UC Davis UC Davis Previously Published Works

Title

International Actions to Reduce Miscellaneous Electrical Loads Energy Consumption

Permalink

https://escholarship.org/uc/item/6zx1q6b3

Authors

Butzbaugh, J Meier, A Kini, R

Publication Date

2022

Peer reviewed



Building Technologies & Urban Systems Division Energy Technologies Area Lawrence Berkeley National Laboratory

International Actions to Reduce Miscellaneous Electrical Loads Energy Consumption

Josh Butzbaugh¹, Kini Roshan¹, Alan Meier²

¹Pacific Northwest National Laboratory, Richland, WA ²Lawrence Berkeley National Laboratory, Berkeley, CA

Energy Technologies Area May 2022

Butzbaugh, Josh, Kini Roshan, and Alan Meier. May, 2022. "International Actions to Reduce Miscellaneous Electrical Loads Energy Consumption." In *Energy Efficient Domestic Appliances and Lighting (EEDAL)*. Toulouse (France).



This work was supported by the Assistant Secretary for Energy Efficiency and Renewable Energy, Building Technologies Office, of the US Department of Energy under Contract No. DE-AC02-05CH11231.

Disclaimer:

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.

International Actions to Reduce Miscellaneous Electrical Loads Energy Consumption

Abstract

Miscellaneous electric loads (MELs) research dates back over 30 years, with the earliest publications about MELs originating in the late 1980s. As the number and types of MELs have grown during the intervening decades, so has the body of minimum energy performance standards (MEPS) and regulations put in place to control what is now a significant energy end use in the residential and commercial sectors. In particular, these MEPS are designed to control off-mode, standby, and connected standby power consumption to prevent energy waste.

Research on MELs focuses a great deal on analyzing the characteristics of MELs, approaches for measuring their consumption, and at a higher level what constitutes a MEL. Despite these advances, there have been few comparisons of different approaches to curtail MELs energy consumption across regulatory bodies of MELs—both between and within countries—to identify similarities, gaps, and opportunities for crafting common language and standards. This study provides an analysis of international MELs-related voluntary and mandatory MEPSs across 12 economies to address this gap. The analysis demonstrates that although economies may share the commitment to regulate the energy consumption of MELs, there still is no common language for framing MELs, nor is there a shared understanding for harmonizing MEPS for MELs.

Introduction

Miscellaneous electrical loads—MELs—in buildings are products outside the end uses of heating, ventilation, and air-conditioning (HVAC), refrigeration, water heating, lighting, and "white goods" (such as clothes washers). Hundreds of products fall into the "miscellaneous" category, including TVs, microwave ovens, elevators, and vending machines. Many MELs are not covered by energy efficiency regulations even though they collectively are forecasted to be responsible for a growing fraction of electricity use in buildings. One survey compiled MELs and estimated their energy consumption in the United States (U.S.) (Figure 1). MELs were found to be responsible for roughly a third of total electricity use in both residential and commercial buildings.

Figure 1 shows the large number and diversity of products that fall under the MEL category [1]. Together, MELs consume more energy than any other end use category and therefore warrant increased scrutiny. The MEL category also exists in other countries, though perhaps not yet at the extent or level of energy consumption found in North America.



Site electricity consumption, 2020 (TWh)

Figure 1. U.S. Site Electricity Consumption, 2020

(Source: U.S. Department of Energy, Building Technologies Office, 2022)

Goal of this Paper

This paper describes the range and scope of energy efficiency policies covering MELs internationally. We surveyed efforts by different countries to reduce MEL energy use. While not comprehensive, this information can nevertheless be used to share best practices and launch internationally-coordinated efforts to reduce the energy use of MELs.

The Landscape of Miscellaneous Electrical Loads

There is no widely accepted definition for MELs; indeed, it is often defined by what is excluded. Other terms are sometimes used for groups of products inside the MEL category, including plug loads, electronics, office equipment, small appliances, or simply "other." Energy modelers have even called the MEL category the "residual" after accounting for the conventional end uses. From a regulatory perspective, MELs might be defined as the set of products generally not covered by mandatory minimum energy performance standards (MEPS). Figure 2 is a Venn diagram depicting the MEL landscape.

MELs overlap with the collection of regulated products, though the extent varies by jurisdiction (e.g., region, country, state). For example, some jurisdictions regulate the energy efficiency of rice cookers, while others have no special policies directed toward their energy use. The term "plug loads" (referring to products that plug into a 120-volt outlet) covers most MEL products, but it can also include large household appliances) and does not include hardwired products; that is, components that are permanently wired into a building and do not have physical plugs (e.g., elevators). Consumer electronics—products whose primary function is processing or presenting information—are an important component of plug loads but can also receive power exclusively from batteries (as shown in Figure 2).



Figure 2. The Landscape of Miscellaneous Electrical Loads

No simple name or definition perfectly captures this diverse collection of devices. But this ambiguity does not prevent an exploration of the international landscape. It's important to note two significantly different categories of MELs. One category consists of very common products, each using very little energy. This category includes, for example, most consumer electronics. A second group of MELs consists of products that feature high per-unit energy consumption but are less common in the building stock. Residential elevators and commercial kitchen ventilators are examples. This diverse population of products complicates measurement and policymaking.

Some characteristics distinguish MELs from conventional (and mostly regulated) white goods and appliances (i.e., large electrical appliances used domestically, historically white in color). Not every MEL has all of these features, but many have several.

These features typically include:

- Each MEL represents a relatively small fraction of national energy consumption
- Connectivity to a local network or the internet (for new products)
- Less energy efficiency regulation and ratings relative to traditional end uses
- Features and services provided are rapidly evolving
- Embodied energy (i.e., energy use in production and disposal) may exceed the lifetime operating energy.¹

Each MEL has unique applications and power levels; hence, each device requires distinctive strategies to improve its power consumption. Nearly all new MELs involve standby power consumption; that is, they continuously draw power even when not in an operational mode. Standby power is used to maintain displays, including Light Emitting Diode (LED) status lights, as well as sensors and internet connectivity. Losses in power conversion from electricity mains to low-voltage DC also contribute to standby power consumption. Products with battery-charging capability typically feature continuous power consumption as well. Over the course of a year, standby energy consumption may be responsible for most of the product's total consumption, as is the case for many consumer electronics products. Popular video game consoles and TV sound bars are two examples. Alternatively, standby power

¹ Life cycle energy impacts of MELs are not discussed in this paper but are nevertheless important.

consumption may be modest compared to operational energy use (such as that in a pool pump or commercial transformer).

In the subsequent sections, we present high-level results from our survey of MELs. We begin with a description of our data-gathering methods. Then, we examine MELs policies in several economies to illustrate the range of policies. Finally, we examine several cross-cutting topics revealed by our survey.

Data-Gathering Approach

We examined mandatory and voluntary limits relevant to MELs² in 12 countries/economies and one U.S. state. The economies included Australia, Canada, China, the European Union (EU), India, Israel, Japan, New Zealand, the Republic of Korea (ROK), South Africa, Taiwan, and the United States, plus California. Approximately 170 different specifications and requirements for MELs were reviewed.

Our goal was to collect information about equipment type, power mode/state requirement, and the maximum power allowed for as many MELs as possible. The implementation year (also referred to as effective date) and target sector (residential/commercial/both) were also collected, when readily available.³ In practice, public information regarding MELs policies is difficult to find. The data are spotty because governments are inconsistent with the categorization of end uses and authority of programs. For example, some countries (such as ROK) established independent programs directed solely toward standby power for all products. Other countries include limits for MELs with refrigerators, water heaters, and other conventional appliances. Some countries have updated their policies but did not update the associated English-language information. Still others reference levels established by other authorities (such as ENERGY STAR). For these reasons, the findings described in this paper are incomplete.

The Collaborative Labeling and Appliance Standards Program's (CLASP's) Policy database served as the starting point for information about and data on standards and requirements. When the CLASP database did not contain certain information about a specific standard from a given nation, we viewed the nation's web pages on energy efficiency legislation, regulations, voluntary specifications, or labeling requirements for specific products, and other reports.

Findings

Some of the regulations and specifications applying to MELs are described below to illustrate the diversity of approaches and motivations internationally.

With more than 35, China had the most standards and requirements among the economies studied. China regulates many MELs that other countries ignore (or regulate for only standby power). For example, China has both performance and standby regulations for floor and table fans. It even created a three-level rating scheme [2].

Several countries—EU, Taiwan, ROK—have horizontal standby limits that address multiple MELs. In addition, the state of California is in the process of setting similar horizontal standby limits. At least six countries either refer to or base their mandatory and/or voluntary levels on ENERGY STAR voluntary specifications: Canada, China, EU, India, Japan, and Taiwan. Among these nations, ENERGY STAR requirements are used for specifications for TVs, computers, and office equipment, mostly with respect to sleep and standby modes. A subset of these nations only refers to the ENERGY STAR levels for setting standby power requirements.

The rest of this section summarizes the findings for certain economies and programs by providing background and examples. These examples are not intended to be comprehensive but illustrate the diversity of products covered, types of administrative action, and unique approaches.

² For this paper, MELs were defined as products outside the end uses of HVAC, refrigeration, water heating, and lighting.

³ Test procedures are an important consideration for MEPS, but our research was not intended to review test methods.

United States

The U.S. Department of Energy (DOE) conducts MEPS rulemakings primarily for end uses identified in a series of laws enacted by Congress, such as those listed in 42 U.S. Code § 6292. Thus, while DOE has conducted analyses and set MEPS for more than 60 end uses, called covered products, only a subset of MELs is included among them [3]. The U.S. Secretary of Energy can establish MEPS for any end use that exceeds 100 kWh annually per household and that is deemed appropriate by the Secretary [21]. The MEPS for nine MELs were reviewed for this paper: commercial ceiling fans, commercial clothes washers, commercial low-voltage dry-type distribution transformers, microwave ovens, miscellaneous refrigeration products (e.g., wine chillers), pool pumps, residential ceiling fans, residential dehumidifiers, and residential furnace fans.

Among MELs for which DOE has set MEPS, microwave ovens are unique because their MEPS only address power limits for standby mode and not active mode. DOE chose to regulate only the standby power consumption (rather than the cooking fraction) because it assumed that energy efficiency improvements for the magnetron were not feasible. Standby consumption for countertop microwaves must be less than 1 W and built-in units less than 2.2 W [4]. Microwave ovens can achieve standby power levels of 0.02–0.04 W using default automatic power-down functionality, and certain microwave oven models sold in ROK are equipped with this functionality. However, since this technology shuts off the clock display, DOE has screened this technology out for MEPS because of a related decrease in consumer utility. DOE is currently proposing to update the test procedure for microwave ovens to better address clock display energy and connected or networked microwave oven standby power [5].

Recently, technologies have appeared, such as solid-state amplifiers, that increase the energy efficiency of microwaves during active mode compared to magnetrons [6]. However, since the DOE test procedure only addresses standby mode energy, it's insufficient to measure the energy efficiency improvement from active mode improvements. This is a potential downside of addressing just one mode or aspect of a MEL's energy consumption through MEPS.

California

Similar to the DOE MEPS, U.S. state-level MEPS historically have targeted core loads rather than MELs for regulation. However, over the past 15 years, as DOE has expanded its scope of covered products and preempted states from regulating many core end uses, states have focused more on MELs. In particular, the California Energy Commission (CEC) has set MEPS for a wide range of MELs from battery chargers to TVs to portable electric spas. California was the first state in the U.S. to adopt appliance and equipment efficiency standards in 1977 and its authority pre-dates DOE. More recently, in December 2016, the CEC adopted the first-ever mandatory energy efficiency standards for computers and monitors in North America, covering five types of computers (desktops, notebooks, small-scale servers, workstations, and thin clients) and three types of monitors (computer monitors, gaming monitors, and enhanced performance displays) [7].

The CEC desktop computer standards set targets for annual energy use based on the power draw of idle, sleep, and off modes with minimum performance dependent upon the model's technological specifications and features. There are two tiers of standards for desktop computers. The initial tier of desktop standards took effect on January 1, 2019, and a more stringent tier of desktop standards became effective on July 1, 2021. The standards for monitors and notebook computers also set targeted annual energy use based on the power draw of active, sleep, and off modes [9]. The workstation and small-scale server standards require more efficient power supplies and Energy-Efficient Ethernet. The CEC's MEPS for computers and monitors are multifaceted in their application to technological modes and market features.

In April 2017, the CEC initiated pre-rulemaking activity to determine potential low power mode and power factor requirements with an aim of setting these requirements horizontally across different types of appliances and plug loads. As part of this pre-rulemaking activity, the CEC is using a new approach involving a roadmap for certain low power mode and power factor capabilities and corresponding voluntary requirements [10]. Thus far, the CEC has released an invitation to participate (similar to a request for information), an invitation for proposals, and a request for additional data (including a data

collection procedure) to interested stakeholders. Upon completion, the CEC's low power mode and power factor voluntary standards would be just the second horizontal standards implemented by the CEC, following the battery charger and external power supply mandatory standards. Several other U.S. states have adopted all or part of California's standards.

ENERGY STAR

In addition to mandatory federal and state-level MEPS, the U.S. has voluntary specifications and programs. ENERGY STAR[®]—a voluntary labeling program started in 1992 and run by the U.S. Environmental Protection Agency (EPA)—is intended to identify and promote the most energy efficient product models sold in the market. Manufacturers participate in ENERGY STAR so their products receive the label, which consumers use to inform their purchasing decisions and government agencies use for procurement.

ENERGY STAR has specifications for many MELs, ranging from commercial food service equipment (e.g., coffee brewers) to office equipment (e.g., printers, multifunction devices, voice-over-internet protocol phones, data centers) to electronics (e.g., computers, televisions, audio/video equipment, set-top boxes). Numerous countries harmonize with or refer to ENERGY STAR specifications and requirements for their own mandatory and voluntary standards, specifications, and requirements.

The ENERGY STAR specifications for set-top boxes (STBs) are unique because they vary with both the type of network connection as well as the additional features provided. There are seven different STBs that have base annual energy use requirements: cable, cable digital television adapter (DTA), satellite, multichannel video programming distributor internet protocol, thin-client/remote, terrestrial, and over the top internet protocol. Each of these STB types has its annual energy limit increased depending on its additional functionality, such as whether it is equipped with a cable card, digital video recorder, high-efficiency video processing, multi-room, Wi-Fi routing, and so on. In addition, a STB receives credit towards the annual energy limit if it provides deep sleep functionality, or if it saves power when sending content to remote client STBs.

Republic of Korea

The Korea Energy Agency (KEA) in the ROK has three national programs that aim to decrease the energy consumption of MELs. The Energy Efficiency Labeling and Standard was introduced in 1992 to mandate MEPS for commonly used products that consume a large amount of energy along with complementary labeling of those products with energy efficiency ratings ranging from level 1 to 5 (least to most energy consumption, respectively) [8]. Covered products include many MELs such as kimchi refrigerators, rice cookers, vacuum cleaners, battery chargers, TVs, and electric heating pads.

The KEA also implements the High-efficiency Appliance Certification program, which certifies highefficiency equipment and energy-saving facilities to promote energy conservation. In this voluntary program, a certification is issued to equipment meeting high levels of energy efficiency performance. The program includes 45 different products and equipment across 7 categories, which includes the Electricity Equipment category with MELs such as power supplies, motors, pumps, fans, and blowers. As a consequence of the large number of apartment buildings, ROK uniquely regulates the energy use of intercoms and home control pads (see Table 1) [11]. Note that the standby power limit for inapartment wall digital keypads and displays is zero watts, presumably relying on external actions (such as pressing a button or receipt of a signal) to activate the unit.

Table 1. Energy Regulations for Door Phones in Kor
--

Category	Standby Power Limit (W)
Mono-function door phone	1
Multifunction (video) door phone	5
In-apartment wall digital keypad and display	0

The KEA e-Standby program is a unique approach to reducing the standby power of end uses, primarily MELs, by using a combination of mandatory MEPS, reporting, and labeling. e-Standby has a mandatory reporting requirement for the standby power of 22 products, all of which are MELs. These 22 products are targeted to meet a standard of 0.5 W in standby mode. To meet this level, these products must automatically switch into energy-saving mode, thereby minimizing standby power. Manufacturers with products that meet the standard can voluntarily attach the energy-saving label to indicate compliance to consumers. However, products that do not meet the standard are required to have a warning label to indicate non-compliance [11]. The warning labels appear to have been used primarily as a threat to manufacturers and have not been widely applied due to manufacturer compliance.

European Union

The European Union (EU) has energy efficiency regulation jurisdiction for most of the countries within the European continent through its Ecodesign Directive, starting in 2005. The Directive covers standby and off mode power limits for MELs such as computers, TVs, audio and video equipment, microwave ovens, and electronic toys. In accordance with the Ecodesign requirements, these devices must not consume more than 1 W in standby mode with status display and 0.5 W in off-mode or standby mode without status display. In addition to the standalone power requirements, the EU proposed a time limit when certain MELs are required to switch to a lower-power mode [12]. The Directive is regularly updated and expanded to include new products. For example, the scope was extended to include motor-operated adjustable furniture, motor-operated building elements, and to further lower some network standby requirements

The EU has an informal policy that a MEPS can be established for a product only if the potential energy savings exceed 1 TWh/year in aggregate. This threshold eliminates many MELs. On the other hand, the EU's horizontal standby MEPS "captures" at least the standby energy portion of their electricity consumption.

Coffee machines are an example of a MEL with time limits for transitioning from active to standby mode. The time limits vary by the type of coffee machine:

Coffee machine types	Time limit before entering standby mode
Drip coffee machines with an insulated jug	Maximum of five minutes after brewing coffee or 30 minutes after descaling
Drip coffee machines without an insulated jug	Maximum of 40 minutes after brewing coffee or 30 minutes after descaling
Non-drip coffee machines	Maximum of (a) 30 minutes after brewing; (b) 30 minutes after activation of the heating element; (c) 60 minutes after activation of the cup preheating function; or (d) 30 minutes after the descaling process

Set-top boxes (STB) are another MEL with time limits for transitioning between modes. However, in the case of STBs, users can extend and override these time limits. STBs are required to switch to the lowest power mode after no more than four hours from the last user interaction, user-adjustable up to eight hours. Users may continue STB inactivity beyond the set period through an override. Additionally, the STB may exit standby to download content and scan for program and system information, but when doing so, it must re-enter standby mode no more than 15 minutes after completing the process.

The Ecodesign requirements also set limits for the electrical power consumption of products while in network standby mode. Networked standby is defined as a condition in which the equipment can resume a function through a remotely initiated trigger via a network connection [12]. The networked

standby requirement covers a wide range of MELs, including networked TVs and decoders, printers, game consoles, and modems. Network equipment are divided into two categories: those with high network availability (HiNA) and those without HiNA, and their requirements are as follows:

- Networked equipment with no network ports shall switch into standby mode in less than 20 minutes.
- Networked equipment with HiNA capability shall have a standby power mode (or equivalent state) that does not exceed 8 W.
- Networked equipment without HiNA capability shall have a standby power mode (or equivalent state) that does not exceed 2 W.

Exceptions to the standby power requirements for network equipment apply to large format printing equipment, desktop thin clients, workstations, mobile workstations, small-scale servers, and computer servers due to their usage profiles.

The EU periodically reviews trends in energy consumption to identify new products for regulation [13]. For example, electronic displays have been identified as products that offer significant energy-savings potential. The EU reviewed different labeling elements with stakeholders and interested parties by analyzing technical, environmental, and economic aspects of electronic displays. In a related action, modifications were made to the EU's energy label beginning in March 2021. Notably, a QR-Code was introduced in the upper right corner of the label, which now leads to the label database and additional product information. This measure facilitates consumer access to more recent product information, which is particularly relevant to the rapidly evolving MEL sector.

Although EU performance standards were developed prior to Brexit, legislation existed after the transition period to ensure that MEPS and energy labeling remain enforceable in the United Kingdom (UK). Furthermore, UK presented Ecodesign regulation in 2021 which ensures that the UK's Ecodesign regime remains aligned with the post-Brexit EU's regime [28]. However, as per sustainable product initiative, EU proposed the overhaul of the Ecodesign regime with the intention of expanding its scope beyond energy-related products, which may diverge the EU and UK regimes in coming years. In addition, UK introduced more stringent energy efficiency rules on household appliances and imposed a legal obligation on manufacturers to facilitate repairs.

India

India has per capita energy consumption nearly a third of the global average and one of India's challenges is to provide reliable electricity access to its 1.3 billion citizens. Additionally, with rapid urbanization, construction of new houses is gaining significant momentum, driving increased energy consumption. India's Bureau of Energy Efficiency (BEE) established MEPS for a wide range of appliances, including some MELs. Table 2 lists the MELs covered by BEE standards and labels [14]. The policies include certain MELs, such as agricultural pump sets and power inverters, that are less common in other countries and thus unaddressed through standards and labeling programs.

Table 2. MELs Covered by BEE Standards and Labels

Appliance Name	Category
Color Television	Mandatory
Distribution Transformer	Mandatory
Agricultural Pump Sets	Voluntary
Ceiling Fans	Voluntary
Solid State Power Inverter	Voluntary
Computer (Notebook/Laptops)	Voluntary

Office equipment (printer, copier, scanners)	Voluntary
Microwave Oven	Voluntary

In 2021, BEE proposed a roadmap for smart home and residential energy efficiency for improving the energy efficiency of both the existing as well as new buildings. This roadmap endorsed ENERGY STAR certified Smart Home Energy Management Systems where requirements and maximum standby power limits for two residential MELS were defined, as shown in Table 3 [15].

Table 3. Maximum Standby Power Limits in Smart Home Roadmap [14]

Device Category	Requirements	Maximum Standby Power
Connected thermostat	ENERGY STAR certified	3.0 W
Plug load monitor/control	Includes smart plugs, smart power strips, and home energy monitors; must be capable of reporting power or energy consumption.	1.0 W

China

China has three programs for setting energy efficiency standards and labeling requirements. The China National Institute of Standardization (CNIS) began setting national MEPS in 1989 and has since expanded the coverage across a wide range of appliances and equipment [16]. For certain products, CNIS uses multi-tier standards with set timelines for transitioning from one tier to the next. In October 2021, China issued revised standards for residential fans, including table fans, box fans, wall-mounted fans, floor fans, pedestal fans, and ceiling fans. These standards are designed using three energy efficiency grades to address fan energy efficiency when a fan is in operation using a minimum ratio of output air volume to input power, as well as standby power when a fan is not operating. The revised standards become effective in November 2022 [2].

The China Standard Certification Center (CSC) started the voluntary energy efficiency labeling program in 2001 to implement standby loss requirements and specifications for TVs, and then expanded the program to include other MELs such as printers, DVD players, computers, monitors, fax machines, and copiers in subsequent years [17]. The CSC collaborated and harmonized with ENERGY STAR in the development of some of its voluntary specifications.

In 2005, the CNIS launched a categorical mandatory energy information label, similar to the EU label, to inform consumers of a product's energy efficiency performance. Initially, the CNIS label covered two products; today it covers more than 40 products, including MELs such as computer monitors, electromagnetic stoves, photocopiers, rice cookers, three-phase motors, and fans [18]. In August 2021, China issued mandatory energy efficiency labeling requirements for flat-screen TVs, STBs, three-phase motors, power transformers, and fans. These requirements complement the revised energy efficiency grades established in 2020.

Taiwan

The Taiwan Bureau of Energy has established MEPS for 25 product categories, including some MELs such as dehumidifiers, motors, electric hot water pots, chilled and hot drinking water dispensers and fountains, electric rice cookers, gas stoves, and air compressors [19]. Standards are revised with the intent of eliminating the least efficient 15–30% of products from the market.

Taiwan has also developed a voluntary energy efficiency labeling program to encourage consumers to purchase more energy efficient products [20]. The voluntary labeling program contains a large number

of products and many MELs such as TVs, fans, dehumidifiers, hair dryers, hand dryers, chilled/hot drinking water dispensers, computer monitors, electric rice cookers, electric pots, audio systems, photocopiers, printers, air cleaners, laptop computers, desktop computers, microwave ovens, external hard drives, and uninterruptible power supplies. Notably up until 2018, TVs and displays were the only products with voluntary specifications only for limiting standby power.

In July 2010, Taiwan introduced a mandatory energy efficiency rating labeling program to provide consumers with useful information and validate the energy efficiency performance of products. As of March 2019, the energy efficiency labeling program included 12 categories of products with the most recent requirement addressing air compressors—an important and overlooked MEL—in 2021.

Characteristics of Energy Policies Toward MELs

In this section, we describe several features of policies directed toward MELs that were revealed during our survey.

Oversight Bodies

Countries rely on different legislative mandates to establish regulations and programs directed toward addressing MELs. Energy efficiency legislation typically requires products to consume significant amounts of energy at the national level before action can be taken. The EU has no formally defined threshold but, informally, regulations will not be considered for products whose potential savings is less than 1 TWh/year. This excludes most MELs. As noted previously, the U.S. Secretary of Energy can establish MEPS for any end use that exceeds 100 kWh annually per household and that is deemed appropriate by the Secretary [21]. Many MELs have national consumption or savings potentials below these thresholds, so no regulatory oversight is triggered. The CEC has a mandate to regulate any product as long as the required energy efficiency improvements are cost effective and result in substantial energy savings. The voluntary ENERGY STAR program has no quantitative threshold beyond "significant national energy savings"; instead, it aims to label products recognized as widely available and cost effective to purchasers, and offer functionality and features the equivalent to or better than conventional products [22].

Standby Power in MELs

The standby mode is the most frequently tracked and regulated aspect of MEL energy use. Unlike other aspects of electrical products, standby power use can be isolated and measured. For some products covered by MEPS, such as microwave ovens and table fans, efficiency specifications cover only standby energy consumption and ignore operational energy consumption. A narrower group of MELs—those with external power supplies—may need to comply with minimum efficiency requirements for just the power supply. Several economies have established "horizontal" regulations, covering categories of products, related to standby power. This creates situations where only a part of an MEL's energy use is regulated. A test procedure exists (IEC 62301) that can be applied across a wide range of products [23].

Certain groups of MELs—notably networked products and those with displays—are allowed to conform to higher standby power levels. The EU distinguishes these products by their network availability (high or low). In contrast, China distinguishes them by network technology, such as Bluetooth. Other products may have unique standby limits because of some technological constraint—such as maintaining security—or historical accidents.

Sleep-Mode and Power Management Requirements

An increasing number of MELs are required to transition into a sleep mode after a period of inactivity. Sleep mode is a low-power mode, which is often treated as a kind of standby. Sleep modes are integrated primarily in consumer electronics, in which the display, hard disk, and other unneeded system components are switched off, but memory is continually refreshed to retain their contents and allow for quick restoration to active mode through external intervention.

ENERGY STAR established the first sleep-mode feature in 1992, but it and other programs have subsequently added many MELs, including computers, TVs, STBs, printers, copiers, escalators, vending machines, rice cookers, water dispensers, and coffee makers. Transitioning from active to sleep mode (after a set amount of time) is the second-most common international policy action directed toward MELs (as either a regulation or a voluntary specification). Manufacturers have voluntarily created sleep modes for products, such as elevators, as an energy-saving measure. They've also created sleep modes to extend battery life of certain consumer electronics, which is a key feature marketed to consumers. Indeed, manufacturers of battery-powered devices have developed advanced methods to maximize lower-power sleep modes during inactivity, even reducing the time duration for devices to wake up so consumers have a seamless device usage. Both electronic and motorized MELs could be similarly redesigned to power-scale to reduce operating energy consumption.

Nontraditional Motivations for MELs Policies

Some regulations pertaining to MELs have been developed outside of conventional energy ministries and agencies. For example, health and safety agencies may be responsible for ventilation and electrical codes that impinge on MELs [24]. In California during the tragic wildfires of 2018, several people were stranded because the power outages prevented garage doors from opening. As a result, the California Legislature enacted a regulation mandating all garage door openers to be equipped with batteries so that they can still open when power is cut.

Health and safety regulations for new homes are also responsible for many new products, few of which have their own energy specifications. Figure 3 shows the growth of these products in new California homes over the past 45 years as a result of gradually stricter building codes. Because of concerns about possible liabilities, the EU, U.S., and other countries have exempted health and safety products from energy efficiency limits.



Figure 3. Growth in Residential Life-Safety Devices Required in New U.S. Homes Estimated current number of individual devices in an average home are shown on the right. Adapted from Rainer et. al. 2021. [24]

MELs and COVID-19

Products in the MELs category (and the way they are used) can be unusually dynamic compared to more conventional white goods and HVAC equipment. An example of this dynamism is reflected in products related to the COVID-19 pandemic. Table 4 illustrates some of the MELs that increased in market uptake, and likely in annual average operating time, in response to COVID-19. These products and behaviors illustrate the challenges of developing test procedures and then energy performance specifications. One policymaking dilemma involves how to adjust current or develop new energy test procedures as these products evolve in their usage profile and increase their prevalence in the market.

Purpose	Household Appliance
Reduce infection risk in homes	24-hour ventilation system and total heat exchanger
Virus removal	Filter air purifier
Virus removal	Virus vacuum cleaner
Maintain healthy humidity level	Humidifier
Virus inactivation and sterilizer	Sterilization deodorizer, lamps, virus-killer air system
Prevent contact-related infections	Voice-controlled equipment, smart speaker
Touchless operation	Automatic doors, delivery boxes with wireless connection

Table 4. Residential MELs and Usage Patterns Caused by COVID-19

Adapted from Omori, Hideki, and Akihiko Kanouda (2021) [25]

Challenges of International Harmonization

Harmonization of performance standards for MELs is especially important because high-volume products are frequently internationally traded, and multiple, differing requirements present significant trade barriers. An example is consumer fans. The EU recently considered establishing a MEPS for comfort fans [26]. However, an EU study found that the energy efficiency data were not reliable enough to set MEPS and energy labeling requirements. In particular, false declarations by manufacturers were a significant problem. The EU considered adopting MEPS based on the requirements set in China and Taiwan. Unfortunately, the required energy efficiency levels were unattainable when measured on the basis of the international test procedure (i.e., IEC60879). Adoption of the proposed requirements would risk a complete ban of most fans in the European market. Ultimately, the EU was unable to identify the least life cycle cost level for fans. Brazil also adopted labeling and minimum efficiency requirements for fans, but the efficiency calculation method is slightly different and the efficiency levels appeared to be considerably lower than those in China/Taiwan.

Conclusions

MELs are an important fraction of global electricity consumption and appear to be growing. Many countries and oversight authorities have developed mandatory and voluntary MEPS for an assortment of MELs. However, these countries have not adopted a consistent approach for regulating or labeling them despite an international market for many MELs. Therefore, internationally coordinated actions to improve MELs energy efficiency, such as ENERGY STAR and the IEA standby power initiative, are likely to be more effective.

The most common policy action toward MELs has been voluntary or mandatory regulation of standby power use. These actions are typically in the form of product-specific limits (such as for TVs) or, more recently, horizontal standby regulations that apply to virtually all products. Alternatively (or in addition), some authorities regulate external power supplies horizontally for a smaller set of products. A slightly

higher horizontal standby level may be applied to networked products. Authorities have adopted different approaches for defining networked products. For example, Europe uses the HiNA criterion, while China uses the type of network (e.g., Bluetooth) as the criterion.

Policies related to sleep mode are the second-most common action toward MELs. This concept began with computer displays but has been applied to products as diverse as rice cookers and elevators. The energy savings from shifting from an operating mode to a sleep mode often overwhelms potential energy savings through reduced standby (when successfully applied). Sleep-mode policies are almost always product-specific and have not been standardized. To date, there are no "horizontal" requirements or guidelines for sleep-mode behavior, even though some product categories could easily apply.

Many countries have mandatory policies to limit energy use of a few MELs. China has been the most assertive in terms of number of products covered, addressing over 40 products that could be considered MELs [27]. These products are sometimes unique to the country. For example, East Asian countries have addressed rice cookers, India targeted power inverters and agricultural pump sets, and the EU has addressed coffee makers. China, Europe, and Brazil adopted (or at least considered) limits on fans; however, no harmonization was possible owing to differences in test procedures, efficiency levels, and unreliable measurements reported by manufacturers.

This survey shows that international policies to limit MELs electricity use are scattered and inconsistent even though the savings potential is large. International cooperation and harmonization are one strategy. At the same time, new policies and approaches may be needed to address this dynamic sector.

References

- [1] U.S. Department of Energy. "Building Electric Appliances, Devices, and Systems." Last accessed January 2022 at: <u>https://www.energy.gov/eere/buildings/building-electric-appliances-devices-and-systems</u>
- [2] Aoki, K. "China issues revised mandatory standards for energy efficiency of fans." Envillance ASIA. December 2021. Last accessed January 2022 at: <u>https://envillance.com/regions/east-asia/cn/report_4885</u>
- [3] U.S. Department of Energy. *Saving Energy and Money with Appliance and Equipment Standards in the United States*. Office of Energy Efficiency and Renewable Energy, Washington, D.C. 2017.
- [4] Title 10 Part 430. U.S. Code of Federal Regulations. Title 10, Chapter II, Subchapter D, Part 430, Subpart C. Available at <u>https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32</u>
- [5] U.S. Department of Energy. *Appliance and Equipment Standards Rulemakings and Notices: Microwave Ovens*. Office of Energy Efficiency and Renewable Energy, Washington, D.C. Last accessed December 2021 at <u>https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=33</u>
- [6] J. C. Atuonwu & S. A. Tassou (2019) Energy issues in microwave food processing: A review of developments and the enabling potentials of solid-state power delivery, Critical Reviews in Food Science and Nutrition, 59:9, 1392-1407, DOI:10.1080/10408398.2017.1408564
- [7] California Energy Commission. 2017. *Appliance Efficiency Rulemaking for Computers, Computer Monitors, and Signage Displays*. California Energy Commission. Sacramento, CA.
- [8] Korea Energy Agency. "Energy Efficiency Labeling and Standard." Last accessed December 2021 at: <u>https://dco.energy.or.kr/renew_eng/energy/appliances/labeling.aspx</u>
- [9] California Energy Commission. October 1, 2020. Amended Title 20 Computer and Monitor Regulations, Express Terms. Last accessed January 2022 and available at: <u>https://efiling.energy.ca.gov/GetDocument.aspx?tn=234975&DocumentContentId=67850</u>
- [10] Pasha, S. August 25, 2021. Low Power Mode Roadmap. California Energy Commission. Last accessed January 2022 and available for download at: https://efiling.energy.ca.gov/GetDocument.aspx?tn=239448&DocumentContentId=72910
- [11] Korea Energy Agency. "e-Standby Power." Last accessed December 2021 at: https://dco.energy.or.kr/renew_eng/energy/appliances/program.aspx
- [12] Ecodesign regulation 801/2013. Official Journal of the European Union. 2013. Available at: <u>https://www.eceee.org/static/media/uploads/site-2/ecodesign/products/lot26-networked-standby-losses/reg-801-2013-standby-losses.pdf</u>
- [13] EUR-Lex. "Commission Delegated Regulation (EU) 2019/2013 of 11 March 2019 supplementing Regulation (EU) 2017/1369 of the European Parliament and of the Council with regard to energy labelling of electronic displays and repealing Commission Delegated Regulation (EU) No 1062/2010." Available at: <u>https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L .2019.315.01.0001.01.ENG&toc=OJ:L:2019:315:TOC</u>
- [14] India Bureau of Energy Efficiency. *Impact of Energy Efficiency Measures for the Year 2019-20*. Ministry of Power, Govt. of India, New Delhi. March 2021. Can be downloaded at: <u>https://beeindia.gov.in/sites/default/files/BEE_Final%20Report_Website%20version_0.pdf</u>

- [15] India Bureau of Energy Efficiency. Smart Home Program Technology Assessment Study and Pilot Design, Report on National Policy Roadmap for Home Automation Technologies for Residential Energy Efficiency. July 2021. Last accessed December 2021 and can be downloaded at: <u>https://beeindia.gov.in/sites/default/files/BEE_Report%20on%20National%20Policy%20Roadm ap%20for%20Home%20Automation%20Technologies%20for%20Residential%20Energy%20Ef ficiency.pdf</u>
- [16] Zhou, N. Status of China's Energy Efficiency Standards and Labels for Appliances and International Collaboration. Lawrence Berkeley National Laboratory. Berkeley, CA. March 2008.
- [17] Bran I., Luo J., Webber C., and Lin J. "Plug Loads and Energy Efficiency Programs: Focusing on the U.S. and China." In 2006 ACEEE Summer Study on Energy Efficiency in Buildings. Pacific Grove, CA. August 2006.
- [18] International Energy Agency. "China Energy Label Law." April 2021. Last accessed January 2022 at: <u>https://www.iea.org/policies/634-china-energy-label-law</u>
- [19] Taiwan Bureau of Energy, Ministry of Economic Affairs. "Efficiency Standards and Benchmarks." Last accessed January 2022 at: https://www.moeaboe.gov.tw/ECW/english/content/Content.aspx?menu_id=1535
- [20] Enviliance ASIA. "Taiwan, Product energy saving & environmental label related." Last accessed January 2022 at: <u>https://enviliance.com/regions/east-asia/tw/tw-label</u>
- [21] 42 U.S. Code §6292(b). "Unannotated Title 42. The Public Health and Welfare § 6292. Coverage." Available at: <u>https://codes.findlaw.com/us/title-42-the-public-health-and-welfare/42-usc-sect-6292.html</u>
- [22] U.S. Environmental Protection Agency. *ENERGY STAR Products Program Strategic Vision and Guiding Principles*. 2012. Last accessed December 2021 at: <u>https://www.energystar.gov/ia/partners/prod_development/downloads/guiding_principles_2012</u>. <u>pdf</u>
- [23] International Electrotechnical Commission. "IEC 62301 Household electrical appliances measurement of standby power." Geneva, Switzerland. 2011.
- [24] Rainer L., Meier A., and Hosbach R. "Energy Use of Residential Safety, Security, and Health Devices." *Energy and Buildings* 250 (November 1, 2021): 111217. https://doi.org/10.1016/j.enbuild.2021.111217.
- [25] Omori H. and Kanouda A. "A Trend of Home and Consumer Appliances in Japan: The Past 50 Years and the Future." *IEEJ Transactions on Electrical and Electronic Engineering* 16, no. 3 (2021): 340–48. <u>https://doi.org/10.1002/tee.23302</u>.
- [26] European Commission. "Implementing Directive 2009/125/EC of the European Parliament and of the Council with Regard to Ecodesign Requirements for Air Conditioners and Comfort Fans." COMMISSION STAFF WORKING DOCUMENT, Full Impact Assessment Accompanying the document Proposal for a Commission Regulation. Accessed January 10, 2022 at: <u>https://ec.europa.eu/energy/sites/ener/files/documents/en_impact_assesment.pdf</u>
- [27] Enviliance ASIA. "China Energy Saving Label." Last accessed January 2022 at: https://enviliance.com/regions/east-asia/cn/cn-energy/cn-energy-saving-label
- [28] United Kingdom Statutory Instruments. 2021, No. 745. The Ecodesign for Energy-Related Products and Energy Information Regulations 2021. June 18, 2021. Last accessed May 2022 at: https://www.legislation.gov.uk/uksi/2021/745/pdfs/uksi_20210745_en.pdf