Setting MEPS for Electronic Products: U.S. and EU Experience to Date and Ways Forward

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ABSTRACT

As electronics' share of total electricity consumption has increased, efficiency proponents and regulators have increasingly looked to minimum efficiency performance standards (MEPS) as one of the tools for fostering improved electronic product efficiency. But the fast-moving nature of electronics technology with respect to both product characteristics and efficiency makes development of meaningful MEPS more challenging than for home appliances. Can effective MEPS be designed for these products without constraining technology evolution? Can standards yield long-lasting energy savings when Moore's Law and mobility drive rapid natural market evolution in electronic devices? How can optimal MEPS levels be agreed upon when traditional cost-analysis approaches hardly apply?

This paper will describe the main challenges related to MEPS in the electronics sector and assess the strategies used by existing EU, U.S., and California efficiency regulations and how well they have worked. Standards assessed include the EU Ecodesign regulations for computers, simple set-top boxes, and network standby; the California standards for battery chargers; the EU and California standards for televisions; and the EU, California, and U.S. standards for power supplies.[1] Voluntary agreements—an alternative or complementary approach proposed for standards for some electronics products in the European Union and United States—will also be assessed.

The recommendations of this paper include designing and implementing MEPS for electronics that keep pace with rapid development cycles, setting short-term and long-term goals through multiple tiers, combining horizontal and vertical standards, and, where necessary, finding creative solutions beyond MEPS to drive savings.

Why Does the Energy Use of Electronic Products Matter?

Many studies and reports have raised the alarm on the growing power consumption of electronic products (e.g., US EIA 2014). *Gadgets and Gigawatts*, a report from the International Energy Agency, forecasts a threefold increase in the global energy use of these devices by 2030 if nothing is done (IEA 2009). This increase would translate into 1,700 TWh of annual electricity use in the global residential sector, equivalent to twice the current overall household electricity consumption of the European Union (JRC 2012).

While the energy use of more traditional appliances (such as refrigerators and clothes washers) has declined thanks to a long history of minimum efficiency performance standards

[1] Where possible, results for assessed standards are expressed in expected annual terawatt-hour savings achieved in 2020.

(MEPS) and energy labeling policies in most developed countries (Mauer et al. 2013), consumption associated with electronic products is still rising. A striking illustration: playing a powerful gaming PC for 2 hours will consume as much electricity as is required to operate a standard-size refrigerator for 24 hours. Given the past success and potential of U.S. and EU MEPS and energy labels for saving energy in many product categories (Lowenberger et al. 2012; CSES 2012) and the growth in energy use of electronic products, efficiency proponents and regulators on both sides of the Atlantic have naturally and increasingly looked to these methods as a policy tool to address this growth.

In this paper, we first provide an overview of the particular challenges inherent in developing MEPS for electronic products. We then describe some of the general approaches taken to date for electronic product MEPS and discuss specific standards adopted or under development in the European Union and United States. We then provide some general recommendations for future electronics MEPS.

Challenges in Developing MEPS for Electronic Products

Electronic products cannot necessarily be regulated in the same way refrigerators are. Certain differences call for designing MEPS and labeling policies that can overcome some specific challenges.

Fast technological change. It is a no-brainer: Technologies are evolving quickly in the electronics area, faster than in the appliance sector. For example, Apple released its first iPad in April 2010; four years later, tablets are projected to outsell PCs (IDC 2013). Computer models are typically only sold for six to nine months before they are replaced by a newer model.

If the development and updating process of MEPS takes too long (e.g., up to several years, as is frequently the case for appliance MEPS), there is a risk of constantly missing substantial savings opportunities achievable in current products and developing efficiency requirements that are outdated when they go into effect (Siderius 2014). As an example, technologies in TVs have changed drastically in recent years with the use of solid-state backlighting. The EU MEPS enforced in 2010 and 2012 were based on a 2007 technical study in which this trend had not been adequately anticipated. As a result, the MEPS levels have been largely ill-designed and have had little impact on the market (Toulouse et al. 2012).

Integration of functions. While a refrigerator has a simple and straightforward function (to keep food cool) upon which it is relatively easy to design an energy performance metric, electronic products are becoming more and more integrated and able to perform multiple tasks. This is stimulated by miniaturization and wireless networking capabilities. Examples of this include new laptop–tablet hybrids, game consoles that also offer video functions, and TV screens that can also be computer monitors and vice versa. This integration presents many challenges: 1) finding a robust and long-lasting definition for the products to be covered in a MEPS scope, 2) defining a test method that encompasses all features, and 3) developing an assumed duty cycle that will remain representative of the use of these devices in the real world. These are some of the key considerations of MEPS development, and overlooking them risks creating loopholes in the regulations and wasting significant parts of expected savings.

Typical cost–benefit relationships often do not hold. MEPS set in the United States and European Union (as well as other countries) are usually price/cost-based through identifying and targeting an economical efficiency point for consumers. This approach supposes that a more efficient product is more costly and there is a tipping point at which additional improvements do not pay off over the product lifetime. This point guides the level of ambition of the policy instruments. However, for electronic products, the correlation between a product's efficiency and its price is often not obvious (Siderius 2014; Toulouse 2013). Efficiency can be achieved through a different silicon chip design or power management features that can be implemented in software using existing hardware without necessarily translating into higher production costs. So we have to determine how to set effective MEPS in this context. Possible options include shifting from life cycle cost-based MEPS to standards based more on product availability (similar to how ENERGY STAR® levels are set) or using a benchmarking approach (such as Top Runner in Japan).

Globalization. Electronic products are mostly manufactured by global brands and traded across the world. Regional variations in testing standards and regulatory requirements are seen by industry as a burden. As a result, producers and importers tend to favor international harmonization. Examples following this path are the joint use of ENERGY STAR in the United States and European Union, and the increased use of an International Electrochemical Commission (IEC) standard to measure standby power use of electronics. However, reaching an international consensus and agreement on a topic may take a long time and is not always guaranteed (Ellis and Rozite 2013). Global harmonization has made little progress so far, and there is a risk of delaying related policy decisions. One illustration is the current request from game console manufacturers to design an international measure for their products, which contributed to stalling progress on the process started in the European Union in 2012. In addition, while harmonization may be used for pulling up standards if initial standards in some jurisdictions are strong, it can also be used as an argument against a jurisdiction considering standards stronger than those already existing elsewhere.

A MEPS Taxonomy

Historically, most MEPS regulate a specific end-use product (e.g., refrigerators, water heaters, etc.). These "vertical" standards can constrain the overall energy use of the device based on an estimated typical usage pattern (e.g., annual energy consumption [AEC] or an energy-use factor). Alternatively, product-specific standards can restrict energy use in one or more specific modes or operating conditions (e.g., watt limits while in standby or efficiency at a given load). Vertical standards can also address particular components of the overall product (e.g., commercial refrigerator lighting). Hybrid approaches can combine total consumption limits with modal limits and/or component standards.

"Horizontal" standards offer a complementary approach. A horizontal standard may set energy or power-use limits for a particular mode (e.g., standby) across many product categories at the same time or regulate a generic component (e.g., an external power supply) that is used across many product categories. Horizontal standards are less common than vertical.

Each variant of the vertical and horizontal approaches has been tried for electronic products. There is no silver bullet though. Horizontal standards target huge scopes and, therfore, have large potential savings. But by their nature they must be more generic, and may be suboptimal for a part of the covered product group and/or include many exemptions. Once a horizontal standard is set, it is important to retain the possibility of being more aggressive in a vertical one. (This is the approach currently followed in the European Union for horizontal standards addressing a mode such as standby.)

Televisions, Computers, and Set-Top Boxes—Vertical Standards

Televisions. California set initial standards for televisions in 2006 that limited standby-passive-mode energy consumption to 3 watts or less. In late 2009, California adopted revised standards lowering the levels for standby-passive mode and setting new active-mode and power factor requirements. Tier 1 of the new standards took effect in January 2011, and Tier 2 in January 2013. California based its Tier 1 standards on ENERGY STAR version 3.0. Tier 2 standards (currently in effect) became effective on January 1, 2013, and increased the stringency of maximum active-mode power consumption based on ENERGY STAR version 4.0 requirements. In calculating active-mode energy consumption, manufacturers are given credit for incorporating automatic brightness controls, which automatically adjust the brightness of the television based on the ambient lighting conditions.

Pacific Gas and Electric (PG&E), the California utility that proposed the television efficiency tiers, estimates that the standards will save California 5.9 terawatt-hours (TWh) each year by 2020 and 6.5 TWh a year by 2023 (3.8 TWh from Tier 1 and 2.7 TWh from Tier 2) after Tier 2 stock turns over.[2] The standards will result in savings of $912.1 million per year on Californians' electricity bills.[3]

The California Energy Commission (CEC) does not have any immediate plans to revise its standards. ENERGY STAR implemented version 5.0 in 2011 and version 6.0 in 2013, each relying on progressively lower modal limits. ENERGY STAR version 5.0 introduced the concept of sufficiency, setting a maximum limit for TVs over 50 inches. ENERGY STAR will initiate its process for the development of version 7.0 in 2014, and it is expected to go into effect sometime in 2015. The ENERGY STAR specifications have driven large market shares for compliant products, as seen in 2012, when 84% of US TV shipments met or exceeded ENERGY STAR v5 levels (EPA 2013).

Developing effective MEPS for TVs in Europe has proven challenging. Initially the European Commission estimated that annual electricity savings from adopted measures would total 43 TWh by 2020 (28 TWh through the MEPS and the rest through labeling efforts). In reality, it is now clear that those estimates were largely inaccurate. TVs placed on the market were able to claim better efficiency levels than anticipated, partly through a faster deployment of solid-state lighting and partly through a change in testing conditions. The MEPS have had little additional impact on the market (Toulouse 2012; CSES 2012).

Because of this, the European Commission initiated a revision process for TV MEPS and labels in October 2012, proposing the following changes:

- Set significantly stricter tiers for the on-mode power consumption in 2014, 2016, and 2017.

[2] Pacific Gas and Electric (prepared by Alex Chase), 2008. *CASE Initiative for PY2008: Title 20 Standards Development. Analysis of Standards Options for Televisions (Revised Proposal)*

[3] Assuming $0.14 per kilowatt-hour

- Refine/strengthen the power management in various modes as well as the peak luminance ratio provisions.
- Review the proposed MEPS four years after it becomes effective in order to keep pace with the fast technological evolution of these products.

The process (which has been stalled) is expected to conclude in 2015. Notably, the ongoing review process presents a good opportunity to increase the focus on absolute energy consumption and address the problem of bigger and bigger TVs consuming more electricity. The use of a logarithmic regression line (instead of the linear one currently used for TVs), concerning the relationship between screen area and power consumption, could be a way to achieve this.

TVs also provide a good example of test procedure harmonization, which can help lower industry costs. In general, TV test methods used in various jurisdictions have been based on those procedures developed by the IEC.[4]

Computers. The European Union adopted its first MEPS for computers and small-scale servers in 2013. This came after a long consultation process initiated by a technical study in 2007 and was subject to various delays along the way (due to staff changes in the European Commission and contentious discussions with the industry). The EU regulation takes a hybrid approach, limiting overall energy usage and modal consumption and regulating components. The methodology, definitions, and levels are largely based on ENERGY STAR version 5.0. However, some variations have been included, notably a much wider range of allowances for graphics adders and some exemptions for high-end PCs. Desktops and laptops are covered by limits on total energy consumption, sleep/off–mode power, and requirements on power-supply efficiency and auto–power down.

Tier 1 will take effect in 2014 and Tier 2 in 2016. Due to the long delays in the preparation of the regulation, the risk of passing obsolete MEPS levels was high (a risk highlighted by nongovernmental organization advocates[5]). When voting for the regulation, however, EU member states decided to increase the stringency of MEPS levels to ensure its relevance (total energy consumption limits were reduced by 15–20% and graphics adders were cut by 10%). These MEPS are expected to save between 12.5 and 16.3 TWh annually by 2020.

Concurrently, the European Union is expected to complete a review and revision of its computers MEPS by the end of 2016. The review will specifically look into updates to the ENERGY STAR program, opportunities to tighten energy efficiency requirements, significant reductions in the energy allowances (in particular for discrete graphics cards), and the potential to address energy consumption of integrated displays. The European Union may also consider other environmental impacts during the different life-cycle phases of this product (e.g., durability, dismantlability, recyclability, critical raw materials).

Following the establishment of computer standards in Korea, China, Australia, New Zealand, and the European Union, in March 2012 California initiated a rulemaking to set the first efficiency standards for computers in the United States. The standards are expected to be finalized in 2015, with a likely effective date of early 2017.

[4] IEC 62301:2005 edition 1.0 for standby-passive mode, IEC 62087:2008(E) edition 2.0 for on mode and power factor.

[5] See, for instance, http://coolproducts.eu/blog/press-release-europe-to-vote-on-computer-energy-efficiency-standards.

US DOE has published a schedule for establishing federal efficiency standards for computers, indicating a final rule is scheduled for September 2016. Per statute, new standards would become effective five years after adoption; therefore, national standards for computers are not expected to be in effect until 2021 at the earliest. DOE's notice of coverage published in February 2014 proposes to include all consumer computers, servers, and uninterruptible power supplies in the same standards.

ENERGY STAR has been covering computers since 1992. The latest version, 6.0, is scheduled to go into effect in June 2014. The ENERGY STAR computer version 5.0 specification was the basis for all international MEPS to date, with some adjustments in levels, particularly around discrete graphics adders. In their proposal to CEC in August 2013, the California investor-owned utilities and the Natural Resources Defense Council proposed using the version 6.0 specification as the basis for California standards.[6] Adoption of these levels in 2017 would result in projected annual savings in California of 2.1 TWh by 2023. If DOE adopted the same standards nationwide, annual savings of around 17.5 TWh could be achieved after stock turnover.[7]

ENERGY STAR and MEPS based on ENERGY STAR use an annual typical energy consumption (TEC) metric, mostly driven by idle power as a proxy for active power consumption. TEC limits vary depending on performance-based categories and functional adders for discrete graphics, memory, disk, and display size (for version 6.0). ENERGY STAR and some MEPS also include minimum power-supply efficiency requirements. The use of idle as a proxy for active power has been a useful simplification in the recent specifications; however, it needs to be reexamined for future specifications and MEPS as computers become better able to scale power between idle and active states, and idle may no longer be a good enough approximation of active power demand.

Setting MEPS for computers is challenging due to the especially rapid pace of technology evolution. Standards are set based on existing market data, but go into effect several years later, when new technologies have permeated the market. Some technology changes, such as semiconductor efficiency gains, result in reduced computer energy consumption; however, they are not applied consistently across all form factors, and are partly or in some cases fully offset by other factors such as increases in screen size, graphics performance, and always-on modes.

Set-Top Boxes. The EU MEPS for simple set-top boxes (SSTBs) were adopted in 2009 and came into effect via a staged approach in 2010 (Tier 1) and in 2012 (Tier 2). The MEPS included power consumption limits, as well as requiring a standby mode and automatic power down. It was estimated that the adopted measures would lead to annual electricity savings of 9 TWh in 2014. With the ascent of digital TV sets, it was assumed that SSTB as a product would become obsolete and disappear from the market. (In reality, manufacturers have found ways to integrate additional functions to keep their market share.)

Complex STBs (CSTBs) incorporate many more functional capabilities compared to a SSTB and consequently have to be differentiated. The European Union asked industry to propose a voluntary agreement to regulate CSTBs and eventually recognized it in 2012. The impetus for this approach came from the difficulty of regulating a product for which manufacturers are only

[6] California Investor-Owned Utilities (prepared by Nate Dewart et al.), 2013. *CASE Initiative for PY2013: Title 20 Standards Development. Analysis of Standards Options for Computers (Revised Proposal)*

[7] National annual energy savings estimate derived from projected California savings (California representing approximately 12% of US population)

partly responsible for the level of energy use. Service providers can also play a significant role (notably for implementing auto–power down and other energy-saving features). The voluntary agreement sets staged total energy consumption limits for boxes in 2010 and 2013, respectively.

In the United States, a similar agreement was developed, based on the TECs initially developed for ENERGY STAR. TECs vary based on the functions performed by a particular box. The US voluntary agreement levels initially require that boxes comply with ENERGY STAR 3.0 levels. In 2017, boxes must comply with levels that are 10–45% lower than the ENERGY STAR 3.0 levels. The voluntary agreement expires in 2017, but an extension with new efficiency levels may be negotiated if participants find the first years of the agreement to be successful.

In the European Union, SSTBs are included in a wider review exercise, the so-called Omnibus review, tackling various already-adopted product regulations. This review, expected to be completed in 2014, has highlighted that limited additional energy savings potential is available. A simple evolution could be achieved by updating definitions based upon those in the EU Code of Conduct on Energy Efficiency of Digital TV Service Systems[8] and the CSTB Voluntary Agreement,[9] widening the scope of the MEPS as well as updating power demand requirements. The study underlines that there is an opportunity to increase material savings. These savings could be achieved through the definition of requirements that address wider life-cycle impacts (e.g., information requirements on installation), as well as the possibility of setting a maximum limit on the weight of SSTBs. Estimated annual savings linked to a light revision of the SSTB regulation is in the region of 0.3 TWh by 2030, whereas tackling material efficiency aspects (e.g., improved ecodesign for disassembly and recyclability) could lead to estimated indirect energy savings of 4.7 TWh by 2030. Addressing the other environmental aspects related to SSTBs could be an opportunity to further improve the environmental performance of these products. To date, MEPS in the European Union and United States have hardly addressed such material savings, focusing instead on savings from direct energy consumption.

Network Standby, Battery Charger Systems, and External Power Supplies—Horizontal Standards

Standby (including network standby). The EU horizontal regulation on standby—a famous and often highlighted example of a horizontal MEPS[10]—was adopted by the European Commission in 2008 and covers a plethora of household, information and communication technology, consumer, and leisure equipment (e.g., TVs, computers, radios, etc.) It sets universal power consumption limits for the standby and off modes, as well as auto–power down requirements. It started with passive standby with tiers in 2009 and 2012. Annual savings of 35 TWh by 2020 were expected in the European Union. In 2013, this regulation was expanded to cover networked standby modes. MEPS have been set for 2015 (Tier 1), 2017 (Tier 2), and 2019 (Tier 3). The MEPS levels distinguish between products requiring a high network availability (a

[8] http://iet.jrc.ec.europa.eu/energyefficiency/sites/energyefficiency/files/code_of_conduct_digital_tv_service_systems_v9_final.pdf

[9] http://ec.europa.eu/energy/efficiency/ecodesign/doc/20121217_voluntary_industry_agreement_cstb.pdf

[10] See for instance in the IEA 4E report on network standby (http://standby.iea-4e.org/files/otherfiles/0000/0104/Network_Standby_Report_Final.pdf) or the BIO Intelligence Service report for the Australian government on horizontal policy approaches (http://standby.iea-4e.org/documents-results/horizontal-policy)

list is provided, including mainly Internet access devices that need a fast reactivation time) and those that don't need more than low network availability (all other networked devices, unless the manufacturer can justify otherwise). Auto–power down after 20 minutes is also to be set by default in networked products. Expected annual savings are in the region of 36 TWh by 2020 and 49 TWh by 2025.

MEPS levels (third stage) for passive and networked standby are expected to be reviewed in 2016.

Battery charger systems. California adopted the first battery charger system (BCS) efficiency standards in the world in January 2012. They became effective in large part in February 2013, with later dates for certain products. Battery charger systems consist of products with rechargeable batteries where the battery, charge control circuitry, and power supply are sold together as a single system. Covered electronic products include cordless phones, cell phones and tablets, and notebook computers. The standards regulate "standby" loads (maintenance of full charge in the battery and system standby power when the battery is disconnected) as well as charge and maintenance efficiency over a 24-hour period. By including a standby power requirement, the standards effectively address a large fraction of the total energy consumption of products with small battery capacities, like cell phones and MP3 players, that consume most of their energy in standby. For products with larger battery capacities, such as notebook computers, where active energy consumption dominates, the standards only address a fraction of the overall product energy consumption. For many products, compliance with California BCS standards can be achieved by not overcharging batteries when fully charged and by reducing standby power.

The state of Oregon adopted the California standards in 2014, and US DOE is in the process of establishing national US efficiency standards for consumer BCSs. DOE's initial proposal in March 2012 was weaker than the California standards and could have resulted, after preemption of California standards, in an increase in national energy consumption. DOE is currently revising its proposal, taking into account existing California standards, and is expected to finalize the standards in 2015 (DOE 2014).

ENERGY STAR implemented a BCS specification in January 2006. ENERGY STAR only addressed standby power, not active charging efficiency, and covered a relatively small subset of battery chargers (mostly motor-operated and detachable battery products not covered by the external power supply specification). In December 2013, EPA proposed to sunset this BCS specification given the existence of more comprehensive and more stringent California standards.

Expected annual savings from the California BCS standards are projected to be 2.2 TWh by 2020. If DOE adopted the California standards, national annual savings would amount to 18.3 TWh after stock turnover.[11]

External power supplies. California implemented the first external power supply (EPS) MEPS in the world. Tier 1 (Level III) went into effect in California in 2007 for both consumer and commercial EPSs, and Tier 2 (Level IV) went into effect in 2008. With the Energy Independence and Security Act of 2007 (EISA 2007), the U.S. Congress expanded the California Tier 2 to the entire country for consumer EPSs.

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[11] National annual energy savings estimate derived from projected California savings (California representing approximately 12% of the US population)

The US DOE recently published regulations that increase efficiency requirements for most EPSs already covered by the 2007 standards and extend coverage to most other consumer EPSs. The new US federal standards will take effect in 2016. They also require compliant EPSs to bear a "Level VI" mark, following on from the previous "Level IV" marking requirements. DOE standards only cover consumer EPS, which are the vast majority of EPSs sold. Nonconsumer EPSs are still covered by California Tier 2 standards at Level IV. In all, the California standards, together with the EISA 2007 and DOE 2014 standards, are estimated to save 8.8 TWh annually by 2020.

ENERGY STAR set voluntary EPS labeling requirements at Level III in January 2005 and Level V over the 2008–09 period, depending on the products. EPA then sunset its EPS program by the end of 2010, as EPS requirements were already integrated into many product specifications.

The European Union adopted its first EPS MEPS in 2009, which came into effect via a staged approach in 2010 (Tier 1) and 2011 (Tier 2), corresponding to "Level IV" and "Level V," respectively. In the European Union, it was estimated[12] that the adopted measures would lead to electricity savings of 9 TWh annually by 2020.

The US and EU MEPS set minimum requirements for two metrics: "no load" which represents the power consumption when the EPS is plugged in but disconnected from the device; and "average active mode efficiency," defined for the latest US federal standard and EU MEPS as the average of EPS efficiency at 25, 50, 75, and 100%of nameplate output power.

The European Commission is currently revising the MEPS for EPS; this revision was initiated in early 2013 and is expected to be concluded in 2015. Additional expected savings due to the revised measures are more than 2 TWh annually. US DOE is required by law to consider further revisions to the federal standards by the middle of 2015.

In April 2013, due to the low savings expected from the revised EU standards process, the European Commission proposed to undertake a light revision rather than one based on an extended analysis. It specifically suggested the tightening of the existing MEPS along the lines of the draft Code of Conduct version 5[13] (e.g., adding a 10% load metric), allowing more generous timelines (e.g., June 2015 and June 2017), the insertion of a Tier 3 (e.g., 2019), and inclusion of the multiple voltage output devices in the scope of the revised regulation.

In November 2013, the European and US household appliances, information technology, and consumer electronics associations[14] wrote a joint letter to EU and US regulators, proposing the alignment of the EU and US EPS requirements. The purpose of this proposal was to reduce costs for industry associated with redesigning products for different markets. More specifically, because the US regulatory process was more advanced, the trade groups requested a single tier for the EU's reviewed EPS regulation set for 2016 (instead of two tiers in 2015 and 2017), including requirements aligning with the US limits. Other areas of possible cooperation and alignment include measurement standards (including tolerances and verification), as well as further alignment for so-called non–class A EPSs like multivoltage.

There remain significant energy-saving opportunities in EPSs beyond the levels in the just-released US standards. These savings could come from power factor correction and low-load

[12] http://ec.europa.eu/energy/efficiency/ecodesign/doc/legislation/2009_fia.pdf

[13] http://iet.jrc.ec.europa.eu/energyefficiency/sites/energyefficiency/files/files/documents/ICT_CoC/code_of_conduct_for_eps_version_5_-_final.pdf

[14] DIGITALEUROPE, CECED, ITI, CEA, AHAM

efficiency, and by extending coverage to EPSs currently excluded from standards, such as certain medical, motor-operated, or detachable battery devices.

Recommendations for Regulators

It can be derived from the above that effective MEPS for electronics should have the following attributes:

Rapid development cycles. Keep MEPS development processes as short as possible and set standards based on the most recent, relevant, and accurate data available. Standards that take too long to develop and implement risk being less effective due to rapidly evolving technology.

Multitier standards. Set both short-term and long-term standards through multiple tiers. Short-term standards based on recent data and implemented rapidly can be very effective at ensuring that the easiest efficiency improvements (often at a nearly zero extra cost) are implemented on all product models. Long-term standards based on maximum technologically feasible efficiency levels can be effective at market transformation by challenging manufacturers and giving them a long line of sight to make required engineering investments.

Ensure ambition. As traditional cost–benefit analyses on efficiency improvements do not hold well with electronics and always run the risk of quickly becoming obsolete, regulators should have a mandate to make well-considered, bold decisions. There are multiple examples of MEPS for electronics that have been insufficiently ambitious and outpaced by the market, and none that have proven to be too ambitious. In case of genuine uncertainties on a long-term tier, regulators in some jurisdictions may consider establishing opportunities for midcourse corrections to ensure that longer-term, higher tiers continue to make sense. (However, this should be done in a secured way to avoid gaming temptations.)

Combination of vertical and horizontal standards. The MEPS evaluated in this research show comparable savings levels for vertical standards and horizontal standards. Vertical standards address specific product categories. While they can be effective for the highest-energy-consuming electronic devices, extending them to many more devices poses practical challenges. Horizontal standards, which regulate common features across many device categories, such as standby power, EPSs, and battery charging, are an effective approach to capturing savings opportunities from the many devices that consume less energy individually but are responsible for high energy consumption in aggregate. Combining these approaches where possible affords the greatest potential coverage and savings.

Performance- and functionality-based standards are necessary but challenging. To account for integrated and hybrid designs offering multiple features and levels of performance, standards often use functional “adders” (e.g., computer graphics, screen size, and set-top box features). However, the more adders are used in a standard the higher the risk of loopholes. Adders that are higher than necessary can result in lots of unnecessary padding in a standard. For example, a high graphics adder for a computer can result in a large, unwarranted allowance for computers utilizing the latest energy-efficient graphics cards that may use 100 kilowatt-hours less per year than the adder allows. This can make the entire standard ineffective. To avoid this situation, adders should be set as low as possible. In any case, these adders should take into account and systematically promote scalable technologies (i.e., the capacity to adjust energy use to the task performed).

Component performance requirements can be complementary to product-level metrics. Product-level metrics capture energy performance for the entire product rather than for individual components. While standards based on product-level metrics provide more flexibility for manufacturers to design to the standards, they may have a shorter shelf-life than component-based standards. For example, the majority of computers on the U.S. market already meet ENERGY STAR v6.0 energy limits, even though many of them still use inefficient power supplies. Including a power supply minimum efficiency requirement in addition to AEC limits (as was done by the EU computer MEPS) ensures that cost-effective savings from efficient power supplies continue to be captured even after the market has moved beyond the AEC limits of the standard in effect.

Beware of harmonization: Convergence may be a better friend. Inconsistent standards in different jurisdictions pose legitimate challenges to global industries. As a result, industry is advocating for global harmonization of standards. Harmonization, however, can prevent or slow the evolution of standards as governments align on standards that may be increasingly out of sync with the market. To keep pace with market and technology evolution, it is important that jurisdictions around the world can build on top of previous standards, as was done with EPSs, computers, and other standards. This can allow the tracking of market and technology evolution in a way that a single agency cannot. A "convergence" rather than "harmonization" approach, which would ensure that relevant metrics and test methods are reused where applicable, allows governments and agencies around the world the flexibility to adjust standards to market evolution. This may in part address industry concerns about inconsistent standards while allowing standards to closely track market evolution.

Room for creativity and flexibility. Energy savings potential in electronics is not always easy to grasp through simple and uniform MEPS limit values. This can be due to the heterogeneity of the configurations available on the market (e.g., high-end products for certain niche consumers), or the difficulty of capturing the main functions of the products in single metrics (e.g., enterprise servers, playing mode of gaming devices), or the fact that the operation of the equipment relies on a broader network environment (e.g., service provider–based STB). So far, these issues have been mostly tackled through exemptions or postponements, thus risking loopholes. For some products, voluntary programs such as ENERGY STAR have driven very high market shares and have been updated on a more rapid cycle than the related MEPS. In addition, approaches such as voluntary agreements or codes of conduct may be explored with the industry in an attempt to achieve more flexibility. However, the experience with voluntary agreements is not yet sufficient to determine if the actual savings will measure up to regulatory options. If voluntary agreements are pursued, as with standards, they must include features that enable efficiency levels to be updated to reflect technology and market evolution. Regulators should retain the option to pursue MEPS in case voluntary agreements fail to achieve intended results.

Conclusion

As laid out in this paper, the challenges of developing effective MEPS for electronic products are many. Rapid product cycles, merging technologies, and products manufactured for a global audience provide a unique set of challenges. But despite these challenges, many jurisdictions, including California, the United States, and the European Union have developed MEPS for a variety of electronics products that have, and/or are expected to, drive energy savings. By 2020, MEPS savings are projected as follows:

- Televisions—5.9 TWh per year (6.5 TWh per year by 2023) in California
- Computers—2.1 TWh per year (in 2023) in California and as much as 16.3 TWh per year in the European Union
- Set-top boxes—9 TWh per year in the European Union
- External power supplies—8.8 TWh per year in the United States and 9 TWh per year in the European Union
- Battery chargers—2.2 TWh per year in California
- Standby—36 TWh per year (49 TWh per year by 2025)

Many of these MEPS work in tandem with voluntary initiatives such as ENERGY STAR that pull the market to higher levels of efficiency. If followed, the recommendations for regulators identified in this paper increase the likelihood of the continued development and implementation of meaningful electronics MEPS.

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