Improving global comparability: how do Europe's S&L policies stack up

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Keywords

standards, labelling, mandatory standard, energy efficiency policy

Abstract

Comparing energy performance requirements for appliances from country to country is difficult because of variations in product definitions, misaligned energy test procedures, and divergent efficiency metrics. This complex landscape can prevent policymakers from identifying or adopting global best practices in standards and labels (S&L). It can also present barriers to the proliferation of highly energy-efficient products.

S&L policies are built on a series of technical foundations: product definitions, test procedures, efficiency metrics, and performance levels. Policymakers can increase alignment of product policies by improving the alignment of any of these building blocks.

Approximately 18 products are currently comparable across major economies: they either have internationally aligned test procedures or have been the subject of a benchmarking study that establishes robust conversion factors among divergent test procedures. This paper will discuss how the European Union (EU) compares to other major economies in product coverage for a set of 100 products and in policy stringency for these 18 comparable products. The paper will also examine the costs and benefits of increasing the coverage and stringency of S&L policies in Europe to match world best levels.

For those products whose S&L policies cannot currently be compared, this paper will discuss concrete opportunities for increased alignment of the technical foundations or building blocks that underlie product policy, with a focus on implications for the EU.

This paper builds on a study conducted by The Policy Partners for CLASP, which presents the largest and most comprehensive comparison of minimum energy performance standards (MEPS) and energy labels ever compiled.[1] It covers nine major economies Australia, China, the European Union, India, Indonesia, Mexico, Russia, South Africa and the United States and more than 100 products across eight different product areas. The analysis describes which product policies are comparable across economies, which are not, and which could be.

Introduction: Improving Comparability of Appliance Standards and Labels

The global landscape of test procedures and energy efficiency metrics can seem complex and impenetrable. Policymakers can use international comparisons of energy performance requirements and product coverage to better inform decisions about energy performance standards and energy labels (S&L), thereby enabling more stringent policies. However, the current lack of comparability of S&L among economies can lead regulators to set more conservative efficiency requirements than they might if they could easily translate or adapt other economies' more stringent policies in their own policy terms.

COMPARING ENERGY PERFORMANCE REQUIREMENTS[2]

Energy performance regulations are built on a series of interconnected parts, each defining one building block for energy performance requirements and energy labels, and each one

1. Improving Global Comparability of Appliance Energy Efficiency Standards and Labels. 2014. More information is available online at: http://clasponline.org/igc

2. For more information see: Improving Global Comparability of Appliance Energy

affecting the comparability of these policies. Comparing energy performance data from one economy to another requires finding a way to convert energy performance measurements or declarations from one set of test procedures and energy efficiency metrics to the next. The ease or difficulty with which test procedures can be converted varies greatly depending on a wide variety of factors, as does the reliability of the conversion factors developed. In some cases there is only one test procedure in use (e.g., machine tools) while at the other end of the spectrum, some products (e.g., walk-in cold rooms) have multiple test procedures with differences so large that estimating a conversion factor is virtually impossible

In all economies, less than half of all regulations are fully aligned internationally. Full alignment requires that, first, test procedures are aligned[3] and, second, that local usage characteristics are comparable enough for a globally aligned efficiency metric to define a globally acceptable way of describing what constitutes energy performance for a product. Australia, with its policy of international alignment, shows fully aligned test procedures and efficiency metrics for 14 out of its 36 regulated products (included in the analysis underpinning this paper) and Mexico, with its policy of aligning with the US, for 9 out of 22 analysed regulations. The EU shows a level of alignment on par with Australia and Mexico and the US follows closely behind. The EU and the US both regulate substantially more products than other economies, yet show levels of alignment not much below Australia. This may partly be explained by these two economies typically tackling products that have not been regulated elsewhere, and thus setting an international benchmark for testing and evaluating efficiency for those products.

Efficiency metrics in general appear to be much harder to align than test procedures. Whereas international test procedures often seem to provide a suitable way of measuring energy consumption under standardized conditions, efficiency metrics are more often adapted, usually to reflect different national circumstances such as climatic conditions or usage patterns. In fact, where there seems to be a movement towards using internationally aligned test procedures in all economies, efficiency metrics seem to be drifting further apart. A good example of this is in air conditioning, where virtually all economies have aligned to the same international test procedure for testing product performance, but then use quite different efficiency metrics to assess energy performance. These differences have increased recently as countries replace energy efficiency ratios (EER) with more accurate but less comparable seasonal energy efficiency ratios (SEER). In a way, this negates the progress being made in aligning test procedures for the purpose of product comparability but it also creates a barrier for the transfer of energy-efficient technologies between economies with different metrics. It is important to recognize, however, that locally tailored efficiency metrics can be important to ensure that MEPS and energy labels are representative of actual usage in an economy.

Figure 1 sets out how various components of energy performance regulations interact. The figure reads from the bottom up, reflecting that the regulations that are most visible build on underlying, less visible parts.

Alignment of Standards and Labels[4]

The report on which this paper builds covered MEPS and energy labels in 9 economies and for over 100 products. In total, 425 regulations were identified, consisting of 228 MEPS and 197 energy labels. The EU and the US are clearly ahead in MEPS and labels coverage for energy-using products with 67 and 70 products regulated, respectively. Perhaps surprisingly, the EU leads in number of MEPS, with regulations for 62 products, whereas the US has more energy labels than the EU. This is a reversal of earlier years in which the EU relied more on energy labels and the US more on MEPS. It should be noted that most US labels are ENERGY STAR endorsement labels, whereas most EU labels are categorical energy labels.[5] The US also has a comparative label, which features a continuous rather than the more commonly used categorical scale and is widely considered less effective than the ENERGY STAR label.

Internationally, the most regulated product areas are consumer electronics (CE) and information and communications technology (ICT), household appliances, and space and water heating. Lighting products, motors, fans and pumps, and commercial refrigeration products follow closely. The number of regulations is lower for cooking products, air conditioning products and transformers.

There is substantially more alignment of test procedures and efficiency metrics in the household appliances, lighting, CE/ICT, motors, fans and pumps, and transformers product areas, and less alignment for air conditioning and commercial refrigeration equipment. There is virtually no alignment for space and water heating products or cooking products. Partly, this reflects the level to which products themselves are internationally comparable.

ALIGNMENT OF TEST PROCEDURES AND EFFICIENCY METRICS

Of the 72 products analysed, less than 25 % have aligned test procedures today, and only 4 products have aligned efficiency metrics. As figure 2 shows, there is the potential for over 60 % of products to have aligned test procedures, with almost 40 % of those having the potential for aligned efficiency metrics. The best potential for alignment of test procedures and efficiency metrics appears to be in the lighting products, CE/ICT, and motors, pumps and fans areas, and the best potential for test procedure only alignment is in the household appliances and cooking products areas.

Efficiency Standards and Labels. 2014. Available online at: http://clasponline.org/igc

3. Aligned, in the context of this study, refers to a situation in which the test procedures and other relevant characteristics of S&L are materially the same, for example that these are copies or translations of the same international test procedure, even though the actual regulatory document may be different.

4. For more information see: Improving Global Comparability of Appliance Energy Efficiency Standards and Labels. 2014. Available online at: http://clasponline.org/igc.

5. Endorsement labels, or "seals of approval," are given to products that meet a set of specified criteria. Categorical labels are a type of comparative label, which allow consumers to compare performance among similar products using discrete categories of performance. For more information, see the CLASP Standards & Labeling Guidebook, available online at: http://clasponline.org/en/Resources/Resources/StandardsLabelsGuidebook.aspx.

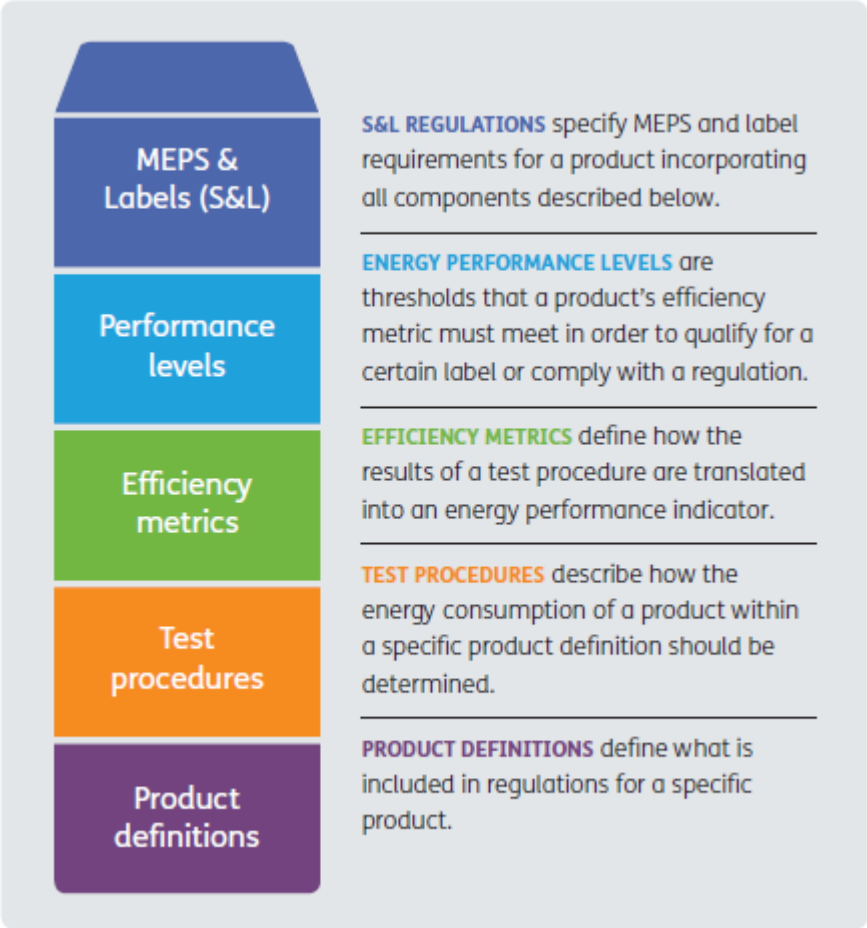

Figure 1. The building blocks of energy performance regulations.

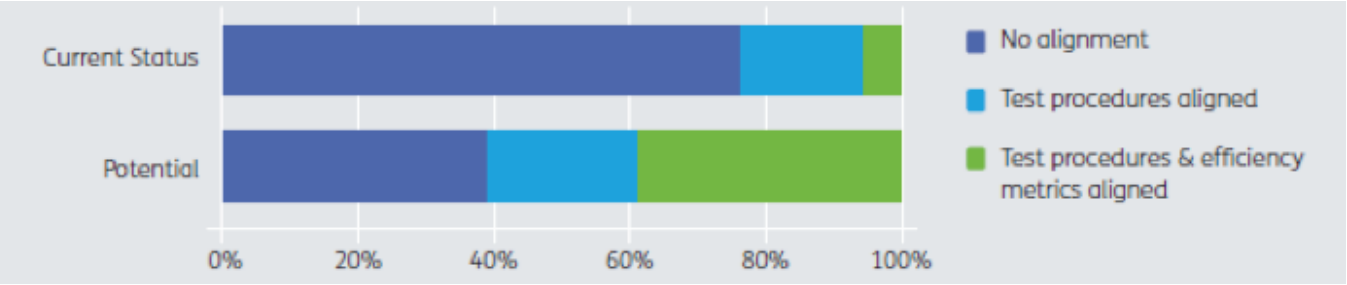

Figure 2. Potential for alignment of test procedures and efficiency metrics.

OPPORTUNITIES TO INTRODUCE MORE ALIGNMENT IN STANDARDS AND LABELS.

Technologies as well as test procedures differ for many products; however, there are products that are sufficiently comparable across economies in terms of basic technology and product design, as well as in their usage. For those cases, there is potential to align standards and labels, thus opening up additional potential for energy savings.

Energy savings through alignment of S&L can occur either directly, through economies adopting more ambitious standards and label requirements already in place in another economy; or indirectly, through creating a larger market for more efficient products, which stimulates product development and drives down the cost of new (energy efficient) technologies and features.

Opportunities to improve the alignment of efficiency metrics and test procedures are related to, but distinct from, opportunities to increase the stringency of S&L to the world's best levels (defined here as the highest levels among those include in this analysis). For all products, there is some potential for harmonization of test procedures, efficiency metrics and/or performance levels, although in some cases that seems limited to components of test procedures. For many heating and cooling products, for example, it may be possible to define common tests of product components or modes of operation; such an approach has recently been used success-

Table 1. Products covered by S&L (MEPS and/or labels) by economy for all products analysed.

Country	MEPS	Labels	MEPS or Labels
US	47	40	70
European Union	62	35	67
China (PRC)	39	42	51
Australia	35	18	41
Mexico	23	23	33
India	5	14	16
Russia	8	9	14
Indonesia	7	8	10
South Africa	2	8	9
TOTAL:	228	197	311

fully for ISO standards for pump systems. In other cases, such as household refrigerators, fully aligned test procedures seem to be achievable.

Efficiency metrics, however, appear to be much harder to align than test procedures. Alignment of efficiency metrics first requires that test procedures are aligned. In addition, local usage characteristics must be similar enough for a single efficiency metric to acceptably describe what constitutes energy performance for a product globally.

Test procedures and efficiency metrics alignment can be complicated by existing national procedures and metrics. Many product designs are tailored to national procedures and metrics, in which case a switch to a different test procedure or efficiency metric may result in substantial shifts in the energy efficiency rankings of existing products in an economy. In addition, existing national test procedures and efficiency metrics may reflect product designs that differ substantially between economies (as is the case for many heating products), or be representative of specific local usage patterns or climatic conditions not found elsewhere (as, for example, for many cooking products). A case-by-case assessment is needed to determine the expected benefits and the potential for the development of internationally aligned test procedures and efficiency metrics.

Factors influencing the selection of opportunities include the current alignment of test procedures, efficiency metrics, and S&L, and the timing of S&L updates scheduled in major economies. In addition, a sector by sector assessment revealed significant differences in technology use between sectors:

- Household appliances have larger regional differences; however, these products have been regulated for energy performance for decades and the impact of different regulations on their performance is by now better known.
- Many consumer electronics & ICT products as well as lighting products are globally traded and the same all over the world.
- Air conditioning product regulations use the same international test procedure for packaged products, though not for components, and vary greatly in the efficiency metrics used, leading to less alignment overall.
- The motors, pumps and fans area scores lower on alignment than might have been expected based on the product area description. This reflects that energy performance regulations are new to these products and that there are many products currently only regulated in one economy. Where that is the case, international alignment is undefined and therefore comes across as being low. With low numbers of existing regulations, these products represent good opportunities for future alignment. Where multiple regulations exist, these are usually built on internationally agreed test procedures.
- Cooking and space and water heating products show large regional differences in their design, usage and characteristics, and regulations are typically built on regional test procedures and efficiency metrics, leading to virtually incomparable MEPS and labels for these products.

Comparing the EU to Other Economies

The number of products covered by S&L has grown substantially in recent years. The main driver for this has been the extension of scope and ambition level of several S&L programs, primarily in the EU and China.

S&L AMBITION LEVELS

The ambition level of MEPS and labels could only be compared with some reliability for 25 % (18 out of 72) of the products covered in the analysis, across household appliances, lighting products, some CE/ICT products, air conditioning and motors.

Across these comparable products, the EU stands out as the clear leader in S&L development. The EU has by far the largest number of MEPS as well as the most ambitious MEPS and energy labels for more than half the comparable S&L. Table 2 shows the number of most ambitious S&L for each economy (including those where the lead is shared with other economies), as well as the number of unique most ambitious S&L (where the lead belongs to that economy alone).

Of the comparable products identified in the analysis, there are six products shown in Table 3 for which the EU MEPS is not the most stringent: room air conditioners, medium refrigerator-freezers, external power supplies, clothes dryers, non-directional lamps, and televisions. The most stringent MEPS is shown in Table 3 in bold along with the year that regulation took effect, while the EU MEPS is set at a baseline of 0 % for all products. Figure 3 maps the same data in graphical form to display the differences among MEPS stringencies for these selected products and countries.[6]

Potential benefits of implementing best identified MEPS in Europe

Although countries can gain insights and set stricter standards by looking at existing policies in other countries even when they do not have comparable test procedures, it is necessary

6. Data from Improving Global Comparability of Appliance Energy Efficiency Standards and Labels. 2014. Available online at: http://clasponline.org/igc

Table 2. Most ambitious S&L identified by economy for comparable products only.

Country	Most Ambitious		Unique Most Ambitious	
	MEPS	High Label	MEPS	High Label
European Union	9	9	8	8
Australia	3	5	2	3
United States	5	1	5	–
China (PRC)	2	3	1	1
Mexico	2	2	1	–
India	–	1	–	–
***Note:** In some instances, more countries share a "most ambitious" MEPS or High Label. As a result, the sum of MEPS and High Labels across countries is not identical to the total number of MEPS and High Labels that can be compared: those totals are 18 comparable MEPS and 15 comparable High Labels.*				

Table 3. Comparing EU MEPS for selected products with other selected countries.

For all products, the EU is set at 0 %; higher is more efficient	European Union	Australia	China	India	Mexico	United States
Room Air Conditioners	0 %	–	**10 % (2013)**	-21 %	–	0 %
Medium Refrigerator-Freezers	0 %	-31 %	-36 %	-41 %	-26 %	**3 % (2014)**
External Power Supplies	0 %	-1 %	-1 %	–	–	**4 % (2016)**
Clothes Dryers	0 %	–	–	–	–	**14 % (2015)**
Non-Directional Lamps	0 %	-10 %	–	–	–	**41 % (2013)**
Televisions	0 %	**30 % (2013)**	–	–	–	–

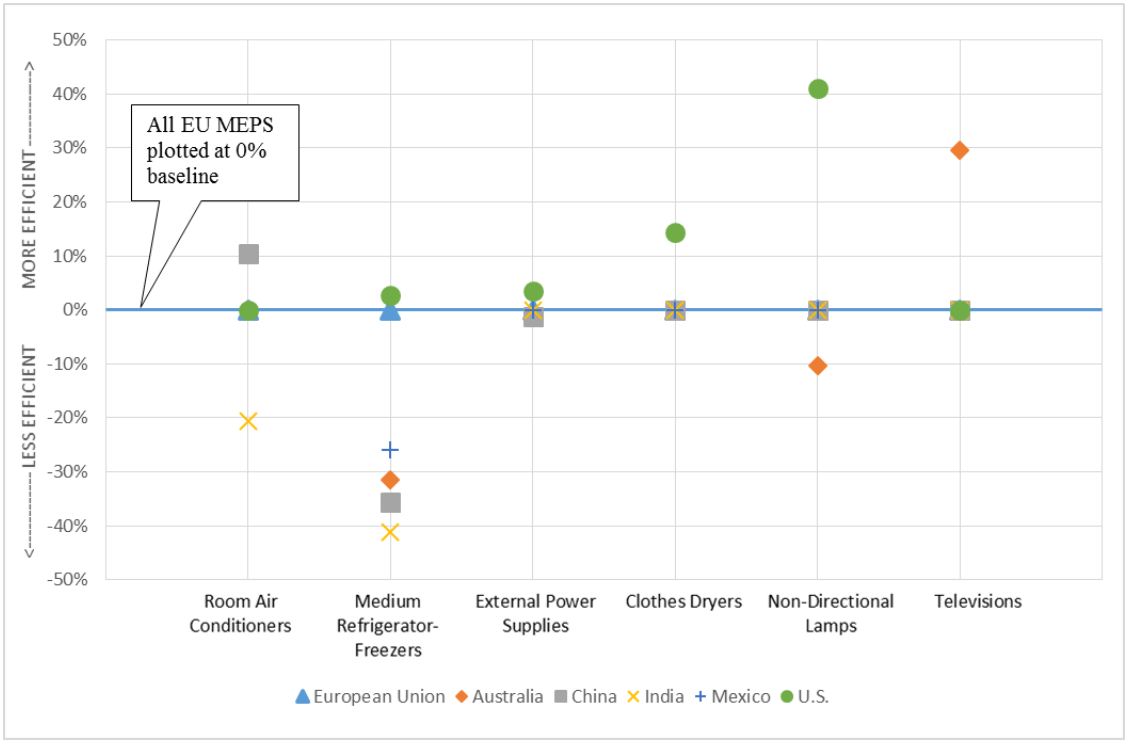

Figure 3. Comparing EU MEPS for selected products with other selected countries.

Table 4. Inputs to BUENAS analysis for four comparable products.

Product	2015 Sales[A]	Unit Energy Consumption: Base Case[B]	Unit Energy Consumption: Best Identified Policy Case[B]	Maximum change in Unit Energy Consumption
	Million Units	*kWh/year*		
Clothes Dryers	4.3	530	460	-70
External Power Supplies	845	6.6	6.4	-0.2
Medium Refrigerator-Freezers	4.2	224	218	-6
Room Air Conditioners	2.8	1,200	1,090	-110

Notes:
A: Sales figures are modeled in BUENAS.
B: Unit Energy Consumption for the Base Case and the Best Identified Policy Case were derived from the 2014 Improving Global Comparability report (available at: http://clasponline.org/igc)

to have comparable test procedures and efficiency metrics in order to align up to the most ambitious standard. For this discussion, we focus on where the EU could benefit from aligning with an economy with more ambitious MEPS, building on this comparability where possible.

To determine the potential energy savings of improving the EU MEPS to the best identified policy levels, an analysis was done[7] using the Bottom-Up Energy Analysis System (BUENAS).[8] For four comparable products that are also modelled in BUENAS – clothes dryers, external power supplies, medium refrigerator-freezers, and room air conditioners – this analysis used data from the 2014 Improving Global Comparability study to run a policy scenario for the Best Identified Policy Case in BUENAS.[9] For medium refrigerator-freezers, this data was complemented with market data from the most recent EU Preparatory Study for domestic refrigerators and freezers.[10] These input data are presented in Table 4.

Non-directional lamps and televisions, both included in Figure 3, are not included in this quantitative analysis. Non-directional lamps were excluded because they require a more in-depth modelling effort than is currently available in BUENAS for lighting products. For televisions, energy efficiency is improving so rapidly in the baseline scenario that it is difficult to note the impacts of MEPS of varying stringencies on the current and foreseeable market.

Per the data shown in Table 4, the unit energy consumption for the base case and the best identified policy case are drawn from MEPS levels in each case. BUENAS uses these figures to represent the market average energy demand of a product. However, the EU has categorical labels in addition to MEPS for some of the products analyzed which communicate the energy performance of products to consumers and thus motivate manufacturers to introduce products to the market that sometimes significantly exceed the MEPS level. This means that the market average energy demand of a product is lower (more efficient) than the MEPS would indicate. Therefore, use of the MEPS level as a proxy for average unit energy consumption leads to a high estimate of average unit energy consumption in the base case (i.e., less energy-efficient). This could lead to a significant overestimate of potential savings, particularly for refrigerator-freezers and room air conditioners, where a large share of the EU market is at label classes above the MEPS level. However, the potential savings identified are quite reasonable if labels were to be revised simultaneously with and proportional to the MEPS being made more stringent. In this case, the increase in stringency of the MEPS level (i.e., the decrease in the average energy demand of a product) can serve as a first-order proxy for the reduced energy demand (i.e., energy efficiency improvement) in the market as a whole.

It is also important to note that there is widely varying reliability for the conversion factors developed and evaluated to compare MEPS stringency among selected economies in the 2014 Improving Global Comparability study. For products with the highest level of confidence, converted results are expected to be within 10 % of the indicated value. This includes external power supplies (where the difference in MEPS performance level is less than 10 %). For products with a medium level of confidence, results are expected to be within 25 % of the indicated value. These include clothes dryers, medium refrigerator-freezers, and room air conditioners.

Given these two caveats – the use of MEPS levels as UEC and varying confidence levels for conversion factors – the en-

7. The authors would like to acknowledge the contributions of Michael McNeil, Lawrence Berkeley National Laboratory, in carrying out this BUENAS analysis.

8. BUENAS is a policy analysis tool created by Lawrence Berkeley National Laboratory (LBNL) and supported by CLASP, the Super-efficient Equipment and Appliance Deployment (SEAD) initiative, and the International Copper Association.

9. More information about the methodology of BUENAS is available online at: http://www.clasponline.org/en/Resources/Resources/PublicationLibrary/2012/BUENAS-Methodology-Results.aspx

10. Lot 13: Domestic Refrigerators and Freezers. Final Report. December 2007. Figure 10 and Table 2.8. Refrigerators over 250 liters were classified, for this analysis, as "medium". Available online at: http://www.eceee.org/ecodesign/products/domestic_fridges_and_freezers/Final_Report_Lot13

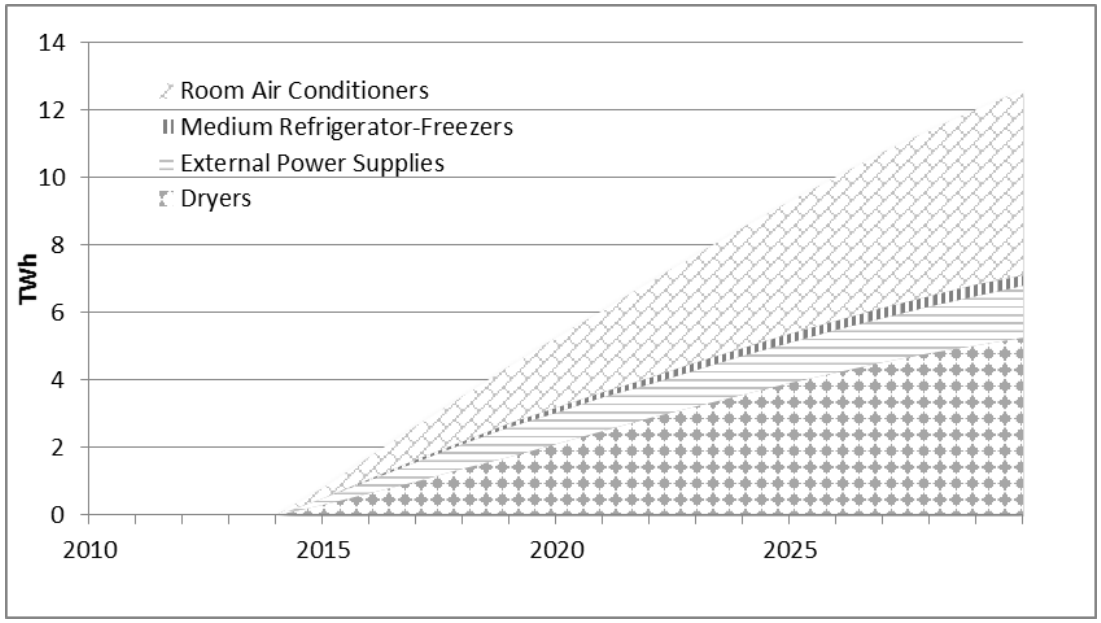

Figure 4. Potential annual EU energy savings (TWh) from four products.

Table 5. Approximation of potential EU energy savings from four products.

Product	Energy Demand		Annual Energy Savings				Cumulative Energy Savings	
	2020	2030	2020	2030	2020	2030	2015-2020	2015-2030
	TWh		*TWh*		*%*		*TWh*	
Clothes Dryers	35	43	2	5	6%	12%	7	47
External Power Supplies	28	45	1	1.5	3%	3%	3.7	16
Medium Refrigerator-Freezers	16	15	0.1	0.3	1%	2%	0.5	3
Room Air Conditioners	43	59	2	5.5	5%	9%	7	47

ergy savings potentials presented in Table 5 should be taken as indicative approximations, rather than precise determinations.

A 2013 paper that examined the potential additional energy savings from upcoming revisions to EU S&L policies also included an analysis of external power supplies.[11] The figures for 2015 sales (in Table 4) and 2020 energy demand (in Table 5) were both significantly lower in that study than in the present analysis. This is likely due to the differing methodologies taken. The 2013 paper used US Department of Energy estimates for the US and made adjustments for the EU's larger population and lower GDP per capita; this methodology includes "direct operation" EPSs. The BUENAS analysis in this paper uses data from an EU Ecodesign analysis, which also includes "indirect operation" EPSs (used only to provide power to a battery, but which cannot operate an end-use product directly).

EPSs have similar basic designs for the US and the EU, and it is unclear whether the difference in EU and US MEPS requirements also translates into different products on the market. A more detailed analysis, also taking into account the different voltages and frequencies used in each economy and how these affect energy performance of similarly designed EPSs, could shed more light on these nuances. Despite all of this, there is a strong case for alignment of EPSs for future S&L; this is explored in more detail in the next section.

Figure 4 displays the potential energy savings data from Table 5. Room air conditioners and clothes dryers show sizable savings from EU alignment with the China and US MEPS, respectively. Each of these would save about 5 TWh (annually) in 2030. Interestingly, there are also significant potential savings from EPSs, despite a small difference in efficiency between the US and the EU, because so many of these are sold each year. For medium refrigerator-freezers, there are not many savings from aligning EU MEPS with the US level. The MEPS for this product are already very close, and the EU is less stringent than

11. CLASP 2013. Estimating potential additional energy savings from upcoming revisions to existing regulations under the ecodesign and energy labelling directives: a contribution to the evidence base. Available online at: http://clasponline.org/en/Resources/Resources/PublicationLibrary/2013/CLASP-and-eceee-Point-To-Additional-Savings-from-Ecodesign-and-Energy-Labelling.aspx

the US for only about 30 % of the European market. For smaller refrigerators, the EU has a more stringent MEPS than the US.

Policy opportunities for increased alignment of building blocks of energy performance regulations

For all products, there are opportunities for improved alignment of the building blocks of energy performance regulations. Even for those best-aligned products, there are small differences in national policies – be they in the product definitions, test procedures, efficiency metrics, or performance levels – that make products less comparable around the world.

SHORT- TO MEDIUM-TERM OPPORTUNITIES

Directional lighting: Align cone shape

Australia, the EU, and the US have MEPS for directional lighting. These use comparable test procedures, but the US and Australia efficiency metrics cannot be compared with the EU efficiency metric.

The EU MEPS metric for directional lamps only considers light within a 90 or 120 degree cone (depending on lamp type), whereas most other economies (such as the US and Australia) consider the light in a 180 degree hemisphere. Converting between the EU "cone" approach and the more often-used "hemisphere" approach is difficult because the relationship between these methods is likely to vary for various lamp types. Developing a relationship would require in-depth examination of light distribution data from many lamps.

Even though the test method is the same – measure the light output from the lamp – the EU MEPS considers a more limited amount of the measured light (the light within the "cone") while other test methods measure a larger share of the light produced (the light within the "hemisphere").

Therefore, there is an opportunity to improve global comparability if the EU were to adopt the efficiency metric that considers the light in a 180 degree hemisphere.

All lighting: Agree generic performance levels

Lighting products are generally globally traded, including general service lamps (incandescent lamps, halogen lamps, compact fluorescent lamps CFLs high-intensity discharge (HID) lamps and systems, linear fluorescent lamps and systems, and light-emitting diodes (LED) lamps and systems.[12]

Therefore, lighting products could become more globally aligned through international agreement of generic performance levels for efficacy. This concept is already in use for electric motors, in which the IEC defines international efficiency levels which countries then choose among for adoption into national regulations.

Going one step further, these generic performance levels could also include aligned quality characteristics. Many voluntary lighting programs for highly-efficient products[13] already incorporate quality characteristics to ensure consumer satisfaction with the overall product. This, in turn, increases the likelihood that consumers will make an energy-efficient product choice in the future, rather than developing a distrust of new energy-efficient technologies.

Televisions: Agree on test patterns and automatic brightness control testing

Televisions are a global commodity and are traded internationally. Although most programs use the same international test method (IEC 62087), there are two main issues that remain unaligned.

First, different regions use different test patterns when testing the energy consumption of a television. These test patterns can be static or dynamic, and have differing Average Picture Levels (APLs).[14] Differing APLs can have an enormous impact on television energy consumption, most notably for emissive technologies such as plasma or OLEDs.

Second, different countries use different test points for background luminance and different calculation metrics for automatic brightness control (ABC). ABC-enabled televisions will adjust the brightness of the screen based on the amount of light in the room. Therefore, as long as countries use different background lighting levels to test ABC-enabled televisions, those results cannot be compared. In addition, even if those background lighting levels were aligned, countries use different calculation metrics to give varying weights to those different lighting levels. This, too, prevents comparison of the final metrics for television energy consumption in ABC mode.

External Power Supplies: Agree generic performance levels

An international test method for external power supplies (EPSs), now published as AS/NZS 4665 Part 1 and Part 2, was created in 2005 as a collaboration among China, Australia, Energy Star International, the State of California, and the EU.[15] Because of this, the test methods, efficiency metrics, and energy performance levels for EPSs may be better aligned internationally than those for any other product. Alignment is particularly desirable for EPSs, given that most are traded globally. Nevertheless, there are still opportunities for improvement. Product definitions and scope of coverage are challenging, partly because of the horizontal nature of EPS regulations and the wide variety of end-use products in question. There will probably always be some differences between jurisdictions in which products are allowed what exceptions, but as a general rule governments would be wise to harmonize these policies as much as possible to facilitate compliance and maximize energy savings. The expanded and more stringent MEPS due to take effect in the United States in February 2016 would ideally trigger regulators elsewhere to take action to retain the current high degree of policy alignment by aligning MEPS upwards to this new benchmark.

12. See, for example, Waide 2010. *Opportunities for Success and CO_2 Savings from Appliance Energy Efficiency Harmonization*. Available at: http://clasponline.org/harmonization.

13. Examples include ENERGY STAR (lamps and luminaires), the IEA-4E Solid State Lighting Annex (http://ssl.iea-4e.org/), and the SEAD Global Efficiency Medal competition for efficient lighting products (http://superefficient.org/lightingawards).

14. The Average Picture Level (APL) refers to the brightness of the image averaged across the screen. Test patterns are made up of areas of white (being the brightest), gray, and black (being the least bright).

15. Waide 2010. Part 2: An Assessment of Test Procedures and Efficiency Metrics, of *Opportunities for Success and CO_2 Savings from Appliance Energy Efficiency Harmonization.*

Refrigerated cabinets & display cabinets: Agree common test conditions and efficiency metrics

Commercial refrigeration equipment – specifically, refrigerated cabinets and display cabinets – are subject to a number of diverse test methods around the world, which can produce very different energy performance test results for the same equipment types.[16] Therefore, improved alignment in this product category would have to begin with international agreement on test conditions and the subsequent calculation of efficiency metrics. Given that S&L for commercial refrigeration products are currently being developed in several major economies, there is potential to create aligned S&L, or their building blocks, and thus a larger market for energy efficient technologies.

Conclusion: Large Potential Benefits from Alignment of S&L

This analysis demonstrates the substantial potential available for consumers in the EU from aligning S&L for a selection of comparable products to the current global best level. For four selected products – clothes dryers, external power supplies, medium refrigerator-freezers, and room air conditioners – potential benefits add up to almost 13 TWh in energy savings annually in 2030, if S&L performance levels were aligned with the best identified policies in place today.

In addition, there are several products for which other economies would benefit from aligning their S&L to the EU's level, where this is more demanding. These products include: small refrigerators, small refrigerator-freezers, chest freezers, clothes washers, dishwashers, and several lighting products (HID sodium high pressure; HID metal halide; HID ballasts; fluorescent tubes). Costs and benefits from alignment in other economies have not been assessed as part of this analysis. It is reasonable to expect, however, that benefits for each major economy from aligning their S&L with the world's most stringent S&L are proportionally in the same order of magnitude or larger than for the EU, given that the EU already has the most stringent S&L for many comparable products.

In addition to more stringent S&L providing benefits for countries through reduced energy demand and CO_2 emissions, and for consumers through reduced cost of using products, there are likely substantial benefits from increased global trade in highly energy efficient products. Aligning S&L and their building blocks allow for products to be traded more easily in more major economies. This increases the overall market potentially available to the same technology and product design, allowing production volumes to increase more quickly. Since an increase in production volume lowers the incremental cost of new technologies through learning, and since larger sales allow for a quicker return on investment for manufacturer R&D, it may be expected that aligned S&L lead to faster innovation with additional benefits for manufacturers, consumers and countries alike. These secondary effects are beyond the scope of this paper and could not be assessed in detail; however, further research into these positive feedback loops is recommended.

16. Waide et al, 2014. *CLASP Commercial refrigeration equipment: mapping and benchmarking*. Available at: http://clasponline.org/en/Resources/Resources/PublicationLibrary/2014/Benchmarking-Analysis-Compares-Commercial-Refrigeration-Equipment.aspx