports on the findings. Concerns about the impact of the proposed legislation on businesses can be

[19] See https://mappingandbenchmarking.iea-4e.org; https://superefficient.org/publications; https://www.clasp.ngo/publib, accessed on 31 August 2020

reviewed and potentially addressed. Often, this is about ensuring a level playing field and providing sufficient advance notice, and explanation of the pending regulations and how they are to be implemented. Equally, they provide valuable feedback that can inform programme design. If local stakeholders are reluctant, some combination of sources including international comparison may be necessary. This approach can be a catalyst for stakeholders to engage more fully.

3.2.3 Data analysis

Data is used to inform the various analyses necessary to settle on the MEPS and labelling design. Table 1 links the types of data to the types of analyses and Annex 2 provides details on how to conduct analyses with various techniques, case studies, and a summary of tools and resources. Section 4 provides illustrations of the main kinds of impact analyses.

The depth to which these analyses are undertaken depends on the objectives and the resources available. The ex-ante analyses used to inform the design of the EU's Ecodesign and Energy Labelling Regulations (see Case study: The EU Ecodesign Methodology) are a good illustration of a robust and consistent approach.[20] Following these steps will provide insights necessary to design a programme (excepting manufacturer and utility impacts) while also supporting future ex-post impact analyses. Not all economies can commit to such extensive investigations and hence alternatives are needed. Some of the steps in the ecodesign process can be merged and the order adjusted, as needed.

[20] An international comparative review of how Australia, the EU, Japan and USA devised their MEPS and labelling programmes is available in LBNL (2012) *International Review of the Development and Implementation of Energy Efficiency Standards and Labeling Programs*: https://eta-publications.lbl.gov/sites/default/files/lbl-5407e-esl-programfeb-2012.pdf

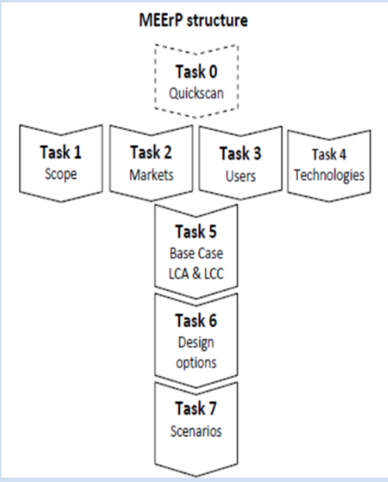
Case study: The EU Ecodesign Methodology

When a product is due to be regulated, the European Commission hires consultants to conduct a preparatory study according per the Methodology for Ecodesign of Energy Related Products (MEErP). It entails conducting the analyses described below and shown in Figure 5.

- Task 1 - Scope (definitions, standards and legislation, first screening)
- Task 2 – Markets modelling (volumes and prices)
- Task 3 – Use modelling (product demand side)
- Task 4 – Technologies (product supply side), includes both best available technology (BAT) and best not yet available technology (BNAT)
- Task 5 – Environment and economics (base case life cycle analysis and LCC of product reference cases)
- Task 6 – Design options to improve the life cycle impacts and optimize the LCC
- Task 7 – Scenarios (consideration of policies, derivation of a base case scenario, policy impact scenarios and related assumption sensitivity analyses).

A market assessment provides the data needed for the assessments and scenarios.

Figure 5: The EU's Methodology for Ecodesign of Energy-related Products



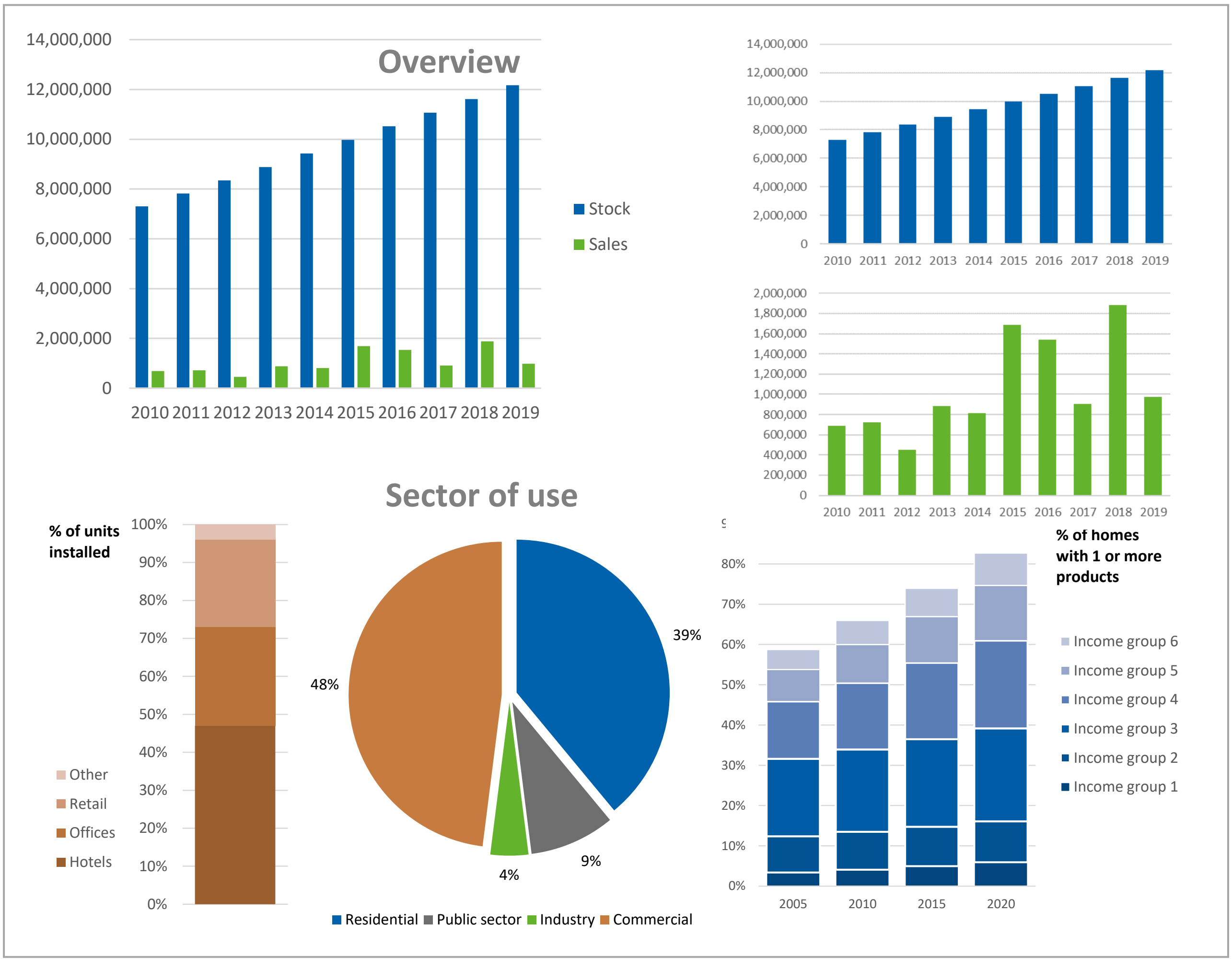
Market review

Detailed analysis of the current and historical state of the market brings together the available data on all aspects that affect the product under consideration, including:

- Stock and sales analysis by volume and value by end-user sector, main sub-technology categories, product technology characteristics – including efficiency, and price (e.g. MEErP Task 2 and 4). See Figures 6a, 6b and 6c for sample outputs.
- Supply chain review (e.g. MEErP Task 2). See Figures 7a, 7b, 7c and 7d for sample outputs.
- Usage review (e.g. MEErP Task 3).

The product overview assesses the technologies used to deliver the service in the local market, what is available in other markets, and what technologies will be potentially available in the future. This analysis helps define the reference case products and the potential to improve energy performance.

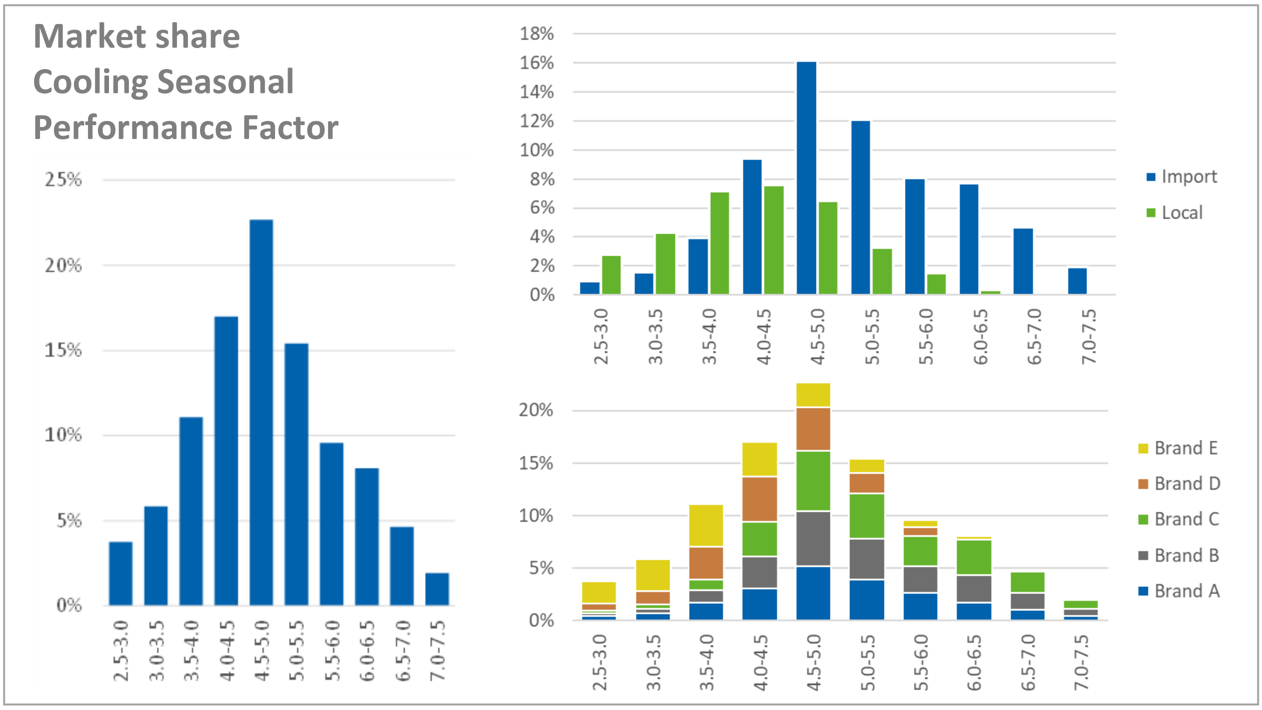
Figure 6a: Stock and sales review – overview

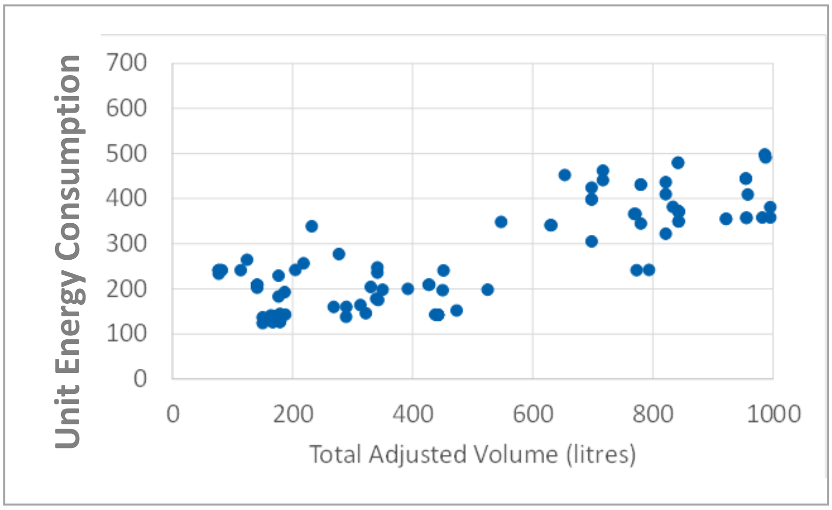


Note:

- The stock and sales review help with estimates of the affordability of the product in different sectors and demographic groups.
- Variations in stock and sales splits can show emerging trends in the purchasing preferences.
- Greater granularity allows more insight into how each sub-sector or demographic will be impacted.
- Sales data can be variable, so that collecting data for multiple years improves reliability.

Figure 6b: Stock and sales review – efficiency

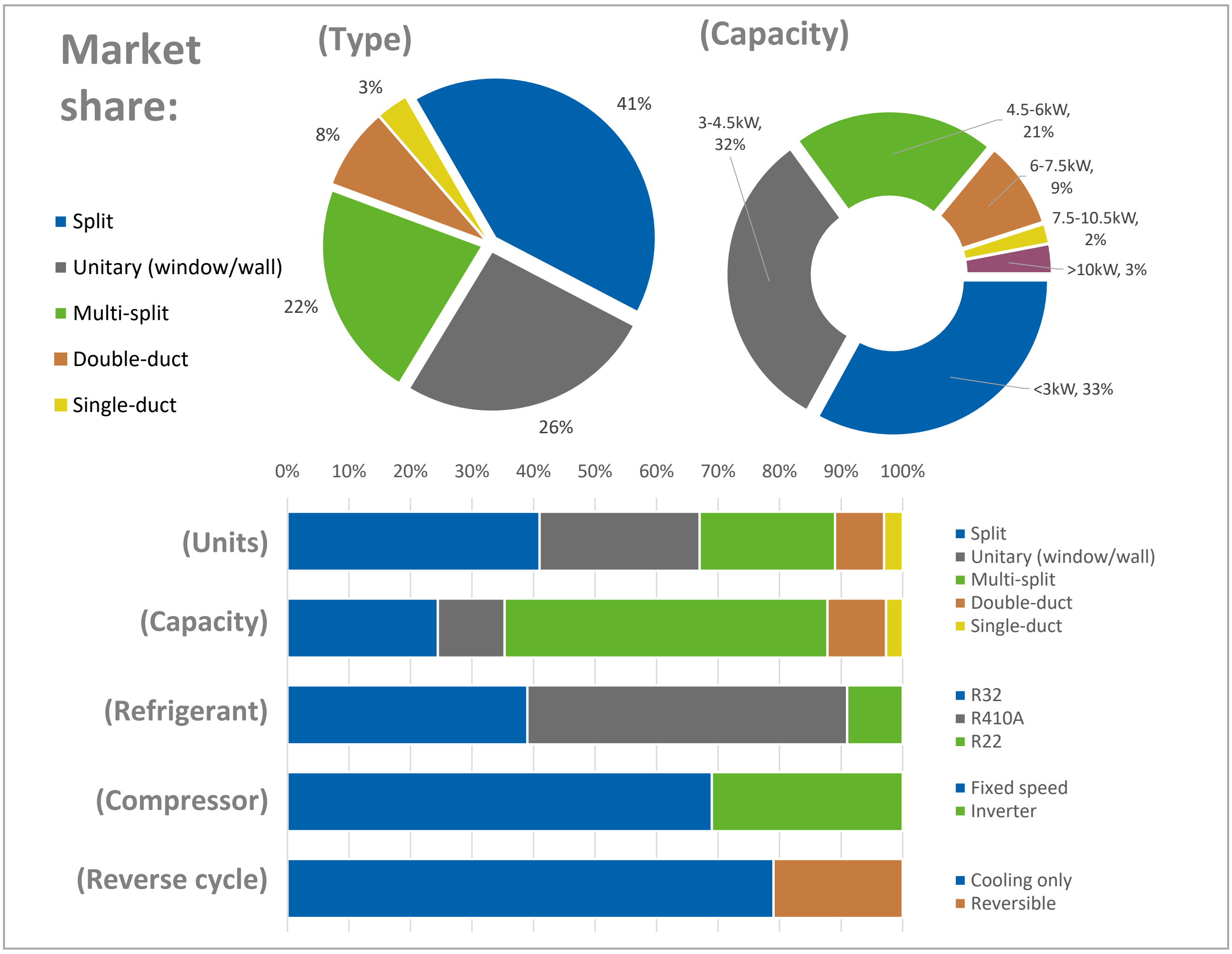




Note:

- Normalised frequency distributions of the main efficiency metric are the simplest approach.
- Separating imports vs local production and brands gives visibility of the differential impacts on stakeholders.
- Product level review can reveal other market characteristics that help with the design of MEPS and labels.

Figure 6c: Stock and sales review – other product characteristics



Note:

- Separating the stock and sales by product type gives visibility into how regulations should be designed. MEPS and labelling levels are often differentiated at the product type, so tracking each is necessary.
- Comparing the total installed capacity of each type gives a clearer picture of energy use and is used in the calculation of energy savings as well in utility and economic impact assessments.
- Presenting data on other product characteristics can help understanding of other policy priorities, in this case the refrigerant mix which is needed to track Kigali Agreement impacts.
- Investigating underlying technologies that impact energy use is revealing. Compressor type directly impacts CSPF (cooling seasonal performance factor). The prevalence of reversible heat pumps underscores the need to regulate heating and cooling.

The next stage is to show how the supply chain works (e.g. MEErP Task 2) both structurally and in terms of the share of different manufacturers and suppliers. This means developing a clear picture of the different routes by which the product reaches customers in the market to understand the supply chain. Data collection efforts can target the most important aspects.

Figure 7a: Illustration of supply chain overview – product sales channels

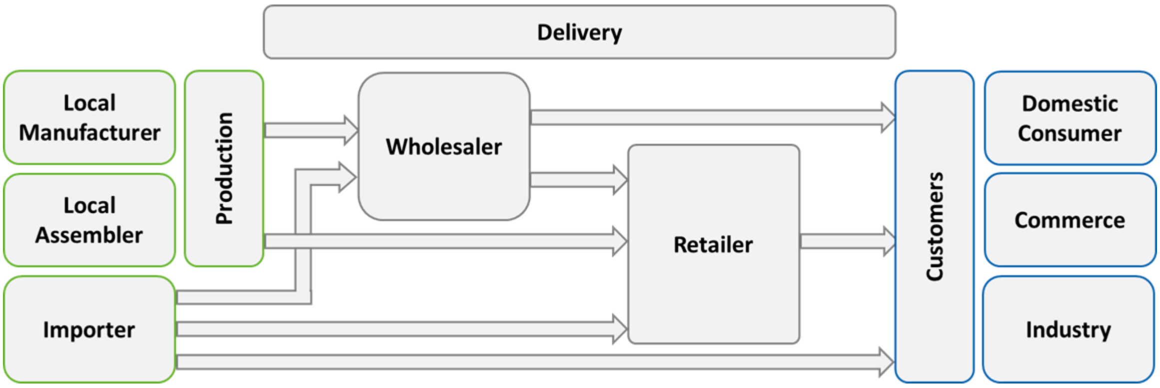


Figure 7b: Illustration of supply chain overview – product market share of distribution channels

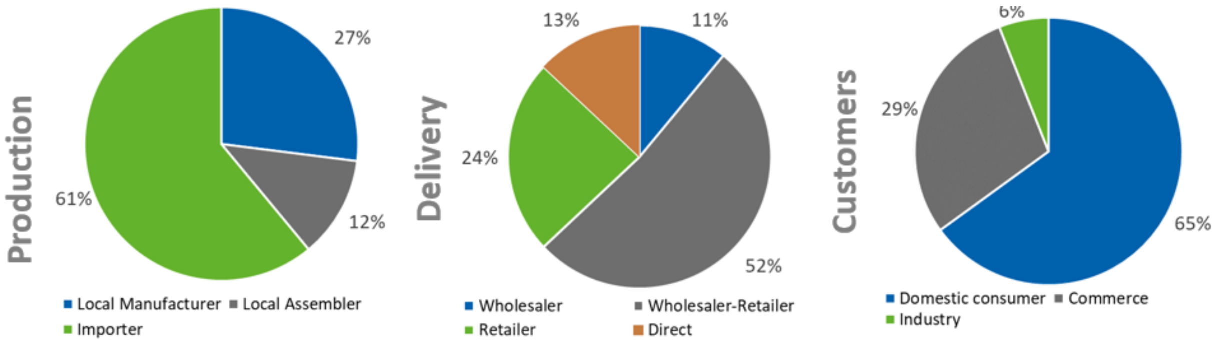
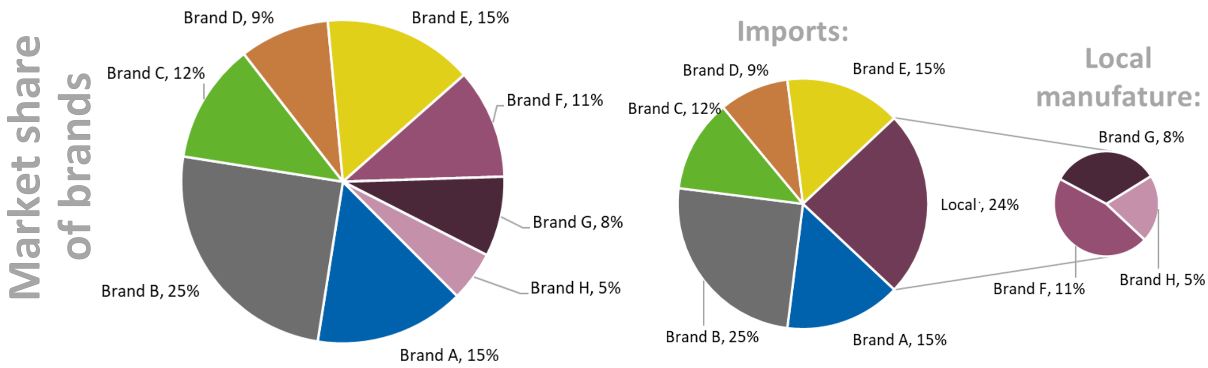


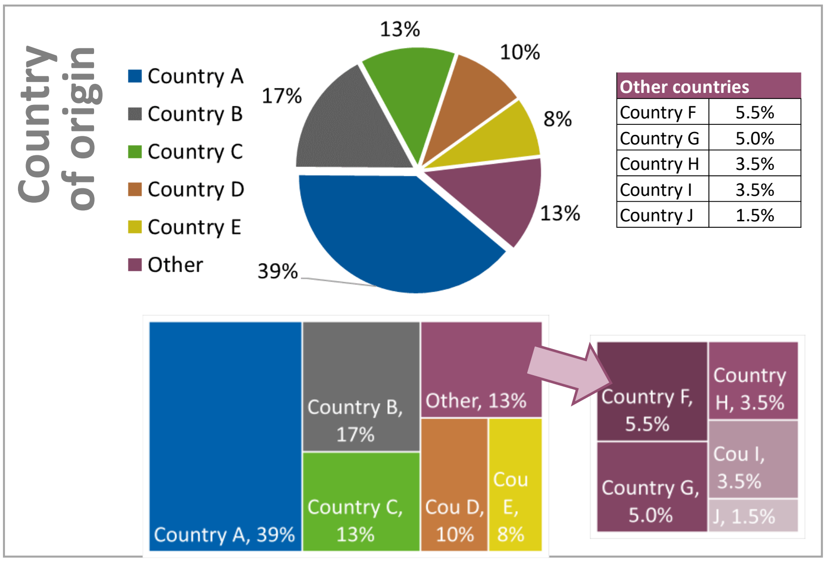
Figure 7c: Supply chain review – brand analysis from market data



Note:

- Check the best products in other markets to help consider the viability of efficiency and refrigerant requirements.
- Granular data on how market share splits by technology and efficiency can show which brands are most impacted.

Figure 7d: Supply chain review – brands and country of origin



Note:

- Helps policymakers establish whether products are already tested and rated according to the IEC test procedure.
- Differentiation by brand can also be used to understand which are tested according to the IEC method, particularly for countries with little or no local industry.
- It is crucial to check manufacturer home pages to see their product energy performance test procedures.

Analysis of the usage patterns provides insights into the total current energy consumption of the technology. Usage analysis needs to estimate how many products are already in use in different market sectors and how products are used across different end-user groups (e.g. MEErP Task 3). Figure 8 gives an example of the output – in this case for air conditioners. Figure 9 shows an illustration of how the average hours of use may vary as a function of the outdoor temperature.

Figure 8: Illustration of how average air conditioner usage may vary with season

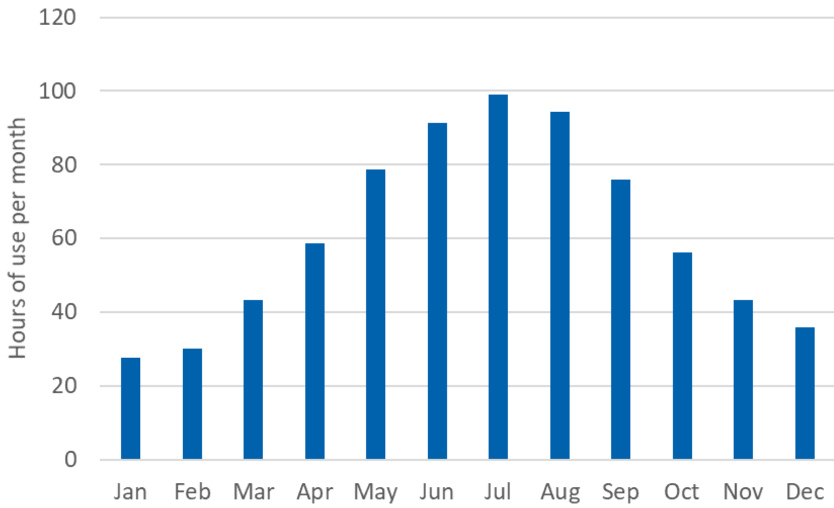
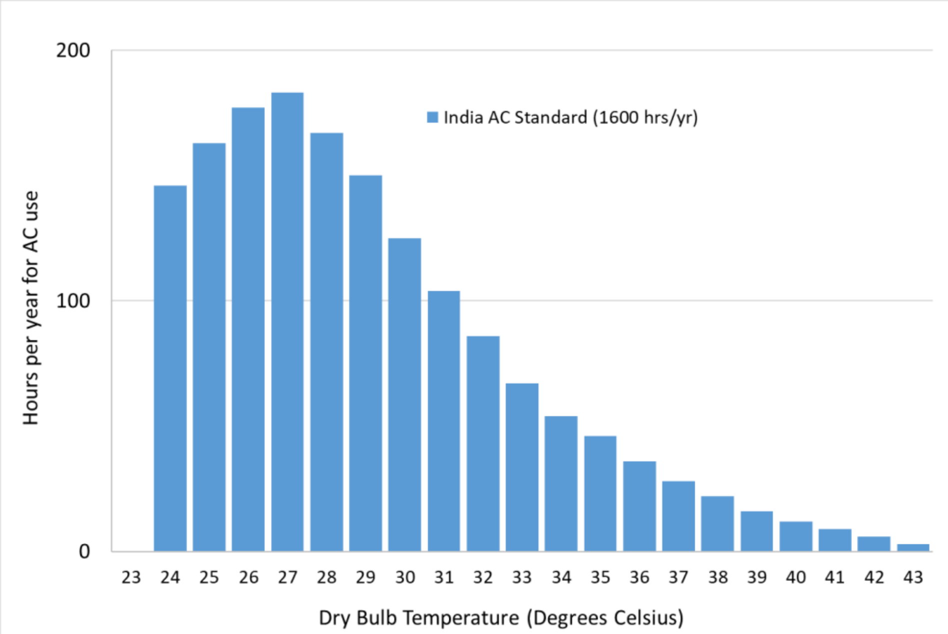


Figure 9: Illustration of how average air conditioner usage may vary with outdoor temperature[21]



Techno-economic and life cycle analysis

Techno-economic analysis (e.g. MEErP Tasks 5 and 6) establishes the average product technology types currently in the market in terms of efficiency, usage and energy consumption. These insights are used to consider design options to improve energy efficiency. The results are related to the cost of manufacture, distribution and retail to derive estimates of how typical product prices (paid by the consumer) will vary as a function of product efficiency. This makes it possible to derive the LCC as a function of efficiency once product usage profiles and energy tariffs are known.

In advanced analyses, specialised energy-engineering simulation tools are used to determine how design improvements affect energy performance. These can be combined with manufacturing cost tools to determine how the cost of manufacture is expected to change as a function of efficiency. Information on supply chain costs and mark-ups can be applied to determine how the cost paid by consumers will vary with energy efficiency. This analysis gives crucial information on the efficiency level that corresponds to the LLCC – the key benchmark to inform energy efficiency thresholds for MEPS and labelling.

Techno-economic analyses are the most technically demanding of all analyses and require considerable expertise, market knowledge and suitable simulation tools. Many economies hire qualified experts when a priority is placed on the quality of such analyses, such as when there is a high proportion of local manufacturing or assembly. Alternatively, internationally published

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[21] LBNL's analysis based on Bureau of Energy Efficiency (2017) The Gazette of India, Extraordinary, Part II, Section 3, https://www.beestarlabel.com/Content/Files/AC_Notification.pdf

analyses (such as those in support of the regulatory processes used in the EU and USA)[22] can be adapted for domestic application. Examples of such findings are given in Figures 2 and 12, Table 4, and Annex 2.2.

In principle it could be possible to conduct statistical analysis on the price and features of products available on the market to attempt to establish product price-versus-efficiency relationships (which are half of the input needed to do LCC analysis). However, because price is strongly influenced by the product type, capacity, additional features, brand, and efficiency, it can be challenging to separate these effects. Analysing the variance of price as a function of efficiency for technically similar products is a workaround but requires a large enough dataset with available details.

Savings potential analysis

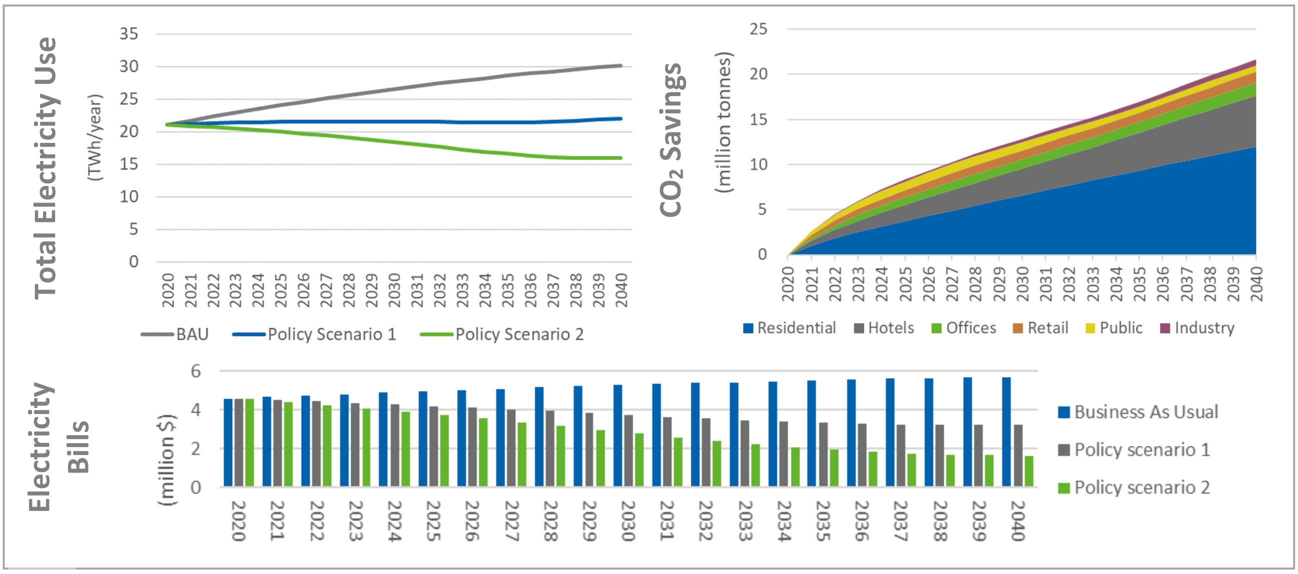
Once the current market is well understood, the potential benefits of introducing MEPS and labelling can be forecast (e.g. MEErP Task 7). Savings potential analyses project the development of the market over time and assess the total energy use in different scenarios, with at least a policy case versus no policy (business as usual) case. These projections of energy use under different scenarios allow policymakers to see the impacts of policy intervention on energy consumption, GHG emissions, and electricity costs. Figure 10 illustrates the savings potential analysis related to such forecasts. Off-the-shelf tools are available to help with these types of analysis. See Annex 2.3 for further details.

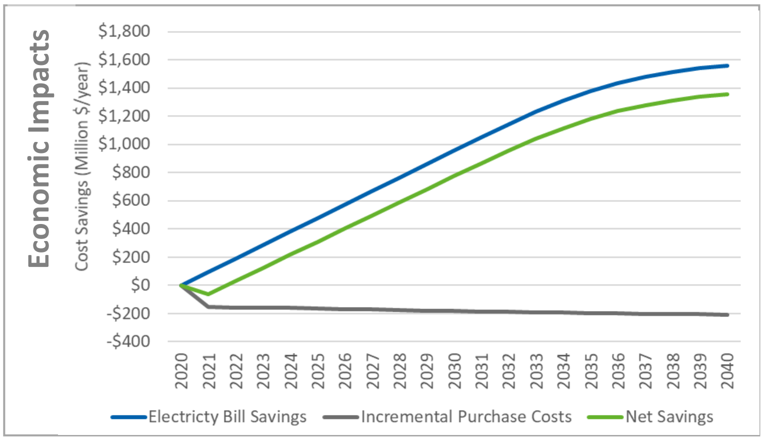
Other impact assessments

The market assessments described above all feed into the broad set of assessments (consumer, manufacturer, utility and societal impact assessments) discussed in Sections 4.1 to 4.4. Collectively these types of assessments help design the MEPS and labelling programme to deliver the policy objectives as effectively as possible. They allow policymakers to undertake comparisons of MEPS and labelling set at different levels and develop robust policy on that basis. Ideally, all analyses should include a sensitivity analysis, which allows the sensitivity of the projected impacts to be tested against critical assumptions.

[22] The EU is migrating its preparatory studies to: https://ec.europa.eu/energy/studies_main/preparatory-studies_en. The US technical support documents can be found at: https://www.energy.gov/eere/buildings/appliance-and-equipment-standards-program in accordance with https://www.energy.gov/sites/prod/files/2013/12/f5/as_accessing_documents.pdf

Figure 10: Illustration of economy-wide annual savings potential from MEPS and labelling





Note:

- Scenario analyses project electricity demand via models that either estimate product usage bottom-up with product level energy consumption estimates or via econometric analyses to estimate electricity using a top-down approach.
- The bottom-up approach allows forecasting the impact of refrigerant switching and a comparison how the economic impacts play out in different sectors over time (see example on left).

3.2.4 Tools for undertaking the analysis

Analytical tools vary depending on available data, needs of the programme and access to expertise. The type of analyses to produce the most important aspects of the market review and national level impacts can be computed using simple spreadsheet tools. These include product stock models (necessary to derive societal impacts – economy wide impact estimates for energy, costs and benefits, and the environment) and techno-economic models to derive LCC (for consumer impacts, ex-ante policy design and as input to societal cost-benefit analyses). Examples are discussed in Annex 2.

3.2.5 Getting the analysis done, resources and schedules

Planning and conducting the work

MEPS and labelling programme managers need to set out a clear set of actions to be conducted, allocate resources to conduct the work, hire any assistance needed and devise a schedule. Typically, it will entail hiring qualified consultants to assist in the process according to a set of terms of reference (ToR). The ToR need to be realistic and manageable with the resources and schedule allocated. Illustrative ToR are included in Annex 3. It is better not to rush the process to ensure that technical inputs are secured, well-founded and based on an appreciation that there can be many unknowns at the outset. Gathering, processing and validating the data will usually take at least a year.

Allocation of resources and scheduling work

The main challenge is securing sufficient resources at the inception of the development process of MEPS and labelling to conduct an adequate market assessment, with the baseline clearly established, and implementation properly monitored and improved over time. At the inception phase, the market knowledge gap is typically greatest, and resources are most limited. Government agencies that control funding allocations and international donor agencies (when relevant) should appreciate the importance of investing in this data gathering process. Well-designed MEPS and labelling save energy at a cost that is many times lower than supplying that energy. This is especially the case in economies with growing power demand that need to invest in adding generation, transmission and distribution capacity.

Funders sometimes underestimate the importance of programmatic design and evaluation, underappreciating the benefits which accrue relative to the risks from hasty shortcuts. This can lead to too much emphasis on passing regulations and insufficient focus on the quality of the regulations and subsequent implementation. Communicate the importance of a strong process in design and implementation relative to having the legislation in place. Even in the best funded programmes, the cost of design and implementation is typically a tiny fraction of the net benefits.

3.3 Validating and applying the results

Once market assessment data has been gathered, present it to the stakeholder community for validation via public workshops and other outreach channels. This ensures that stakeholders have an opportunity to point out errors or misconceptions, which may help to improve the robustness of the analysis. This process will stimulate real engagement by stakeholders, especially those with a commercial interest in the outcome. Often commercial stakeholders do not initially react to surveys or other data requests. They may only come forward after seeing initial market data estimates, especially if these are based on international values which are too general for a local market.

Summary of steps to support data collection

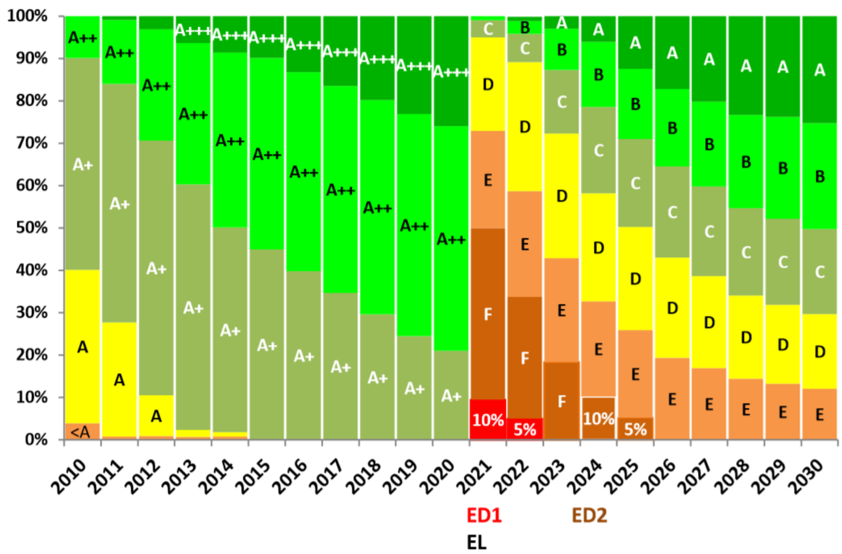
- Make the case for adequate funding and time (approximately one year) for data collection and analysis – indicate the value proposition via rough initial savings estimates compared with supply side costs.
- Host a public workshop to explain the purpose of the programme and request data and input.
- Secure support from line ministries with close contact with the parties to establish connections.
- consider a non-disclosure agreement for critical data sources with business sensitive information
- host a validation workshop for input on provisional findings and follow-up to address gaps

3.4 On-going data collection and analysis to support review

As MEPS and labelling evolves from inception through implementation, maturity and revision, informational needs also evolve. Market data need to be gathered in an ongoing or periodic manner to allow progress to be tracked and to inform decisions about policy revisions. The most mature MEPS and labelling programmes have revised their criteria several times since their inception, mostly to increase the ambition of policy settings.

Policymakers should set a review date when the regulations are published, by which time a full review of their impacts needs to be conducted. Reviews inform policymakers of whether the initial programme's goals were achieved and on amendments necessary to drive cost-effective efficiency gains in the future. Figure 11 shows how refrigerator energy labelling classifications were recently revised in the EU to return to a recalibrated A to G scale, after previously adding A+, A++ and A+++ classes to an original A to G scale.

Figure 11: Energy label class distribution of household refrigerating appliance models in the EU from 2010-2030 (actual figures for 2010-2016; projections for 2017-2030) with proposed LLCC-measures[23]



[23] EU (2019) *Commission Staff Working Document Impact Assessment* https://ec.europa.eu/transparency/regdoc/rep/10102/2019/EN/SWD-2019-341-F1-EN-MAIN-PART-1.PDF

This policy design decision was informed by an ex-post market impact assessment, which showed the actual trend in sales by energy label class from 2010 to 2019, and an ex-ante assessment showing projected sales under the new A to G classification from 2021 to 2030. Future ex-post evaluations will determine whether these ex-ante projections are correct.

4. Impact Analyses

Impact assessments provide the evidence that should prove the programme has been designed to be in line with the national interest and will/has benefit(ed) society while being at least net neutral on the impact for industry and commerce. They allow costs and benefits to be monitored and help ensure programmes are designed and implemented effectively. This section discusses the consumer, manufacturer, utility and societal impact analyses for energy efficiency MEPS and labelling programmes especially applied to refrigerators and air conditioners. In all cases these take as inputs relevant findings from the market assessments described in Section 3.

4.1 Consumer impact analyses

The impacts of MEPS and labelling on consumers are determined by the changes in product:

- Price/affordability.
- Operating costs.
- Availability.
- Features.
- Other usability, safety, and/or environmental impacts (e.g. pollution, noise, light flicker).

Most markets have as many products on the market, with as many features, after the introduction of MEPS and energy labelling as they had before. Product price changes affect the product's affordability and LCC. The operating costs are proportional to the energy consumption (the better the energy efficiency,[24] the lower the energy consumption), proper installation, and maintenance. However, regulators need to monitor the price to ensure markets are operating effectively.

[24] Energy efficiency might be defined in different ways depending on the product and might also vary in different regulations.

To assess product prices, gather data at the beginning of the programme to establish the baseline and afterwards to establish ex-post impacts. When designing MEPS and labelling, it is important to have an ex-ante view of how prices are anticipated to change as a function of the efficiency thresholds so that policy settings can be optimised.[25] Two methods can be used:

- Gather data on products already on the market and plot their price as a function of efficiency (see Figure 12). Ideally a multiple regression analysis is used to determine the strength of factors that affect price, such as: product capacity, features, brand, warranty, and potentially the nature of the purchase agreement (e.g. terms of credit).[26] If insufficient local data is available, price-efficiency relationships can be benchmarked to regional or international prices at comparable efficiency points and then relative changes can be incorporated.
- Techno-economic analysis (see Section 2.3.4) quantifies the real incremental costs that suppliers incur to manufacture or procure efficient products. It is challenging to conduct such analysis if there is insufficient model data, no efficient products on the market, or if other aspects affecting product price, asides from efficiency, are not separated.

Often, a hybrid approach is needed where local price and efficiency data are compared to the extent possible to equivalent international data, and bottom-up analyses from major markets are adapted to local circumstances to allow working estimates to be derived.

Figure 12: Illustration of price analysis

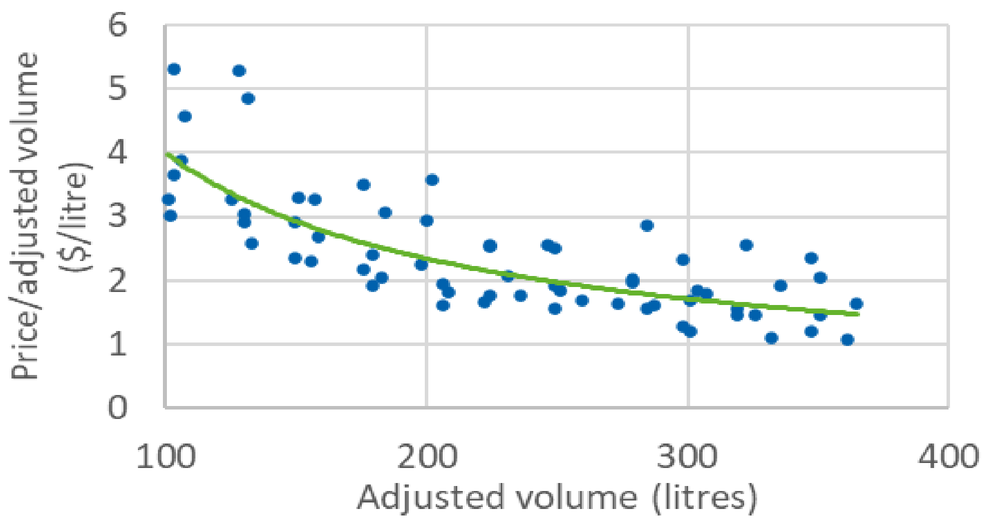


Table 4 and Figure 2 illustrate the results of techno-economic LCC[27]-versus-efficiency analysis for refrigerators. Energy efficiency is expressed as an energy efficiency index (as used in the EU).

[25] Desroches, Garbesi, et al. (2013) *Incorporating Experience Curves in Appliances Standards Analysis*: https://www.sciencedirect.com/science/article/pii/S0301421512008488?via%3Dihub.
Product price vs efficiency relationships will also evolve over time such that higher efficiency products tend to become relatively cheaper in real terms over time.
[26] Multiple regression is an extension of simple linear regression. It is used to predict the value of a variable based on the value of two or more other variables.
[27] Not all markets include the end-of-life costs (collection, recycling) or benefit (resale) term in their analyses. More details on how to calculate the life cycle cost for a product can be found in EU (2011*) Methodology for Ecodesign of Energy-related Product,* Section 6.1.1 (Page 132), https://ec.europa.eu/docsroom/documents/10024/attachments/1/translations/en/renditions/pdf.

In Figure 2, there is a gentle price increase as energy consumption declines, which becomes sharper as the highest efficiency design (Option 9 in Table 4) is reached. This increase in purchase price is more than offset by the declining operating costs (during lifespan of product), except for the last design option. The LCC for the consumer declines as the efficiency improves and reaches a minimum at design Option 8 – a product that uses 24 per cent of the energy of a reference product with an EEI[28] of 100. This illustration is with relatively inexpensive electricity (and modest supply chain cost and mark-ups). Higher tariffs would increase the LCC and potentially bring the EEI corresponding with the LLCC down further. Higher supply chain costs and mark-ups would increase the LCC but make the EEI corresponding with the LLCC higher.

Table 4: Illustration of techno-economic analysis for a two-door direct cool refrigerator-freezer

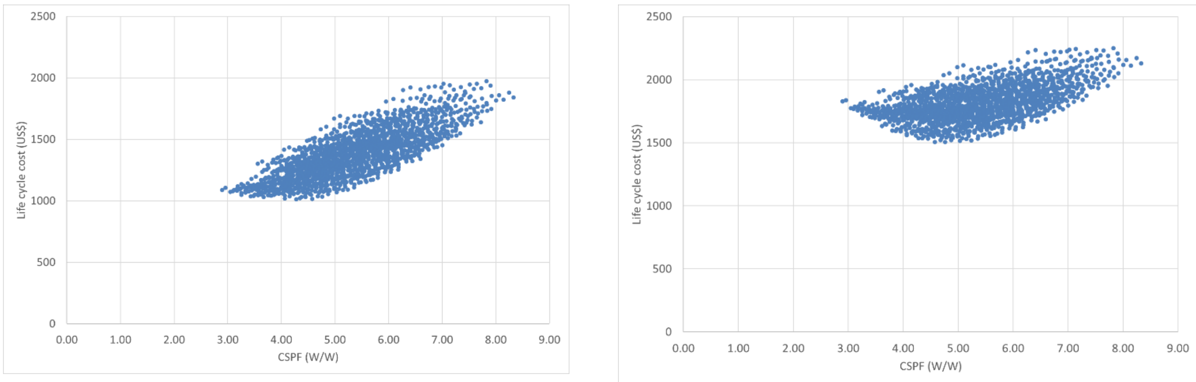
Design	Energy consumed	Energy saved	Improve over last option	Purchase Price	Delta Purchase Price	Manu-facturing cost	Value of Electric-ity[1]	Electricity Savings	LCC	Pay-back period	Net Volume	Volume corrected LCC	EEI
Option	kWh/year	kWh/year	%	USD $	USD $	USD $	USD $	USD $	USD $	years	litres	USD $	
Base-case	747	0	0	430	0	188	90.2	0.0	1367	0	184	1367	128
1	645	101	14	440	288	189	78.0	-10.4	1249	3	184	1249	111
2	597	48	7	440	288	189	72.2	-16.3	1189	1.9	184	1189	102
3	547	50	7	452	403	199	66.2	-22.3	1139	2	184	1139	94
4	410	137	19	552	1306	230	49.6	-38.9	1066	3.7	184	1066	70
5	250[1]	160	22	541	1207	241	30.2	-58.2	854	2.3	175	882	44
6	204	46	6	541	1213	241	24.6	-63.8	797	2.1	173	829	36
7	169[2]	35	5	545	1243	243	20.3	-68.1	756	2	161	818	31
8	132	37	5	545	1247	243	15.9	-72.5	710	1.9	161	743	24
Design option with less certain impacts:													
9	111	21	3	1007	5447	426	13.4	-75.1	1146	8	161	1209	21

[1] The value of electricity is the annual operating cost

[28] The Energy Efficiency Index (EEI) is an efficiency metric used in many markets. It is the ratio of the energy consumption of a product divided by that of an equivalent reference product that provides exactly the same service. The EEI is expressed as a percentage. The principle is that the reference product should have an average efficiency at the initiation of a MEPS and labelling programme and hence would have an EEI of 100%. A more efficient product would have an EEI of 99% or a lower figure.

Figure 13 simulates different energy performance design options for room air conditioners. Techno-economic engineering analysis shows how the LCC is expected to change as a function of energy efficiency (measured as CSPF in this example). In case a), usage is 500 hours per year (a residential user) and the LLCC occurs at a CSPF of 4.5 W/W. In case b), usage is 1000 hours per year (a business user) and the LLCC occurs at 5.1 W/W. The results underscore the importance of knowing usage profiles by sector (or region). Such analyses are contingent on the underlying air conditioner production cost as a function of efficiency, which, as previously noted, can sometimes be adapted from techno-economic analysis published for major economies.

Figure 13: Illustration of the sensitivity of air conditioner LCC to the hours of use per year[29]



a) 500 hours use per year

b) 1000 hours use per year

4.2 Manufacturer impact analyses

Manufacturer impact analyses are important where there is local manufacturing. In the least sophisticated instance, there may be assemblers of imported kits, which tend to be more common when significant import duties are applied to finished goods. The other end of the spectrum entails fully integrated manufacturers that make their own designs, conduct assembly and testing (some use external services), and manufacture most key elements (e.g. cabinet, doors, heat exchangers).

Most integrated manufacturers purchase some components, such as compressors, thermostats, fans and controls, from specialized component manufacturers. The complexity of adapting to pending MEPS and labelling is greater for integrated manufacturers than assemblers. The latter can simply request more efficient models from kit suppliers who are typically used to supplying a range of products without needing to retool or make up-front investments, so it requires less time to adjust before the policy is implemented. Highly integrated manufacturers that produce their own designs need to understand what is required to cost-effectively produce suitable products. They need sufficient lead-time to manufacture, test and fine-tune prototypes. A

[29] The figure shows how the LCC and energy efficiency vary for distinct combinations of potential design options – ordinarily manufacturers choose those that give the best energy performance for the cost (i.e. matching the lower boundary of the cloud of points).

simple analysis of which models would be affected by the prospective regulations, and discussion with the manufacturers on the strategies they would need to replace these models, can help clarify the situation and identify a reasonable policy pathway.

Components such as compressors are often more expensive if they are more energy efficient. Refrigerator manufactures may need to invest in new moulds for cabinets and doors.[30] These can be the largest upfront investment and traditionally require a large quantity of product sales before their costs are amortized. The timing of the investments in relation to amortized cost recovery from existing tooling (designing and engineering tools used to manufacture components) is generally the most sensitive issue for manufacturer profitability and competitiveness.

The most cost-effective means of improving refrigerator efficiency is thicker insulation. The cost of foaming materials and agents is modest, but thicker insulation requires larger cabinets and doors for the same interior storage capacity and that requires more steel for the cabinet shell and plastics for the lining. Better heat exchangers require more material – thus the cost of condensers and evaporators increase. Controls and valves may also be more sophisticated and hence more expensive.

More efficient air conditioners have significantly more material in the heat exchangers and compressors (especially if using variable speed drive/inverter units). Air conditioner performance testing is more costly and time consuming than for refrigerators and hence this can be an important incremental cost for new designs during product development. Controls, fans and ancillary components tend to be more costly for higher efficiency designs.

Manufacturer impact analyses need to assess these aspects and determine the sensitivity of profits and how prospective regulations are likely to affect demand for the current range of products and the need to develop new products. Product design and development costs are impacted by components, materials, tooling, labour, and so forth. Differentiate fixed and variable costs. Fixed costs include how existing tooling is amortized and future tooling can be amortized. Identify synergies and optimal strategies. If policy measures are to drive replacement of high global-warming potential (GWP) refrigerants as per the Kigali Amendment to the Montreal Protocol, examine synergistic energy efficiency improvements.

[30] UNEP U4E (2018) Policy Guide Series – Climate-Friendly and Energy-Efficient Refrigerators, Page 18, https://united4efficiency.org/resources/accelerating-global-adoption-energy-efficient-climate-friendly-refrigerators/; and UNEP U4E (2017) U4E Policy Guide Series – Energy-Efficient and Climate-Friendly Air Conditioners, https://united4efficiency.org/resources/accelerating-global-adoption-energy-efficient-air-conditioners/

Case study: Grand Atelier du Nord

In 2001, the Tunisian government began developing MEPS and labelling for refrigerators with support from the Global Environment Facility and international consultants. Manufacturing impact analysis identified nine assemblers whose businesses were enabled because of import duties applied on finished products. One highly integrated manufacturer, Grand Atelier du Nord (GAN), produced their own designs and manufactured everything except for compressors, thermostats and controls. The assemblers had small numbers of employees and added little value to the economy, but GAN had a significant employee base and the Government was keen that the company is not unduly affected by pending regulations.

Their analysis showed that about half of the product range would not comply with the draft MEPS and that other products would need to improve to be well positioned under the label. Using detailed energy simulation and economic optimization tools, it was found that a number of products could be adapted to be more efficient through better components and minor design changes. In one case, a high selling but inefficient chest freezer was improved by four energy classes through such minor changes.

The analysis showed that the most sensitive challenge was replacing the moulds for cabinets with designs allowing thicker insulation. The investment in current moulds was not yet fully amortized. The government introduced the MEPS and labels in phases to allow more of the investment to be recovered before new, more flexible production tooling was needed. The assemblers and GAN continued to thrive after the MEPS and labelling were introduced. However, the assemblers left the market once import duties were lifted. Nearly 20 years later, GAN accounts for 40 per cent of the domestic market and exports its products.

Source: Paul Waide insights from the project, *Assistance Internationale Pour La Mise En Place D'un Programme De Certification Energétique Des Appareils De Refrigeration Domestique En Tunisie*, Agence Nationale pour la Maitresse de l'Energie, Tunisia

4.3 Utility impact analyses

MEPS and labelling impact power utilities due to the reduction in sales of electrical energy and the reduction in peak power demand. Their revenues need to cover the operating costs with surplus for investment in replacement capacity, to meet demand for additional capacity, cover liability costs, and provide shareholders with a return on their investment, if privately owned. The tariffs charged should cover these costs, but because power demand varies as a function of the time of day, day of the week and season, there is usually a significant difference in the cost of supplying power at the moment of peak demand and the cost at minimum (or baseload) demand. Power supplied at peak demand is usually sold at a loss because the capacity to meet peak demand is required, but the peak occurs during a brief period. This loss is usually compensated by selling baseload power at a profit.

When utilities are unable to meet peak demand, brownouts, blackouts or load shedding may occur. The extent to which the costs fall on the utility or end users depends on how the utility is regulated. Some regimes allow failures because power costs are restrained close to cost recovery levels, so that power remains affordable for a larger segment of the population. Some users purchase their own generating capacity – often diesel generators – to maintain a secure supply, but it is usually much more costly than if the utility addressed peak demand. The costs to society from unreliable mains power are immense, given significant loss of productivity and negative health implications due to increased use of diesel generators, food loss and waste as refrigeration is lost, and so forth.

MEPS and energy labels can reduce both peak demand and net electrical energy demand at a fraction of the cost of increasing power supply. For utilities, the impact depends on the variety of circumstances that affect their financial viability and the manner in which MEPS and labelling lower future changes in peak power demand. In economies where power demand is growing, MEPS and labelling tend to ameliorate investments in generation, transmission and distribution capacity, which for many utilities lowers stress on their operational environment and increases the security of their investors. This is especially the case for MEPS and labelling regulations that lower incremental peak power demand, as is generally the case for air conditioner policies.

Utility impact assessments aim to determine the magnitude of the impacts of MEPS and labels on key parameters that affect utility planning, costs and economics. Specifically, the impact of the proposed (ex-ante) or existing (ex-post) regulations will be on:

- Energy demand.
- Power demand (daily, weekly, seasonally and annually).
- Incremental power sector investment needs for generation, transmission and distribution.
- Incremental cost of supply i.e. the long run marginal cost (LRMC) of supply.

These assessments are ordinarily done using scenario analysis methodologies for a no policy base case compared with MEPS and labelling policy cases to determine impacts such as:

- Avoided peak power and energy demand.
- Cost recovery with current and future tariffs – including the impact on avoided subsidies.
- Projected investments, cost recovery and reliability.
- Ability to extend electrification.
- Security of supply.
- Net imports (e.g. for power sector equipment/hardware and fuel).

4.4 Societal impact analyses

The development of MEPS and labels is influenced by anticipated societal impacts:

- Macroeconomic – costs, savings, imports and exports of the product and energy.
- Employment across supply chain sectors – direct and indirect.
- Environmental impacts – GHGs, materials, pollutants to air and water.
- Health and well-being.

Macroeconomic impacts consider the value of energy savings at the societal level, the increase in product costs, the economic impacts on the supply chain (e.g. producers, importers, distributors, retailers), the impacts on net imports (e.g. the net change in imports minus exports for products, components, materials used in manufacture), in energy supplies (either imported/exported electricity or fuels used for electricity generation) and in electricity generation and distribution equipment), the impacts on power reliability and its value, the impacts on taxes, duties and overall fiscal revenues.

Direct employment impacts can be determined in relation to the macroeconomic impacts on the product's supply chain. Employment tends to increase when revenues increase, which is the usual effect of MEPS and labelling, but potentially decline in the energy sector due to lower demand for electricity.[31] If MEPS and labelling are introduced over a period that is sufficient to allow local industry to amortise sunk investments before investing in production of higher efficiency products, overall employment is likely to be at least as high as without the policy. However, if the transition period is too abrupt, there is a risk of production moving out of the country, either through foreign imports to entirely replace this capacity, or manufacturers turning into assemblers. Indirect employment impacts are less certain but can often be much larger due to the employment triggered by consumers spending their energy bill savings on other needs. These indirect impacts increase employment.

Environmental impacts arise from the indirect GHG emissions due to energy use (particularly from fossil fuel generation) and potentially also the avoidance of direct GHG emissions due to lower GWP refrigerants. Other environmental impacts are associated with the material use of the products, which can increase in more energy efficient products, and the production process.

Health impacts are seldom assessed, in part because of uncertainties about the values to apply. When assessed, impacts may be high depending on the nature of avoided electricity generation. The EU's Smart Readiness Indicator project (see Case study: EU Impact Assessments) has tentatively projected health impacts from the adoption of energy saving technologies. It shows the median value of the projected health benefits to be of a similar order of magnitude to the value of energy savings[32] based on a meta-analysis of the value of health and the impact of pollutants on mortality and morbidity.

[31] This is not necessarily the case in countries with frequent power outages, as the reduced demand triggered by MEPS and labelling will simply tend to improve the reliability of supply, and not directly diminish investment or employment in the production, transmission and distribution of power.

[32] EU (2020) *3rd Interim Report of the 2nd Technical Support Study on The Smart Readiness Indicator For Buildings*, https://smartreadinessindicator.eu/sites/smartreadinessindicator.eu/files/sri2-_third_interim_report.pdf, Page 256 onward.

Case study: EU Impact Assessments

The EU conducts ex-ante impact assessments for all prospective energy labelling and Ecodesign (MEPS plus other environmental criteria) regulations in two stages. First, a preparatory study examines prospective policy measures with long-range energy, economic and environmental impact scenarios. If policy measures are considered for adoption, a formal and independent ex-ante impact assessment is conducted.

Periodic ex post impact assessments are conducted. The most recent in 2016 (EIA 2016) determined:

- In 2010, covered products accounted for 38,700 PJ of annual energy consumption.
- 925 mtoe of direct and indirect primary energy consumption (53 per cent of total of the EU total).
- EU-28 gross energy consumption in 2010 (1759 mtoe). For these products the following main results were obtained for the EU-28 in 2020 (Ecodesign scenario versus BAU):
  - Close to 6900 PJ (165 mtoe, 1918 TWh) primary energy savings (18 per cent for the average product). Of this, 4320 PJ (103 mtoe, 1200 TWh) is primary energy saving due to saving 480 TWh (41 mtoe) of electricity, and 2580 PJ (62 mtoe, 719 TWh) is direct fuel savings. The sum of electricity saving and direct fuel saving (‘final’ energy saving) is 1199 TWh (103 mtoe),
  - 319 Mt CO_2 equivalent less GHG emissions (7 per cent of 2010 EU-total),
  - 336 million m³ drinking water and 0.4 Mt printer paper, which avoid 144 Kt SO_{2e} equivalent direct NOx-emissions, 141 Kt direct CO-emissions, 10 Kt direct OGC (organic gaseous carbon)-emissions and 9 Kt direct particulate matter-emissions,
  - EUR €112 billion consumer savings (EUR €174 billion gross saving minus EUR €62 billion in acquisitions),
  - EUR € 57 billion extra revenue for industry, wholesale, retail and installation sector,
  - 0.8 million extra direct jobs for industry, wholesale, retail and installation sector,
  - Nearly 52 per cent of the 2020 savings comes from the residential sector, 31 per cent from the tertiary sector, 14 per cent from the industry sector and 3 per cent from other sectors.

For 2030, the results are anticipated to increase by over 60 per cent, and consumer savings to triple (partly due to rising energy prices). For the period 2030-2050, without new measures, the pace of improvements is anticipated to slow and eventually even out.

The 2020 savings represent approximately 9 per cent of the current total EU energy consumption (1759 mtoe in 2010) and 7 per cent of total carbon emissions (5054 $MtCO_2$ equivalent in 2010). In 2030, this is projected to grow to 15 per cent of EU energy consumption and 11 per cent of carbon emission totals. Consumers’ monetary saving is close to 1 per cent in 2020 and 2.6 per cent in 2030 of the current GDP of the EU (EUR €12,790 billion in 2010).

Source: EU (2016) Ecodesign Impacts Accounting, Overview Report
https://ec.europa.eu/energy/sites/ener/files/documents/eia_ii_-_overview_report_2016_rev20170314.pdf
Units: mtoe – mega tonnes of oil equivalent, Mt – mega tonnes (10^9 kg), Kt – kilo-ton (1 million kg), SO_{2e} – sulphur dioxide equivalent

5. Conclusions

Robust market and impact assessments are essential for effective MEPS and labelling design and implementation. The scope and quality of analyses are critical to achieving desired outcomes. Place these activities at the heart of programmes with sufficient funding, capacity and support across key agencies. Impacts should be assessed ex-ante to support proposed regulation and in periodic ex-post reviews to determine whether desired impacts have been achieved to make the case for regular MEPS and labelling enhancements. Refer to the tools and approaches featured in the annex as illustrative examples to facilitate assessments in your market.

Annex 1 – Data Collection

This Annex details the types of data to collect for market assessments based on the product under review[33] and the analysis to be undertaken. It is not a complete list of data to collect but provides a guide to the types of data that are useful, showing why and how they might be used and options for collection.

The data collection tables in the following section list examples of data to collect for the main analyses and suggest potential data sources. Data collection should be planned for the whole assessment at the outset before collection starts.

- The tables are split into Tasks and Outputs for which the data are needed. This is for presentation purposes, but these are interconnected.
- Description and Sources columns support data collection strategy development but are not meant as exhaustive lists.
- The 'data required' for each analysis columns are designed to indicate the key data used in each analysis type, but again are not exhaustive.

Use robust methods for data collection, cleaning, consolidation and processing. At the outset, identify sources and prioritise collection based on the type of analyses, the amount and quality of data available, and the resources and time available for collection (see Section 3.2.3).

A1.1 Data collection guide for a country overview

Sources key:
Glob Res : Global resources: World Bank, UN, IEA, EIA, COMTRADE etc.
Mark Rev: Published market reviews in e.g. US, EU and Japan
Loc Data: Local data: Ministries of Economy, Industry, Customs (COMTRADE) etc.
Prod Reg: Product Registration Databases
Commercial: Commercial resources: Economic data providers, product data providers (e.g. GfK, Euromonitor, BSRIA, NPD and IHS)

Country overview		Description	Sources	Market Overview	Techno-economic Savings Potential	Impact Assessment: Consumer	Impact Assessment: Manufacturer	Impact Assessment: Utility	Impact Assessment: Societal
				Data required for output?					
Qualitative review		Description of relevant political, economic and energy sector characteristics of the country.	Lit Review/Web /Interview/Loc Data	√					
Economic indicators		Population, household size, Number of households, GDP, GDP per capita, urbanisation rate (%)	Loc Data/Glob Res /Commercial	√					√
Energy sector indicators	Electricity usage overview	e.g.: Electrification rate (%), CO_2 emissions factor (kg/kWh), average household electricity use (kWh/y), commercial sector electricity use (kWh/y by type of business), total electricity use by sector, trends in consumption & electrification rates.	Loc Data/Glob Res /Lit Review /Web	√	√			√	√
Energy sector indicators	Costs of electricity	e.g.: Electricity tariffs (residential, commercial, industrial), electricity subsidies, information on capacity planning and the value of the marginal cost of new capacity compared to the marginal cost of capacity avoidance through efficiency.	Loc Data/Survey/Interview /Lit Review	√	√	√		√	√
Energy sector indicators	Grid characteristics	e.g.: Transmission and distribution loss factor (%), brown-outs/black-outs, load shedding and reliability, cost of unreliability, peak power information including peak loads, time of use costs and peak power costs, local and import electricity production share, projected future supply-side capacity.	Loc Data/Glob Res /Lit Review /Web /Survey/Interview	√				√	√

[33] It does not address higher-level economy-wide assessment of potential savings from all products to prioritise policy interventions before these deeper assessments take place.

A1.2 Data collection guide for room air conditioners

A1.2.1 Product review

Sources key:
Glob Res : Global resources: World Bank, UN, IEA, EIA, COMTRADE etc.
Mark Rev: Published market reviews in e.g. US, EU and Japan
Loc Data: Local data: Ministries of Economy, Industry, Customs (COMTRADE) etc.
Prod Reg: Product Registration Databases
Commercial: Commercial resources: Economic data providers, product data providers (GfK, Euromonitor)

Product review		Description	Sources	Market overview	Techno-economic Savings Potential	Impact Assessment: Consumer	Impact Assessment: Manufacturer	Impact Assessment: Utility	Impact Assessment: Societal
				Data required for output?					
Technology overview		Description of the technology options in the market with details on the energy and functional differences of each. Typical product lifetimes and repair cycles.	Lit Review /Web /Interview /Survey/Mark Rev	√	√	√	√	√	√
Product efficiency overview		Overview, mostly from literature, of how product efficiency varies with sub-categorisation and functionality.	Lit Review /Web /Mark Rev		√	√	√		√
Sales analysis by volume and value including:	Technology	Relevant categorisation (e.g. HS code) or by technology type, e.g.: ductless split, self-contained, or portable and/or sub-type e.g.: single-split, multi-split, window, wall, single-duct, double-duct, cassette etc. Reverse cycle, or cooling-only type.	Prod Reg/Web /Survey/On Site/Interview /Commercial	√	√	√	√	√	√
	Primary characteristics	Rated cooling (and heating, if applicable) capacity in kW.* Rated maximum power consumption in kW. Rated performance grade under the local energy label. Rated energy efficiency in [SEER, CSPF, APF, EER, or COP]. Mass of refrigerant used. Refrigerant designation in accordance with [ISO 817 or ASHRAE 34], including ODP and GWP.	Prod Reg/Web /Survey/On Site/Interview /Commercial	√	√	√	√	√	√
	Secondary characteristics (supporting info)	Whether the product is water cooled or air cooled. Number of indoor units. Standby power (W). Number and type of compressor (variable speed / multi-speed compressor/ fixed speed). Climate class of cold test. Cooling test method identifier.	Prod Reg/Web /Survey/On Site/Interview /Commercial		√	√	√	√	√
	Additional reverse cycle characteristics	Heating COP (HSPF in Japan). Seasonal COP. Heating capacity (kW). Effective power input in heating mode (kW). Seasonal heating COP (W/W). With supporting info: - climate class of heating test - heating test method identifier - if different.	Prod Reg/Web /Survey/On Site/Interview /Commercial		√	√	√	√	√
	Price	How price varies with product type, efficiency, capacity and other primary characteristics, brand and sales channel.	Prod Reg/Web /Survey/On Site/Interview /Commercial		√	√	√		√
	Sector	Residential, commercial, industrial, public etc.	Interview /Survey/Loc Data/Commercial/Web /Lit Review	√	√			√	√

Notes: * Or in BTU/h or RT, as appropriate for the market

A1.2.2 Supply chain review

Sources key:
Glob Res : Global resources: World Bank, UN, IEA, EIA, COMTRADE etc.
Mark Rev: Published market reviews in e.g. US, EU and Japan
Loc Data: Local data: Ministries of Economy, Industry, Customs (COMTRADE) etc.
Prod Reg: Product Registration Databases
Commercial: Commercial resources: Economic data providers, product data providers (GfK, Euromonitor)

				Market Overview	Techno-economic Savings Potential	Impact Assessment			
						Consumer	Manufacturer	Utility	Societal
Supply chain review		**Description**	**Sources**	**Data required for output?**					
Supply chain description		By which routes does the product reach the end user? What share is import/local assembly/local manufacture? What share is new/second-hand and formal/informal?	Interview /Web /Survey/Commercial	√			√		√
Supply chain cost/price breakdown		Data on the costs, mark-ups, taxes and duties applicable within each stage of the supply chain to estimate price at each stage of the different routes to market.	Interview /Survey/Loc Data/Lit Review /Glob Res		√	√	√		√
Manufacturing costs breakdown		How do local manufacturing costs split between fixed and variable costs including in product design and development costs, component costs, material costs, tooling costs, labour costs.	Interview /Survey/Mark Rev/On Site				√		
Market share analysis	Overview and split by:	Companies in the supply chain including business to consumer (B2C) retail differentiated by type of retailer, distributors for business to business (B2B) sales, or distance sales via the internet, e.g.: - lists of brands and manufacturers including market shares - lists of importers and distributors including market shares - lists of retailers including market shares and including online sales - sales channel market shares ideally as a function of product sub-type.	Prod Reg/Interview /Survey/On Site/Commercial /Loc Data/Web	√			√		
Market share analysis	Technology	Split using relevant categorisation (e.g. HS[1]) or if not by technology type, e.g.: ductless split, self-contained, or portable and/or sub-type e.g.: single-split, multi-split, window, wall, single-duct, double-duct, cassette etc. Reverse cycle, or cooling-only type.	Prod Reg/Web /Survey/Interview /On Site/Commercial /Loc Data	√	√	√	√	√	√
Market share analysis	Sector	Residential, commercial, industrial, public etc.	Interview /Survey/Commercial	√	√		√	√	√
Attitudes survey		Supply chain views on technology options, barriers to uptake, opportunities and risks of regulation.	Interview /Survey				√		√

Notes: The Harmonized Commodity Description and Coding System (HS) is an international nomenclature for the classification of products. It allows participating countries to classify traded goods on a common basis for customs purposes. At the international level, the HS is a six-digit code system[34].

[34] World Customs Organization website, http://www.wcoomd.org/home_wco_topics_hsoverviewboxes.htm. Accessed on 31 August 2020.

A1.2.3 Usage review

Sources key:
Glob Res : Global resources: World Bank, UN, IEA, EIA, COMTRADE etc.
Mark Rev: Published market reviews in e.g. US, EU and Japan
Loc Data: Local data: Ministries of Economy, Industry, Customs (COMTRADE) etc.
Prod Reg: Product Registration Databases
Commercial: Commercial resources: Economic data providers, product data providers (GfK, Euromonitor)

				Market Overview	Techno-economic Savings Potential	Impact Assessment			
						Consumer	Manufacturer	Utility	Societal
Usage review		**Description**	**Sources**	**Data required for output?**					
Ownership survey		Residential: separated by technology, rural/urban, demographic group, connected to grid. Commercial, industrial, public: separated by technology, sub-sector.	Survey/Interview /On Site/Loc Data	√				√	√
Attitudes survey		User views on technology options, barriers to uptake, opportunities and risks of regulation.	Survey/Interview /On Site		√	√	√		√
Usage review	General usage patterns	Hours of use as a function of the time of day, day of week, and season by each sector and subgroups.	Survey/Interview /On Site/Loc Data/Mark Rev/Lit Review		√	√		√	√
Usage review	Specific usage patterns	Proportion of time products operate at full capacity or various part-load. Typical operating environmental conditions, i.e.: - indoor and outdoor temperatures - typical indoor thermostatic set-points. (All as a function of time of day, week, season).	Survey/Interview /On Site/Loc Data/Mark Rev/Lit Review		√	√		√	√
Usage review	Heating usage	Similar information for the heating mode and humidity when dehumidification is an important part of the air conditioning service.	Survey/Interview /On Site/Loc Data/Mark Rev/Lit Review		√	√		√	√
Purchasing practices		Details of purchasing habits and reasons behind them, how products are bought e.g. by cash or card upfront, by hire purchase [1] or other credit arrangements and how this varies as a function of the sales channel.	Web /Survey/Interview /On Site/Commercial		√	√	√		

Notes: A system by which one pays for a product in regular instalments while having the use of it.

A1.3 Data collection guide for refrigerating appliances

A1.3.1 Product review

Sources key:
Glob Res : Global resources: World Bank, UN, IEA, EIA, COMTRADE etc.
Mark Rev: Published market reviews in e.g. US, EU and Japan
Loc Data: Local data: Ministries of Economy, Industry, Customs (COMTRADE) etc.
Prod Reg: Product Registration Databases
Commercial: Commercial resources: Economic data providers, product data providers (GfK, Euromonitor)

Product review		Description	Sources	Data required for output?					
				Market Overview	Techno-economic Savings Potential	Impact Assessment			
						Consumer	Manufacturer	Utility	Societal
Technology overview		Description of the technology options in the market with details on the energy and functional differences of each. Typical product lifetimes and repair cycles.	Lit Review /Web /Interview /Survey/Mark Rev	√	√	√	√	√	√
Product efficiency overview		Overview, mostly from literature, of how product efficiency varies with sub-categorisation and functionality.	Lit Review /Web /Mark Rev		√	√	√		√
Sales analysis by volume and value including:	Price	How price varies with product type, efficiency, capacity and other primary characteristics, brand and sales channel.	Prod Reg/Web /Survey/On Site/Interview /Commercial		√	√	√		√
	Sector	Residential, commercial, industrial, public etc.	Interview /Survey/Loc Data/Commercial/ Web /Lit Review	√	√			√	√
	Technology	Relevant categorisation by technology type, e.g., refrigerator only, refrigerator-freezer, or freezer, and sub-groups within these.	Prod Reg/Web /Survey/On Site/Interview /Commercial	√	√	√	√	√	√
	Primary characteristics	Volume of the different compartments and an indication of whether they are frost-free. Rated performance grade under the local energy label. Yearly energy consumption in kWh at reference ambient temperature in °C or °F used in performance rating. Refrigerant and foam-blowing designation in accordance with ISO 817 or ASHRAE 34, including ODP and GWP.	Prod Reg/Web /Survey/On Site/Interview /Commercial	√	√	√	√	√	√
	Secondary characteristics (supporting info)	Whether the product is free-standing or built-in (usually indicated). Number of external doors. Whether the product has a through-the-door icemaker, or drinks dispenser. Whether the product has a chiller compartment or not. The climate class (SN, N, ST, T - not always indicated). The star rating of the frozen food compartments (not always indicated). The freezing capacity from ambient (in kg, sometimes indicated). Maximum power demand (sometimes indicated). Number and type of compressors (sometimes indicated). Dimensions (width, depth, height in mm). Absorption type (yes/no) – this is only needed for data sets where Absorption types may be mixed with vapour compression types. Any other information needed to calculate the energy efficiency index according to the local regulation.	Prod Reg/Web /Survey/On Site/Interview /Commercial		√	√	√	√	√

A1.3.2 Supply chain review

Sources key:
Glob Res : Global resources: World Bank, UN, IEA, EIA, COMTRADE etc.
Mark Rev: Published market reviews in e.g. US, EU and Japan
Loc Data: Local data: Ministries of Economy, Industry, Customs (COMTRADE) etc.
Prod Reg: Product Registration Databases
Commercial: Commercial resources: Economic data providers, product data providers (GfK, Euromonitor)

Supply chain review	Description	Sources	Market Overview	Techno-economic Savings Potential	Impact Assessment: Consumer	Impact Assessment: Manufacturer	Impact Assessment: Utility	Impact Assessment: Societal
			Data required for output?					
Supply chain description	By which routes does the product reach the end user? What share is Import/local assembly/local manufacture? What share is new/second-hand and formal/informal?	Interview/Web/Survey/Commercial	√			√		√
Supply chain cost/price breakdown	Data on the costs, mark-ups, taxes and duties applicable within each stage of the supply chain to estimate price at each stage of the different routes to market.	Interview/Survey/Loc Data/Lit Review/Glob Res		√	√	√		√
Manufacturing costs breakdown	How do local manufacturing costs split between fixed and variable costs, including in product design and development costs, component costs, material costs, tooling costs, labour costs.	Interview /Survey/Mark Rev/On Site				√		
Attitudes survey	Supply chain views on technology options, barriers to uptake, opportunities and risks of regulation.	Interview/Survey				√		√
Market share analysis — Overview and split by:	Companies in the supply chain including business to consumer (B2C) retail differentiated by type of retailer, distributors for business to business (B2B) sales, or distance sales via the internet, e.g.: - lists of brands and manufacturers including market shares - lists of importers and distributors including market shares - lists of retailers including market shares and including online sales - sales channel market shares ideally as a function of product sub-type.	Prod Reg/Interview /Survey/On Site/Commercial/Loc Data/Web	√			√		
Market share analysis — Technology	Split using relevant categorisation (e.g. HS [1]), if not by technology type, e.g., refrigerator only, refrigerator-freezer, or freezer. Large appliances used for refrigeration in the commercial and industrial sector.	Prod Reg/Web /Survey/Interview /On Site/Commercial/Loc Data	√	√	√	√	√	√
Market share analysis — Sector	Residential, commercial, industrial, public etc.	Interview /Survey/Commercial	√	√		√	√	√

A1.3.3 Usage review

Sources key:
Glob Res : Global resources: World Bank, UN, IEA, EIA, COMTRADE etc.
Mark Rev: Published market reviews in e.g. US, EU and Japan
Loc Data: Local data: Ministries of Economy, Industry, Customs (COMTRADE) etc.
Prod Reg: Product Registration Databases
Commercial: Commercial resources: Economic data providers, product data providers (GfK, Euromonitor)

			Market Overview	Techno-economic Savings Potential	Impact Assessment			
					Consumer	Manufacturer	Utility	Societal
Usage review	**Description**	**Sources**	**Data required for output?**					
Ownership survey	Residential: separated by technology, rural/urban, demographic group, connected to grid. Commercial, industrial, public: separated by technology, sub-sector.	Survey/Interview /On Site/Loc Data	√				√	√
Usage review	Hours of use as a function of the time of day, day of week, and season, seasonal kitchen temperatures.	Survey/Interview /On Site/Loc Data/Mark Rev/Lit Review		√	√		√	√
Purchasing practices	Details of purchasing habits and reasons behind them, how products are bought e.g. by cash or card upfront, by hire purchase [1] or other credit arrangements and how this varies as a function of the sales channel.	Web /Survey/Interview /On Site/Commercial		√	√	√		
Attitudes survey	User views on technology options, barriers to uptake, opportunities and risks of regulation.	Survey/Interview /On Site		√	√	√		√

A1.4 Data collection approaches

This section gives guidance on collecting data from specific types of source and provides case study examples.

International product registration databases

Many countries require that products sold in the market be registered in a PRS to capture key data. U4E offers guidance on how to develop a PRS (See Section 3.2.3). If a local PRS is not available, data drawn from international databases can still be informative for the design of local programmes.

A variety of PRSs in used by Australia, China, Europe, India, the United States, and beyond (see Annex 1.5 for links). Some can be downloaded and used instantly, but this needs to be done with caution to ensure that it is comparable to local data. Differences in reported technical information arise for instance when different test procedures are used. In some PRSs, only a limited subset of the data may be available or there may not be an option to download it. It may be necessary to request access through the database administrator.

Customs databases

Customs data can be gathered via COMTRADE and UNCTAD or from national customs data sources. This section uses the COMTRADE database (see Annex 1.5), which has data on the imports and exports of products, as an example (see Section 3.2.3) Gathering the longest time series possible is important to see past, and anticipate future, market trends. However, the data is only as reliable as the customs authorities' process. Also, there may be a sizeable informal market that is not accounted for in customs data.

Customs data is only distinguished by the classifications used in harmonized customs codes. These codes are internationally harmonized at the 6-digit level, and often have a strong degree of harmonization at a deeper 8-digit level.

At the six-digit level, the following distinctions are made for refrigerators and air conditioners:

- HS 8418: Refrigerators, freezers and other refrigerating or freezing equipment.
    - 841810: Combined refrigerator-freezers, fitted with separate external doors.
    - 841820: Refrigerators, household type.
    - 841830: Freezers of the chest type, not exceeding 800 litres capacity.
    - 841840: Freezers of the upright type, not exceeding 900L capacity.
    - 841850: Other furniture (chests, cabinets, display counters, showcases) for storage and display, incorporating refrigerating or freezing equipment.
    - 841899: Parts.

Refrigerators and freezers imported or exported as whole units will be in the first four of these codes. If imported as kits, they can be under code 841899. The code 841850 addresses other types of (non-domestic) refrigerators or freezers such as commercial display cabinets etc.

The 6-digit code (841510) captures all room air conditioner types, but further distinction can be made at the 8- and 10-digit level, as shown in the case study of the United Kingdom (UK) below.

Economies with richer data at the 8- or 10-digit level includes additional distinctions, such as whether products operate on AC main electricity supply or DC off-grid, use of the vapour-compression cycle (the main focus of most MEPS and labelling) or absorption refrigeration (some hotel minibars, camper van refrigerators, etc.), portable or fixed air conditioners, and so forth. This data can be sought from trade and commerce ministries.

Such data will not capture energy performance or the price of individual products. However, it can provide an estimate of the average import price of finished products, from which comparison with other data on the average final price of products will indicate how much additional costs and mark-ups are due to the distribution and retail of products.

Case study: Harmonized Code Classifications Applied by UK Customs for Air Conditioners

HS 8415: Air-conditioning machines, comprising a motor-driven fan and elements for changing the temperature and humidity, including those machines in which the humidity cannot be separately regulated:

HS 841510: Of a kind designed to be fixed to a window, wall, ceiling or floor, self-contained or "split-system":

- 84151010: Self-contained:
    - 8415101010: Pre-charged with hydroflurocarbons (HFCs) or hydrocarbons (HC)
    - 8415101090: Other
- 84151090: Split-system:
    - 8415109010: Pre-charged with HFCs or HC
    - 8415109090: Other

HS 841520: Of a kind used for persons, in motor vehicles
HS 841590: Parts

All relevant air conditioners will be found under code 841510; as the first six-digits are harmonized across all economies this will be true for all. However, parts are under 841590. Air conditioner kit-assembly is not as common as refrigerator kit assembly so this may be less important than the equivalent code for refrigerators, however, it can help to inform thinking on the product repair market. The 8-digit detail employed in the UK system allows the market to be differentiated into split and self-contained types which is helpful for MEPS and labelling development, not least because these are likely to be subject to distinct efficiency requirements. The UK classification at the 10 digit-level allows products to be partly distinguished by their choice of refrigerant.

Internet product data

Gathering data via the internet is normally done manually,[35] which is time consuming and should be targeted. Critical data for calculating a products' energy efficiency are indicated in bold below.

For refrigerating appliances, minimum information should include:

- Model name / serial number.
- **Type of unit (refrigerator, refrigerator-freezer, or freezer).**
- Country where the product was manufactured.
- **Volume of different compartments and an indication if they are frost-free.**
- Rated performance grade under the local energy label.
- **Yearly energy consumption in kWh at ambient temperature in °C or °F.**
- *Reference ambient temperature(s) used in performance rating (unlikely to be listed but it will be declared in the test procedure).*
- Refrigerant and foam-blowing designation per ISO 817 or ASHRAE 34.
- Including ODP and GWP and gas quantity.

It may also include:

- Product brand
- **Whether the product is free-standing or built in.**
- Number of external doors.
- **Whether the product has a through-the-door icemaker, or water dispenser.**
- **Whether the product has a chiller compartment.**
- Climate class (SN, N, ST, T - sometimes indicated).
- **Star rating of the frozen food compartments (sometimes indicated).**
- Freezing capacity from ambient (in kg, sometimes indicated).
- Price (indicated on retailer sites but not always on manufacturer sites).
- Maximum power demand (sometimes indicated).
- Number and type of compressors (sometimes indicated).
- Warranty information (sometimes indicated).
- Dimensions (width, depth, height in mm).
- **Absorption type (yes/no).**
- Any other available information needed to calculate the energy efficiency according to the local regulation.

[35] There are alternative approaches that use "web crawling" or "screen scraping" technologies to automate the collection of data from the internet, see the IEA website (https://www.iea.org/articles/case-study-crawling-for-market-surveillance-and-policy-development) for an example. These approaches become more economic with scale and so are worth considering for larger data collection exercises.

For air conditioners, the minimum information should include:

- Model name/serial number.
- **Type of unit (ductless split, self-contained, or portable).**
- Country where the product was manufactured.
- **Rated cooling (capacity in kW).**
- Rated maximum power consumption in kW.
- Rated performance grade under the local energy label.
- **Rated energy efficiency in (CSPF, APF, SEER, EER depending on the metrics used and reported).**
- Refrigerant designation per ISO 817 or ASHRAE 34, including ODP and GWP and gas quantity.

It may also include:

Product brand:

- **Product sub-type (single-split, multi-split, window, wall, single-duct, double-duct, cassette, etc.).**
- **Yearly electricity consumption in kWh (if a standard reporting method exists).**
- Reverse cycle, or cooling-only type (sometimes indicated).
- Whether the product is water cooled or air cooled.
- Number of indoor units (sometimes indicated).
- Standby power (W) (sometimes indicated).
- Number and type of compressor (variable speed / multi-speed compressor/ fixed speed) (often indicated).
- Price (indicated on retailer sites but not always on manufacturer sites).
- Climate class of cold test (sometimes indicated).
- Cooling test method identifier (sometimes indicated).
- Any other available information needed to calculate the energy efficiency according to the local regulation.

For reversible units offering heating and cooling:

- **Rated heating energy efficiency (HSPF, SCOP, APF, COP depending on the metric).**
- **Rated heating capacity (kW) (sometimes indicated).**
- Effective power input in heating mode (kW) (sometimes indicated).
- Climate class of heating test (sometimes indicated).
- Heating test method identifier - if different (sometimes indicated).
- Warranty information (sometimes indicated).

Surveys and interviews

Primary data collection is often necessary to address data gaps. It is pursued through:

- Written surveys of different stakeholders (e.g. manufacturers, retailers, online retailers, importers, trade associations, policymakers, market and sector experts, end-users from households and businesses).
- Detailed interviews of stakeholders in person or by phone.
- Site surveys – visit industrial, retail, commercial, public, and domestic locations.

Each survey or interview requires a structured survey instrument, such as:

- A questionnaire that respondents complete and return.
- An interviewer who questions the interviewee and completes the survey with the responses.
- Internet surveys of product technical and price data in which the analyst enters the information gathered online into the survey instrument.
- Site surveys at retailer premises in which the analyst enters product technical and price data gathered by inspecting products available for sale into the survey instrument.

Whichever mix of methods is used, the survey instrument and the survey should consider:

- Likelihood of data availability (avoid asking for data that no one has).
- Likely willingness to respond (avoid asking for data that requires a lot of effort from the respondent unless they are particularly interested).
- Sensitivity of the data (data not in the public domain and/or with commercial value may be difficult to obtain – sometimes requiring a non-disclosure agreement for actors to supply it and allow some non-public processing to inform policy design).

One of the biggest risks is that data will not be provided because it is unknown, or market actors are unwilling to disclose it. Every effort should be made to only ask for what is known and make it as easy and risk free as possible for respondents to provide. To provide some indication of the approach, an example of a survey addressing different questions for a number of products and in different sectors is shown in the following section.

Questionnaire for Suppliers (HVAC Companies, Retailers)

Responses to this questionnaire are of critical importance to properly understand the market for refrigerators and air-conditioners in the country. The results will be used by UN Environment to help inform recommendations on policies and programs to increase adoption of energy-efficient products. UN Environment will treat questionnaire responses as business-sensitive information. The findings will be aggregated across the pool of organizations that participate to avoid attribution to any particular entity.

Company name	Location	Point of contact	Title	Email	Phone

Part A: Air-conditioners

(1) Product characteristics and sales of the most common/popular products

Type of Air Conditioner (split, unitary (window/wall), single duct, double-duct, other)	Brand and Model /Series	Cooling Capacity (Btu/hr or kW)	Energy Efficiency Metric (EER, SEER, COP, SCOP, APF, CSPF etc.)	Energy Efficiency Value (EER, SEER, COP, SCOP, APF, CSPF etc.) W/W	Compressor Type	Heat Pump Mode (y/n)	Refrigerant Gas (R-xxx)	Energy Label Type, if any (e.g. China, Energy Star)	Energy Label Class, if any e.g. A-G or 1-5 etc.	Country of Origin	Quantity of Units Sold Annually	Sales Price per Unit (US$)

Note: add rows as needed to cover all commonly sold products

(2) Profile of your clients (if known):

Client Type	Annual quantity sold to replace existing equipment	Annual quantity sold as first-time installations	Typical quantity sold to an average client for their project	Expected demand growth over next 3 years. Rank: from 1 = lowest to 9 = highest opportunity
Hotel				
Restaurant/Food Service				
School/Education				
Hospital/Healthcare				
Retail				
Office				
Manufacturing/Industrial				
Residential (homes, apartments, condos)				
Other (please indicate)				

(3) Overall sales and market share

Type of Air Conditioner	Current Annual Sales Total (US$)	Current Share of the National Market (%)	Expected Sales in 2020 (US$)	Expected Share of the National Market in 2020 (%)
Unitary (Window/Wall-type AC)				
Mini-split (wall-mounted, floor-standing or cassette)				
Multi-split system				
Single-duct				
Double-duct				
Other (please specify)				

(4) Factors that impact your ability to sell more energy-efficient products to clients

Factor	Explanation of what occurs and recommended solutions to address the challenges
Lack of trust that the product will achieve energy performance / payback claims	
Lack of awareness of energy performance	
Upfront cost and financing constraints	
Concerns about product quality/reliability	
Focus on purchase price instead of total ownership cost	
Power quality (impact of voltage fluctuations on VFD)	
Subsidised electricity tariff	
Taxes, duties, or incentives	
Policies or regulations	
Other (please describe)	

(5) Ways that you might want to be involved in the air-conditioners aspect of this project

Participation opportunities	Explanation of how you could potentially contribute to any of these that are of interest
Provide feedback on draft policy documents	
Help raise awareness among consumers/public	
Assist with training for technicians, sales reps, or officials	
Participate in recycling/waste management programs	
Participate in trials/demonstrations	
Pilot new financial mechanisms	
Other (please describe)	

Part B: Refrigeration

(6) Product Characteristics and Sales of the Most Common/Popular Products

Type of Refrig-erator (1 - 10);	Brand and Model /Series	Total Net Storage Volume (litres)	Energy Consump-tion (kWh/ year)	Refriger-ant Gas (R-xxx)	Energy Label Type, if any (China, EU)	Energy Label Class, if any e.g. A-G or 1-5	Country of Origin	Quantity of Units Sold Annually	Sales Price per Unit (US$)	Net storage volume of			Frost Free (Yes/ No)	Free-stand-ing or Built-in	Climate Class (SN, N, ST, T)
										Fresh Food Compart-ment (litres)	Frozen Food Compart-ment (litres)	Chiller Compart-ment (litres)			

1 = Refrigerator with one or more fresh-food storage compartments;
2 = Refrigerator-cellar, cellar and wine storage appliances;
3 = Refrigerator-chiller and refrigerator with a 0-star compartment;
4 = Refrigerator with a 1-star compartment;
5 = Refrigerator with a 2-star compartment;
6 = Refrigerator with a 3-star compartment;
7 = Refrigerator-freezer;
8 = Upright freezer;
9 = Chest freezer;
10 = Multi-use and other refrigerating appliances

Note: Add rows as needed to cover all commonly sold products

(7) Client profile

Factor	Explanation of what occurs and recommended solutions to address the challenges
Lack of trust that the product will achieve energy performance / payback claims	
Lack of awareness of energy performance	
Upfront cost and financing constraints	
Concerns about product quality/reliability	
Focus on purchase price instead of total ownership cost	
Power quality (impact of voltage fluctuations on VFD)	
Subsidised electricity tariff	
Taxes, duties, or incentives	
Policies or regulations	

(8) Factors that impact your ability to sell more energy-efficient products to clients

Factor	Rank	Explanation of what occurs and recommended solutions to address the challenges
High upfront costs		
Lack of trust that the products will achieve energy performance/payback claims		
Lack of awareness on energy savings in the long run		
Concerns about product quality and reliability		
Focus on purchase price instead of total ownership cost		
Power quality (impact of voltage fluctuations on VFD)		
Low electricity tariff		
Lack of suitable financing		
Taxes, duties, or incentives		
Policies or regulations		
Others, please describe		

(9) Ways that you might want to be involved in the refrigerator aspect of this project

Participation opportunities	Explanation of how you could potentially contribute to any of these that are of interest
Provide feedback on draft policy documents	
Help raise awareness among consumers / public	
Assist with training for technicians, sales reps, or officials	
Participate in recycling / waste management programs	
Participate in trials / demonstrations	
Pilot new financial mechanisms	
Other (please describe)	

A1.5 Data sources

Source/Link	Description	Data: R	AC	Ref Other
Global resources				
UNEP U4E	Country Savings Assessments, Policy Guides, Model Regulations, Technical Guides, etc.	√	√	Lighting, motors and distribution transformers.
COMTRADE UNCTADSTAT	Two United Nations trade platforms that provide international trade statistics including customs data.	√	√	All product shipments.
UN Data	Wide ranging macroeconomic data for all countries.			Population, Economy, Price Indices, Energy Production, CO2 emissions
World Bank Open Data	Wide ranging macroeconomic data for all countries.			Population, GDP, energy specific indicators including electricity production and consumption.
IEA: Data and Statistics	Extensive data on historical energy trends.	√	√	Detailed energy supply and demand data and some product data.
World Energy Outlook	Forecasts of future energy trends.			Detailed energy supply and demand data.
IEA 4E	Product efficiency specific data resource including international comparison of product energy consumption over time.	√	√	10 other products including Lighting, motors and distribution transformers.
US EIA open data	Energy indicators and forecasts including electricity production and consumption.			
Topten - EU, China, Chile, Argentina, Brazil	Tools to enhance sales, improve quality and lower barriers for market access for efficient equipment.	√	√	Information in households, offices, buildings, industry, transportation
EBRD Technology Catalogue	Online shopping-style platform to help vendors of green tech connect with businesses and consumers.	√	√	>10 more including lighting
Cool Technologies Database	Info on manufacturers that produce HFC-free cooling products using natural refrigerants and other sustainable cooling technologies.	√	√	
Green Cooling Initiative database	Interactive map on current and forecast data on energy and refrigerant-related GHG emissions in various cooling sub-sectors per country.	√	√	RAC, domestic refrigerators, commercial Refrigeration, mobile AC,
Searchable PRS in other countries (Mexico, South Africa and Sweden (lights) also have iOS and Android efficient product apps):				
Australia and New Zealand Energy Rating product lists	Detailed data[36], Advanced search options, CSV download available.	√	√	>10 more including lighting, distribution transformers and electric motors
Brazil Energy Efficiency/Consumption tables	Detailed data, download as PDF list.	√	√	>10 more including lighting, distribution transformers and electric motors
California Appliance Efficiency Database	Detailed data, Advanced search options, CSV download available.	√	√	>10 more including lighting, distribution transformers and electric motors
Canada Searchable product lists	Detailed data, Advanced search options, CSV download available.	√	√	>10 more including lighting, distribution transformers and electric motors
China Energy Label database	Chinese language search function here .	√	√	>10 more including lighting and electric motors
Taiwan, Province of China Certified products database	Limited data, Advanced search options, no download function.	√	√	>10 more including lighting
European Union Eurovent certification database	Limited products covered with download function.		√	Limited commercial refrigeration data
Hong Kong, China Labelled products database	Detailed data, Advanced search options, no download function.	√	√	6 more including lighting
India Star Label product database	Detailed data, no download function.	√	√	>10 more including lighting, distribution transformers and electric motors
Japan Product database	Detailed data, no download function.	√	√	>10 more including lighting
Korea efficiency rating system	Detailed data, Efficiency class search option, Excel download available.	√	√	>10 more including lighting and electric motors

[36] Limited data means a single energy metric with up to two other primary characteristics (capacity, sub-type etc.). Detailed data includes more energy information and/or product characteristics allowing a deeper analysis.

Source/Link	Description	Data: R	AC	Ref Other
Malaysia Suruhanjaya Tenaga (Energy Commission)	Limited data, Excel download available.	√	√	>10 more including lighting
Philippines Labelled and certified product lists	Limited data, download as PDF list – updated quarterly.	√	√	None
Saudi Arabia Saudi Label & Standard	Limited data, no download function.	√	√	Washing machines and Cars
Singapore Database of Registered Goods	Detailed data, Advanced search options, Excel download available.	√	√	Lighting, electric motors, televisions, Clothes dryers.
Thailand Label No. 5 Products Database	Limited data, no download function.	√	√	>10 more including lighting
US DOE Compliance Certification Database	Detailed data, Advanced search options, Excel download available.	√	√	>10 more including lighting and distribution transformers
US EPA ENERGY STAR Qualified Product Finder	Efficient products only, Detailed data, Advanced search options, CSV download available.	√	√	>10 more including lighting
Germany Blue Angel	Environmental endorsement label to help consumers live, shop, construct, or equip an office.	√		>10 more including lighting
European Commission, European Product Database for Energy Labelling (EPREL)	As of 1 January 2019, suppliers (manufacturers, importers, authorised representatives) need to register appliances, which require an energy label in EPREL, before selling them on the European market.	√	√	>10 more including lighting
Published market reviews				
EU Ecodesign	These highly detailed analyses are undertaken in preparation for the development of regulations. They offer a useful touchstone for data collection and analysis in any market. The approaches vary but they present in-depth analysis across many aspects of the regulation development process.	√	√	>10 more including lighting, distribution transformers, electric motors
Japan Top Runner		√	√	>10 more including lighting, distribution transformers, electric motors
US DoE		√	√	>10 more including lighting, distribution Transformers, electric motors

Other resources	
Other public sources	There are many public organisations and NGOs working in product efficiency and these organisations are a good source of international data, guidance and good practice. • High efficiency product data can be found through a number of websites established to promote efficiency such as ENERGY STAR, SUST-IT and TOPTEN. • Additional analysis and related reports can be found at sources including Appliance Standards Awareness Project, CLASP, Cool Products, ECEEE, GIZ, K-CEP, LBNL, Rocky Mountain Institute, SEAD.
Commercial resources	There are a number of commercial providers of product data and broader market assessments. Because these services are paid, they are mostly available in larger developed economies, but they may provide international comparison data when no other sources are available.

Annex 2 – Data Analysis

This Annex details some of the analysis techniques used for market assessments, off-the-shelf tools and some ideas for presenting the results in a useful manner.

A2.1 Analysis techniques

This section is not a 'how-to' guide but offers good practice examples to improve the outcomes of analysis.

Data validation

As data is likely to come from many sources, quality issues and gaps need to be addressed before analysis is undertaken. Consolidate and compare sources to test consistency and how realistic it seems for the market.

- Check plausibility within a data source: Customs data often includes multiple metrics. Compare whether the product sales align with the total value (estimate typical product price) or the total weight (estimate typical product weight) to see if the data is internally consistent. Often the weight and value are more reliable than the number of units as these are more easily monitored at ports.
- Compare between sources: Test whether sales data from two sources align or check whether sales data compare sensibly with estimates of the installed stock from household surveys, given the lifetime and likely turnover of the product.
- Compare with top-down estimates: Do sales look reasonable given the number of households and resources available to consumers. Review products sold per year per household or develop more sophisticated models to estimate sales and stock from theoretical relationships of ownership rates to macroeconomic data on electricity use, prosperity, electrification rate, etc.
- Consult market experts: Test the results by speaking with trade officials, trade associations and product suppliers who may have been unable or unwilling to supply data to the process initially but are willing to review and comment on estimates of market levels gathered from other sources.

Addressing missing data

After multiple sources have been validated, some necessary data may be unavailable, contradictory or uncertain. If possible, commission primary research to address the gaps. Otherwise:

- Interpolate and extrapolate to estimate between reliable data points in the same dataset. This can be made more robust by using multiple regression analyses to link estimates to other known data.
- Combine existing data with assumptions from other known data to estimate missing values. Consumer prices can be derived from import value data by assuming supply chain mark-ups (or vice versa to derive value through the value chain) once the average product price declared at customs is known.
- Use the top-down approach described above for data validation.
- Use proxy data from other similar markets (see Section 3.2.3). If two countries' markets are served from the same primary ports of entry and have similar socio-economic circumstances, it reasonable that the products offered in both countries are similar. Not all data is directly comparable without first accounting for differences in what is measured and reported. The definition of efficiency and the test method can vary between markets (and for cooling products, by climate zones within the same market).

Data analysis

The type of analysis depends on the assessment. Ex-ante energy savings and economic impact assessments need a product energy consumption stock model to examine how the energy consumed and related parameters vary as a function of the energy efficiency of products sold in the future. Reliable time series data are needed on unit sales and the unit energy consumption (UEC) of products where the latter varies as a function of the efficiency changes induced by MEPS, labels or other interventions.

The UEC is typically derived for the most important sub-categories of the product being treated. Refrigerators can be split into refrigerators, refrigerator-freezers and freezers, with the average annual energy consumption and energy efficiency determined for each sub-category.[37] As refrigerators are usually plugged in all year, it suffices to acquire their rated energy consumption (usually reported per 24-hours on the rating plate) and consider whether to adjust it for the typical temperature the appliances are used in. Data on the energy consumption of individual models makes it possible to calculate these averages. The same is true for the product energy efficiency – a survey of products on the market should allow the efficiency values to be estimated using the techniques described in the U4E Model Regulation Guidelines or local regulations.

Societal impact analysis requires both historical data and future projected data. In the absence of older model data, historical estimates of the UEC and energy efficiency can be estimated assuming the local market follows trends seen in proxy markets or by making a working assumption (e.g. assume the average energy efficiency has been improving at 0.5 per cent or 1.0 per cent per annum) and the average product capacity (e.g. adjusted volume for refrigerators) has also followed a fixed annual change (e.g. +0.3 per cent per annum).

Projecting future trends requires assumptions about what would happen with and without policy measures. The no policy case assumes continuation of the changes applied for the historical time series. The policy case assumes that products that fail to meet the MEPS are replaced by those which just satisfy the requirements. For labelling, assume that when a label is introduced the rate of efficiency improvement across the spectrum of products accelerates compared to the historical average. If the label sets efficiency classes, the impact can be modelled by assuming a certain probability that a current model will be replaced by one in the next higher efficiency class per year and then model the shift in the distribution. Proxy data from other markets with labels in place for some time can be used to estimate these shifts.

A2.2 Analysis case studies

This section describes two of the most common analyses used in a market assessment.

Ex-ante policy design

Gather data on the energy efficiency of products sold on the current market. To determine the expected energy savings from higher efficiency levels, identify the energy consumption of typical products. Determine how changing efficiency of new product sales affects the economic impacts in terms of product price, operating costs and life cycle costs (how prices vary as a function of energy efficiency). There are usually many factors (e.g. brand, features, retail channels, warranty, purchase agreements) that drive price differentials which are difficult to tease out.

[37] More sophisticated analyses would split these into further sub-categories e.g. upright and chest freezers; refrigerators with no frozen food compartment, or with a 1-star, 2-star, or 3-star frozen-food compartment; etc.

Savings potential analysis within the societal impact assessment

In parallel with the ex-ante policy design, savings potential analysis[38] estimates the nationwide savings potential from MEPS over the medium to long term. This can be done via:

- A '***top-down***' approach in which the total energy use of a product is estimated from wider economic indicators (per cent of total sector electricity consumption by the product accounts; complex analysis of how the total product electricity consumption relates to a range of economic and climate indicators based on regression analyses from local and other markets).
- A '***bottom-up***' estimate of the total number of products in use across different sectors of the economy alongside estimates of the energy performance of products in those sectors from which total energy use can be estimated with and without regulation.

Bottom-up Analysis Step 1: Stock and sales projections

Estimate the number of products in use and sales over time. Stock models use real data to make an estimate of current and historical stock and sales volumes and then make projections about how those will change in the future using other assumptions such as economic growth, product replacement patterns, and product saturation levels. A robust stock model will:

- Break the market into sectors to make assumptions on typical product capacity and efficiency, usage patterns and likely growth rates.
- Gather data on sales and stock volumes in each sector over as many years as possible.
- Align this data with relevant known economic indicators[39] to estimate sales and stock levels to several decades before the analysis period.
- Rebuild a full model of the installed stock forward, with replacement sales based on assumed product lifetimes and new sales based on assumptions or how those relate to the selected economic indicators.
- This provides an estimate of current stock and sales levels which can be validated against known data. If there is a discrepancy between how the sales and stock numbers calibrate, assess which data used for validation is more robust. Sales are subject to natural variability while stock models generally predict stable growth. Prioritise stock model alignment unless robust sales data is available over the years.
- Project future stock and sales using the recalibrated model and projections of the economic indicators. Future projections also need to account for market saturation.

Bottom-up Analysis Step 2. Establishing a base case

Within each sector, estimate the typical annual energy consumption of the range of products:

- **Typical product type:** Use a subset of product applications to approximate the variety within the market, making estimates of what proportion of the stock and sales these account for now and into the future. This can sometimes be done from available data if it is rich in detail, but most often consultation with experts or using data from other markets as proxies is necessary. Energy efficiency will differ between the installed stock and sales, but the analysis normally focuses on the latter where data is more available. Estimate how the energy efficiency of sales changes over time (many international studies exist).
- **Typical product usage:** Understanding the hours of use at different times of day, month, and year, and how much of this use is at full- and part-load. Because this will vary by sector and application, it is linked with typical product analysis and the two must be done alongside each other.

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[38] U4E (2020), *Country Savings Assessments*, https://united4efficiency.org/countries/country-assessments/

[39] e.g. For both air conditioners and refrigerators, ownership is generally linked to household income, electrification rate and urbanization rate, while for air conditioners, the local climate is also a significant driver.

Establishing an acceptable level of granularity is complex and will depend on the resources available. There will be diminishing returns if increased granularity is not based on robust evidence. Adopt approaches with transparency about the assumptions taken and direct resources to areas where greatest benefits can be achieved.

Bottom-up Analysis Step 3. Developing scenarios

The savings potential analysis compares total energy consumption for all products in a BAU scenario with one or more scenarios in which policy interventions are introduced. A number of scenarios can be tested to establish how the benefits vary depending on the stringency. It is then necessary to make assumptions:

- How will the energy efficiency of new products change in each scenario? In the U4E Country Savings Assessments, a per cent improvement in efficiency per year is used for refrigerators, while room air conditioners have a mix of improvements with a shift from fixed-speed to variable-speed inverters. The assumptions may be the same in all scenarios or vary in stringency and scope.
- How will product usage patterns change over time and will that differ between the scenarios? An increase in prosperity might mean products are used more, while lower running costs make it more prevalent in the policy scenarios.
- How will the number of products in use vary between scenarios? If regulations are introduced alongside financial incentives, product numbers may increase compared with BAU. Alternatively, if regulations increase purchase prices without financial support for buyers, product numbers may decline.

Establishing the best approach to these issues can be done in consultation with experts in the field or through reference to international sources such as published market reviews in large markets. The analysis needs to estimate how other metrics will change (e.g. GDP per capita, electrification levels, CO_2 emissions from a kWh of electricity, etc.) in the stock model analysis and the conversion of energy savings to other benefits.

Bottom-up Analysis Step 4. Calculating the savings potential

The total energy consumption of all products in a market in each scenario can be calculated as:
Where for all applications in each sector (AS):

$$\sum_{AS} P_{1-n} \times UEC_{1-n}$$

- P_n is the total number of products remaining in use that were sold in Year n
- UEC_n is the typical annual energy consumption of products sold in Year n
- 1−n is all previous years from which products are still in use (from the stock model)

This analysis will give an output as shown in Figure 9. The energy use in each scenario can then be converted into other metrics to demonstrate other benefits (energy, climate, economic, etc.).

A2.3 Tools and resources

It is not always necessary to build bespoke analysis tools. Where data and resources are limited, off-the-shelf tools can give a first order insight into some of the key areas interest.

U4E Country Savings Assessments

U4E Country Savings Assessments are based on stock models and tailored outputs are available for 150 countries.[40] While these models are not available for public use, the U4E team can provide limited support to policymakers to refine the projections based on local expertise and good quality data available from a market assessment on stock and sales levels or local product characteristics. It is also possible to investigate different policy scenarios as part of a wider societal impact analysis process.

PAMS

The Policy Analysis Modelling System (PAMS) tool developed by Lawrence Berkeley National Laboratory (LBNL)[41] is a self-contained spreadsheet model that provides semi-automated cost-benefit analysis for appliance efficiency standards. The tool allows policy analysts to produce a first-cut analysis for their choice of policy parameters and market assumptions. The tool uses a bottom-up approach and technical specifications to calculate the costs and benefits from two distinct but related perspectives:

- The Consumer Perspective examines costs and benefits from the perspective of the individual household or enterprise using an LCC calculation as described in the ex-ante policy design section.
- The National Perspective projects the total national costs and financial, energy and environmental benefits. It includes net present value calculations.

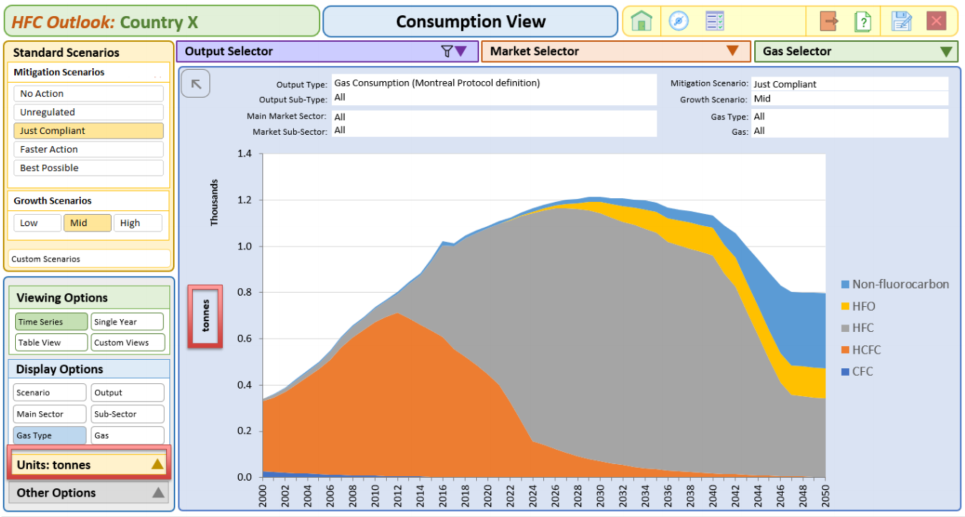
PAMS is designed to operate for a wide variety of countries and any amount of available data. It will produce better results if high quality, locally relevant data is used. The model has built-in default values for 150 countries for room air conditioners, refrigerators, and washing machines. The 2007 iteration of the model is open source and available for general use with a user guide[42]. Alternatively, LBNL has continued to develop the model and will work with policymakers using the most recent version.

HFC Outlook

The HFC Outlook tool was first developed in 2012 to support deliberations on possible fluorinated refrigerant gas regulations in the EU, and it was subsequently expanded to cover Article 5 countries in consideration of the Kigali Amendment to the Montreal Protocol. Policymakers can assess refrigerant transition scenarios for over 40 refrigerant end uses, including but also going well beyond residential refrigerators and air conditioners. The tool is being updated to reflect the latest available data on refrigerants and to include energy modelling features, enabling policymakers to explore a simultaneous transition toward more energy-efficient products with lower GWP refrigerants. It will be possible to compare direct and indirect GHG emissions. Refrigerants models have been built for the EU and for 10 Article 5 countries. By 2021 the updated energy and refrigerants model will be available for a number of countries. These examples are illustrative for others considering the tool to model their markets (see the sample below). HFC Outlook does not have a software licence fee, but each model must be built and customised to a specific country based on data gathered for the country. Each model is confidential to that country, so they are not available online.[43]

[40] U4E (2020), *Country Savings Assessments*, https://united4efficiency.org/countries/country-assessments/
[41] LBNL Policy Analysis Modeling System, accessed on 31 August 2020, https://international.lbl.gov/policy-analysis-modeling-system
[42] LBNL User Instructions for the Policy Analysis Modeling System, accessed on 31 August 2020, https://ses.lbl.gov/publications/user-instructions-policy-analysis
[43] HFC Outlook development briefing conducted in June 2020 by U4E.

Sample output from HFC Outlook tool



GIZ Proklima GHG inventories of the cooling sector

GIZ's cooling projects have comprehensive GHG inventories of the cooling sector[44] in cooperation with country governments. The inventory is based on the IPCC guideline Tier 2 methodology and takes into account input data relevant to estimate current and future energy and refrigerant-related emissions and can be used to calibrate MEPS, energy labels as well as ecolabels for various standardized cooling appliances.

CLASP's Energy Efficiency Policy Model

In early 2021, CLASP will launch a new modelling and data visualization tool for analysing the energy and climate impacts of efficiency policy scenarios. The tool offers a dynamic, user-friendly interface to identify policy opportunities, compare the benefits of implementing policies for different product types, and analyse the energy and carbon reduction impacts of different policy options.

The tool will be available via CLASP's website[45] and is:

- Designed for users ranging from novice to experienced energy efficiency practitioners.
- Pre-loaded with data for most countries and major appliances, with frequent data updates.
- Equipped with a range of data configuration and visualization options, for use online or via download.
- Based on widely accepted methodologies and inputs.
- Free to use online.

[44] Select Inventories and Cooling Strategies option under Publication Type on the Green Cooling Initiative publications page at https://www.green-cooling-initiative.org/news-media/publications
[45] CLASP's website, www.clasp.ngo

Annex 3 – Sample Terms of Reference (ToR)

This Annex sets out an illustrative ToR for a consultant to be hired to gather information and conduct analysis for designing an effective energy labelling and MEPS programme for cooling products. Successful conduct of the activities would provide programme designers with the inputs they need to design an optimised set of regulations. It is possible to make more analytical short-cuts than envisaged in this ToR, but this could be at the risk of sub-optimal energy, emissions and economic impacts. The U4E Model Regulations[46] should be tailored for use based on the local market.

Activities 2 to 4 establish the state of the market prior to the introduction of policies (making it possible to evaluate the impact of the policies after introduction and justify sustained resources for the scheme). Activities 5 and 6 allow the economic optimisation of the MEPS and energy labels (in conjunction with the scenario analysis of Activity 7). The stakeholder workshops of Activity 8 capture stakeholder insights to inform programme design and foster communication about the planned measures.

The following activities could be omitted from the ToR given the associated caveats:

- Activities 4.2 to 4.5 – if regulators are not concerned about knowing supply-chain mark-ups and impacts on actors in the supply-chain.
- Activities 5.1, 5.3 and 5.4 – if it is assumed that international data on product prices is sufficiently representative.
- Activity 6.5 – this information is informative but not vital.
- Activity 7 – can be simplified by using an existing stock model rather than creating one from scratch and considering fewer scenarios (this only save a modest amount of effort).

The most important prospective short-cut is to establish a PRS,[47] as this will systematically provide the information set out in Activities 1 to 3. It takes time and typically a legal mandate to establish a PRS. If the legal mandate comes from the energy labelling or MEPS regulations, then the PRS can only be used to establish the initial state of the market if it operates before the MEPS and labels come into effect. If the PRS dataset is used to inform the efficiency thresholds applied in the initial MEPS and labels, this period needs to be sufficiently long to allow the data to be gathered and analysed, the regulations designed and adopted, and the market to have sufficient time to conform to the requirements. While PRSs are always useful for tracking implementation, supporting conformity and compliance and informing revisions of MEPS and labelling requirements may need to be piloted and used in conjunction with other market data collection methods at the outset.

[46] UNEP U4E (2019) *Model Regulation Guidelines: energy-efficient and climate-friendly air conditioners:* https://united4efficiency.org/resources/model-regulation-guidelines-for-energy-efficient-and-climate-friendly-air-conditioners/ and *Model Regulation Guidelines: energy-efficient and climate-friendly refrigerators*: https://united4efficiency.org/resources/model-regulation-guidelines-for-energy-efficient-and-climate-friendly-refrigerating-appliances/

[47] UNEP U4E (2019) *Guidance Notes on: 1) What is a Product Registration System and Why Use One; 2) Planning to Build - Foundational Considerations; 3) Planning to Build – Detailed Considerations; 4) Implementing a Product Registration System:* https://united4efficiency.org/product-registration-systems/

PROJECT TITLE
"Development of MEPS and energy labels for [Country Name]"

1. Background Information

[Country name] is developing energy efficiency regulations for room air conditioners and refrigerating appliances. Technical and market consultancy services are sought to inform the design of the programme.

The aim is to enhance the efficient use of electricity, save consumers money on their utility bills and mitigation greenhouse gas emissions by accelerating market penetration of superior appliances via a conducive legal and regulatory environment. Consultancy services will include gathering and analysing market and technical information on products sold in the country and globally to underpin the efficiency and refrigerant thresholds.

The project implementation is expected to result in the following outcomes:

(1) Collection and analysis of information on the market, including:

- actors (importers, distributers, retailers and local assemblers) active in the national market
- annual domestic sales (number of units and value) of new products over the last 10 years
- energy efficiency of new products placed on the market for sale
- product prices as they are imported into the country and how costs and mark-ups change along the supply chain during distribution and retail
    - cost information to estimate how product prices are expected to vary as a function of their energy efficiency and refrigerants
    - key product benchmarks to determine the energy efficiency level consistent with: a) the least life cycle cost (LLCC) for the consumer; b) the highest and lowest efficiency new products currently on sale domestically; and c) the highest efficiency products on sale internationally.

(2) Derivation of national scenarios showing the impacts on energy consumption, purchasing costs, and operating costs as a function of the ambition of MEPS and energy labelling policies.

(3) Liaison with market actors and other key stakeholders to: inform them of the project and how it will inform the design of the pending MEPS and energy labels, solicit the highest quality technical and market data, verify the project findings.

2. Activities and deliverables

Activities	Deliverables
Activity 1: Collection and analysis of information on market actors	
1. With support from the government, compile a list of market actors (importers, distributers, retailers and local assemblers) active in the market for new products. This is to be done initially via: accessing government the national PRS, databases held by the Ministry of Commerce, communication with local chambers of commerce and industry/retailer associations, checking online retailers/wholesalers, speaking to key retailers. 2. Assemble the information into an initial map of stakeholders (importers, distributers, retailers and local assemblers) active in the national market. 3. Verify the findings for completeness with key stakeholders and more broadly at the 1st stakeholder workshop (see Activity 8).	Verified list of market actors engaged in the supply of products to and within the nation
Carried out mainly through desk review. Interviews of selected stakeholders will be pursued when needed to collect views on progress and to identify key findings and conclusions.	

Activity 2: collection and analysis of the annual sales (number of units and value) of new room air conditioners and refrigerators sold within the country over the last 10 years	
1. Compile information on the annual import, local production/local assembly, and export of new room air conditioners and refrigerators placed for sale on the national market over the last 10 years in terms of the number of units sold and the annual sales value. *2.* Verify these figures with key stakeholders through direct contact and via the 1st stakeholder workshop (see Activity 8).	Data and short report on annual sales (volumes and values) of new products
Access customs databases for imports and exports for whole products and product kits or components (if used in local assembly), liaison with key market stakeholders, compilation of other relevant information (market reports), and verification with stakeholders attending the 1st stakeholder workshop.	
Activity 3: The collection and analysis of information on the energy efficiency of new room air conditioners and domestic refrigerators placed on the national market for sale	
1. Assemble a database of models of new air conditioners and refrigerators available for sale on the national market including the technical information on their energy performance (energy efficiency and related technical values). 2. Validate the database with key stakeholders and at the 2nd stakeholder workshop per activity 8.	Validated database of new products sold in the market (types, features, capacities, energy efficiency, brands)
Compile extensive technical data on the models offered for sale on the national market by a mixture of survey of internet sales information and targeted written surveys of key market actors as identified in Activity 1. Where necessary, visit retailers and/or assemblers and compile technical data on each of their models. Participants in the 1st stakeholder workshop will be invited to complete a survey of the models they offer for sale. Findings to be reported and validated at the 2nd stakeholder workshop.	
Activity 4: Collection and analysis of product prices imported into the country and how the costs and mark-ups change along the supply chain during distribution and retail	
1. Where possible, compile prices of models available for sale on the national market. 2. Compare prices to equivalent information from international sources and to the value per unit of imported products (derived from Activity 2). 3. Conduct interviews of key market stakeholders (as identified in Activity 1) to determine typical prices of new products when they arrive at the borders or leave the factory floor of assemblers, the typical costs and mark-ups incurred as these products are distributed (distributor or wholesale costs) and retailed (final retail price paid by the consumer). 4. Analyse this information to determine the typical costs and mark-ups through the supply chain. 5. Validate this information with key stakeholders and at the 2nd stakeholder workshop per Activity 8.	Price information added to the database from Activity 3. Report on the costs and mark-ups.
Use the same techniques as Activity 3 to assemble and validate product price information. Activity 4.2 requires desk research of published international reports used in MEPS and labelling regulatory determinations in major economies. Activity 4.3 requires surveys and interviews with key market stakeholders. Activity 4.4 requires that results be circulated to key market stakeholders prior to the 2nd stakeholder workshop and for their feedback to be compiled and reported at the workshop.	
Activity 5: Collection and analysis of product cost information to estimate how new product prices are expected to vary as a function of their energy efficiency	
1. Conduct price versus efficiency analysis of products compiled within the national product database per Activities 3.1 and 4.1. 2. Compile internationally published information on how product prices are expected to vary as a function of energy efficiency for products as they leave the factory / arrive at borders. 3. Apply supply-chain costs and mark-up information from Activity 4 to the information gathered in Activity 5.2 to determine how new product prices (as paid by consumers) are expected to vary as a function of their efficiency on the national market. 4. Compare findings from Activities 5.1 and 5.3 and reconcile them based on other factors which can affect price (brand, main product features, additional product features, retail channel etc.). Apply the results to derive the best estimate of how standard products (typical new room air conditioners and domestic refrigerators) will vary as a function of their energy efficiency while all other factors are held constant. *5.* Derive estimated price (paid by the final consumer) versus energy efficiency curves for the most representative products.	Report of how the price of how the price of new products are expected to vary with energy efficiency (all other aspects being held equal) at each stage in the supply chain.
Activity 5 is to be conducted using the methodological approaches described above.	

Activity 6: Data collection and analysis to determine key product energy efficiency benchmarks for: a) LLCC for the consumer, b) highest and lowest efficiency new products currently on sale on the national market, c) highest efficiency products on sale internationally	
1. Compile data on typical use (average hours per year) of room air conditioners and domestic refrigerators in the country. 2. Compile electricity tariffs by end use sector (households, non-domestic). 3. Using the results from Activity 3, compile information on the most efficient products on the national market, the least efficient products and average efficiency for new products. 4. Drawing upon internationally published sources, determine the typical energy efficiency and highest energy efficiency of products available for sale on the international market. 5. Collate internationally published information on the highest efficiency products sold on the international market to determine the energy efficiency of the internationally best available products (IBAT). 6. With the findings of activities 5, 6.1, 6.2 and 6.4, derive life cycle cost (LCC) as a function of energy efficiency for each product sold in the country. Plot curves of LCC as a function of efficiency. Determine the energy efficiency that produces the LLCC for each product.	Report on energy efficiency, usage and costs.
Activity 6 determines the key energy performance benchmarks to inform the energy efficiency thresholds for MEPS and energy labelling. Use the methodological approaches described above.	
Activity 7: Derivation of national scenarios showing the impacts as a function of the ambition of MEPS and energy labelling.	
1. Analyse the time series of annual unit sales information from Activity 2 and establish relationships between total product sales and macroeconomic economic indicators (e.g. GDP per capita, GDP, number of households, electrification rates) to establish a model for unit sales in the future as a function of the variables. 2. Develop a product energy stock-model for room air conditioners and domestic refrigerators with available data and project it for the next 30 years to derive a base case scenario for business as usual energy efficiency and refrigerants. The model should calculate the total energy consumption, operating costs, product purchase costs, direct and indirect CO_2 emissions from the national stock over that timeframe. 3. Derive additional benchmark scenarios for the next 30 years: 1) all products sold from two years hence at the energy efficiency consistent with LLCC; 2) all products sold from two years hence consistent with BAT; 3) all products sold from two years hence consistent with IBAT. 4. Derive two MEPS and labelling policy scenarios and projections in the same manner as Activity 7.3	National energy, economic and environmental impact assessment stock model. Ex-ante impact assessment of key scenarios (base case, key benchmark scenarios for LLCC and BAT, and two policy scenarios) for the next 30 years compiled in a report.
Activity 7 supports the drafting and adopting of new support policies and tools.	
Activity 8: Support the programme manager in the staging of stakeholder workshops	
1. The programme manager organizes an inaugural stakeholder workshop after Activity 1. The consultant presents preliminary findings, invites comments, asks for data, and circulates survey instruments. 2. The programme manager organizes a second stakeholder workshop after Activity 7. The consultant presents their findings and invites comments. With the programme manager, the consultant amends Activities 2 through 6 analysis informed by the feedback.	Two stakeholder workshops with amended analysis.
Activity 8 includes cross-cutting support to the programme manager: identifying invitees, preparing presentations, circulating materials, presenting analysis, addressing comments, compiling minutes.	

3. Timeline

The assignment is 12 months starting from the date of contract award. A priori it is expected that Activity 1 will take two months, the first stakeholder workshop (Activity 8) will be held in the third month, data collection for Activities 2-6 will take three months, analysis and initial reporting require two months, draft results circulated two weeks prior to the second workshop (held in the ninth month). Thereafter, reports using validated information will be finalized.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