ENERGY LABELLING GUIDANCE FOR LIGHTING AND APPLIANCES

United Nations Environment Programme – United for Efficiency (U4E)

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Table of Contents

List of Tables

List of Figures

Acronyms

AEC	Annual energy consumption
APF	Annual performance factor (for air conditioners)
BAT	Best available technology
BNAT	Best not- available technology
COP	Coefficient of performance (for air conditioners)
CSPF	Cooling Seasonal Performance Factor
EEI	Energy efficiency index
EER	Energy efficiency ratio (for air conditioners)
GWP	Global warming potential
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
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)
U4E	United for Efficiency
Wh	Watt-hour

1. Introduction

Over 120 countries have adopted, or are developing, labels to indicate the energy efficiency of energy using equipment and appliances to consumers. The schemes that stimulate the greatest shift towards higher efficiency products are those which follow good practices in the energy label design, amongst other policy measures. This guide aims to distil that experience to inform policymakers and programme managers who are engaged in the development of such schemes and to support their deliberative processes. The contents complement other U4E guides on market transformation, indicating how and why to set labelling categories, building on the three thresholds included in U4E's Model Regulation Guidelines.[1] Although it focusses on cooling products, the principles of this guide are also relevant to energy labelling for other energy using appliances.

Section 2 sets out the theory and characteristics of energy labels and how this interacts with complementary policy measures, such as minimum energy performance standards (MEPS). Various types of energy labels are described, as well as how energy labels fit within broader labelling frameworks. Examples illustrate these concepts and provide necessary background for those responsible for developing energy labelling.

Section 3 articulates the steps and rationale to design comparative and endorsement labels. It draws upon decades of international experience in the design and development of these labels and addresses issues, such as:

- The nature of comparative scales used to display the principal energy performance indicator.
- The choice of principal energy performance indicator.
- The nature of additional supporting information to be conveyed.
- The importance of the authority behind the development and implementation of the scheme.
- The importance of the label's purpose.
- The clear identification of the product and the brand to which the label relates.
- The treatment of multiple languages (when applicable).
- The additional supporting information (e.g. QR code) links should be included.
- The layout and priority given to the elements on the label.

Recommendations on the placement, and generation, of energy labels are then provided. The Model Regulation Guidelines and this complementary material recommend approaches to address both the enhancement of efficiency and the refrigerant transition, in recognition of their importance under the Kigali Amendment to the Montreal Protocol.[2]

[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] Numerous EU examples are provided given the well-documented history (including lessons learned) and reports

2. Theory and Characteristics of Energy Labels

2.1 Energy labelling and market transformation

The purpose of energy labelling is to help overcome an informational market barrier to energy efficiency, wherein consumers of energy-using equipment are unaware of the energy performance of the equipment they purchase and thus are unable to take this aspect into account in their procurement decisions. Energy labels seek to address this by presenting information on equipment energy performance at the time the procurement decision is being made.[3] In theory, when there is no information on energy-using products there is no incentive for suppliers to improve the energy performance of their products. In such situations, the distribution of sales as a function of energy efficiency may be random (see red curve in Figure 1).

When energy labelling is introduced, energy efficiency levels become more apparent. Policymakers should use a mix of tools, from communications to financial mechanisms and incentives, to spur adoption of the highest performing products, to build awareness, and to encourage a market shift aligned with policy objectives. Amplifying demand for products with higher efficiency will spur suppliers to introduce more efficient products, which can yield economies of scale and bring down the cost of these products.

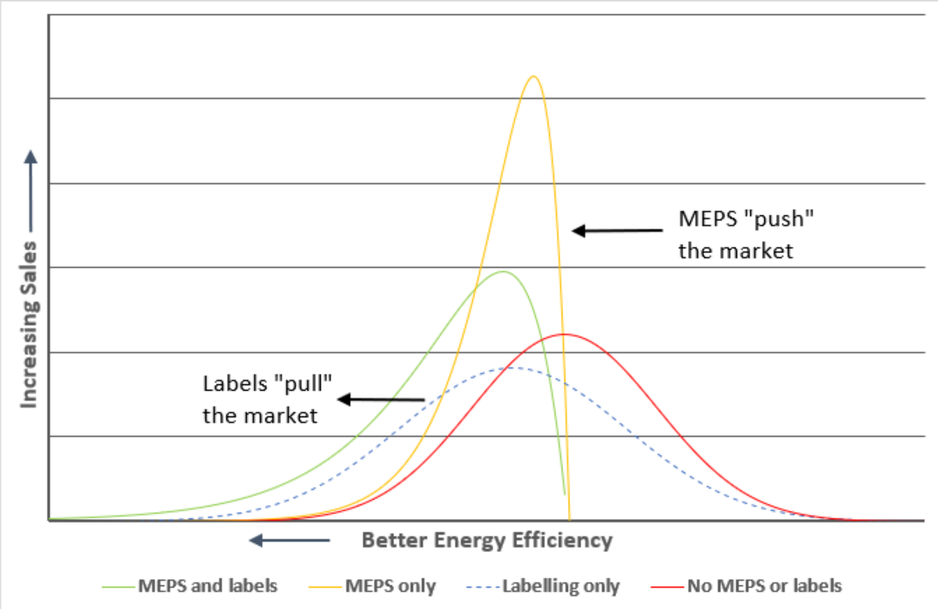
Energy labels alone (without MEPS) can increase demand for higher efficiency products (see blue dot curve in Figure 1), but inefficient products will persist in the market. MEPS alone (without energy labels) drive suppliers to replace non-compliant products with alternatives that just meet the threshold (see yellow curve in Figure 1). When MEPS and energy labelling are used together, the least efficient products are 'pushed' out of the market and the energy label 'pulls' higher efficiency products in, causing an overall market shift (see green curve in Figure 1).

This can create a dynamic situation where more ambitious MEPS can be introduced once enough products are available that meet existing standards – thanks to the demand created by the energy label. More ambitious energy label criteria can also be established that stimulate demand for yet higher efficiency products. Some economies have now been through multiple cycles of revisions of MEPS and energy labelling criteria and have succeeded in driving continuous improvement in the energy performance of affected products via this dynamic policy interaction.

that are available, as well as the popularity of EU-like approaches in other markets. Other examples may be equally valid.

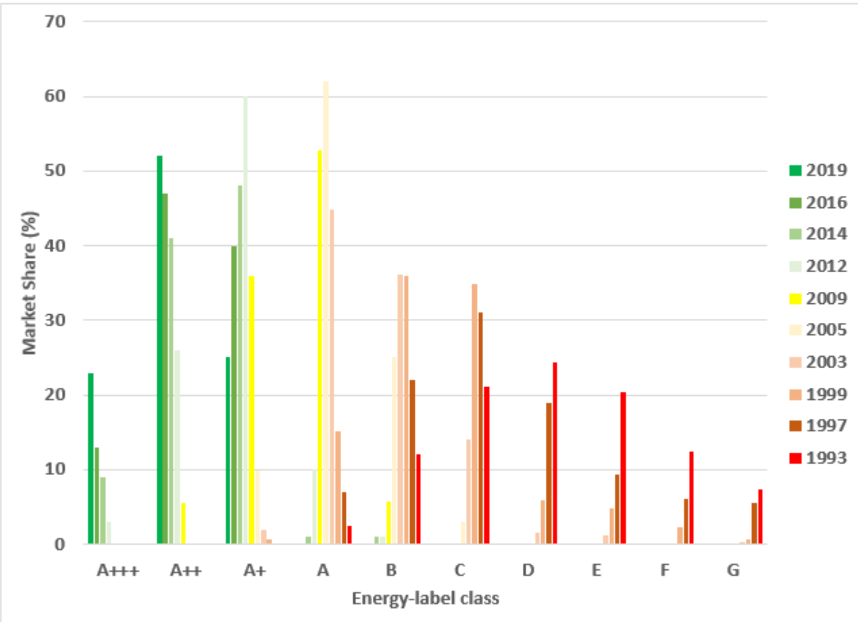
[3] UNEP (2017), *Guidelines for Providing Product Sustainability Information*. https://www.oneplanetnetwork.org/sites/default/files/guidelines_for_providing_product_sustainability_information_ci-scp_2017_revised.pdf

Figure 1: Market transformation theory of MEPS and energy labelling



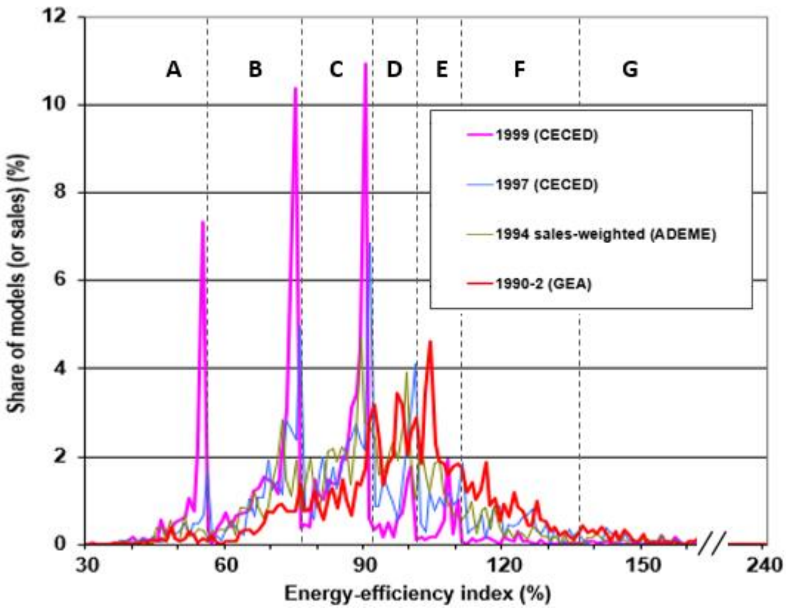
This is the market transformation theory of MEPS and energy labelling and there is ample evidence to confirm that it works in practice. A good illustration is how the distribution of refrigerator sales of the European Union (EU) as a function of their energy efficiency evolved from prior- to post-labelling. In 1995 the EU introduced mandatory energy labelling for refrigerators that classified their energy efficiency into one of seven classes from G (least efficient) to A (most efficient). Prior to this, the distribution of products by efficiency was almost completely random (see Figure 2) but, after the introduction of labelling, the distribution of sales by efficiency moved substantially towards higher efficiency products and has continued to evolve since.

Figure 2: Evolution of EU refrigerator sales as a function of energy labelling class from 1993 to 2019



Of itself, this change in product distribution might not be deemed proof of the impact of the energy labels, as it could be due to ongoing efficiency improvements. However, more detailed evaluation showed a genuine market reaction to the introduction of energy labelling. Figure 3 shows how the distribution of the energy efficiency index (EEI), which determines which energy labelling class a product falls into, evolved from being a random distribution prior to labelling (see red curve in Figure 3) to a spiked distribution with three large peaks at the thresholds of the A, B and C classes a few years after labelling (see purple curve in Figure 3). The products on offer were revised to meet the newly defined higher efficiency thresholds once the labelling scheme was understood by industry and enforced.

Figure 3: Evolution of EU refrigerator sales as a function of EEI from 1993 to 1999[4]



This experience reveals some key principles that need to be taken into account when designing energy labelling schemes:

- Labels must indicate energy performance in a manner that is easy to understand, that is motivating for suppliers, and which is easy to remember.
- The thresholds applied must challenge the market to improve and complement MEPS (if used) to stimulate a dynamic transformation of the efficiency of new products sold on the market.[5]
- Market actors (suppliers and industry) must be aware of the requirements and have confidence in them to create market pull for higher efficiency products.

[4] Adapted from: *COLD II the Revision of Energy Labelling and Minimum Energy Efficiency Standards for Domestic Refrigeration Appliances - Final report – November 2000, European Commission DG Energy, Contract DG-TREN SAVE N°XVII/4.1031/Z/98-269. Co-ordinator: Paul Waide, PW Consulting (UK) on behalf of ADEME (France)*
[5] UNEP (2017), *Guidelines for Providing Product Sustainability Information,* https://www.oneplanetnetwork.org/resource/guidelines-providing-product-sustainability-information

2.2 Types of energy labelling

2.2.1 Common classification of energy labels

In principle, energy labels can be distinguished by the following main aspects:

- Mandatory or voluntary.
- Comparative or endorsement type.

Energy labels may be mandatory or voluntary. If they are voluntary, as seen in Switzerland, Brazil and Hong Kong, only higher efficiency products tend to be provided with labels, as suppliers would not ordinarily choose to indicate products that have poor performance unless required to by law.

The two main types of energy labels are **comparative energy labels** and **endorsement energy labels**. While both are used, and sometimes simultaneously, comparative labels are more common. Either may be used, depending on the local context.

Comparative labels show how efficient a product is compared to other products on the market and use a scale to indicate where the efficiency of a product is positioned within the spectrum. There are two primary types of comparative energy labels:

- Continuous scale types – where the efficiency scale is a continuum (see Figure 4)
- Categorical scale types – where the efficiency scale is divided into a set of efficiency classes (see Figure 5).

Figure 4: The US Energy Guide label – an example of a continuous comparative energy label reporting annual operating costs

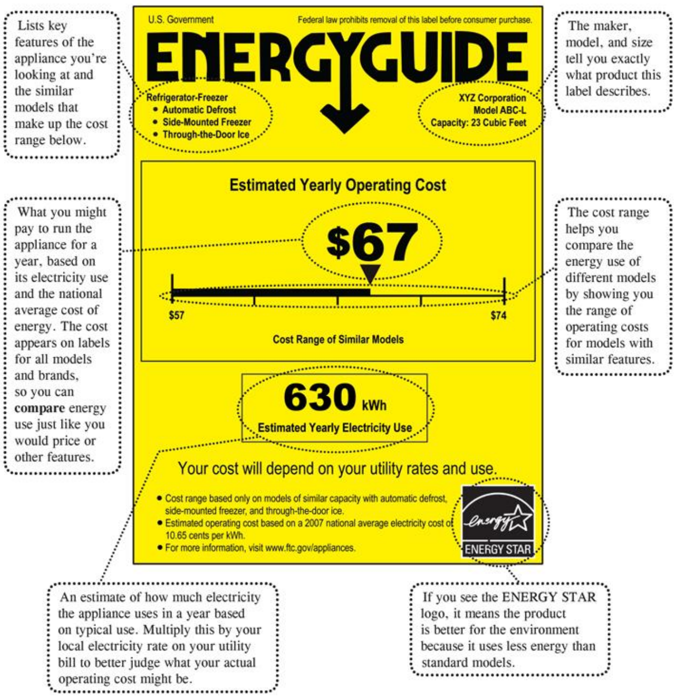
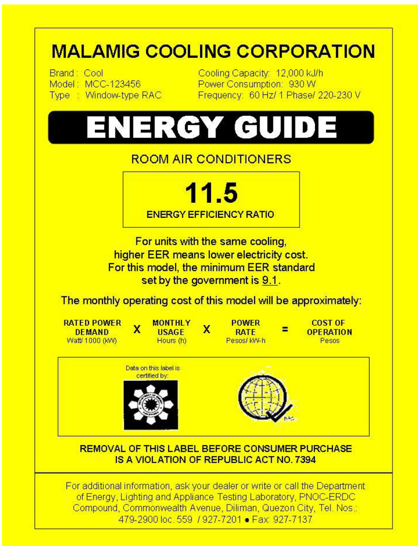


Figure 5: Examples of comparative energy labels

From left to right: the EU refrigerator energy label[6], the current Australian energy label, the current Korean energy label

Some early energy labels were pure information labels, with the energy performance of products expressed as a number but without a scale for comparison (see Figure 6). These labels have fallen out of favour because it has been shown that comparative energy labels are more effective at transforming markets.[7] The scale enables a consumer to see the spread in performance that may be observed in the market and where each product is positioned within this scale. Intuitive visual information, like colour coding on efficiency scales, helps consumers choose more sustainable options.

Figure 6: Example of a pure information energy label from the Philippines



[6] Note: The EU label for refrigerators is being updated. A new rescaled label, that returns to the original A to G scale, will come into effect from 1 March 2021.

[7] UNEP (2019), *Consumer Information Tools and Climate Action: Tourism, Buildings and Food Systems*, shows that a scale going from green to red works better with consumers than a label which only bears a number. Page 22, https://www.oneplanetnetwork.org/sites/default/files/consumer_information_tools_and_climate_change.pdf

Endorsement labels are labels that indicate formal recognition (or endorsement) of a product (see Figure 7 for examples of prominent energy labels and Case study: Ecolabelling of Room Air Conditioners for an insight into this related aspect of endorsement energy labels). Endorsement labels tend to have a simple design, such as a logo, and are usually promoted by a respected state authority. They also tend to have eligibility criteria, where a product either meets (passes) or does not meet (fails) the requirement. The passing product is recognized as attaining a higher-than-average level of energy performance (where the threshold and associated criteria are set by the governing body). The label may also indicate that the product's performance level has been independently verified by a qualified third-party.

Figure 7: Examples of voluntary endorsement energy labels

From left to right: US Energy Star label and China's Energy Conservation Certification label

Given these characteristics, endorsement labels are voluntary, while comparative labels are generally mandatory. Suppliers of low efficiency products are unlikely to display the efficiency of their products on a comparative energy label scale unless it is mandatory. Thailand is an exception; here labels are voluntary, but as product efficiency levels are higher than the MEPS, the vast majority of products carry one.

Suppliers are often happy for their products to carry endorsement labels because this indicates they have attained a superior level of performance. However, this tends to be the case only when the endorsement label is well-known and respected, as the added value to the suppliers needs to exceed the cost of the administrative effort required to be awarded and display the label.

Endorsement labels therefore need to be heavily promoted. Incentives are often included, such as the endorsement being used as a precursor for a product to be eligible for rebates, public procurement programmes, or tax incentives.

Case study: Ecolabelling of Room Air Conditioners

Eco-labels may cover some of the same performance aspects as energy labels, even though their focus is on the overall environmental footprint of a product. Ecolabels are voluntary endorsement labels and they most closely resemble endorsement labels in their conception and methods of adoption. Some prominent examples for room air conditioners are shown below, along with the eligibility criteria to receive the label. These include both minimum energy performance criteria and the ODP and GWP of the refrigerant used. The U4E Model Regulation Guidelines cover both elements, with greater stringency than some of the illustrative examples provided here.

Ecolabel		China Environm. Labelling	Korea Eco-Label	Green Label Thailand	Nordic Swan	Blue Angel
Country/Region		China	South Korea	Thailand	Scandinavia	Germany
Latest Version		2013	2013	2016	2018	2016
Selection of Requirements	Energy Efficiency[12]	Range from: SEER≥5.4 (Seasonal Coefficient of Performance (SCOP)≥4.5) for units <4.5 kW SEER≥4.7 (SCOP≥3.7) for units with 7.1 to 14 kW	fulfill first class Energy Efficiency Rating, according to the efficiency man-agement equipment operation regulations	EER>2.82 Based on Thai Industrial Standard TIS 2134: Room ACs: Energy Efficiency (EGAT Label No. 5 requirements)	SCOP≥3.4 (for European climatic zones C to SCOP≥4.0 zone A If GWP<150 SCOP≥3.1 (zone A) and SCOP≥3.4 (zone C)	SEER≥7 SCOP≥4.6
	Refrigerant	Ozone Depleting Potential (ODP)=0 No GWP limit	ODP=0 GWP≤2,500	ODP=0 GWP≤2,500	ODP=0 GWP<2,000	halogen-free, ODP=0 GWP<10
	Noise Level[13]	Sound Pressure Limits Cooling Capacity (CC) <2.5 kW IDU: 39 dB(A) ODU: 40 dB(A)	CC < 4kW IDU: 45 dB(A) ODU: 55 dB(A) 4kW≤CC<10 kW IDU: 50 dB(A) ODU: 60 dB(A)	Sound Pressure Limits CC <8 kW IDU: 50 dB(A) ODU: 57 dB(A	Sound Power Limits CC <6 kW IDU: 50 dB(A) ODU: 60 dB(A)	Sound Power Limits CC ≤4.5 kW IDU: 50 dB(A) ODU: 58 dB(A) 4.5 kW<CC≤6 kW IDU: 55 dB(A) ODU: 62 dB(A)
Reference		China Environmental United Certification Center (CEC); UBA (2018)	Ecolabel Standard EL401: Air ConditionersKorea Ecolabel Standard EL401: ACs	Green Label Product Room AC (TGL-7-R3-14)	Nordic Swan Ecolabel	Blue Angel, The German Ecolabel: Stationary ACs DE-UZ 204

Source: GIZ (2019) *R290 Split Air Conditioners Resource Guide*. https://www.international-climate-initiative.com/fileadmin/Dokumente/2019/R290_SplitAC_ResourceGuide_Proklima.pdf

2.2.2 ISO environmental labelling definitions

The International Standards Organization (ISO) standard ISO 14020:2000, Environmental Labels and Declarations – General Principles, establishes guiding principles with categorizations that can be applied to energy labels. The ISO 14020 family of standards covers three types of labelling schemes:

- Type I is a multi-attribute label developed by a third-party.
- Type II is a single-attribute label developed by the product producer.
- Type III is an eco-label whose awarding is based on a full life-cycle assessment.

Single attribute labels, such as energy labels, only report on one characteristic, such as the product's energy performance. Multi-attribute labels report on more than one product characteristic. Energy labels are single attribute schemes developed and governed by third parties and hence are a hybrid between the ISO Type I and Type II labels. Energy labels, if governed by third parties, are thus sometimes referred to as "Type I".

3. Designing Energy Labels

The design of an energy label is not simply a matter of settling on informational content and appearance. It entails establishing technical definitions to underpin the information to be conveyed and to account for interactions between label design features and implementation procedures, such as:

- Conformity assessment – the process suppliers undertake to establish the energy performance of their products,
- Rules and practices to be followed when products are to be placed on the market,
- Conformity verification procedures.
- Procedures to be followed when non-compliance is detected.[8]

The design of a labelling scheme needs to consider **effectiveness factors** and **technical factors** and optimize the net effect of both.

Effectiveness factors include design features that influence how well the label encourages consumers to demand, and vendors to supply, energy-efficient products, including:

- The extent to which the information shown is understandable by the target audience.
- The salience of the design and how much it motivates demand for higher efficiency products.
- The ease with which suppliers can comply with the requirements and their readiness to do so.

[8] This topic is addressed in: UNEP U4E (2021) *Ensuring Compliance with MEPS and Labelling Regulations*, available at: https://united4efficiency.org/resources/publications/

Technical aspects are the technical underpinnings of the information, including:

- How energy performance is defined and measured.
- The division of product groups into sub-categories of comparable functionality.
- The means required by suppliers to establish conformity with the requirements.
- The choice of efficiency thresholds to be used.

The following sections set out step-by-step guidance for the design of comparative and endorsement energy labels for refrigerators and air conditioners. Applying the U4E Model Regulation Guidelines[9] simplifies the design steps. Policymakers may pursue additional labelling classes beyond the three identified in the U4E Model Regulation Guidelines, for example, but the general principles remain.

3.1 Step-by-step guidance on designing comparative energy labels

3.1.1 Consider conducting consumer research

The design process should be informed by consumer research to test the efficacy of design concepts and to examine the extent to which key elements are comprehensible, motivating and memorable. Some label designs have suffered from not being informed by this type of research. While panels of policymakers and experts can often derive sensible design options, it is not always possible for them to know how consumers, who are generally less close to the topic, will react. Poorly understood labels tend, at best, to result in their information being ignored. At worst, consumers draw the opposite conclusion from what was intended.

Consumer research must be of adequate quality and structured to test essential design issues to avoid misleading outcomes. Due to cultural differences, labels that work effectively in one community may not work effectively in another. Thus, consumer research is important even if the initial expectation is to take advantage of design concepts used in other markets. Testing key label design concepts can include evaluating one aspect in isolation or presented as a complete package. Ideally, it should examine each of the design elements listed in Section 3.1.2, especially the choice of performance indicator and its scale, followed by the signification of the label's purpose and the overall layout of the design elements. It should involve a blend of **qualitative and quantitative research methods**.

[9] *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/

The former is usually carried out via sets of consumer focus groups[10] which probe the reactions of small panels of consumers exposed to different label design concepts. The latter typically involves conducting consumer surveys. Here, a relatively large set of participants are invited to complete a survey designed to test how well they understand information on given sets of energy label design concepts and to rank how motivating they find them. The focus group approach can be used to examine a wide range of candidate design concepts. Typically, a professional graphic design agency is hired to work with a consultancy to produce candidate designs with several examples based on existing international energy labels, as well as some wholly original designs.

The key **comprehension test** is how well consumers understand each candidate energy performance scale. These are generally based upon a set of candidate mnemonic[11] scales. The key **motivation test**, also to be assessed via the survey, involves the respondents ranking (e.g. on a five or ten-point scale) how motivating they would find the information presented when considering a prospective purchasing decision. Overall, the research can be structured to initially evaluate a set of candidate scales, and once the leading candidate has been identified, it is repeated to determine the optimal layout.

The number of panels and size of the survey needs to be sufficient to give a reasonably representative indication of the target populations response. If multiple cultures are being addressed, the research should cover an adequate cross-section.

3.1.2 Steps to follow

The label design process is summarised below and explained in this subsection.

1 Determine test methods, product categories, efficiency metrics and label class thresholds

- Adopt energy performance test method.
- Set product categories and sub-categories.
- Define efficiency metrics.

2 Determine the choice of principal indicator - efficiency or operating costs

- Consider pros and cons of both choices.
- If operating costs are likely to be used, first check via consumer research.

[10] Focus groups can also probe the extent to which additional awareness campaigns are necessary for consumers to make informed decisions. This can be achieved by having focus group participants respond to a question individually, and then discuss it with the group to re-consider the answers. The EU Energy Labeling Comprehension Study is illustrative of this process and is available at: https://storage.googleapis.com/clasp-siteattachments/2013_05_EU-Energy-Labelling-Comprehension-Study.pdf. Another report from CLASP is anticipated on this topic in early 2021 with findings from Thailand.

[11] A mnemonic is a system, such as a pattern of letters, ideas, or associations, which assists in remembering and classifying something. See Step 4 in Section 3.1.2 for further details.

3 Determine the choice and design of energy performance scale

- Establish how product efficiency is distributed on the market.
- Establish how life cycle cost (LCC) varies with efficiency.
- Establish performance benchmarks, such as internationally best available technology (IBAT), best available technology (BAT), regionally best available technology (RBAT), least life cycle cost (LLCC).
- Consider impact of MEPS and technological progress.
- Determine the upper and lower threshold boundaries.
- Set the number of efficiency classes and the interval spacing between them.

4 Establish the choice of mnemonic and use of colour

- Use of mnemonics.
- Use of colour.

5 Settle other label design elements

- Signification of purpose.
- Signification of governing authority.
- Product identification information.
- Treatment of multiple languages (as needed).
- Additional supporting information.
- Indication of the climate impact of the appliance.
- Use of QR code.
- Layout and priority of elements.
- Label pollution and exclusivity of use.

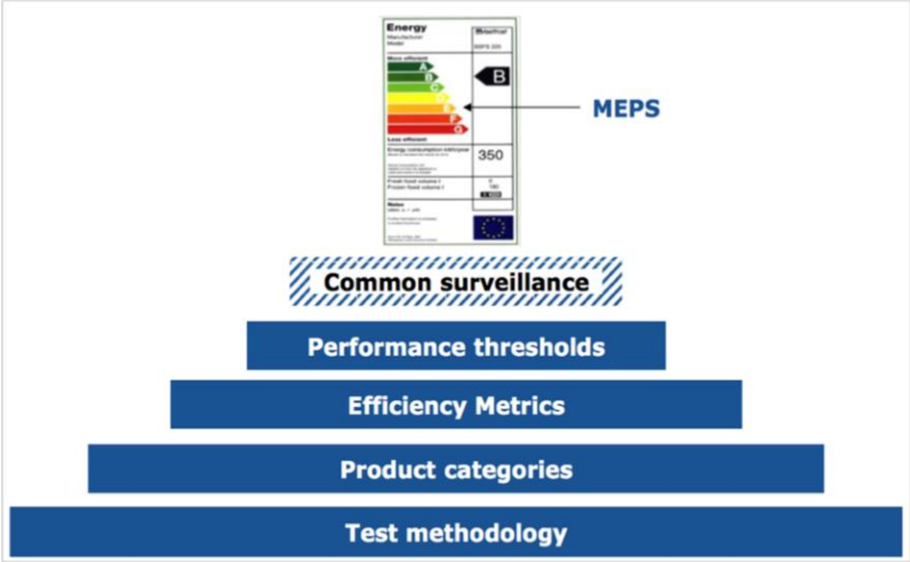
Notes:

- Steps 2 to 5 should be informed by consumer research on trial design elements.
- Steps 1, 2, 3 (and, to a lesser extent, Steps 4 and 5) should consider international alignment opportunities.

Step 1: Determine test methods, product categories, efficiency metrics and label class thresholds

Many of the same steps are taken when developing MEPS or labels (see Figure 8). In both cases, performance thresholds, efficiency metrics, product categories and test methods need to be determined. It is recommended to use the U4E Model Regulation Guidelines as a starting point.

Figure 8: The hierarchy of technical aspects underpinning energy labelling and MEPS



If pre-existing approaches are already in place or regional alignment is underway (e.g. on the test method), care should be taken to consider whether:

- The test methods, product categories and sub-categories and efficiency metrics between MEPS and labelling are aligned, and if not, how to do so.[12]
- The requirements are well-established and respected or if product suppliers need to learn and adopt a new system.
- The market is large enough to justify suppliers' efforts to comply, and if not, opportunities to align with other markets to present a more compelling and viable pathway.

Step 2: Determine the choice of principal indicator – efficiency or operating costs

The choice of principal indicator is between an energy efficiency metric or reporting the operating costs (e.g. the typical annual energy bill, as done in the US Energy Guide label – see Figure 4). Most economies opt to report the energy performance rather than the operating costs. There are arguments in favour of either approach.

In some markets, consumers indicate that operating costs are what they are most interested in knowing. Research shows that consumers generally understand that operating costs are proportional to the energy efficiency,[13] but it also has been found that a significant proportion of consumers can misinterpret annual operating costs as savings[14] and hence results in the opposite incentive to what was intended. Other challenges are that disclaimers are necessary to explain that the actual operating costs will depend on the tariff applied and on how the product is used.

[12] Note: The way energy efficiency is defined for MEPS and labelling should be aligned for the same product.
[13] du Pont, Peter and Egan, Christine (1999) *Consumer Information Processing and Effective Program Design*. In Proceedings of the European Council for an Energy-Efficient Economy 1999 Summer Study. Mandelieu, France.
[14] du Pont, Peter (1998) *Energy Policy and Consumer Reality: The Role of Energy in the Purchase of Household Appliances in the U.S. and Thailand. Doctoral dissertation for University of Delaware.*

If the electricity cost differs by location or over time, consider explaining the operating cost separately from the energy label, such as though online calculators that use the local, present electricity cost.

Some labelling schemes are used across jurisdictions with different tariffs. Also, although products like refrigerators tend to be used relatively consistently, others like air conditioners are highly dependent on how frequently the product is used. An energy label usually sets a usage scenario to calculate the annual energy consumption. An efficiency metric makes it clear what the potential spread in efficiency is between otherwise identical products on the market whereas the magnitude of operating costs is quite dependent on the functional characteristics of the product (e.g. its size and service levels). For these reasons, most energy labelling schemes use energy performance (efficiency) as the principal performance metric to be reported.

Policymakers that wish to test the hypothesis via consumer research should consider the following questions:

- What proportion of consumers correctly interpret the monetized information presented to be operating costs, as opposed to cost savings?
- How credible is the operating cost information perceived to be given the variation in tariffs and usage that arise?
- Is operating cost information significantly more motivating for consumers than relative energy performance information?
- Is the difference in operating costs between similar types of products with different efficiency levels large enough to motivate consumers to consider purchasing a higher efficiency option that may be more expensive to purchase?
- Over what time period should the operating costs be integrated (annually, monthly, other)?

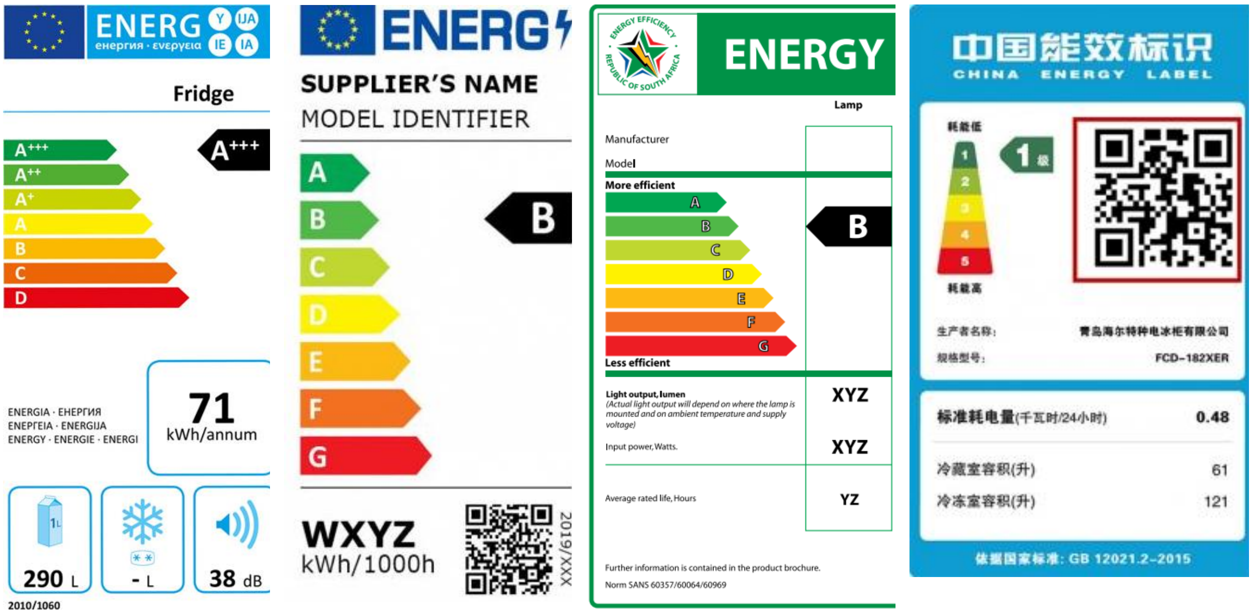
If the answers are not clearly in favour of indicating operating costs, use a pure energy performance indicator.

Step 3: Determine the choice and design of energy performance scale

The vast majority of comparative energy labels are categorical with distinct efficiency classes grouped between efficiency thresholds, rather than a continuous efficiency scale. Categorical comparative labels should be simple to understand and remember, which helps motivate purchasers.

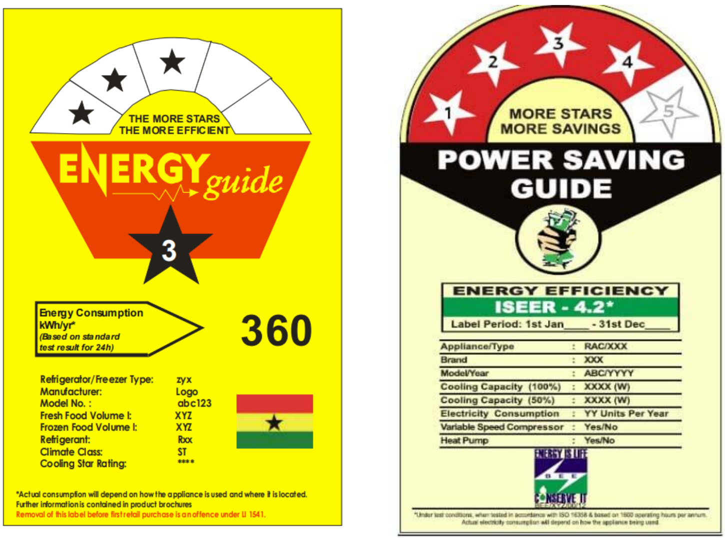
Among categorical comparative label designs, two major approaches have emerged. One, typified by the EU energy label and numerous similar examples (see Figure 9), uses vertical stacked bars ranked from the highest efficiency class at the top to the lowest efficiency class at the bottom. The other, typified by the Australian and Indian label designs, uses a dial ranging from the lowest efficiency class on the left to the highest efficiency class on the right of the dial (see Figure 10).

Figure 9: Examples of comparative energy labels with stacked bar categories



From left to right: the current refrigerator energy label in the EU, the latest lamps energy label in the EU, the new energy label in South Africa and the new energy label in China.

Figure 10: Examples of comparative energy labels using dial designs with star categories



From left to right: Ghana and India energy label

The U4E Model Regulation Guidelines for refrigerators and air conditioners have already defined performance metrics (Step 1) which can be applied to create an efficiency scale. To determine the energy performance scale when using a mnemonic efficiency classification:

- Fix the lower and upper efficiency thresholds (lowest and highest energy efficiency classes).
- Decide how many efficiency classes (intervals) are appropriate.
- Decide how to set the thresholds between the different efficiency classes.

The U4E Model Regulation Guidelines include three energy efficiency intervals for air conditioners and refrigerators: low, intermediate and high efficiency[15]. While these indicate the likely spread in efficiency that regulators may encounter, conduct analyses to adapt these as appropriate for the target market. The discussion below sets out guidance on what needs to be considered, and best practice methodologies that can be applied.

Upper and lower threshold boundaries

The top efficiency class needs to be challenging and perhaps even aspirational, such that it is not yet met by any products currently on the local market. Product efficiency continually improves and quite rapid improvements in efficiency can be anticipated when a comparative labelling scheme is first introduced. When the EU energy label was started for refrigerators and freezers in 1995, most products where in energy classes E, F, and G. 15 years later, the available products had evolved to be better than energy class A. Three additional energy classes had to be added in 2011 (A+, A++, A+++) to accommodate this evolution that exceeded the original A-G scale. This type of progression has been seen in most markets with mature labelling programmes.

If saturation in the top classes occurs too quickly, the label ceases to exercise the same pull on the market due to insufficient differentiation between the top and bottom ends of the efficiency scale. There is little reward for products that comfortably exceed the top efficiency threshold compared to those that just attain it (as the peaks per labelling class threshold shown in Figure 3 demonstrate). The market pull of the label is very sensitive to the top threshold over the longer term. For instance, the EU labelling regulation requires a label update if 30 per cent of the products reach the top efficiency class, or if 50 per cent reach the top two efficiency classes.

A challenging top efficiency class will lead to longer periods before the label needs to be re-scaled. There is a tension between aiming for a relatively stable set of energy labelling classes – which creates a foundation for product suppliers to have confidence in planning investments to deliver specific energy performance classes – and the need to avoid having a prolonged saturation with the majority of products in the top labelling class.

[15] See Annex 2 of *Model Regulation Guidelines: Energy-Efficient and Climate-Friendly Air Conditioners*, and Annex 3 of *Model Regulation Guidelines: Energy-Efficient and Climate-Friendly Refrigerators*, both available at: https://united4efficiency.org/resources/model-regulation-guidelines/

How to decide on the upper threshold

The determination of the upper labelling class threshold should be informed by the following energy performance benchmarks:

- The highest efficiency product on the local market – sometimes referred to as the best available technology (BAT).
- The highest efficiency product available more broadly – the internationally best available technology (IBAT) and regionally best available technology (RBAT).

These benchmarks should be complemented by data and analysis to establish the relationship between product price and efficiency (how the price of a representative product – in terms of type, capacity and features – varies as a function of product efficiency).

Then the relationship between the product efficiency and its life cycle costs (LCC) should be determined, where the LCC is the sum of the product price and the discounted operating cost over the product's average expected lifespan.[16] This is derived using data compiled on typical product usage profiles to determine the average unit energy consumption. This is the energy consumption (in kWh) per year for representative products – typical product types with average efficiency and typical capacities and features.

From this, the benchmark of the least LCC i.e. the efficiency level at which the life cycle cost is a minimum (the LLCC), can be determined and so can the LCC of the BAT, IBAT and RBAT. Ideally, this information would be complemented by insights into the best not available technology (BNAT) which is an indication of the efficiency that could be achieved if all known design options to improve efficiency were applied. The EU routinely derives BNAT values for each product covered by MEPS or energy labels, so other economies could make use of these analyses. Equally useful are insights into how the price versus efficiency relationship (and thence the LCC versus efficiency relationship) is expected to evolve over time.

Energy using products experience a technology learning curve, where the cost of manufacture for a given efficiency level tends to decrease over time. This is due to the progressive identification of less costly ways of delivering higher efficiency performance levels and to the cost-economies that come from deploying higher efficiency technologies at progressively greater scale. Typical learning curve rates might have approximately 15 per cent of cost reduction when the number of manufactured products at a given efficiency level doubles.[17] Insights into this evolution enables a projection of the life cycle cost of BAT, IBAT, RBAT and BNAT as a function of time.

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[16] For more information on calculating life cycle costs, see: UNEP U4E (2020) *Protocols to Conduct Market and Impact Assessments*, available at: https://united4efficiency.org/resources/publications/

[17] Robert Van Buskirk (2013), *Modelling the dynamics of appliance price-efficiency distributions*, Proceedings of the ECEEE Summer Study, https://www.researchgate.net/publication/271854592_Modelling_the_dynamics_of_appliance_price-efficiency_distributions

Figure 11 shows an illustrative example where the life cycle cost is plotted as a function of an EEI for a refrigerator in a hypothetical case that is illustrative of what is often found in markets. Design options for a refrigerator could include, for example, vacuum panels, variable speed drive compressors, upgraded expansion valves and heat exchangers, among others. The EEI of an average product on the local market is 100 per cent, while that of the best available technology is 39 per cent (the BAT consumes only 39 per cent of the energy of an average product to deliver the same service). The IBAT has an EEI of 20 per cent. The LLCC occurs at an EEI of 30 per cent and is not yet attained by any product available for sale on the local market. However, it is attained by those on the international market and may soon be by those on the regional market.

Figure 9: Hypothetical relationship of life cycle cost with efficiency[18]

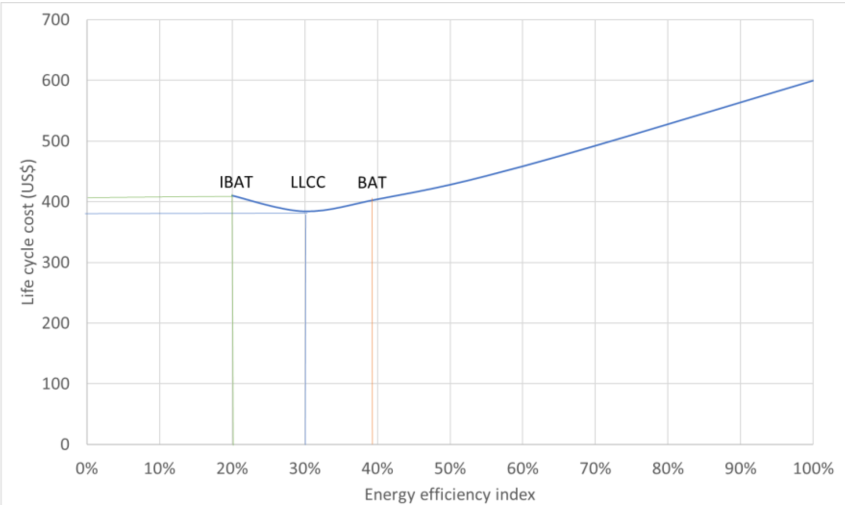


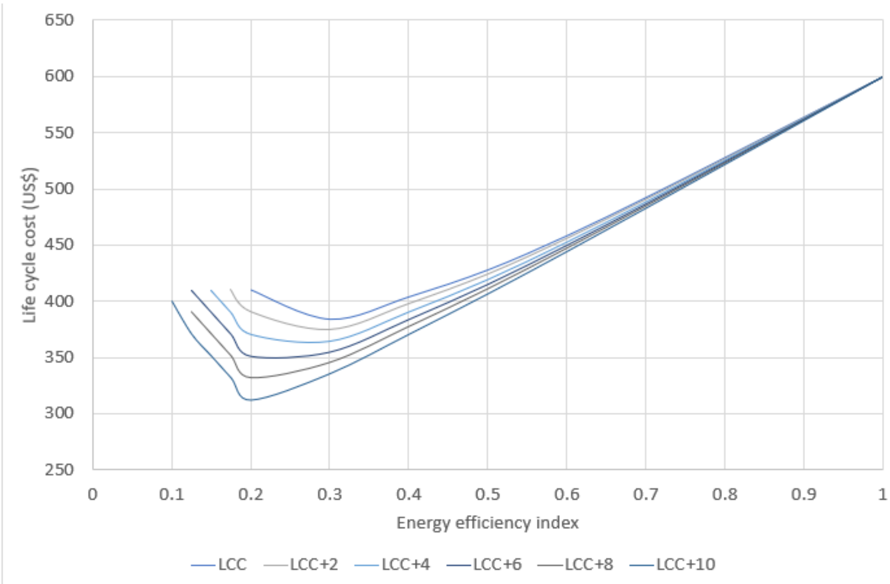
Figure 12 shows the current LCC curve and the estimated LCC curves every two years in the next 10 years, which consider the learning effect over time. In this case, the learning curve is such that the incremental price of the BAT and IBAT over the average product is expected to decline by about 15 per cent every two years. In addition, the EEI of the IBAT is expected to continue to decline as more advanced energy saving technology is introduced. This analysis produces estimated evolutions in the LCC, the LLCC and IBAT. In this example, the IBAT is expected to attain an EEI of 15 per cent in four years' time and 10 per cent in ten years' time. In addition, the EEI associated with the LLCC is projected to decline from 30 per cent currently, to 20 per cent in six years' time.

In addition, the learning curve analysis shows how the affordability of more efficient products would be expected to improve over time. The incremental price of a product with an EEI of 30 per cent is US$64 or 32 per cent of the price of a product with an EEI of 100 per cent in this example. However, after five years, it is projected to be US$40 (20 per cent) and after 9 years to be US$21 (10 per cent).

[18] Efficiency is expressed by an EEI where a low value is a more efficient appliance than a high value. The figure shows the BAT, IBAT and the point of LLCC. For insights into how the LLCC is calculated, see UNEP U4E (2021) *Protocols to Conduct Market and Impact Assessments*, available at: https://united4efficiency.org/resources/publications/

Armed with this information, policymakers can make an informed decision of where the top efficiency level in a categorical label should be placed on a pure techno-economic basis. The current BAT on the local market does not seem to be particularly challenging to attain, and hence the top threshold should likely be placed higher than that. The current LLCC is at 30 per cent and the IBAT is at 20 per cent but is expected to improve to 15 per cent in four years' time. Therefore, a top efficiency class at the current LLCC or somewhat beyond it seems warranted. With an incremental cost of just 32 per cent (US$64) of the average product, yet a LCC saving of US$216 (a benefit to cost factor of 3.4), it is likely that many consumers would be willing to make the investment to procure greater longer-term savings.[19] Furthermore, as the products at that efficiency level are already internationally available, constraints on supply are unlikely if fresh demand is created via the stimulus of the energy label.

Figure 10: Hypothetical relationship of life cycle cost with efficiency[20]

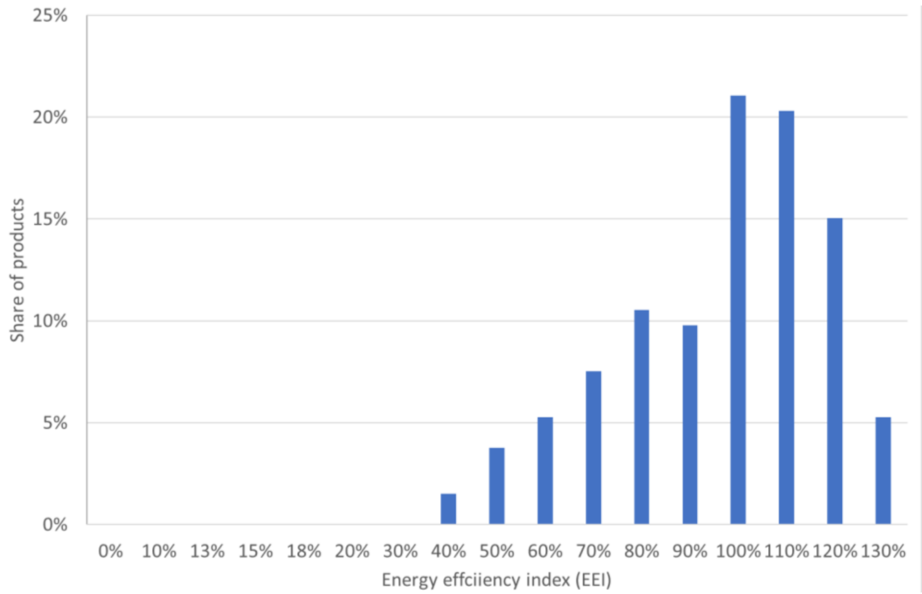


How to decide on the lower thresholds

The next factor to consider is the distribution of products on the current market as a function of their efficiency. Figure 13 shows a hypothetical example of the share of products as a function of their efficiency prior to the introduction of energy labelling.

[19] Note: The label itself will not make this value proposition clear to consumers, so additional communication is necessary. This can be done with the addition of an LCC calculator linked to a QR code (discussed elsewhere in the document), public communication campaigns, and training retailers to include this in their sales promotions.
[20] Hypothetical relationship of LCC with efficiency (expressed by an EEI where a low value is given to a more efficient appliance than a high value) where LCC is the curve at the time the analysis is conducted, LCC+2 is the projected curve in two years' time, LCC+4 the projected curve in 4 years' time, etc.

Figure 11: Hypothetical distribution of products as a function of efficiency (expressed by an EEI where a low value is a more efficient appliance than a high value)



In this case, the least efficient products on the current market have an EEI of 130 per cent, the most efficient an EEI of 40 per cent, and the average EEI is 100 per cent. This kind of distribution is not untypical for refrigerators if there has been no prior energy efficiency policy. The range between higher and lower product efficiency is large (a factor of 3.3). From this, it is apparent that the threshold for the lowest energy labelling efficiency classes could be set anywhere above an EEI of 100 per cent. Typically, market analyses would show there is essentially negligible difference in the price of products in the 100 per cent to 130 per cent range, so the only question is where to set the level.[21]

However, this is not the only consideration. If MEPS are also poised to be introduced – as recommended in the U4E model regulations[22] – consider how to relate the bottom label threshold to the MEPS threshold. Logically, the lower boundary of the bottom label class would be set at the MEPS level, but there may also be considerations of regional or international harmonization.

Setting the label class thresholds when MEPS are also coming into effect

If MEPS have been set, the label design needs to consider whether it is appropriate to include efficiency classes which are no longer permitted for sale on the market. Most schemes are structured either to exclude them, or only permit them when MEPS are first coming into effect if this occurs after the implementation of the energy label. If MEPS and labels come into effect at the same time, set the bottom efficiency class to be at a level that is permitted for sale on the market.

[21] See the example analysis presented in UNEP U4E (2021) *Protocols to Conduct Market and Impact Assessments*, available at: https://united4efficiency.org/resources/publications/

[22] See *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/

Deciding on the number of efficiency classes and the spacing of intervals between them

A balance has to be struck between conveying a difference between efficiency classes and having so many that the consumer is overwhelmed. This trade-off has resulted in labelling schemes with seven classes (EU and those inspired by it), six (Australia and New Zealand), five (India, Republic of Korea, Thailand, and some products in China), and three (for most products in China).

The choice is also informed by whether there is sufficient differentiation between the high and low efficiency thresholds to permit a relatively large number of classes without measurement tolerances blurring the distinction between classes. With refrigerators and air conditioners, there is usually a large potential spread in product efficiency to permit five to seven classes, unless ambitious MEPS are already in use.

The method to set the spacing between the efficiency classes can be either:

a) An equal improvement in relative efficiency from each class to the next highest class.
b) An equal division of the energy efficiency metric (e.g. R[23] and EEI for refrigerators and cooling seasonal performance factor (CSPF), annual performance factor (APF), seasonal energy efficiency ratio (SEER), or similar for air conditioners).

Setting efficiency intervals so that label classes are equally populated at the beginning of the energy labelling implementation is not recommended because this leads to counterintuitive intervals between label classes. If EEI is the principal energy performance metric, with seven classes between the top threshold of 30 per cent and the bottom threshold of 110 per cent, the classification in Table 1 would arise.

Table 1: Example energy label classes as a function of an EEI with different approaches

Label class (1 = highest efficiency; 7 = lowest efficiency)	Approach a) with equal improvement from one EEI threshold to the next (%)	Approach b) with equal division of EEI thresholds (%)
1	<30%	<30%
2	≥30% EEI <37%	≥30% EEI <46%
3	≥37% EEI <46%	≥46% EEI <62%
4	≥46% EEI <57%	≥62% EEI <78%
5	≥57% EEI <71%	≥78% EEI <94%
6	≥71% EEI <89%	≥94% EEI <110%
7	≥110%	≥110%

[23] Note: The U4E Model Regulations use an efficiency metric of R. This is a similar concept to that of the EEI except it is the inverse (i.e. the EEI is similar to 1/R)

Approach a) has a constant improvement in *relative* efficiency of 19 per cent from one class to another. This approach is recommended as it can be continued indefinitely into the future if new classes need to be added. Approach b) is common as it is straightforward. However, it is difficult to keep improving by the same energy consumption reduction rate (an EEI interval of 16 per cent in this case). This means that products will tend to bunch into the top class over time with no easy way of rescaling on the same basis.

In future label updates, where the energy efficiency is defined with a reference value (e.g. for refrigerators), it is recommended to adjust the reference so that it represents the new MEPS or the lowest efficiency class in the label (e.g. R=1 in the U4E model regulations, or whatever EEI corresponds to the MEPS level when EEI is used as the efficiency metric).

Stability of the scheme

When deciding the number of intervals, it is important to ensure the future stability of the scheme, based on analysis on how the market is likely to evolve once the energy label is introduced. Strike a balance such that consumers remain motivated to purchase efficient appliances and suppliers are motivated to supply them. If the spread is too little, or insufficiently challenging, the top labelling thresholds can be saturated while the bottom classes are empty. The scheme would have to be revised by recasting the whole classification, to either be more ambitious or to add higher efficiency classes above the existing ones.

If this occurs too frequently, different labelling versions may be present in the market and lead to confusion between old and new labels, complicating matters for suppliers and potentially leading to lower compliance. After the current revision of the EU labelling schemes, A+++ refrigerators and freezers will become approximately B or C class on the revised label. Therefore, for a certain time period, the same efficiency refrigerator will be rated A+++ on the old label and B or C on the new label.[24]

Consistency of the number of classes across other product labels

Across products types, most energy labelling schemes apply the same number of energy performance classes, or perhaps a maximum of two approaches, so the label classes retain a similar salience. This means that the decision on how many classes to be applied for related products, such as refrigerators and air conditioners, should strive for consistency. Sometimes, such as in China, two partially consistent approaches are used where three efficiency classes are applied for most products and five for some products. In both cases, the same mnemonic is used for the top class (Class 1). This differentiated approach can work when the top class of the mnemonic scale is fixed and clear for all products (e.g. Class 1 or Class A) but may be less effective when a mnemonic scale with an unbounded top class (such as stars) is used.

[24] For more information on the EU experience, see: https://www.europarl.europa.eu/RegData/etudes/BRIE/2017/599282/EPRS_BRI(2017)599282_EN.pdf

Impact of measurement and production tolerances

Variation in product manufacture and testing can give rise to variations in measured energy performance for a seemingly identical product. There can be some tolerance in the manufacture of a product in a production series that results in the same design model for each unique serial numbered unit having slightly different energy performance. With modern production methods, repeatability of manufacture is high, and producers apply a safety margin using statistical methods to compensate for production variance. Of greater practical concern is the variation that can occur when the same product is tested more than once. If the same product is tested more than once in the same test laboratory, the variance is regarding repeatability. When the product is tested in different laboratories, the variance is regarding reproducibility. In general, the reproducibility variance is greater than the repeatability variance, and both are greater than the manufacturing tolerance.

For these reasons, test standards and regulations usually specify permitted verification test tolerances, such that "providing the product's reported performance is within the tolerance range of the measured performance under a verification test, the product is in conformity with the standard". The same is often true of verification tolerances applied by authorities when evaluating compliance with MEPS and labelling via conformity verification testing. Some regulatory regimes apply a verification tolerance of zero. In these cases, suppliers make slightly more conservative performance claims to internalise the possible variations of laboratories performing verification testing.

The verification tolerance is a maximum of a few per cent of the values found by a qualified test laboratory. Therefore, some labelling schemes have been mindful to set threshold intervals to be significantly bigger than these tolerances for fear of a product being declared in one class when it should be within another. In theory, there is no need to be concerned if tolerances are clearly established, communicated, and applied consistently for verification. If so, there is a level playing field for market actors and the responsibility lies with the supplier to ensure their product falls within the declared performance class. Some risk of misunderstanding and a non-level playing field may arise if verification tolerances are not in line with common practice.

International harmonisation

Labelling schemes do not operate in a vacuum as all economies allow imports and most technology and products are widely traded internationally. Compliance with labelling requirements can add additional burdens on industry and suppliers and thus there is a natural reluctance from market actors to have to adjust their operations to comply with additional fragmented requirements across diverse markets. In consequence, fragmented requirements could lead to:

- Misunderstanding of requirements, leading to lower conformity with them.
- Extra costs and higher prices.
- Unwillingness to comply – in the worst cases suppliers might cease to serve a market or potentially seek to intentionally bypass the requirements.

The first issue is a significant risk and must be considered when developing labelling requirements. Small economies, in particular, face this risk as industry and supply chains are less likely to have processes to follow, and hence to fully understand and comply with, the requirements, because the market value may not be considered sufficient to justify the expense of implementing them.

Often, a decision to align with an existing labelling scheme is driven by broader motivations, such as trade. There is usually significant freedom to adopt different labelling formats, provided underlying technical aspects are sufficiently aligned. Thus, harmonization is not usually a yes or no question, but often one of "to what level", as per the distinctions set out in Figure 8. The most common level of harmonization is to use the same energy performance test methodology, referencing an international standard, such as IEC 62552:2015 for refrigerators and ISO 5151:2017 for air conditioners.[25]

The next step is to harmonise how efficiency is defined, including the nature of the efficiency metrics and the sub-categorization of products used to permit comparison under a level playing field. A decision could also be made to harmonise the number of labelling classes to be used, the efficiency thresholds applied, and potentially the mnemonic. Lastly, there is the possibility to harmonise the label design elements. Implementation protocols should also be considered, such as conformity assessment requirements, registration procedures, conformity verification practices, permitted tolerances and other aspects, but these do not concern the design of the label, per se.

Another reason to harmonise with an existing scheme is that the new scheme can often benefit from the technical development work carried out by the existing scheme, help avoid time consuming and duplicative efforts. It is important for policymakers to understand enough about the local circumstances to know how appropriate harmonization to an existing scheme would be, and what trade-offs it might entail. Harmonization is most relevant for efficiency definitions and conformity declaration processes, followed by alignment of classes and thresholds. Alignment with the look of the label mnemonic is less important, as labels are easy and cheap to print.[26]

In 2014, the EU released a study[27] which examined the extent of alignment on test methods for energy labelling. Maps from this study express the degree of alignment (see Figures 14 and 15).

[25] Note: ISO 5151:2017 specifies performance testing, the standard conditions and the test methods for determining the capacity and efficiency ratings of air-cooled non-ducted air conditioners. ISO 16358 references this and sets-out the method to calculate the seasonal energy performance.

[26] For example, the EU provides an online energy label generator at: https://ec.europa.eu/energy/topics/energy-efficiency/energy-label-and-ecodesign/energy-label-generator_en, accessed on 07 December.

[27] Ecoyfs, Waide Strategic Efficiency, Tait, ISR, Consumer Research for DG ENER (2014), *Impacts of the EU's Ecodesign and Energy/Tyre Labelling Legislation on Third Jurisdictions*, https://ec.europa.eu/energy/en/studies/impacts-eu%E2%80%99s-ecodesign-and-energytyre-labelling-legislation-third-jurisdictions

Figure 12: The degree of alignment of product energy performance test procedures to those used in the EU circa 2014[28]

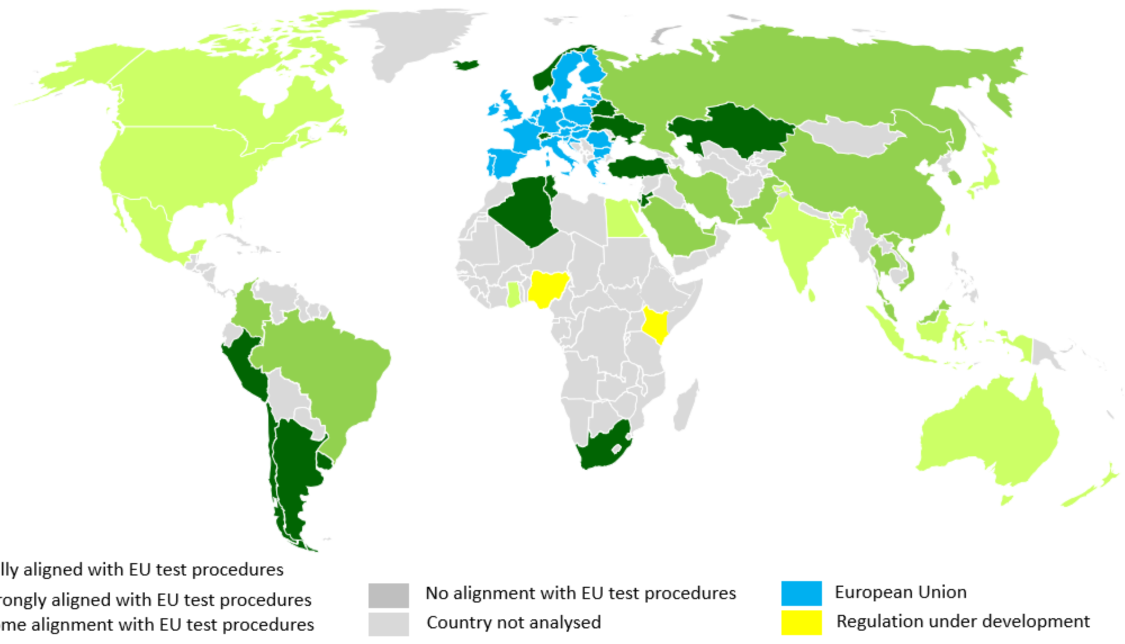
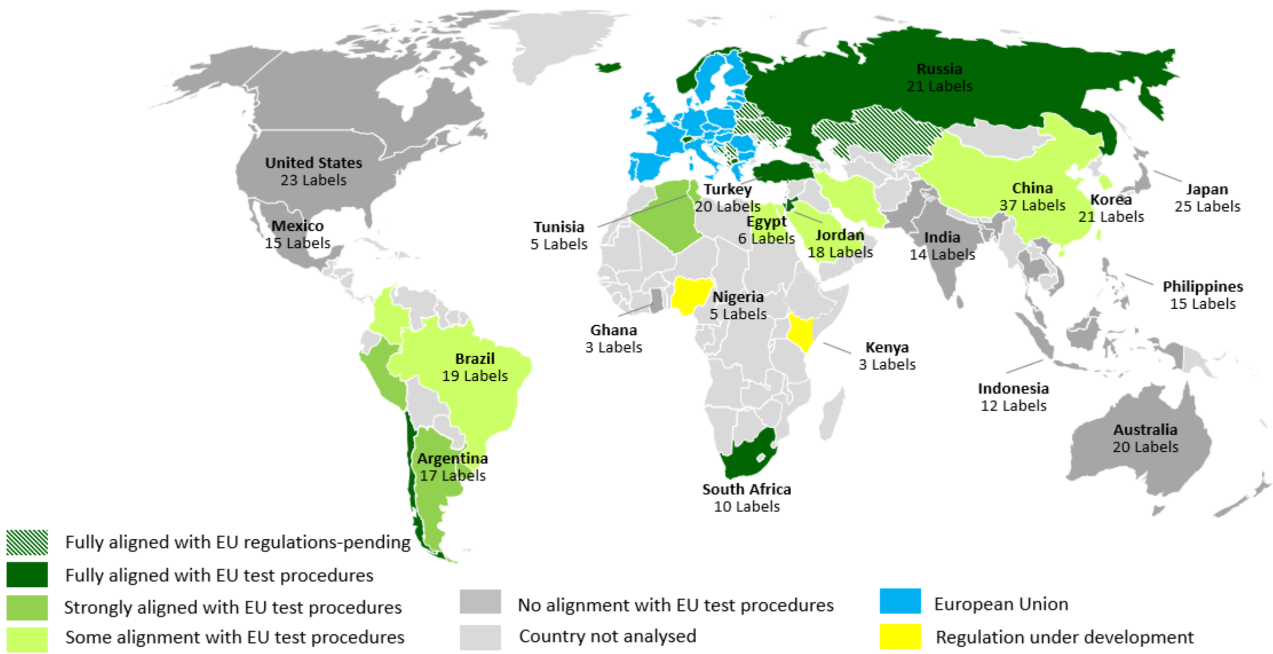


Figure 13: The degree of alignment of energy labelling schemes to those used in the EU circa 2014[28]



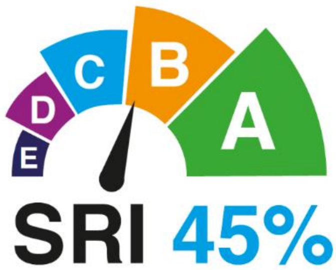
[28] Ecoyfs, Waide Strategic Efficiency, Tait, ISR, Consumer Research for DG ENER (2014), *Impacts of the EU's Ecodesign and Energy/Tyre Labelling Legislation on Third Jurisdictions*, https://ec.europa.eu/energy/en/studies/impacts-eu%E2%80%99s-ecodesign-and-energytyre-labelling-legislation-third-jurisdictions

Step 4: Establish the choice of mnemonic and use of colour

Among comparative energy labelling programmes, the vast majority now make use of mnemonics to facilitate consumers in processing the underlying energy efficiency information. Mnemonics are a system, such as a pattern of letters, ideas, or associations, which assists in remembering and classifying something. For comparative energy labelling, the mnemonics are designed as an easy aide memoire that allows the user to understand where the product is ranked on an energy performance scale and facilitates remembering different rankings to support procurement decisions. The international harmonisation on the label mnemonic is much less important, as labels are easy and cheap to print.

The choice of mnemonic is best guided by the outcome of consumer research on candidate options (e.g. letters, numbers and stars). The association is usually that the higher the number of stars, the better the efficiency. Numbers are quite culturally specific. In China, 1 is the highest efficiency class, whereas in Thailand it is 5. A trial graphic for consideration in the EU's Smart Readiness Indicator for Buildings blends these options (see Figure 16),[29] using a dial (as opposed to stacked bars), a mnemonic letter ranking with A as the best and E as the worst, a five point scale (as opposed to 7 in the EU energy label), a precise numerical score (this could be an efficiency index for an energy label) and a chromatic scale.

Figure 14: Trial label graphic design from the EU's smart readiness indicator project[30]



While several early energy labels were monochromatic with a black font, designs since the early 1990s have tended to incorporate a chromatic scale to reinforce the ranking. This chromatic scale usually has green for the highest efficiency class and red for the least efficient class. However, variants exist, such as Tunisia's (see Figure 17) where the highest efficiency class is blue. Whichever design is considered, care needs to be taken to ensure that it is widely understood as intended.

[29] European Commission (2018), *Smart Readiness Indicator for Buildings*, https://smartreadinessindicator.eu/
[30] European Commission, DG Energy (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

Step 5: Settle other label design elements

The other label design elements need to address the following elements:

√ State label's purpose

Let consumers know that the label concerns the energy performance of the product. Insert a clear title at the top so consumers immediately grasp this before looking further. "Energy" or "Energy Guide" or "Energy Label" are usually used.

√ Signify the authority behind the scheme

Allow users to appreciate that the label is operated by government authorities and hence is not a private sector initiative. Rather than state which agency is responsible for overseeing the scheme, use text or symbols to indicate that the label is a national or pan-national scheme (e.g. use a flag or text such as "China Energy Label").

√ Specify product brand

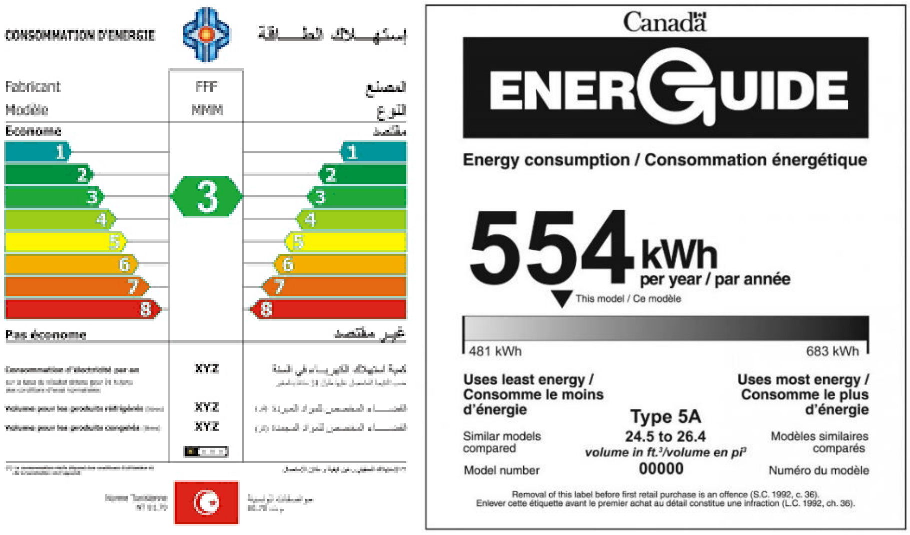
Make the data on the label clearly identifiable. Include the product brand or supplier and a unique model identification code.

√ Manage multiple languages, when applicable

Ensure the label works in markets where more than one language is used. Work with a graphic designer to draft trial concepts and test their efficacy using consumer research. If two languages are necessary, the Tunisian label offers a useful example. It combines French on the left with Arabic on the right and both relate to the centre where the classification is given. Another example is the Canadian EnerGuide in English and French (see Figure 17).

If more than two languages apply, the EU experience is insightful. The label originally had a common background in each national language. Retailers had to assemble this along with a strip from suppliers containing technical details in a universally comprehensible alphanumerical format, prior to putting the product on display. Compliance challenges plagued this approach. The second-generation label exploited consumer familiarity with the first design to reduce the text and mostly use icons. Only the word energy was written in "ENERG" at the top with multiple endings for EU languages (except for Greek and Bulgarian which are written in full in smaller fonts). A more recent incarnation of the label for lamps amends this to "ENERG" with a lightning symbol (see Figure 9).

Figure 15: Examples of dual language comparative energy labels (Tunisia on the left and Canada on the right)



√ Additional supporting information

Provide more information without distracting consumers from the label's principal message about energy performance. Additional technical information may be required in the product's manual or technical fiche, such as the product sub-type and efficiency index, but it is not usually on the label. For the label, additional information often includes energy consumption per usage cycle or per year, based on an assumed annual use profile, capacity, functional performance (e.g. cleaning and drying performance for a washing machine), and ancillary aspects (e.g. noise).

For refrigerators, this typically includes:

- Estimated energy consumption annually (kWh/year).[31]
- Storage capacity (e.g. fresh food storage volume and frozen food storage volume in litres).
- Nature of the frozen food compartment (e.g. the IEC star rating from 0 to 4 stars).
- Rated power (W).
- Noise (dB) – sometimes this is optional as it is relatively expensive to test.

For air conditioners, this typically includes:

- Seasonal energy efficiency ratio (CSPF or equivalent, such as SEER) value, which indicates the cooling energy efficiency across part-load operating conditions (W/W)[32]).
- If a full-load energy efficiency ratio (EER) is used for the cooling efficiency ranking (rather than SEER), this should be indicated (W/W).
- Typical annual energy consumption in the cooling mode (kWh/year).
- Cooling capacity at full load (kW).
- Rated power demand (W).

[31] Power outages – unless sustained for a very long time – do not render this information irrelevant because the compressor has to work harder to bring the space back to temperature when the power resumes, so net annual energy consumption is likely to be reasonably similar to the rated consumption.

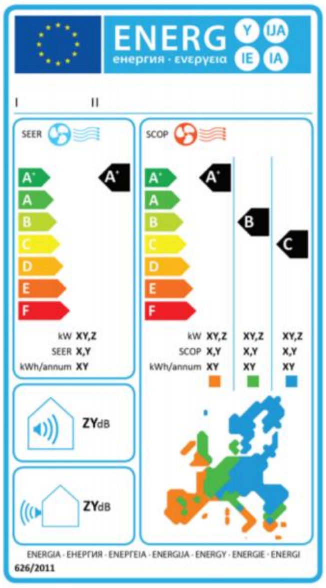
[32] A ratio of the cooling capacity delivered by a system in BTU/h to the power consumed by the system in watts (W) at any given set of rating conditions. 1 BTU/h is equivalent to 0.293 W. Here we use the units of W/W for the energy efficiency performance.

If the air conditioner is reversible (has a heating mode), the following is typically included:

- Seasonal coefficient of performance (SCOP, or equivalent) value, which indicates the heating mode energy efficiency across part-load operating conditions (W/W) and/or the annual performance factor which combines the heating and cooling performance (W/W).
- If a full-load coefficient of performance (COP) is used for the heating mode efficiency ranking (rather than a seasonal efficiency ranking), this should be indicated (W/W).
- Typical annual energy consumption in the heating mode (kWh/year).
- Heating capacity at full load (kW).
- Rated power demand (W).

Not all markets include the annual energy consumption for air conditioners, as these values may vary significantly from one user to another. Even in markets with relatively uniform climates, usage patterns can be quite different from a typical residential user to a typical commercial user. Energy labelling for air conditioners can be complex if the diversity of climate types being addressed is so large that a separate efficiency ranking is required for regions with different climates. The EU's air conditioner energy label is one of the few that currently reports different efficiency values and mnemonic efficiency rankings as a function of the climate. It does this via a graphic design that attempts to relate the ranking to locations on a map (see Figure 18).

Figure 16: EU energy label for reversible air conditioners showing different heating mode rankings as a function of the climate that are indicated via a map



√ Indicate the climate impact of the appliance

Address the impact of the energy use and global warming potential (GWP) of the refrigerants used in air conditioners and refrigerators, as well as the foam blowing agent GWP which is used for insulation. The Kigali Agreement to the Montreal Protocol calls for simultaneous action to address indirect and direct greenhouse gas emissions. While the refrigerant quantity and GWP is on the rating plate for service technicians, it may not impact purchasing decisions unless this information is clearly described in outreach campaigns. The following are potential approaches that could be considered:

- Include an endorsement for lower GWP refrigerant products. For example, GWP limits of 750 for split-system air conditioners, 150 for self-contained air conditioners, and 20 for refrigerating appliances are included in the U4E Model Regulation Guidelines. The German Blue Angel eco-label has a GWP limit of <10 and requires a SEER ≥ 7.
- Have one scale for energy performance and another for climate impact (as of this writing, there are no examples of this concept).

√ Insert a QR code that links to additional supporting information

With the increasing ubiquity of smart phones, some energy labels include web-links that can take consumers to pages with additional information that cannot readily be incorporated into the label. The QR code can be read by a smart phone app to display the information on the phone screen (see Figure 9), which may include:

- Estimated operating costs based on the current local energy tariff and information entered on the expected individual usage to derive a personalised calculation.
- Information on other products in the market to allow for comparisons.
- Technical details, such as additional performance information.
- Product manuals or operating guidance.
- Other information such as awards, certification, etc.

√ Layout of the label elements

The typical layout has text and symbols indicating the label's purpose and governance at the top, followed by the information on the manufacturer and model number. The next element is generally the energy performance scale. The additional information is then supplied, usually with slightly less prominence.

The mnemonic scale can affect this ordering. If a dial is at the top, the symbol indicating the governance and the model identification information can come below. Sometimes an implementing authority may also give prominence to additional information, such as the annual energy consumption or a seasonal energy efficiency rating value shown in large font next to, or beneath, the mnemonic. QR codes can be positioned at the bottom or righthand side.

√ Label pollution and exclusivity of use

Many energy labelling schemes have a tendency for suppliers or retailers to add extra private sector labels onto products with unofficial and often unverified claims. This is known as label pollution. Such private sector labels distract from the energy label and can undermine their impact. Include provisions that make it illegal to apply non-official labels on the appliance when an energy label is required to be displayed at the point of sale.

3.2 Step-by-step guidance to design endorsement energy labels

Endorsement labels are simpler to design than comparative labels as they only indicate that the product is endorsed for meeting certain requirements. There is no scale to communicate and usually no additional product information for comparison with other products. Nevertheless, the guidance for endorsement labels shares some considerations with comparative energy labels. For the design, a market research agency and graphic designer are usually hired to develop trial logos and gather input via focus groups. The logo may be a pure logo or include a strap line with short text to indicate the purpose. Because endorsement labels may be less self-evident than comparative labels, they need to be accompanied by a strong promotional effort. Typical design steps include:

1 Determine test methods, product categories, efficiency metrics and label threshold(s)

The same principles apply as for comparative labels. See Section 3.1.2 for information.

2 Determine the principal indicator

Endorsement labels are generally used to indicate that a product has attained a higher efficiency level. The choice of indicator is influenced by the motivation behind the endorsement label. For example, an environmental endorsement label could recognize a low GWP refrigerant and foaming agent in the case of refrigerators. The three main reasons to develop an endorsement label are:

- To complement a comparative energy label as an additional seal of approval for extra, non-binding quality (e.g. third-party certification of claimed energy performance that is above a mandatory minimum self-certification otherwise applied in a mandatory scheme). China's energy conservation certification label (see Figure 7) complements information in the mandatory comparative energy label. It is simply a logo with text to underscore the value of third-party certification. The US Energy Star label also requires third-party certification, but it complements a continuous comparative energy label.
- When there is insufficient political will to implement a mandatory comparative energy label but there is willingness among market actors to engage in a voluntary scheme.
- When the technology is evolving too rapidly for a comparative energy label, which is common for information technology products but not refrigerators or air conditioners.

3 Determine the choice of energy performance scale

When the label is to indicate attainment of higher than average energy efficiency, many of the same analytical steps as for comparative labels are required to settle on the efficiency threshold. It is important to know the distribution of products by efficiency on the local market and some indication of the BAT, IBAT and/or RBAT. Endorsement labels often apply a simple principle to set the threshold, such as the top 20 percent of products on the market. Endorsement labels need be updated more frequently than comparative labels. This requires regular monitoring of the efficiency of products sold and for the qualifying criteria to be periodically amended in response to the evolution in their efficiency. When a product is endorsed, it should include a timeframe in which the label can be used before suppliers must reapply. A version number should be designated to denote the version of the scheme and the applicable criteria. When products are in a product registration system, it becomes possible to create extra recognition for the highest efficiency products, as is done for the EPA Energy Star Most Efficient recognition.[33]

3.3 Label placement

Labelling regulations need to set out conditions regarding how, who, and when the label is to be placed and displayed. This is to ensure that the labels are displayed at the point of sale and able to inform purchase decisions. The regulations should place obligations on suppliers to provide labels to dealers. For example, for air conditioners and refrigerators, dealers are typically required to ensure the following:

Label display requirements applicable to air conditioners

- Air conditioners, at the point of sale (in-store or online), bear the label provided by suppliers on the outside of the front or top of the appliance, in such a way as to be clearly visible.
- Air conditioners offered for sale, or hire purchase, where the end-user cannot be expected to see the product displayed, are marketed with the information provided by suppliers as set out in the regulations.
- Any advertisement for a specific model of air conditioner contains a reference to the energy efficiency class, if the advertisement discloses energy-related or price information.
- Promotional material concerning a specific model which describes the technical parameters of an air conditioner includes a reference to the energy efficiency class(es) of the model and the instructions for use provided by the supplier.

Label display requirements applicable to refrigerators

- Refrigerating appliances, at the point of sale, including at trade fairs, bear the label provided by suppliers, with the label being displayed for built-in appliances in such a way as to be clearly visible, and for all other refrigerating appliances in such a way as to be clearly visible on the outside of the front or top of the refrigerating appliance.
- In the event of distance/online selling, the label is provided as set out in the regulations (specify, for instance, how to display the label on web pages).
- Any visual advertisement for a specific model of refrigerating appliance, including on the internet, contains the energy efficiency class and the range of energy efficiency classes available on the label as set out in the regulations.

[33] See Energy Star Most Efficient 2020: https://www.energystar.gov/products/most_efficient, accessed on 04 December 2020.

- Any technical promotional material concerning a specific model of refrigerating appliance, including on the internet, which describes its specific technical parameters includes the energy efficiency class of that model and the range of energy efficiency classes available on the label as set out in the regulations.

3.4 Generating labels

Generating labels can be carried out by various routes and best practice depends on the circumstances. Some jurisdictions, especially large economies, such as China and the United States, require suppliers to generate the label for their products according to a set of label design specifications and in accordance with the technical information derived via the conformity assessment requirements. In China, the QR code is automatically generated through the label registration system and then suppliers download it to generate the final label. In the EU, authorities provide a link to an automated label generation app which suppliers use to generate the label.[34]

Conversely, many economies with a product registration system (PRS)[35] require the label to be generated by the PRS operator and issued to the supplier once the product is approved. In India, suppliers pay the PRS operator for the label, which creates a revenue stream that can be used to support the PRS and potentially other activities, such as market surveillance. When officials generate and issue the labels for a PRS, they can control the process and ensure evidence is available to merit the label. However, if a vast quantity of products is anticipated, it may overwhelm authorities unless staff are adequately trained and resourced. Inadequate preparation can create delays and barriers that deter legitimate actors from supplying compliant products.

3.5 Online labels

Appliances are increasingly sold through e-commerce via online retailers, so mandatory energy labelling schemes include requirements for energy labels (label class and the other relevant information that would be displayed on a physical label) to be displayed in online sales materials. Rules should stipulate how much prominence this information should receive.

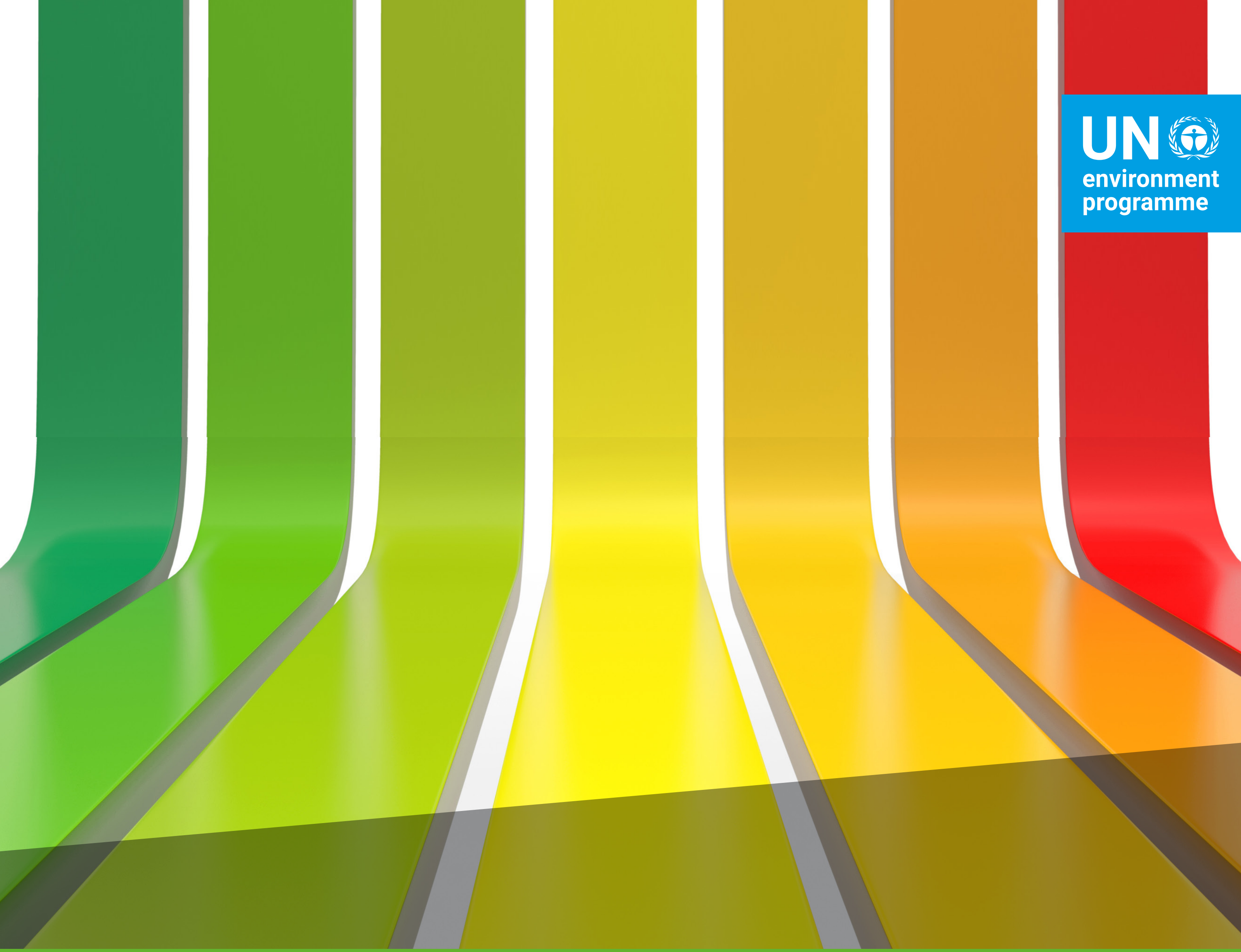
[34] The EU allows energy labels to be generated via their EPREL energy label product registration database or using the Energy Label Generator, available at https://ec.europa.eu/energy/topics/energy-efficiency/energy-label-and-ecodesign/energy-label-generator_en

[35] UNEP U4E (2020) *Product Registration System Guidance Notes,* include: 1) *What is a Product Registration System and Why Use One? 2) Planning to Build a Product Registration System? – Foundational Considerations* 3) *Planning to Build a Product Registration System? 4) Detailed Consideration Implementing a Product Registration*, all available at: https://united4efficiency.org/product-registration-systems/

3.6 Raising awareness

It is critical to accompany labelling with awareness raising activities to promote and explain the scheme. A good example of this is the recent energy labelling awareness campaign operated in Kenya.[36] Campaigns can be targeted exclusively at consumers and work with retailers who promote the label to consumers through their normal sales activities. Such schemes add value to the activities of retailers as they can help the public to understand that a new national labelling scheme is being inaugurated, and that it is operated by the government for the benefit of the public.

[36] CLASP (2020) *Designing a Consumer-Centric Energy Label Awareness Campaign in Kenya,* https://clasp.ngo/updates/2020/designing-a-consumer-centric-energy-label-awareness-campaign-in-kenya



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