European Commission

Savings and benefits of global regulations for energy efficient products

A 'cost of non-world' study

Final report

Energy

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Abstract

This study considers the potential for global regulations on energy efficient products. If the most stringent current minimum energy performance requirements (MEPS) for product energy efficiency had been harmonised globally at this point in time, global final energy consumption would be 9% lower, and energy consumption due specifically to products would be 21% lower. This saving of 8,950 TWh is equivalent to closing 165 coal-fired power plants, or taking 132 million cars off the road globally.

In an expanding world of limited resources, where energy consumption is expected to increase by 30% by 2030, there has never been a greater need for such efficiency improvements. If we begin to work toward ambitious global efficiency requirements now, for example implementing the current most stringent MEPS globally from 2020, then annual gross energy savings of 14% (7,600 TWh) could still be achieved by 2030 compared to a business as usual scenario; This would be equivalent to 5-6% of total global final energy consumption in 2030. These savings would occur across all regions, albeit with small variations due to country specific characteristics. Such savings bring with them economic benefits and increased welfare, freeing up consumer spending to grow the whole economy. Working towards harmonisation in this way could result in economic benefits of €280-410 billion per year, driving innovation, enhancing the competitiveness of EU industry and creating of 1.7-2.5 million jobs compared to 2030. In order to achieve these benefits, there are a number of barriers to be overcome - however, the core requirement for harmonisation is simply the coherence and comparability of test standards and policy approaches, which is achievable through coordinated efforts in the short to medium term at relatively low cost.

Glossary

Key terms and concepts:

Cost of Non-World: this study is labelled a cost of non-world study, this is developed from the concept of 'the cost of non-Europe' studies whose central notion is that the absence of common action at European level may mean that, in a specific sector, there is an efficiency loss (cost) to the overall economy and/or that a collective public good that might otherwise exist is not being realised. This study takes a similar approach, but on a global rather than EU level. It considers the avoided cost resulting from common requirements on energy efficiency of products on a global level.

Energy labelling: refers to the process by which energy-related labels are associated with a product. These can include a description and/or rating of the product energy use / efficiency. They may also include other basic product or environmental information. The goal of these labels is to better inform those purchasing the product, so that energy use (and costs) are taken into account and compared on a fair basis with other similar products. The logic is that this will result in the purchase of more efficient products, stimulating innovation and competition between product manufacturers to reduce energy use and/or increase efficiency. Energy labels can be mandatory or voluntary and may be introduced by Governments or industry sectors. Our focus in this work is on Government introduced energy labels.

Harmonisation: refers to the process of creating more coherent and in some cases common technical standards and policy requirements. Necessary steps towards this include increased international dialogue, mutual recognition, coherent definitions of products/scope, equivalence or at least comparability of test procedures, coherent product performance level frameworks etc. These may or may not lead to matching performance requirements, depending upon the economic and political situation in any given economy.

Minimum Energy Performance Standards (MEPS): sometimes also referred to as Minimum Energy Efficiency Requirements (MEER), are regulatory measures applied in a particular country or region specifying performance requirements for an energy-using device. They effectively limit the maximum amount of energy that may be consumed by a product, or the minimum level of efficiency, in performing a specified task. By specifying the minimum acceptable efficiency levels, MEPS define which products can be marketed and sold. A MEPS is usually made mandatory by a government energy efficiency body. It may include requirements not directly related to energy; this is to ensure that general performance and user satisfaction are not adversely affected by increasing energy efficiency. A MEPS generally requires use of a particular test procedure that specifies how performance is measured. The EU Ecodesign Directive is the primary means for setting MEPS in the EU.

Standards: distinct from standards referred to in the MEPS definition above, these refer to technical standards, which are agreed norms or requirements which establish uniform technical criteria, methods, processes and practices, for example of test methodologies will typically confirm to an agreed technical standard. Technical standards are typically set by or agreed through standardisation organisations such as ISO, IEC, ANSI, CEN/CENELC, etc.

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1 Introduction

1.1 Background

This study is a follow-up to the study 'Impacts of the EU's Ecodesign and Energy/Tyre labelling legislation on third jurisdictions' prepared for DG Energy by Ecofys, Waide Strategic Efficiency, ISR Coimbra University, Consumer Research Associates and Tait Consulting in April 2014[1].

The key findings of this previous work included, in summary:

The building blocks of Minimum Energy Performance Standards (MEPS) and labelling

Labels and Minimum Energy Performance Standards (MEPS) have to be built on a very specific technical platform, as shown in Figure 1. Most fundamental is the test methodology, but products must also be categorised in an appropriate way for testing, and for later setting thresholds of performance. The metrics are also crucial (kWh per day etc.) and the setting of thresholds appropriate to the local market. Policy can only be truly effective if enforcement follows, and common surveillance is possible and important once the other technical foundations are established. Thus useful harmonisation must begin with the test methodology (technical standard), extend to the product categorisation and efficiency metric – the systems can then be considered coherent and therefore easily comparable one to another (even if, for example, some simple conversion factors are necessary between units). This may (but does not have to) lead to harmonised energy efficiency thresholds used in regulations.

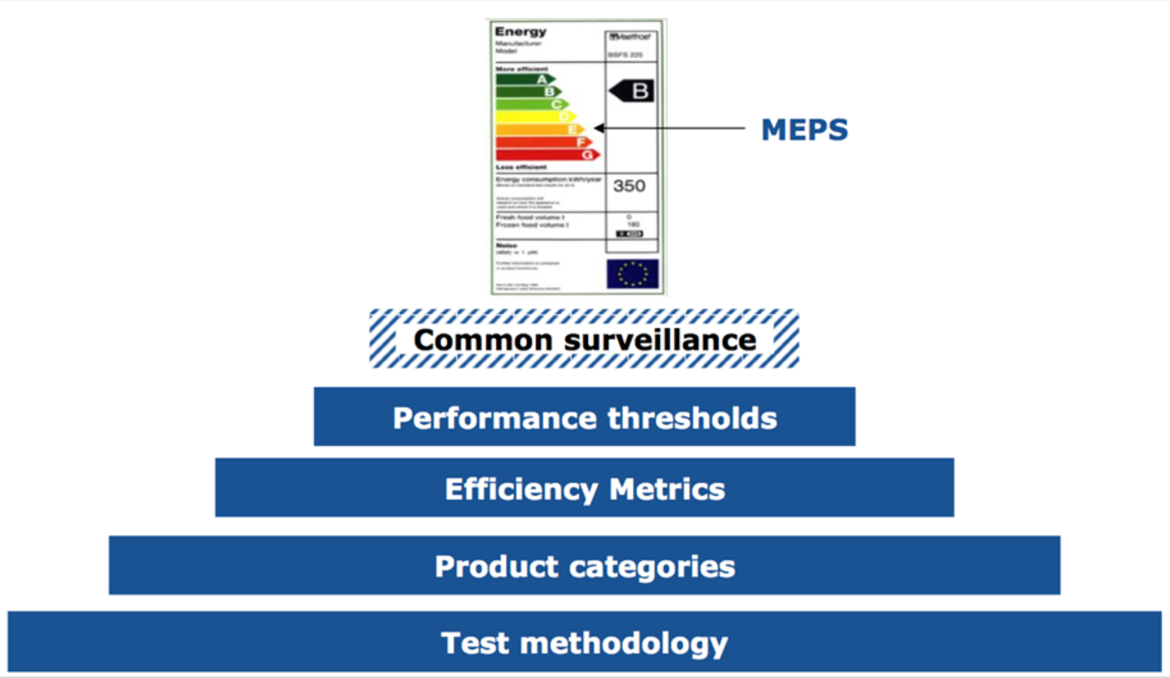

Figure 1: The hierarchy of building blocks that are necessary to establish energy labels and MEPS (source: presentation in support of final report for DG ENER: Impacts of the EU's Ecodesign and Energy/Tyre labelling legislation on third jurisdictions, Ecofys, April 2014).

1 Available at https://ec.europa.eu/energy/sites/ener/files/documents/201404_ieel_third_jurisdictions.pdf

The scale of the challenge for global product policy harmonisation

- By 2013 more than 87 countries (including the EU Member States) have comparative energy labels in place for one or more energy using product.
- By 2013 73 countries (accounting for more than 90% of global GDP and 70% of global population) had adopted regulations setting some form of minimum energy efficiency requirement for one or more energy using/related products.
- The number of energy labels and/or minimum energy performance standards (MEPS) is increasing each year, both in countries with existing programmes and in countries that are new to such approaches.
- The EU Energy Labelling Directive is influential globally:
    - The EU label's colour coding and arrows system is particularly influential and emulated, due to its being easily recognisable and understood by consumers. More than 50% of studied energy labels were fully or partially derived from the EU system, including major economies such as China, Russia and South Africa. Other leading economies, including the US, Japan, India and Australia, adopted their own labelling systems with little or no alignment with EU labels (although sometimes with some alignment within the other regions).
- The EU Ecodesign Directive is also influential globally:
    - More than 50% of the non-EU countries with MEPS adopted a MEPS fully or partially derived from the EU system, including major economies such as China, Australia and South Africa. Other leading economies, including the US, Japan and India adopted their own MEPS requirements with little or no alignment with the EU.
- The greatest global alignment on product energy efficiency policy can be found in the area of test procedures. There is a high level of alignment with EU test procedures, including some alignment of procedures with policy-divergent countries such as the US, Japan, India, and Australia.
- Motivations for alignment of policies and procedures include the desire to avoid duplication of effort, to facilitate international trade and to avoid product dumping.
- Alignment typically follows a 'lead' country for that product. This varies by product, i.e. laundry equipment (EU), electric motors (US).

Organisations already working to support closer global harmonisation

This started from a very limited base in the 1990's and has now evolved to include a number of important initiatives and developments, including:

- a dedicated NGO (CLASP) that supports international technical assistance on equipment standards, MEPS and labelling;
- a dedicated IEA implementing agreement (the IEA 4E) which addresses energy efficiency cooperation in electrical equipment;
- a global policy support framework in the Super-Efficient Appliance Deployment (SEAD) initiative created through the Clean Energy Ministerial[2];
- a dedicated UN agency supporting energy efficient lighting, in the form of UNEP's en.lighten programme, and which is now being expanded by UNEP to cover other household appliances and some commercial equipment;
- programmatic funding sources that can assist countries to develop equipment energy efficiency standards, MEPS and labelling programmes and measures via the GEF, the World Bank Group, EBRD and other regional multilateral development banks;

[2] http://www.cleanenergyministerial.org/Our-Work/Initiatives/Appliances

- bilateral programmatic funding to support equipment energy efficiency policy through international technical assistance programmes operated by the EU, USAID and State Departments, METI (Japan), RET in Australia and many others, including several EU Member State agencies.

It was noted that significant institutionalised international cooperation and harmonisation had only developed in one or two product groups (electric motors, distribution transformers). In the case of electric motors this resulted in common energy performance tiers founded on common test procedures, common product categories and common energy efficiency metrics.

The huge potential for further benefits from alignment and harmonisation
The study highlighted the support these new institutions provided to the process of harmonisation, particularly providing a catalyst for the exchange of knowledge and best practice. It also noted that there were 'certainly potential benefits from increasing the scale of these efforts'. The study recommended a variety of ways in which the EU should support further alignment. These included various awareness raising, cooperation and dissemination activities, and work to expand harmonisation to other products where global cooperation was most likely to result in agreement on common tiers, testing, categorisation, metrics and thresholds, as achieved for electric motors.

It is clear that product energy efficiency requirements such as MEPS and energy labels are having a significant impact globally. The report estimated annual electricity consumption savings at 17% in the EU[3] and 14% in the US[4], and similarly high energy savings in many other economies. Yet it was also identified that there is vast further potential for energy savings. A study by Waide et al (2011)[5] estimated that global alignment to the most advanced MEPS in place in 2010 by 2030 would result in annual savings in 2030 of 4000 TWh of final electricity demand (12% of the total) and 45% of oil and gas demand in the residential, commercial and industrial sectors[6]. More recent work[7] also estimates savings of this magnitude for existing MEPS and labels, with savings of 10-25% achieved.

Thus, the key motivations for this study are to further quantify the huge potential savings (and avoided costs and wider impacts) from global harmonisation, and refine the understanding of the overall benefits (and costs) of greater global harmonisation. This is also in-line with the European Commission's Energy Union and the 'energy efficiency first' principle.

1.2 Objectives

Building upon the context outlined above, this study had the following objectives:

- To prepare a general overview of [the impact of] global policies to improve the energy efficiency of energy-related products, especially using previous studies such as the study 'Impacts of the EU's Ecodesign and Energy/Tyre labelling legislation on third jurisdictions'.

[3] Ecofys (2012) Economic Benefits of the EU Ecodesign Directive
[4] ASAP (2012) The Efficiency Boom: Cashing In on the Savings from Appliance Standards
[5] Waide, P. et al. CLASP (2011a) Opportunities for Success and CO2 Savings from Appliance Energy Efficiency Harmonization.
[6] Excluding energy used for transport and industrial process heat, equivalent to 2600 Mt of CO2 emissions (11% of emissions from these sectors)
[7] IEA4E (2015) Achievements of appliance energy efficiency standards and labelling programs: a global assessment

- To assess in detail the potential benefits of aligning these policies to create common, world-wide minimum energy efficiency performance levels or labelling schemes for energy-related products, establishing the 'costs of non-world', on:
    - environmental aspects such as, but not limited, to the impact on energy consumption, resource efficiency and environmental pollution, both on a world-wide level and specifically for the European Union;
    - socio-economic aspects such as, but not limited to, the impact on the labour market, economic situation for households, affordability of energy-related products, technical barriers to trade between economies, competitiveness of industry and general economic costs or benefits, both on a world-wide level and specifically for the European Union;
    - technological aspects such as, but not limited to, the impact on invention and innovation of novel technologies, the market penetration of energy efficient products, and functionality and usability of energy-related products, both on a world-wide level and specifically for the European Union;
- To evaluate and present barriers to aligning these policies with common, world-wide minimum energy efficiency performance levels for energy-related products; and
- To structure the study in a clear and precise manner to give a complete overview on the 'costs of non-world' to policy makers but also to a non-technical audience like the general public.

1.3 Structure

Reflecting these objectives, the executive summary presents an overview of the 'costs of non-world' for non-technical readers. The remainder of this report presents the research and evidence that underpins the conclusions presented in the summary, as follows:

- Chapter 2: Summarising the methodology used in this work, including the main approach and scope and the quantitative modelling used to calculate energy savings.
- Chapter 3: Presenting the key results of the impact assessment at global and EU levels, of global harmonisation of policies to improve product energy efficiency. This examines the energy and environmental impacts, the economic impacts and the impact on citizens.
- Chapter 4: Reviewing the barriers to greater global harmonisation.
- Chapter 5: Presenting an assessment of the overall merits of harmonisation based on the findings of chapters 3 and 4.
- Annexes: Providing more detailed elaborations of the specific tools used and results at the product and country level.

2 Methodology

This chapter details the scope of this work and describes in more detail the quantitative modelling used to produce the energy saving estimates.

2.1 Approach

Our approach to this study was based on two key elements, (1) quantitative modelling of energy saving potential from global harmonisation; and (2) qualitative investigation and assessment of other impacts of global harmonisation. The first element is discussed in more detail in section 2.2. The remainder of this section describes our overall approach, including the qualitative assessment.

Our approach was underpinned by assumptions on the level at which global harmonisation is achieved, these are described more fully in the scenarios modelled and their descriptions (see section 2.2.1). The scenarios examine situations where global harmonisation has led to higher product efficiency requirements, at least in some regions, and for which we then assess the potential benefits such as:

- Increased energy savings;
- Other benefits from energy savings (i.e. reduced costs for consumers, reduced environmental impact, job impacts);
- Reduced costs for (internationally operating) companies as it simplifies their way of working of selling the same products for different markets;
- Increased imports and exports of products, although other legislation (e.g. safety) may keep posing barriers.

The wider issue of the ambition level actually possible in a global agreement is explored throughout the text, and particularly in chapter 4 on barriers. This addresses the question of whether global harmonisation can contribute to increasing overall ambition levels or if it is more likely to lead to a lowest common denominator type agreement, which while it may be better than nothing for currently unregulated countries would be unlikely to provide much benefit to energy saving in the economies with ambitious current requirements.

The analysis followed the following steps:

1. Inventory of product groups: MEPS and labelling requirements were examined for each of the product groups and economies in the scope of this study. This provided key model inputs and contextual information for the study.
2. Product group energy consumption modelling: based on the quantitative approach described above.
3. Assessment of other benefits and savings: including expanding the results to the Rest of the World and using the results to estimate further environmental and economic impacts.
4. Assessment of other impacts: including the various socio-economic, technological and trade impacts of harmonisation.
5. Assessment of barriers and merits of harmonisation: based on the impacts and known barriers the various practical aspects of harmonisation were discussed.
6. Conclusions and recommendations: based on the assessment conclusions and recommendations were derived.

The qualitative aspects of this assessment were heavily based on desk review of the most relevant documents globally, particularly in the focus countries and regions of the study (see below). The desk research was supplemented by stakeholder contact where necessary.

2.2 Quantitative modelling of energy savings

To conduct the quantitative analysis a detailed bottom-up model of product energy use was developed and linked with a top down energy model based on projections from the International Energy Agency (IEA). This hybrid top-down/bottom-up model analyses 102 specific energy end-uses that are subject to either minimum energy performance standards (MEPS) regulatory requirements or to energy labelling regulatory requirements or both, in one or more economies around the world. It aggregates the results by equipment type and energy end-use service (e.g. lighting, space cooling, motive power, etc.) into one of the residential, tertiary and industrial sectors. Transportation energy use and losses due to the production and transmission of energy are not considered. In both cases this is because different energy saving policies and ministries are involved than is the case for MEPS and energy labelling. In addition, direct fossil-fuel consuming industrial end-uses and customised industrial electrical end-uses, such as arc furnaces are not considered. This is because there are currently no Ecodesign-style MEPS policies applied to these end-uses and the equipment types concerned are not widely traded. All other energy end-uses are included and thus the ensemble of equipment types subject to MEPS or Energy Labelling style regulatory activity around the world are encompassed in the analysis[8].

A more detailed description of the model is presented in Annex I.

2.2.1 Scope of the modelling exercise

Given the large number of existing requirements and regulated product groups it was decided to scope the study to defined geographies and product groups with the aim of striking a balance between feasibility of the work and maximising the relevance and usefulness of the results. For key inputs we analysed the following regions/countries in detail in this work:

- China
- The European Union
- India
- Republic of South Africa (RSA)
- The USA

This country/region grouping includes both industrialised and developing economies, covers a high proportion (~65%) of total global GDP and population (~50%) and also covers a variety of different climates. These economies also include a variety of MEPS and labelling requirements across different product groups.

The modelling exercise also included a 'Rest of the World' (RoW) grouping to capture all the world's energy use and much of the regulatory activity around the product types considered; however, it inevitably required some assumptions to be made regarding the efficiency levels and energy use by product type in the large RoW region. The analysis extrapolated results from the industrialised and developing economies to the rest of world – see Annex I for more specific details.

[8] Excepting some policies applied in the transportation sector

The depth of analysis applied varies by equipment (product) group with the most detailed analyses being conducted for the following energy end-uses:

- Lighting (residential and tertiary [commercial and public] sectors)
- HVAC (heating, ventilation and air conditioning in residential and tertiary sectors)
- Water heating (residential and tertiary sectors)
- White goods (refrigerators and freezers, washing machines, dishwashers and clothes dryers)
- Consumer electronics (televisions, set-top boxes and external power supplies)
- ICT (desktops, notebooks, servers, domestic and commercial imaging equipment)
- Space heating (residential and tertiary sectors)
- Electric motors (industrial sector and related applications for pumping, fans and compressors)
- Transformers (distribution and power transformers in the industrial and tertiary sectors)

Slightly less detailed analyses were conducted for:

- Refrigeration (tertiary sector)
- Cleaning (tertiary sector)
- Pumps (residential and tertiary sectors)
- Cooking (residential and tertiary sectors)

These represent the most common appliance groupings and cover a very high proportion of final energy use. Residential, tertiary (commercial and public) and industrial uses are all considered. Only policies on MEPS and energy labelling were considered, although the influence of technical standards supporting these policies was also taken into account where relevant. Product systems were not analysed.

It should be noted that this product coverage while relatively comprehensive does not cover a majority of the energy efficiency potential that exists, with appliance efficiency being only one of a variety of areas where savings can be made. There can be synergies/overlap between these areas, for example in the area of buildings energy use and heating appliances, where policies that address the quality of the building envelope, i.e. requiring better insulation, can also be highly influential in improving energy efficiency and the impact that improved appliance efficiency has.

2.2.2 Scenarios considered

Four product energy scenarios are developed to explore the implications of the potential for energy savings through the adoption of equipment with higher energy savings potential as describe below.

Business as Usual (BAU) scenario

The BAU scenario considers how much energy would be used by each product type in each economy if energy efficiency policies which have currently been adopted are implemented but no new policies are adopted and implemented thereafter. In the event no product efficiency policies have been adopted this scenario projects the energy consumption as would be expected due to autonomous energy efficiency improvements, i.e. due to unregulated market forces.

Cost of Non World MEPS 2015 scenario

This scenario considers how much energy would be consumed were the average efficiency of products used today (2015) to be at the level equal to the most ambitious currently promulgated MEPS. This Cost of Non World scenario is completely hypothetical in that it is now too late for it to actually happen; however, it is informative in indicating the magnitude of savings that would have been delivered today had the most ambitious MEPS policies been adopted in the recent past on an internationally harmonised basis.

Cost of Non World MEPS + High Label 2015 scenario
This scenario considers how much energy would be consumed were the average efficiency of products used today (2015) to be either at the level equal to the most ambitious currently promulgated MEPS or at the level equal to the most ambitious currently promulgated energy label threshold (i.e. the so-called "High Label" requirement), whichever is most ambitious. This Cost of Non World scenario is purely hypothetical in that it is now too late for it to actually happen; however, it is also informative in indicating the magnitude of savings that would have been delivered today had the most ambitious MEPS and labelling policies been adopted in the recent past on an internationally harmonised basis.

Cost of Non World MEPS 2030 scenario
This scenario is different to the two 2015 Cost of Non World scenarios in that it is a plausible scenario that could yet be actualised. It projects how much energy would be consumed in 2030 were the average efficiency of products sold in the future to be at the level equal to the most ambitious currently promulgated MEPS. It explicitly takes into account the minimum realistic period it would take for all economies to adopt and implement these regulations (typically assumed to be about 5 years i.e. from 2020 onwards) and of the degree to which the stock of equipment in 2030 would be influenced by these regulations. Thus, it takes into account the fact that only a proportion of the equipment stock in 2030 would be affected by these regulations as some proportion of the equipment stock would have been sold prior to the regulations coming into effect i.e. would not have been retired from service by 2030. This scenario gives an indication of how much energy could be saved by 2030 were there to be broadly based international agreement to adopt the world's most demanding MEPS from 2015 by circa 2020. It should be noted that this scenario could be rather conservative, particularly for the countries with already well developed MEPS and labelling schemes, as by 2030 products stocks in these markets are likely in reality to have developed significantly beyond the current highest MEPS levels.

A MEPS + high label 2030 scenario is not modelled as this is not considered realistic within this timeframe.

Annex I contains more details about how these scenarios are derived and modelled. Annex II contains detailed results for each economy while Annex III contains detailed results by equipment type.

3 Potential impacts of global harmonisation

Greater global harmonisation of product policy requirements could have significant impacts on energy use and the environment, the economy and citizens. This chapter assesses what these impacts could be, in the context of the scenarios outlined in section 2.2, and by discussing and analysing the important underlying factors that drive and explain these impacts. In doing so we provide insight into the direction and magnitude of impacts for different countries and affected firms and consumers, including for impacts where a quantitative analysis is not possible.

Impacts are generally analysed in this chapter at the global or selected country/region level. However, for some impacts and benefits it is worth considering the individual consumer level and/or the industry sectoral level - this is done where appropriate.

3.1 Energy and environmental impacts

3.1.1 Impact on energy consumption

Key points:

Significant gross annual energy savings of 13% would be achieved in 2030 if global MEPS were agreed at current highest (most stringent)[9] levels and implemented by 2020: based on the results of the modelling work carried out by this study savings would be experienced across all countries and regions and across a large range of product groups.

Gross annual energy savings would be increased if global alignment were made to either the highest energy label category or MEPS: although it was only possible to model this for a 'dream scenario' of an instantaneous switch in 2015, the total potential of aligning to higher label classes was assessed to be more than 50% higher than only aligning to the highest MEPS levels (34% total gross savings compared to 21% total gross savings).

Energy savings should remain significant even accounting for a rebound effect: while the precise effects are uncertain, literature strongly suggests rebounds of less than 100% in the majority of cases, and effects of 20% or less experienced in the developed world.

Consumer electronics and ICT, lighting and (thermal) heating and hot water products were assessed to offer the highest relative and absolute potential: for energy savings in 2030 if current highest MEPS were applied by 2020. Consumer electronics and ICT and lighting in the residential sector and heating and hot water technologies in both the residential and tertiary sectors offer significant absolute energy saving potential.

[9] Highest is used in this report to denote the most stringent MEPS requirements, in a few cases, i.e. for standby power requirements, the 'highest' or most stringent requirement is actually for the lowest energy use.

Implementing globally harmonised MEPS as described in scenarios presented in section 2.2.1 would have significant impacts on the final energy use of the regulated products. This section presents the quantitative results of the modelling exercise undertaken by this study (the approach is described in section 2.2) to estimate the size of these impacts. Results are presented in aggregate in this section, while comprehensive product and country level results are presented in the annexes.

The results presented below provide both a gross and net estimated impact on energy use. The gross impact represents the saving from simply applying the global MEPS while the net impact is adjusted for the anticipated rebound in energy use caused by the financial savings being re-spent in the economy leading to increased energy use, this is known as the rebound effect and is explained further in Box 1. An indicative rebound effect of 20% is applied to the gross energy savings to arrive at net savings.

Box 1: The rebound effect

The rebound effect of efficiency can in some cases mean that efficiency savings lead to higher overall consumption, this is sometimes referred to as the Jevons Paradox or 'backfire'. For example if less energy is used due to increased appliance efficiency a consumer saves money, which can then be spent either to use the appliance more, buy bigger appliances, or on other activities, i.e. leisure, which also create new energy demand. The applicability of the first effect is limited for many appliances as the demand for their function does not change with efficiency, i.e. a more efficient refrigerator does not logically lead to more use of the refrigerator, indeed energy use is rarely a direct factor in a choice to use an appliance. However the second effect, towards larger product sizes, i.e. increased screen sizes, or more features has been observed, with the result that absolute energy consumption may not decrease in the same proportions as any efficiency improvement. The third effect can also be highly prominent when efficiency savings are made due to the effects on prices and consumption at a macroeconomic level.

Significant amounts of research have been carried out into these rebound effects to better understand and quantify them, to assist policymakers in understanding what the actual result of efficiency policies may be, and particularly to address the concern that policies could 'backfire'. We include an indicative rebound correction of 20% in this study. We base this correction on a study by the American Council for an Energy-Efficient Economy (ACEEE, 2012), which is an assessment of a range of studies. It concludes that the total rebound effect, both direct and indirect, is about 20%. The IEA also investigated the rebound effect in the World Energy Outlook 2012. Their report notes that depending on the country and consumption sector, the direct rebound effect generally ranges from 0-10%, and that estimates of the indirect rebound effect vary widely. Accounting for this, the IEA estimated the overall rebound effect to be 9%. We understand that uncertainty remains on the extent of the rebound effect and that studies have estimated numbers higher than 20%.

As the model used in this study is not sophisticated enough to model specific rebound effects for the different product groups and countries/regions analysed in this study, we have adopted the 20% rates across all products and countries. Further research in this area may be an interesting avenue for future research. While the value we apply is consistent with literature in this area and we believe offers a reasonable assessment of the scale of this effect, the reader should be aware that this is only an assumption and that there remains potential for higher rebounds, and even in a few cases backfire in efficiency measures. This could be particularly relevant in developing countries where energy demand remains mostly unmet. It is also relevant to the other environmental and economic impacts also analysed in later chapters.

CoNW MEPS 2015

This scenario represents the potential energy saving if the highest current MEPS levels were instantly applied to global energy use. Note that results have been rounded.

The results in Table 2 show that BaU 2015 final energy consumption of the analysed products is 43,080 TWh, or approximately 40% of total global final energy consumption[10]. Moving to globally harmonised MEPS is calculated to result in gross reductions in energy use of 21%, or 8,950 TWh. The savings vary by region from 18% in the EU to 27% in India. This difference is a factor of the assessed efficiency of the existing stock being higher in the EU than elsewhere, largely, but not only, the result of the impact of the existing MEPS and Energy Labelling regulations in the EU. Assuming a 20% rebound effect would reduce the net energy savings to 17% globally.

Table 2: Energy savings in the CoNW MEPS 2015 scenario

Country/region	BAU 2015	CoNW MEPS 2015					
	Energy use (TWh)	Gross energy use (TWh)	Change on BAU (TWh)	Gross change on BAU (%)	Energy use rebound (TWh)	Net energy use (TWh)	Net change on BAU (%)
China	5 900	4 900	-1 000	-17%	200	5 100	-14%
EU	5 600	4 600	-1 000	-18%	200	4 800	-14%
India	1 100	800	-300	-27%	60	860	-22%
RSA	280	230	-50	-18%	10	240	-14%
USA	5 900	4 800	-1 100	-19%	220	5 020	-15%
RoW	24 300	18 800	-5 500	-23%	1 100	19 900	-18%
World	**43 080**	**34 130**	**-8 950**	**-21%**	**1 790**	**35 920**	**-17%**

CoNW MEPS + HL 2015

This scenario represents the potential energy saving if the highest current energy labels or MEPS levels were instantly applied to global energy use.

The results in Table 3 show that moving to globally harmonised efficiency requirements set at the highest current Energy Labels or MEPS is calculated to result in gross energy savings of 34%, or 14,600 TWh. The savings vary by region from 27% in China to 36% in India and the Rest of the World (RoW). In addition to the differences from the efficiency of existing stock levels described above, differences also result from differing breakdowns of energy end-uses within a country and the relative stringency of both any existing and the highest label (or MEPS) applied per product. This explains the ranges of impacts between China and India and RoW in this case. Assuming a 20% rebound effect would reduce the net energy savings to 27% globally.

[10] Calculation based on IEA (2015) Key world energy statistics 2014, total World FEC 2012 of 8,979 Mtoe

Table 3: Energy savings in the CoNW MEPS + HL 2015 scenario

Country/region	BAU 2015	CoNW MEPS 2015					
	Energy use (TWh)	Gross energy use (TWh)	Change on BAU (TWh)	Gross change on BAU (%)	Energy use rebound (TWh)	Net energy use (TWh)	Net change on BAU (%)
China	5 900	4 300	-1 600	-27%	320	4 620	-22%
EU	5 600	3 800	-1 800	-32%	360	4 160	-26%
India	1 100	700	-400	-36%	80	780	-29%
RSA	280	200	-80	-29%	16	216	-23%
USA	5 900	4 000	-1 900	-32%	380	4 380	-26%
RoW	24 300	15 500	-8 800	-36%	1 760	17 260	-29%
World	**43 080**	**28 500**	**-14 580**	**-34%**	**2 916**	**31 416**	**-27%**

CoNW MEPS 2030

This scenario represents the potential annual energy saving in 2030 if the highest current MEPS levels were introduced by circa 2020 and naturally replaced the existing stock as it came to the end of its lifetime.

The results in Table 4 show that BaU 2030 final energy consumption of the analysed products is 55,200 TWh. Moving to globally harmonised MEPS from 2020 is calculated to result in annual gross energy savings of 14%, or 7,700 TWh in 2030. The savings vary by region from 10% in China to 16% in RoW. As previously, the difference is a factor of a combination of efficiency of the existing stock, energy end-uses within a country and the relative stringency of both any existing and the applied highest MEPS levels per product. For example the impact is lower in China as it has a relatively high share of industrial energy use for which the improvement potential is relatively low. Assuming a 20% rebound effect would reduce the net energy savings to 11% globally.

Table 4: Energy savings in the CoNW MEPS 2030 scenario

Country/region	BAU 2030	CoNW MEPS 2030					
	Energy use (TWh)	Gross energy use (TWh)	Change on BAU (TWh)	Gross change on BAU (%)	Energy use rebound (TWh)	Net energy use (TWh)	Net change on BAU (%)
China	10 900	9 800	-1 100	-10%	220	10 020	-8%
EU	5 800	5 100	-700	-12%	140	5 240	-10%
India	2 400	2 100	-300	-13%	60	2 160	-10%
RSA	490	420	-70	-14%	14	434	-11%
USA	6 600	5 700	-900	-14%	180	5 880	-11%
RoW	29 000	24 500	-4 500	-16%	900	25 400	-12%
World	**55 190**	**47 620**	**-7 570**	**-14%**	**1 514**	**49 134**	**-11%**

Summary of global results

It is clear from the analysis that all of scenarios would result in globally significant levels of energy savings, see Figure 1. This demonstrates not only the benefits of 'instant' application of the highest current MEPS and/or label requirements globally, but also that in a more realistic modelling of global MEPS implementation that final energy use could still be reduced by 14% compared to BAU. This would correspond to approximately 5-6% of total global final energy consumption in 2030, assuming final energy consumption shares remain broadly the same as in 2015. Due to the high share of electricity in the analysed final energy consumption the corresponding reduction in primary energy consumption may be even higher. Additionally, even taking a 20% rebound effect into account the net savings would remain highly significant. This can also create benefits for energy security, particularly for areas or regions which are net energy importers, such as the EU.

The modelled savings would occur across all regions, albeit with some, relatively small, differences deriving from country specific characteristics.

It should be noted that the modelling approach is based on particular assumptions and simplifications, therefore the results are not to be interpreted precisely but nevertheless provide a strong indication of the scale of the actual potential.

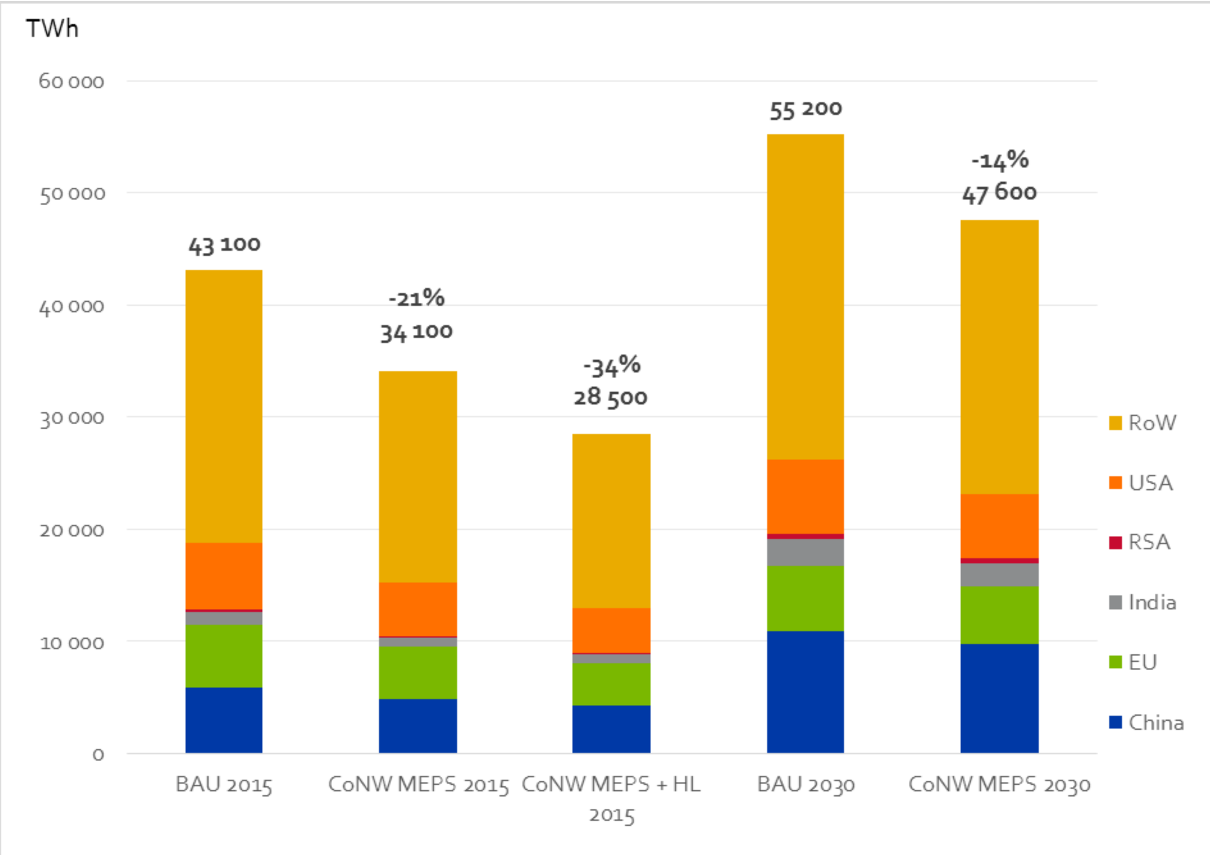

Figure 2: Summary of gross global final energy consumption and savings (%) of all modelled scenarios compared to BAU, rounded to nearest 100 TWh

Prioritisation potentials by product (and country/region)

The previous sub-sections present the global savings across all product groups. Here we identify from the detailed results per product group (also see annexes II and III) the particular product groups where the largest energy savings potential is identified. This can be particularly relevant to prioritising bi-lateral harmonisation or global agreement on particular product groups as a step towards more comprehensive global harmonisation. Results are presented for the CoNW MEPS 2030 scenario.

Table 5 presents the results for product groups in the residential sector, this shows the five highest energy savings potentials as the following, with an indication of the particular countries/regions where potential is higher/lower:

1. Consumer electronics and TVs (-69%)
    a. Highest potential in RSA and RoW

   b. Lower potential in EU and US
2. Circulator pumps (-48%)
   a. Even potential globally
3. Lighting (-44%)
   a. Highest potential in the RSA and RoW
   b. Lowest potential in EU and China
4. ICT and Personal Computers (-40%)
   a. Higher potentials in RSA and RoW
   b. Lower potential in the EU and US
5. Refrigerators (-34%)
   a. Highest potential in China, India, RSA and RoW
   b. Low potential in EU and US

These potentials correspond broadly to the gross energy saving potentials in TWh, with the exceptions of circulator pumps where the total savings are relatively low and the thermal end-use products for heating and hot water, where even the savings of 14-15% translate into very large savings in TWh. In the case of heating this offers by far the largest additional savings potential, with the potential a little lower than the global value in the EU and US, but higher in the other regions.

Table 5: Residential products potential energy savings in CoNW MEPS 2030 scenario (colour scale, greener = larger relative saving potential)

Product group	World			
	BAU 2030 (TWh)	CoNW MEPS 2030 (TWh)	Gross % change	Gross change (TWh)
Electric end-uses				
Lighting	1 177	664	-44%	-513
Electric (resistance/HPs)	891	797	-11%	-94
Circ. Pumps	159	83	-48%	-76
Ventilation	398	325	-18%	-72
AC	1 495	1 289	-14%	-206
Electric water heaters	912	835	-8%	-77
Refrigerators	896	592	-34%	-304
Clothes Washers	319	235	-26%	-84
Clothes Dryers	160	126	-21%	-34
Dishwashers	122	90	-26%	-32
CE/TVs	1 392	426	-69%	-966
ICT/PCs	563	338	-40%	-224
Electric	426	391	-8%	-35
Sub-total	***8 908***	***6 191***	***-31%***	-2 717
Thermal end-uses				
Heating	15 147	12 850	-15%	-2 296
Hot Water	2 596	2 221	-14%	-375
Cooking	846	792	-6%	-54
Sub-total	***18 589***	***15 863***	***-15%***	**-2 726**
Total	**27 497**	**22 054**	**-20%**	**-5 443**

Table 6 presents the results for product groups in the tertiary (commercial and public) sector, this shows the five highest energy savings potentials as the following, with an indication of the particular countries/regions where potential is higher/lower:

1. ICT (-25%)
   a. Higher potential in RSA and RoW

   b. Lower potential in EU and US
2. Air Handling Units/Other (-22%)
   a. Even potential globally
3. Central and Room Air Conditioning and Chillers (-17%)
   a. Higher potential in RS, India and RoW
   b. Lower potential in the US and China
4. Electric resistance heaters and heat pumps (-15%)
   a. Even potential globally
5. Pumps (-15%)
   a. Even potential globally

These potentials correspond broadly to the gross energy saving potentials in TWh, with the exceptions of lighting where even though potential is relatively low at 10% this still offers significant savings of 149 TWh compared to 2030 BAU. As with the residential technologies thermal heating and hot water offer the highest energy savings in TWh, although proportional potential is assessed to be lower, again potential in these product groups is a little lower than the global value in the EU and US but higher in the other regions.

Table 6: Tertiary products potential energy savings in CoNW MEPS 2030 scenario

Product group	World			
	BAU 2030 (TWh)	CoNW MEPS 2030 (TWh)	Gross % change	Gross change (TWh)
Electric end-uses				
Lighting	1 454	1 304	-10%	-149
Resistance/HPs	843	719	-15%	-124
AHU/Other	608	475	-22%	-132
Central/RAC/Chillers	901	743	-17%	-157
Hot water systems	305	294	-4%	-11
Refrigeration	689	638	-7%	-51
Cleaning	196	189	-4%	-7
ICT	400	301	-25%	-99
Cooking	190	190	0%	0
Pumps	589	501	-15%	-88
Sub-total	***6 174***	***5 355***	***-13%***	***-819***
Thermal end-uses				
Heating	4 167	3 618	-13%	-549
Hot Water	1 544	1 345	-13%	-200
Cooking	570	570	0%	0
Sub-total	***6282***	***5533***	***-12%***	***-749***
Total	**12 456**	**10 888**	**-13%**	**-1 568**

Table 6 presents the results for product groups in the industry sector and transformers, this shows the energy savings potentials of industrial motive power of 2%, within this the potentials are highest for fans and pumps. The potential for transformer loss savings is assessed as 14%. Potential for both is assessed as broadly even across all countries/regions. In TWh the gross savings achieved in each product group are broadly similar.

Table 7: Industrial products potential energy savings in CoNW MEPS 2030 scenario

Product group	World			
	BAU 2030 (TWh)	CoNW MEPS 2030 (TWh)	Gross % change	Gross change (TWh)
Industry motive (electric)	13 563	13 286	-2%	-278
Transformer losses	1 756	1 508	-14%	-248
Total	**15 319**	**14 793**	**-3%**	**-526**

On the basis of the product level analysis the most significant products (proportionally) for energy savings all fall within the residential product groups, especially consumer electronics and TVs and lighting. In addition thermal products for heating and hot water for both residential and commercial uses, while assessed to have relatively moderate efficiency increase potential, can produce the largest energy savings in TWh of all products groups. This suggests that if maximum impact is sought then these four product groups should be among those focused on for harmonisation.

3.1.2 Other environmental impacts

Key points:

Reducing energy use can have important environmental benefits: Energy use has many negative environmental impacts associated with it, reducing energy use can bring significant environmental benefits. This report has used a simplified life-cycle approach to provide a broad order of magnitude estimate of the environmental benefits that may result from the calculated energy savings. The results scale directly in proportion to the energy savings. Results are presented gross, but even taking into account a rebound effect of 20% would still leave significant environmental benefits.

In summary we calculate environmental benefits of:

- CoNW MEPS 2015: 20-21% reductions in all environmental impacts compared to 2015 BAU
- CoNW MEPS + HL 2015: 28-35% reductions in all environmental impacts compared to 2015 BAU
- CoNW MEPS 2030: 13-14% reductions in all environmental impacts compared to a 2030 BAU

Note: significant caution should be taken in using these estimates, yet it is clear the potential benefits are significant.

Climate change mitigation would be one of the most significant benefits: with gross emissions reduction potential compared to baseline estimated alternately at 4,650 MtCO2e (CoNW MEPS 2015), 7,200 MtCO2e (CoNW MEPS +HL 2015) to 4,450 MtCO2e (CoNW MEPS 2030), or 10%, 15% and 7% respectively of total global BAU GHG emissions.

Terrestrial acidification and particulate matter formation would also benefit: reductions in energy use by appliances can have the most significant impact on total global impacts in these areas. Benefits in other environmental aspects are also positive but less significant globally.

The energy savings calculated above will naturally translate into reductions of environmental damage resulting from energy production. This will impact upon the emissions of greenhouse gases (GHG) and also other emissions to land, water and air as less energy generation is needed.

We use a simplified life-cycle analysis approach to estimate the scale of the environmental benefits of the energy savings. This utilises the environmental impacts associated with use of the key fuels included the energy model. The environmental impacts per use of a unit of fuel are sourced from the Ecoinvent dataset[11], where we use the ReCiPe v1.11 life-cycle analysis framework[12] to assess impacts on the following environmental aspects (and units):

- Climate change (tonnes CO_2 eq.)
- Ozone depletion (kg CFC-11 eq.)
- Terrestrial acidification (kg SO_2 eq.)
- Freshwater eutrophication (kg P eq.)
- Photochemical oxidant formation (kg NMVOC)
- Particulate matter formation (kg PM_{10} eq.)
- Natural land transformation (m^2)
- Water depletion (m^3)
- Metal depletion (kg Fe eq)

The database provides impacts on each of these aspects per MWh of each fuel used, with country specific entries used wherever these are available. Annex IV describes these input values in more detail.

The impact values are multiplied by the known TWh savings as calculated by the model and as presented in the previous section and annexes II and III to arrive at gross environmental benefits. An additional step is then taken to account for an anticipated rebound in energy use as the money saved on energy use is re-spent elsewhere in the economy leading to growth in energy use (and environmental impacts) in other sectors. This rebound effect does not consider any additional environmental impacts from the increased economic activity in the other sectors, although in reality further negative environmental impacts could be expected. See Box 1 above.

Important notes: It should be noted that the impact factors that are used are underpinned by various scientific studies and assumptions, with some areas more developed than others and some remaining areas of scientific debate and uncertainty – this should be kept in mind when interpreting the results presented below.

The highly simplified approach and broad assumptions means that the results provide only order of magnitude estimates of potential environmental benefits and should not be used as precise estimates. They will also not provide specific, deeper insights, i.e. it is not possible to indicate specifically where the land transformation or water depletion is prevented, although it is clear that the geography is important to the actual end-benefit.

[11] http://www.ecoinvent.org/database/database.html
[12] http://www.lcia-recipe.net/

The 2030 impact results assume no change in emissions factors/environmental impact of the fuels over time, while this may be a relatively robust assumption for direct fuel combustion, the associated emission factors for electricity are likely to change significantly (reduce) in each country/region over the next 15 years. Therefore actual savings may be lower.

The results of the environmental benefit calculations are presented below in Table 4 which shows that for climate change the CoNW MEPS 2015 scenario would result in net emissions reductions of approximately 4,700 MtCO_2e, or 21%, compared to the 2015 BAU. These savings would be 10% of estimated total global GHG emissions in 2015.[13]

Extending the scenario to compliance with the highest MEPS or energy label category (CoNW MEPS + HL 2015) would increase the mitigation potential to 7,200 MtCO_2e, or 32% savings compared to the 2015 BAU. These savings would be 15% of estimated total global GHG emissions in 2015.

Finally, considering the scenario of global adoption of the highest current MEPS by 2030, the GHG mitigation potential would be 4,450 MtCO_2e, or 13% savings compared to the 2030 BAU. These savings would be equivalent to around 7% of estimated total global GHG emissions of 62,000 MtCO2 in 2030. This percentage would be higher assuming an emissions reduction pathway consistent with a 2 degree C increase is followed. As noted above, as no change in emissions factors is assumed the actual benefits may be lower.

Other environmental impacts all experience similar proportional changes per scenario, -20% to -21% for the CoNW MEPS 2015 scenario, -28% to -35% for the CoNW MEPS + HL 2015 scenario and -13 to -14% for the CoNW MEPS 2030 scenario. In addition to climate change these changes would have particularly significant positive impacts on terrestrial acidification and particulate matter emissions, with benefits to buildings, crops (both acid damage) and biodiversity from the former and to human health from the latter.

[13] Based on global emissions of approximately 48,000 MtCO_2e in 2012, see WRI CAIT dataset

Table 9: Calculated gross environmental impacts of energy savings

	Climate change	Ozone depletion	Terrestrial acidification	Photochemical oxidant formation	Particulate matter formation	Natural land transformation	Water depletion	Metal depletion
	Mt CO2 eq	kg CFC-11 eq	Mt SO2 eq	t NMVOC	t PM10 eq	ha	million m3	t Fe eq
BAU 2015	22 515	1 333 586	124	56 215 850	35 079 282	269 494	42 624	177 083 729
% of 2000 global total	54%	1%	53%	16%	41%	4%	-	7%
CoNW MEPS 2015	17 844	1 053 013	99	44 820 546	28 031 098	213 974	34 185	139 663 029
Change from BAU	-4 671	-280 573	-25	-11 395 303	-7 048 184	-55 520	-8 439	-37 420 700
Change from BAU (%)	**-21%**	**-21%**	**-20%**	**-20%**	**-20%**	**-21%**	**-20%**	**-21%**
CoNW MEPS + HL 2015	15 312	865 510	87	39 167 847	24 654 024	178 887	30 797	116 892 139
Change from BAU	-7 203	-468 076	-37	-17 048 003	-10 425 258	-90 608	-11 827	-60 191 590
Change from BAU (%)	**-32%**	**-35%**	**-30%**	**-30%**	**-30%**	**-34%**	**-28%**	**-34%**
BAU 2030	33 238	1 387 006	207	92 589 728	60 005 210	305 852	76 255	227 873 660
CoNW MEPS 2030	28 794	1 191 352	181	80 787 590	52 483 733	265 443	66 290	195 780 073
Change from BAU	-4 444	-195 654	-27	-11 802 138	-7 521 478	-40 410	-9 964	-32 093 587
Change from BAU (%)	**-13%**	**-14%**	**-13%**	**-13%**	**-13%**	**-13%**	**-13%**	**-14%**

Note: the % of 2000 global total row provides contextual information on the share of the global impact that the BAU 2015 scenario would contribute. We understand that comparing 2015 estimates to 2000 base information (based on the ReCiPe normalisation factors for year 2000[14]) is far from ideal, given the likely significant changes in the intervening period. Rather the purpose of the information is to show how relevant the energy savings the scenario would achieve are to this particular impact. The key lesson is that the impacts on climate change, terrestrial acidification and particulate matter formation are particularly significant and where the largest benefits will arise, while the beneficial impacts on the other aspects, and particularly ozone depletion and natural land transformation, are much less important at the global level.

[14] http://www.lcia-recipe.net/file-cabinet/LCA_ReCiPe_normalisation_2000_factors-revised_2010.zip?attredirects=0

3.2 Economic impacts

3.2.1 Economic impact of energy savings

Key points:

Energy efficiency brings economic benefits and increased welfare: greater energy efficiency, as with efficiency in general, brings economic benefits as the increased efficiency enables increased production and/or consumption, increasing the welfare of consumers. In the scenarios examined in this study greater energy efficiency delivers significant net energy savings, which can then be spent by consumers on other things, increasing overall economic welfare. This already takes into account that appliances that are more energy efficient will cost more. These additional costs are more than repaid by the energy savings.

In summary we calculate energy savings economic benefits of:

- CoNW MEPS 2015: €310-470 billion per year, or 13-19% savings compared to 2015 BAU
- CoNW MEPS + HL 2015: €490-730 billion per year, or 20-29% savings compared to 2015 BAU
- CoNW MEPS 2030: €280-410 billion per year, or 8-13% savings compared to a 2030 BAU

Energy savings can influence economic structure and have important impacts on trade: as money is spent outside the energy sector and elsewhere in the economy the relative share of the energy sector in the economy will reduce. There are likely to be benefits for the appliance manufacture sector, which will be beneficial for the EU. In addition regions, such as the EU, which are major energy importers are likely to see improved trade balances as less energy imports are required. Although understanding the full impacts is too complex to fully explore here.

Economic savings can also be achieved by others: global implementation can help spread the costs across more players, reducing the costs for all and avoiding inefficiencies from parallel or duplicate approaches. Sharing information can also help to save costs in testing, compliance and enforcement as well as in policymaking.

Energy efficiency is almost always economically beneficial as it leads to more efficient consumption (and production) in an economy, which improves the economic welfare of consumers. A recent study[15] points to net benefit:cost ratios of existing MEPS and labelling in the order of 3:1 or 4:1 highlighting the overall benefit of energy saving.

Based on the modelling of energy savings we are able to make an estimate of the economic benefits resulting from increased efficiency. This is achieved by multiplying the calculated savings by relevant energy prices per fuel, country/region and sector. A cost premium for the more efficient products is subtracted from the savings, representing the higher up-front costs of more efficient products. It was not possible to identify existing work into price premiums for MEPS compliant products across the full range of appliances and MEPS we consider in this study. For these reasons we revert to, what we believe is, a conservative assumption of a 25% premium. This

[15] IEA4E (2015) Achievements of appliance energy efficiency standards and labelling programs: a global assessment

assumption was also previously used in other work[16] and remains consistent with the cost:benefit ratios descried above. The savings are presented in a +/- 20% range from those calculated, given the potential uncertainties in prices, particularly for the rest of the world.

Important note: given the inherent uncertainties in the calculations the following results should be treated as estimates of the potential order of magnitude of the energy savings rather than precise estimates.

The results of the calculation are presented below in Table 5 which shows that compared to global energy costs of more than €2.5 trillion in 2015 the instant compliance of all appliances to the current highest MEPS could save between €310-470 billion per year, or 13-19% savings. The savings would be worth €50-75 billion per year to the EU.

Extending the scenario to compliance with the highest MEPS or energy label category would increase the savings to €490-730 billion, or 20-29% of current energy expenditure. The savings in this scenario would be €90-140 billion to the EU.

Finally, considering the scenario of global adoption of the highest current MEPS by 2030, the savings are calculated at €280-410 billion, or 8-13% savings on estimated global energy use of €3.3 trillion per year. These savings are estimated on the basis of 2015 energy prices, assuming that in reality energy prices will increase the actual savings would be higher, although we would expect the calculated percentage changes to remain representative.

Table 10: Estimated economic impact of global harmonisation of MEPS and energy labelling requirements

	Gross energy costs - BAU	Net change in costs - low	Net change in costs - high	Net change in costs - low	Net change in costs - high
	billion euros	billion euros	billion euros	as % of BAU	as % of BAU
CoNW MEPS 2015					
China	307	-29	-44	-9%	-14%
EU	478	-50	-74	-10%	-15%
India	86	-12	-18	-14%	-21%
RSA	9	-1	-2	-11%	-22%
USA	322	-42	-62	-13%	-19%
RoW	1 293	-180	-269	-14%	-21%
World	**2 495**	**-314**	**-469**	**-13%**	**-19%**
CoNW MEPS + HL 2015					
China	307	-43	-65	-14%	-21%
EU	478	-90	-135	-19%	-28%
India	86	-18	-27	-21%	-31%
RSA	9	-2	-2	-22%	-22%
USA	322	-65	-98	-20%	-30%
RoW	1 293	-270	-405	-21%	-31%
World	**2 495**	**-488**	**-732**	**-20%**	**-29%**

[16] Ecofys (2012) Economic benefits of Ecodesign

	Gross energy costs - BAU	Net change in costs - low	Net change in costs - high	Net change in costs - low	Net change in costs - high
	billion euros	billion euros	billion euros	as % of BAU	as % of BAU
CoNW MEPS 2030					
China	640	-35	-52	-5%	-8%
EU	510	-37	-55	-7%	-11%
India	212	-18	-26	-9%	-12%
RSA	16	-1	-2	-6%	-12%
USA	369	-33	-49	-9%	-13%
RoW	1 535	-153	-230	-10%	-15%
World	**3 282**	**-277**	**-414**	**-8%**	**-13%**

As noted above these energy savings will be re-spent by consumers, either in terms of increased use of the appliance (the rebound effect) or in the wider economy, increasing overall welfare. This change in spending can lead to structural economic change, most directly reducing the income of the energy sector while increasing the income of the appliance manufacturing sector. These changes would be largely beneficial to the EU as a net energy importer and major producer of energy efficient appliances.

Beyond the direct effects, the indirect increase in consumption will also lead to increasing consumption of services across the whole economy. This will have knock-on effects on the macro-economy and trade balances. Although the savings are primarily of electricity and therefore will impact most on imports of gas, coal and other fuels, and less so oil, which is by far the most important energy carrier in global trade. It is not possible here to quantify the scale or direction (positive or negative) of such impacts. This can be an interesting subject for future research, particularly given the various knock-on effects of such changes on energy markets and prices.

For implementing authorities a globalised approach can also help to reduce costs of market verification, standardisation and testing, and enforcement. By aligning activities, development costs and sharing information the benefits can be experienced by all, reducing inefficiencies from parallel or duplicate approaches, and costs can be spread across more players, reducing the costs for all. The benefits would include enabling the quicker comparison of the performance of equivalent products between countries and regions, and comparison of policies and their impacts. Policymakers could then also transpose and adapt analyses from other markets to determine appropriate domestic efficiency requirements, reducing the cost of policy making.

3.2.2 Impact on employment

Key points:

Economic savings will have a positive net employment impact: the economic savings from greater energy efficiency will translate into impacts on the energy sector and wider economy as spending on the former is reduced and most of the reduction is then re-spent in the latter. The relative labour intensity of the two sectors is such that this is likely to result in job creation, as the wider economy employs more people per unit of turnover than the energy sector, which is more capital intensive.

In summary we calculate net employment benefits of:

- CoNW MEPS 2015: 1.8-2.8 million additional jobs compared to 2015 BAU
- CoNW MEPS + HL 2015: 2.8-4.2 million additional jobs compared to 2015 BAU

- CoNW MEPS 2030: 1.7-2.5 million additional jobs compared to 2030 BAU

Benefits to the EU from strong starting position of appliance manufacturers in many product markets: The impacts are expected to be beneficial for the EU, perhaps more than estimated due to its leading position as a manufacturer of many of the concerned appliances and the lower level of adjustment required as it often already applies the highest MEPS globally.

Types of employment will change, with some loss of high skilled jobs in the energy sector: Finally, the employment impacts will also be qualitative, likely to lead to a loss of relatively highly skilled jobs in the energy sector, at least in the EU and other developed countries, and an increase of a broad range of jobs in the overall economy, but particularly in the service industries.

The economic impacts described above would also have direct impacts on employment in the EU and globally. As less energy is used revenues and jobs in the energy sector will decline, but at the same time the energy savings will be spent elsewhere in the economy increasing income and employment in other sectors. This latter spending will also include a (small) rebound in employment in the energy sector as the increasing activity in other sectors creates new energy demand.

We have calculated an estimated employment impact of each scenario using an approach used previously in other work.[17] The starting point of the calculation is the calculated net energy saving in each scenario, with this translating to lower revenues and jobs in the energy sector, but higher revenues and jobs in the wider economy (including the energy sector) as the savings are spent. The specific impact is estimated from analysis of Eurostat and OECD datasets on turnover and employment, where employment per million euros of turnover for the energy sector and economy as a whole is used to estimate the impacts of the energy savings on employment. EU specific and non-EU specific values were calculated from Eurostat, and checked for consistency against OECD data, with ratios as follows:

Region	Jobs per million euros turnover	
	Energy sector	Wider economy
EU	0.8	3.1
Non-EU	1.8	9.2

The EU values were applied to the EU and US, while the Non-EU values were applied to all other regions (China, India, RSA and RoW). The ratios are also consistent with those found in a recent IEA4E study (IEA4E, 2015).

Important note: As with the economic impacts, the results are intended as a reflection of the order of magnitude of the employment impacts rather than a precise estimate due to the assumptions and uncertainties underpinning the calculation.

The results of the calculation are presented below in Table 6 below which shows that the net energy savings presented in Table 5 are estimated to result in the net creation of jobs in each scenario.

[17] Ecofys (2012) Economic benefits of Ecodesign

It is estimated that the instant compliance of all appliances to the current highest MEPS (CoNW 2015 scenario) would lead to net job creation of 1.9-2.8 million jobs globally, with EU totals of approximately 0.11-0.17 million jobs.

Extending the scenario to compliance with the highest MEPS or energy label category (CoNW MEPS + HL 2015) would increase the employment gain to 2.8-4.2 million jobs globally. Job creation in the EU would be 0.2-0.3 million jobs.

Finally, considering the scenario of global adoption of the highest current MEPS by 2030 (CoNW MEPS 2030), approximately 1.7-2.5 million additional jobs are anticipated globally. Of these jobs, approximately 0.08-0.13 million would be in the EU. As per the energy savings estimates these employment estimates are based on 2015 energy prices and turnover/employment ratios, in reality energy prices will increase and turnover/employment ratios will change due to automation and other factors. Therefore these estimates should be treated with additional caution.

Table 11: Estimated impact on employment of global harmonisation of MEPS and energy labelling requirements

	Net employment impact - low	Net employment impact - high
	jobs	jobs
CoNW MEPS 2015		
China	220 000	330 000
EU	110 000	170 000
India	90 000	130 000
RSA	10 000	10 000
USA	90 000	140 000
RoW	1 330 000	1 990 000
World	**1 850 000**	**2 770 000**
CoNW MEPS + HL 2015		
China	320 000	480 000
EU	200 000	310 000
India	130 000	200 000
RSA	10 000	20 000
USA	150 000	220 000
RoW	2 000 000	3 000 000
World	**2 810 000**	**4 230 000**
CoNW MEPS 2030		
China	260 000	380 000
EU	80 000	130 000
India	130 000	200 000
RSA	10 000	20 000
USA	70 000	110 000
RoW	1 130 000	1 700 000
World	**1 680 000**	**2 540 000**

The results calculated above include a simple estimate of indirect employment impacts of energy savings from greater global appliance efficiency. They do not account for structural change within the economy or include any further induced effects on employment. As with energy savings it could be expected that if any such global scenario were to be achieved that the EU could benefit further than the calculations suggest due to a relatively strong position in many of the main appliance manufacturing industries and a headstart on innovation and meeting current highest MEPS.

The impact on employment would not only be quantitative, but it would also be qualitative, as the jobs that are lost will not be the same as those that are gained. The jobs lost in the energy sector are likely to be relatively high skilled and high paid compared to those gained, which are more likely to be in the service sectors of the economy as savings are spent on consumption activities. This will have an impact on the labour and skills demand within each economy, and potentially also on average salary levels.

3.2.3 Impact on trade, including technical barriers to trade

Key points:

Lack of harmonised MEPS presents a trade barrier: Significant investment in bilateral trade negotiations to reduce barriers to trade mean that free trade agreements (FTAs) pending or in place are on track to cover over two thirds of EU exports. As *tariff* barriers to trade such as import duties are dismantled, negotiators' agendas shift to the non-tariff or *'technical barriers to trade'*. These barriers are more difficult to address than tariffs and technical regulations. An important element of these is consistency of standards for energy efficiency (in terms of both MEPS and testing methods), as viewed by EU business and also by businesses in other countries facing EU regulations.

Potential EU benefits of product policy on trade: Studies suggest that the EU is in a strong position to gain economically from its investment in Ecodesign and labelling policy. Amongst the top ten EU trade partners, countries accounting for over 50% of EU exports have energy efficiency product regulations that are strongly aligned with those of the EU. Most of the other major trading partners are engaged in free trade negotiations that should facilitate influence on regulations, MEPS and standards.

Working towards harmonisation under trade agreements: Ecodesign and environmental labelling harmonisation has to fit within international trade agreements. In most cases, these do provide political and technical means to make progress on harmonisation. For example the draft EU/US Transatlantic Trade and Investment Partnership (TTIP) specifically address the better alignment of technical regulations. However trade agreements can also act to constrain how harmonisation is achieved. For example:

- under WTO rules, no country is allowed to use trade measures to force a country to adopt environmental regulations in line with its own;
- labelling schemes must not discriminate between trading partner countries and not favour locally produced products over imports;
- yet to be resolved is whether regulations are allowed to specify whether the *method of manufacture* can be included in the scope of a regulatory specification.

These barriers undoubtedly impact SMEs far more than larger multinationals that have the resources to handle certification administration and to influence the development process for the standards to protect their interests.

Trade agreements as a driver for harmonisation: Harmonisation of technical regulations has risen high on the agenda of trade agreement negotiators, now that most tariff barriers have been dismantled. Regulations for energy efficiency have an important and high profile role in this. Trade agreements like TTIP could provide the driver for greater harmonisation – but the key to upholding environmental outcomes will be ensuring that these harmonised levels are appropriately ambitious and do not settle at the lowest common level.

International trade is essential to the economic well-being of the EU. The impact of Ecodesign and energy label regulations on trade is thus an important aspect of their design, especially for the appliance and equipment industries. Care needs to be taken to ensure that the mandatory requirements of Ecodesign and Energy Labelling continue to facilitate fair and open trade, and that requirements are not set in a way that could facilitate or encourage protectionism either within the EU or in trading partners. Since the EU is widely recognised as a global leader in effective product regulation with its policy approaches already adopted or emulated in many countries (see section 1.1), EU manufacturers are well placed to take advantage of both the existing and any further global roll-out of policy approaches emulating those of their home region.

This section assesses the impact that harmonisation of energy efficiency policy approaches could have on trade. Further details of how MEPS and energy labelling fit within WTO activity and FTAs with USA, China, Japan and Canada are given in Appendix III. That analysis shows that trade frameworks are a double-edged sword in this regard: they both impose a few legal constraints to harmonisation, but should also make it easier to develop harmonisation by bringing policy-makers together with shared policy ambitions to remove technical barriers to trade - harmonisation is a clear way to achieve that.

The impact that global harmonisation could have on trade

EU participation in global and bilateral trade agreements and negotiations is led in the European Commission by the Directorate General for Trade (DG TRADE). Many agreements are both in place and under negotiation[18]. The EU is in process of implementing "an unprecedented bilateral trade agenda" with negotiations in place and underway that would see two-thirds of EU external trade within the coverage of free trade agreements (FTAs)[19]. The primary trading partner economies of the EU are illustrated in Figure 1. Whilst the data in Figure 1 is from 2011, it serves to illustrate which are the primary partner economies from around the world. Import/export data from 2014 (shown in Table 4) confirms those same strong partnerships existed in 2014 and adds Switzerland, Turkey, Norway and South Korea as additional significant trade partners. Apart from China and Russia, there are preferential trade agreements in place or in process for all of these economies – with China subject to an ongoing investment agreement with the EU, and Russia without an FTA but engaged under the WTO framework[20].

[18] See OVERVIEW OF FTA AND OTHER TRADE NEGOTIATIONS, updated 17 February 2015, DG TRADE, available from http://ec.europa.eu/trade/policy/countries-and-regions/agreements/#_other-countries, accessed 26 February 2015.

[19] Source: Trade, Growth and Jobs, contribution from the Commission to the February 2013 European Council debate on trade, growth and jobs, p4

[20] Source: OVERVIEW OF FTA AND OTHER TRADE NEGOTIATIONS, DG TRADE, updated 17 February 2015, available from: http://trade.ec.europa.eu/doclib/docs/2006/december/tradoc_118238.pdf

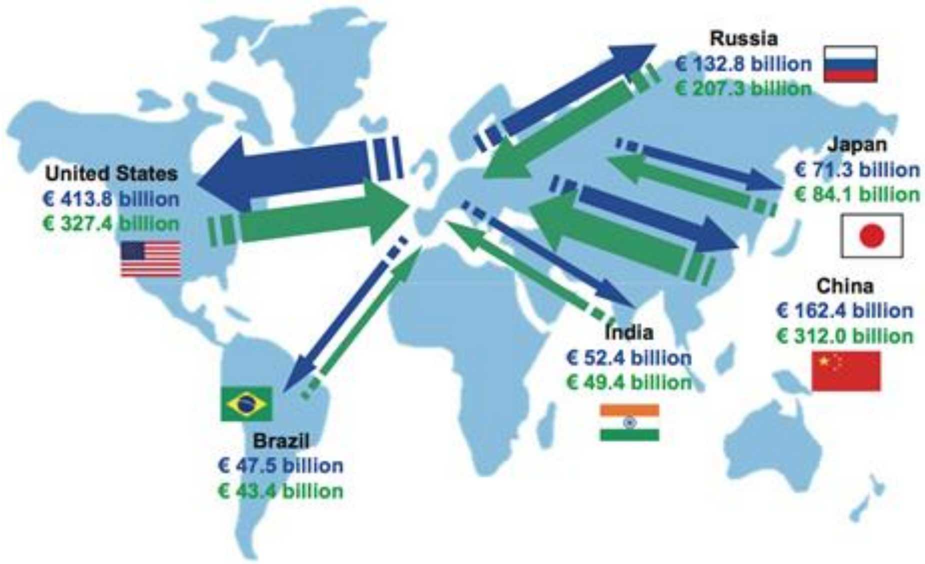

Figure 3: EU exports and imports in goods and commercial services with main partners (2011). Source: Contribution from the Commission to the February 2013 European Council Debate on Trade, Growth and Jobs, DG Trade.

Table 11: Main trading partners of the EU28, from Eurostat statistics as published in February 2015, Billion Euros. Source: Eurostat Euroindicators news release 30/2015 – 16 February 2015, first estimate for 2014.

	EU28 exports to			EU28 imports from			Trade balance	
	Jan-Nov 2013	Jan-Nov 2014	Growth	Jan-Nov 2013	Jan-Nov 2014	Growth	Jan-Nov 2013	Jan-Nov 2014
USA	267	283.9	6%	181.1	187.5	4%	85.9	96.4
China	135.6	150.5	11%	257.4	276.7	7%	-121.8	-126.2
Russia	111.3	96.7	-13%	189.7	170.1	-10%	-78.4	-73.4
Switzerland	158.3	129.9	-18%	87.9	90.5	3%	70.4	39.4
Norway	46.4	46.3	0%	83.2	77.1	-7%	-36.8	-30.8
Turkey	71.7	68.2	-5%	46.5	49.7	7%	25.2	18.5
Japan	49.5	49.1	-1%	52.2	50.2	-4%	-2.7	-1.1
South Korea	36.2	39.1	8%	33.5	36.1	8%	2.7	3
India	32.7	32.3	-1%	34.3	34.1	-1%	-1.6	-1.8
Brazil	36.9	33.9	-8%	30.5	28.8	-6%	6.4	5.1
Subtotal	**945.6**	**929.9**	**-2%**	**996.3**	**1000.8**	**0%**	**-50.7**	**-70.9**

This bilateral trade agenda is making good progress and many of the significant tariff barriers (which are mainly import duties) have either been dismantled or are in process of that, which is a primary aim of the FTAs. However, non-tariff barriers remain, and technical regulations account for a significant and particularly challenging proportion of those non-tariff barriers. The 2013 Commission paper on 'Trade, Growth and Jobs' identifies the US and Japan as together accounting for two thirds of the potential economic gains from the EU bilateral trade agenda, and notes that 'the extent of convergence of regulation regarding goods and services will be the litmus test of their success'[21]. Regarding non-tariff barriers in the US, the same report

[21] p5.

explains that "*these barriers are more difficult* [for policy-makers] *to address than tariffs, especially in formal agreements, as they are based on different approaches to regulation, often deeply rooted in historic or societal approaches and political realities*".

US industry also has concerns about EU regulations, particularly for SMEs: a 2014 report from the US International Trade Commission focused on the plight of US SMEs and cites "*numerous EU trade barriers, particularly standards-related measures* [that] *limit SMEs' exports to the EU more than those of large exporters*"[22]. More specifically, "*SMEs producing machinery, electronic, transportation, and other goods cited a lack of harmonised international standards and mutual recognition for conformity assessment, as well as problems complying with technical regulations and conformity assessment procedures*".

The situation in the Japanese market is worse for trade and presents, according to the European Commission, "*serious non-tariff barriers in the form of discriminatory regulations, unique standards, anti-competitive behaviour*" resulting in the situation that "*Japan has one of the lowest import penetration rates of any country in the OECD (6% or one fifth of the OECD average)*"[23]. These challenges to trade arising from product standards and MEPS are reflected clearly in the section of this report on 'Barriers to harmonisation' (section 4).

These challenges to trade do not only refer to environmental and energy efficiency regulations of course, but these constitute a significant part of the challenge and are the focus of this study. In this regard, not only do all of the trading partners identified in Figure 2 and Table 11 have well-established or rapidly emerging systems of energy efficiency related technical standards for appliances and equipment, but Russia, Brazil, Turkey and China (which account for just over 50% of the EU exports of Table 11) already have standards and MEPS 'strongly aligned' with the EU. Progress on global alignment of MEPS with the EU standards is summarised in Figure 2.

[22] Trade Barriers That U.S. Small and Medium-sized Enterprises Perceive as Affecting Exports to the European Union, Investigation No. 332-541, Publication 4455, March 2014.
[23] Source: Trade, Growth and Jobs, contribution from the Commission to the February 2013 European Council debate on trade, growth and jobs, p6.

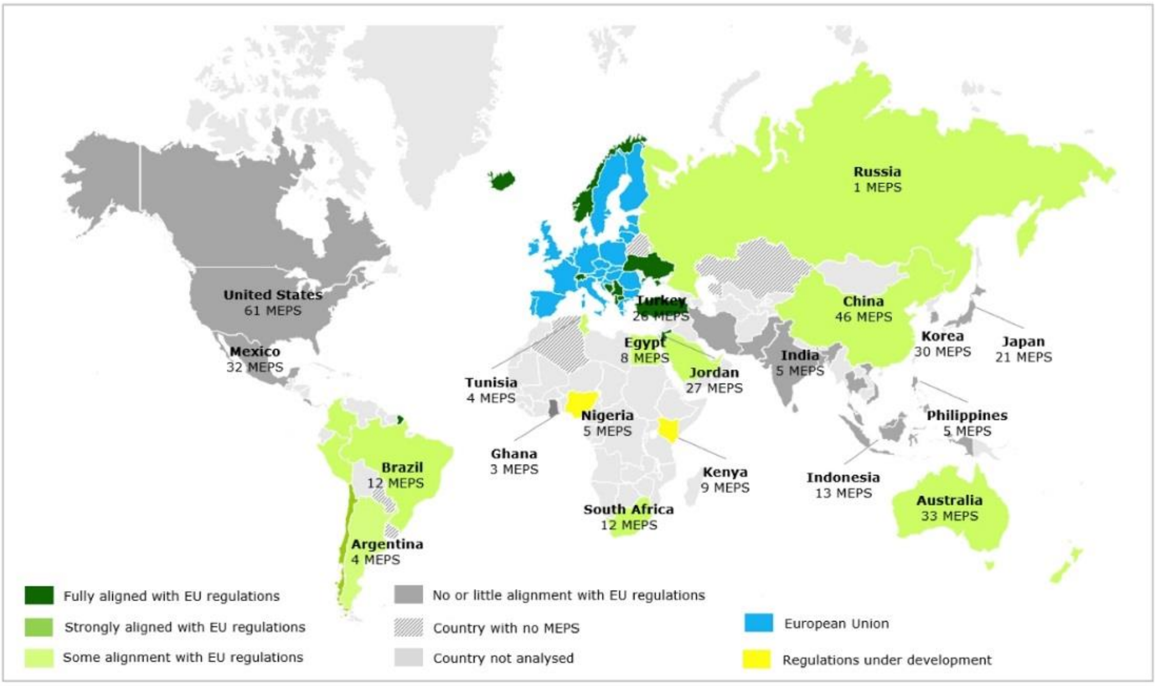

Figure 4: Countries with MEPS and degree of alignment with EU per country (Source: Impacts of the EU's Ecodesign and Energy/Tyre labelling legislation on third jurisdictions, Final Report for DG ENER, Ecofys, 30 April 2014, p4]

There is still work to be done on harmonisation with these countries too, but prospects are good. Progress for the other key trading partners is listed below:

- United States: TTIP aims to set up the political and technical mechanisms to bring closer alignment with the US;
- India: FTA negotiations are in progress;
- Japan: Japan's technical regulations remain significantly out of step with those of the EU;
- Russia: Development of technical regulation is to a large extent modelled on the EU, but is fragmentary and is likely to be exploited to protect Russian industry interests, although Russia's accession to the WTO in 2012 provides at least a mechanism to address major concerns.

A world in which technical standards for energy efficiency were globally harmonised would bring the following specific benefits to trade for businesses large and small:

1. Transparency of performance between markets for strategic planning;
2. Lower cost of compliance in terms of product testing to only one harmonised standard;
3. Reduced barriers to market entry and so faster growth of export markets (which also facilitates competition and stimulates innovation - see later sections)
4. Easier path to reciprocal recognition of certification to build trust in new products.

These benefits are illustrated hypothetically in Box 4.

Box 4: Hypothetical benefits to trade and competitiveness of globally harmonised technical standards (entirely fictitious, but illustrating potential benefits)

At some point in the future.......Now that globally harmonised product efficiency standards are established, the (hypothetical) Amethyst Trading, manufacturer of electric refrigerators based in Mauritius, is making its export plans and finds that:

- A quick check of MEPS published in Canada against its own registered product performance data shows that its products can meet the requirements. The standards are almost completely comparable, once Amethyst's volumes in litres are converted to cubic feet as in Canada; and also the standards include conversion figures between an ambient operating temperature of 32°C, as used in Mauritius, and for 22°C as used in Canada.
- The certification body operating in sub-Saharan Africa, of which Amethyst is a member, has a reciprocal agreement with the body in Canada and so products can quote the Canadian endorsement in advertising their products and so quickly build customer trust in their products (requirements are transparent between the two countries and posed no problem for comparison and the certification bodies have already established common verification procedures acceptable to both).
- Amethyst has invested in product testing for all of its main products, at considerable expense as there was no suitable test house in Mauritius itself, but the results are fully understood and recognised by their agents in Canada and no additional testing is required. This is saving Amethyst tens of thousands of dollars in testing per new target economy, compared with their attempts to export before harmonisation was secured.
- A competitor in the Australian market had challenged an Amethyst efficiency label claim, but check-testing by the Australians proved the label correct. That positive result is shared by enforcement authorities around the world and so the product's clean record is already on file in Canada.

Harmonisation of technical regulations for energy efficiency and Ecodesign thus has a key role to play in developing world trade as viewed from within and outside of the EU, and there are evident political and technical opportunities for making good progress. Trade agreements like TTIP could provide the driver for greater harmonisation, but the key to securing environmental gains will be ensuring that these harmonised levels are appropriately ambitious and do not adopt the lowest common approach. A summary of potential opportunities within current trade frameworks are presented in Annex V to this report. It should also be noted that DG CLIMA, cooperating with DG TRADE, is currently undertaking a study in the area of 'Fostering Climate Action through Trade-Related Policy Instruments' which is considering greater global harmonisation of product MEPS and standards as one of a number of options for achieving climate goals.

3.2.4 Competitiveness of industry

Key points:

Harmonisation will affect the competitiveness of firms in different ways: the harmonisation of performance and labelling requirements is likely to affect the range of market players differently for each product group. International Original Equipment Manufacturers (OEMs) are likely to be least affected, whilst large manufacturers and SMEs operating at a national level in previously unregulated markets are likely to feel most impact, particularly where there is 'imperfect' market competition or a disparity in the cost impacts of regulations or labels between market players.

Aspects of competitiveness likely to be influenced by globally-harmonised product efficiency and labelling requirements include:

- **Cost of manufacture:** Lower prices for efficient components due to economies of scale.
- **Labelling and MEPS compliance:** Reduced compliance costs to international manufacturers and market surveillance authorities. Some increased cost possible for local producers in previously unregulated markets. Important that market surveillance is consistently implemented to ensure compliance.
- **Product price:** A potential shift in market share from cheaper less efficient products toward higher value products justified (to the customer) by reduced running costs. If there are additional manufacture or compliance costs, these are unlikely to be passed on to the consumer.
- **Markets:** Access to new markets for already energy efficient European products. A level playing field for all competitors, preventing 'free riders'. A drive for manufacturers in previously unregulated markets to shift to efficient technologies supported by the security of consumer demand.

Proving adequate adjustment time is important to mitigate any negative competitiveness impacts: The most important consideration in terms of limiting any negative impacts of harmonisation on competitiveness is the timing of the implementation of requirements. Companies whose products would not currently meet the level of ambition for globally harmonised mandatory requirements will require implementation dates that allow sufficient time for design and production adaptations to be made. This would enable the manufacturers to minimise costs by integrating design and manufacturing changes into normal industrial cycles.

The following sections discuss such considerations in more detail.

Cost of manufacture

Increased and wider demand for efficient components over cheaper less-efficient alternatives is likely to broaden supply and drive down the price of these components (even for manufacturers already using them) due to economies of scale. Investments in new technologies will be more secure due to the transparent legislative framework. In addition, global improvements in energy efficiency will, in general, result in savings in household energy expenditure, reducing emissions and pressures on energy supply and ensuring greater energy security for manufacturers[24].

Compliance costs

There are various compliance costs that may be incurred as a result of the harmonisation of regulatory efficiency requirements and energy labelling:

- **Costs for changes to product platforms to comply with harmonised efficiency requirements:** These would not be incurred for Original Equipment Manufacturers (OEMs) already operating in markets where the efficiency requirements for global roll out are already applied. For other manufacturers, costs

[24] Coolproducts estimates that carbon dioxide emissions mitigated could be 56 million tonnes of oil equivalent, enough to offset the energy consumed by 200 large coal power stations, or from 150 million cars. www.coolproduts.eu/infographics

could be in the range of €50,000 to €100,000 or 5 to 10% of annual turnover although there is some indication that such costs have been previously overstated and that they may represent "necessary changes to production that can often be part of firms' on-going efforts to develop better, more efficient and more environmentally friendly products"[25].
If implementation dates take into account sufficient time for design and production adaptations to be made, this can minimise costs by enabling manufacturers to integrate design and manufacturing changes into their normal industrial cycles.

- **Per-unit product costs of compliance:** These would be minimal, incurred by manufacturers operating in previously unregulated markets (up to €10/unit max), and reducing over time due to the economies of scale of global harmonisation. Harmonisation would enable a reduced number of different labels and markings, a decrease in supporting documentation costs, and facilitate more coherent marketing of energy efficiency features of products.
- **Testing and certification costs:** There would be compliance cost savings of harmonised test approaches for companies operating in multiple countries, as manufacturers could potentially test a product in one region and sell in another region (as long as the issue of different voltage-current combinations was addressed). This could also foster improved competition[26]. However, in some cases it may also be necessary to test for other factors such as climatic differences for heating and cooling appliances. Costs for the development and maintenance of relevant documentation would be comparable with other environmental legislation. There would be savings for companies operating in multiple countries due to the need to produce basic information only once, although it may still need to be translated into a range of languages.
- **Market surveillance authority testing costs:** Due to the harmonisation of testing approaches and regulatory requirements, previously unregulated countries would be required to bear the costs of some compliance testing to ensure that requirements are implemented in their markets. However, there would be potential for market surveillance authorities to collaborate on sharing of testing results in order to avoid duplication of tests between different countries and regions (subject to matching voltage-current combinations). This can also help to avoid situations where equipment which is below the MEPS in one market is dumped on another country's market. The consistent implementation of market surveillance testing and follow up is important to ensure that companies adhere to regulatory requirements otherwise regulations will become ineffective.

The costs of compliance could possibly impact profit margins, but reduced unit costs resulting from economies of scale, combined with the increased production volumes potentially associated with harmonised efficiency performance requirements may mean on average, profit margins remain similar[27].

Product price

Rather than an increase in product price, what appears to be more likely, at least for international manufacturers, is a shift in the types of products sold over time. Some

[25] CSES (March 2012), Evaluation of the Ecodesign Directive (2009/125/EC), Final Report http://ec.europa.eu/enterprise/dg/files/evaluation/cses_ecodesign_finalreport_en.pdf

[26] "High quality super-efficient lighting products: the SEAD Global Efficiency Medal", Gallinat, Karpay Weyl et al, eceee Summer Study Proceedings 2015

[27] Policy Studies Institute & BIO Intelligence Service for the Department for Environment, Food and Rural Affairs (February 2011), Impacts of Innovation on the Regulatory Costs of Energy-using Product Policy (SPMT09_045) Final Summary Report http://randd.defra.gov.uk/Document.aspx?Document=EV0703_10122_FRP.pdf

industries have indeed viewed the introduction of regulatory efficiency requirements and energy labelling as an opportunity to shift sales from the lower value products in their range toward the higher value more-efficient products (e.g. lighting), justified to consumers from the viewpoint of lifecycle energy savings and the perceived enhanced quality of higher labelling class products[28].

Price impacts of regulatory requirements tend to be lower than impact assessment estimates, due to under-accounted for productivity improvements, technology changes, economies of scale due to increased production volumes and allowance for lower profit margins[29]. Where there is a price impact due to efficiency regulations, it is unlikely that costs of compliance would be passed-on to the consumer, particularly due to price pressures placed upon manufacturers from retailers[30]. In fact, if any impact on product price occurs for household products (which is often not the case) it is likely to be minimal, justified by energy savings[31], and short term within the context of the wider downward trend in product prices over time. Such trends have been observed for product MEPS implemented in Australia, Japan, the US and the EU[32]. In some cases, decreases in prices of efficient products have been observed that are of similar magnitude to the energy savings of products achieved via MEPS over the same period[33].

Markets

As MEPS tend to be set at a relatively low level of ambition, with the intention of avoiding significant impact on manufacturers and removing only the worst performing products from the market, their impacts are likely to be limited. Likewise, whilst labels have the potential to pull the market toward greater efficiency by influencing consumer decisions they are unlikely to have adverse market impacts. However, depending upon the specific product, the impacts on the different players in the market may be asymmetrical, with some market players being more heavily impacted than others.

There is some degree of risk of a negative market impact of harmonisation on competition where:

- Consumer purchasing criteria (price, quality, choice or innovation) are diminished by the change in nature or intensity of the market competition due to the MEPS or label.
- Markets are characterised by imperfect competition, meaning that there are only a few firms operating (for example the game console market) or the market is comprised of a small number of large firms and a minority of smaller firms, or where there are significant barriers to entry.

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[28] Consumer Focus (December 2012) Under the influence? Consumer attitudes to buying appliances and energy labels http://www.consumerfocus.org.uk/files/2012/12/Under-the-influence.pdf

[29] Larry Dale, Camille Antinori, Michael McNeil, James E. McMahon, K. Sydny Fujita (2009), Retrospective evaluation of appliance price trends, in Energy policy, 37: 597-605 http://www.sciencedirect.com/science/article/pii/S0301421508005193

Mark Ellis, OECD/International Energy Agency (2007), Experience with energy efficiency regulations for electrical equipment http://www.iea.org/publications/freepublications/publication/appliances_ellis.pdf

[30] CSES (March 2012), Evaluation of the Ecodesign Directive (2009/125/EC), Final Report

[31] Coolproducts estimates that cost savings from Ecodesign measures including vacuum cleaners, light bulbs, boilers and fridges will reach €79 billion a year by 2020, breaking down to €350 per European household. www.coolproduts.eu/infographics

[32] Mark Ellis, OECD/International Energy Agency (2007); Policy Studies Institute & BIO Intelligence Service for the Department for Environment, Food and Rural Affairs (2011)

[33] CSES (2012)

- There is a difference in the cost impacts of the requirements between manufacturers.[34] Strict overarching MEPS are enforced on products that have justified regional variations – for example, it was found that ambitious harmonised MEPS on windows would not be optimal for all three European climates (north, central, south)[35]. Stringent MEPS that did not account for the regional variations could have impacted the competitiveness of companies in some climates.

Therefore it is necessary to balance the environmental objectives of harmonisation with the need to preserve market competition. The main market players can be broken down into global OEMs, local manufacturers and SMEs – the market impacts of harmonisation on each of these are considered separately in the following sections.

Global OEMs

Regulatory requirements on energy efficiency of products and energy labels are well established in some economies. These economies tend to be dominated by globally operating manufacturers. To date, no adverse changes in the market structure between component manufacturers, equipment suppliers, and OEMs have been highlighted as a result of historical introduction of such initiatives. For example, the implementation of the Ecodesign and Energy Labelling Directives in Europe has not suggested any impacts in terms of a reduction in imports to the EU. In fact during the period since regulations began to be enforced, a trend toward an increase in imports has been observed, particularly from China and India, but also from the US, Japan or South Korea[36].

Energy labelling is often viewed positively by manufacturers in terms of competitiveness. In particular, positive feedback has been communicated in relation to Energy labelling in the EU on refrigerators, washing machines, domestic dishwashers and laundry dryers[37]. Views on the competitive impacts of regulatory measures are more mixed, although they can sometimes be viewed by OEMs as having a constructive influence. For example, a recent impact assessment for regulatory requirements on vacuum cleaners stated that "the proposed minimum requirements are seen [by manufacturers] as having a positive impact on competitiveness." [38]

The larger international manufacturers tend to have products with a range of efficiencies in their portfolios, and therefore the impact of mandatory performance requirements is more likely to result in a shift from one product model to another, rather than the need to develop a whole new product with associated production overheads. In addition, whilst MEPS are usually set at levels that would not necessitate proprietary technologies, the position of manufacturers with proprietary designs that facilitate improved energy efficiency would probably be strengthened under such a scenario. Profitability may be further enhanced by opening up new

[34] Frontier Economics for the Office of Fair Trading (October 2008), The competition impact of environmental product standards

[35] "Towards an EU energy labelling scheme for windows: insight and learning of the development phase of the first label for an energy-related building product", Janssens, Cédric, Glass for Europe. eceee Summer Study Proceedings 2015

[36] CSES (2012) Evaluation of the Ecodesign Directive (2009/125/EC)- Final report

[37] Molenbrook et al (June 2014), Final technical report: Evaluation of the Energy Labelling Directive and specific aspects of the Ecodesign Directive ENER/C3/2012-523, http://www.energylabelevaluation.eu/tmce/Final_technical_report-Evaluation_ELD_ED_June_2014.pdf

[38] European Commission (2013), COMMISSION STAFF WORKING DOCUMENT: IMPACT ASSESSMENT Accompanying Commission Regulation implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to Ecodesign requirements for vacuum cleaners, http://ec.europa.eu/smart-regulation/impact/ia_carried_out/docs/ia_2013/swd_2013_0240_en.pdf

markets previously served by inefficient, low-cost manufacturers. At the very least, introduction of MEPS in areas where they have not previously been implemented will preclude 'free riders' from remaining unaffected in these markets as well as preventing the flooding of these markets with inefficient products that cannot be sold in already-regulated countries. Harmonised requirements and labels create demand for more efficient products in new markets, and already efficient producers operating in regulated markets will be able to react more quickly and gain a greater proportion of the market.

As such, it is likely that globally trading manufacturers would be able to meet MEPS and implement energy labels if they were harmonised internationally with little if any impact on their markets.

Local manufacturers

The assumption is often made that requiring compliance to the same labelling and performance requirements across the globe would result in a level playing field that would benefit all manufacturers by reducing compliance costs and incentivising efficient technologies.

However, manufacturers operating at a national level in non-EU and particularly less-developed markets tend to focus upon lower-end less efficient technologies, and as a result are more likely to experience mixed impacts due to global regulatory and labelling requirements. Benefits from harmonisation could include the following:

- **Efficiency demand, technology transfer and improved competition:** MEPS and labels can create new demand for more energy efficient products in these national markets, providing the certainty necessary to incentivise a shift in production toward these products. Once these regional / national manufacturers shift to producing more efficient products their competitiveness on the global market will be improved and other new markets may also be opened up for them.
- **Improvements in production costs:** Globally harmonised requirements will reduce the costs of more efficient components due to economies of scale.

Barriers to these changes could include:

- **Investment:** Some national or regional manufacturers may be disadvantaged by much lower investment capacity for research and development. They may not have more-advanced efficient technologies in their product portfolio and therefore be required to invest in design and production. They may have issues raising funding for the transition from established product technologies to more efficient ones.
- **Skills:** Where new production lines require a shift in skill set of the workforce, this may present a timing restraint to the introduction of regulatory efficiency requirements.
- **Compliance costs:** For manufacturers focused on specific markets, the compliance savings of harmonisation will be minimal and there may even be an increase in costs if harmonised requirements are more rigorous than those currently implemented in their country.
- **Greater competition:** The introduction of a labelling scheme may highlight major differences between locally produced products and those of international OEMs. Local products may lag in terms of efficiency. Where customers have previously been unable to distinguish between products on the basis of quality or energy impacts, the introduction of a harmonised label could empower them to make such decisions[39]. Where they were previously able to compete on cost, the transparency

[39] Frontier Economics for the Office of Fair Trading (2008)

provided by energy labelling could result in them losing market share by being considered more expensive to run and lower quality.

- **Regional market characteristics:** These may include divergences in energy prices, technology availability, market readiness, consumer attitudes, appliance usage etc.

The majority of the above barriers can be overcome by allowing sufficient time for the transition to harmonised requirements. In countries where technology is lagging in terms of efficiency, sufficient time-delay in the application of requirements can enable the shift in production toward more efficient models without incurring undue cost.

Box 13: Competitiveness case study on televisions

Televisions are a globally traded product with the market dominated by the large OEMs, such as Sony, LG, Samsung and Panasonic. This means that the same products are generally available globally with little regional variation. However, some variation does exist in terms of regional manufacturers and/or variations in market composition. Regional brands generally, but not exclusively, occupy the lower efficiency end of the market, lagging the technology advancements of the larger OEMs. Some local manufacturers in countries such as India and China are still producing TVs using older CRT or plasma technology that would be unlikely to meet harmonised efficiency requirements. Sometimes production lines are dismantled and transferred from countries that have shifted to newer more efficient technologies. It has been suggested that plasma and even CCFL LCD TV (less-efficient LCD screen) production lines could be dismantled from Taiwan and Eastern European countries and become established in India over the next few years. In the event of harmonisation of global MEPS, the production lines of these regional/national manufacturers would have to make the jump toward more efficient technologies sooner.

If this transition is poorly timed, there could be a prohibitive cost to these local manufacturers. However, if sufficient indication is given prior to the implementation of regulatory requirements, the transition could substitute the transportation of an old technology TV production line for the setting up of a production line for newer more-efficient TV technology. Costs of one approach compared to the other are already in a fine balance as economies of scale bring down the manufacturing costs of more efficient LED–LCD displays. Therefore, the harmonisation (and appropriate timing) of MEPS could provide the additional incentive to jump to the more efficient technology whilst avoiding undue costs in the transition.

Small and medium enterprises (SMEs)

The degree to which there is a competitive advantage of harmonisation for European business depends upon the level of ambition of any MEPS that are globally implemented. Lower or equal ambition to what is already implemented in Europe may give smaller EU manufacturers an advantage over local businesses in previously unregulated areas (should they choose to expand to these markets).

As profitability of larger OEMs increases due to harmonisation, their supplier manufacturers in already regulated areas may see some benefits in terms of a shift back toward more local component manufacture.

It is possible that SMEs manufacturing end products in newly regulated areas could be disadvantaged by the fixed costs for entry to market associated with the introduction of performance thresholds. This is due to lower product volumes over which to spread compliance costs and the costs of any necessary production changes. However, in sectors where SMEs are the innovators, for example lighting and the area of LEDs and other specialist applications (such as museum or street lighting), they can benefit from regulation and labelling as they can take advantage of expanded market opportunities as the market or technology radically changes and/or provided opportunities for their specialist solutions. In such cases it can be the OEMs that are slower to react to the changing market.

3.2.5 Impact on innovation and technological development

Key Points

Harmonisation will affect the innovation activities of firms in different ways: As with competitiveness, international OEMs are likely to be least affected, whilst large manufacturers and SMEs operating at a national level in previously unregulated markets are likely to need to adapt their innovation activities the most. The impact on innovation is strongly influenced by the ambition of the MEPS requirement levels and labelling classes, as well as the timescale on which they are implemented. The issue of compliance is also relevant, as weak compliance systems will create disincentives to innovate.

Aspects of innovation and technological development likely to be influenced by globally-harmonised product efficiency requirements include:

- **Investments in innovation may increase:** at the global level implementation of harmonised MEPS will provide an incentive for firms, particularly those with only domestic scope, operating in previously unregulated economies to increase their innovation to meet the new (higher) requirements. Globally harmonised labels, set with relatively stretching upper thresholds, would be more likely to drive innovation across all firms. In both cases, but particularly labelling, the ambition of the requirements in both the level and timing, can have a strong bearing on new innovation investments – if not on the total investment, then on the focus (see below).
- **Innovation speed can be increased:** the timing of the implementation of any global requirements will play a crucial role in affecting innovation speed, in general, longer timescales encourage more incremental innovation, while shorter timescales encourage more radical solutions and faster innovation progress. It is important to strike a balance on timing, as some firms, particularly in previously unregulated economies, will not be able to keep up with tight timescales. Other problems can also arise, for example:
    - Innovative firms being discouraged if there is not sufficient time to recoup the costs of their previous innovation efforts.
    - Innovation being required on timescales that are tighter than normal product development cycles, resulting in undue cost to manufacturers[40].
    - Innovation moving too fast for consumers to adapt or afford.

  A tiered approach can be useful to address these issues.
- **Innovation focus on energy efficiency:** introducing globally harmonised MEPS and labelling requirements can lead to a greater innovation focus on energy efficiency, again, particularly for firms in previously unregulated

[40] Note – this is only an issue for some product groups. For fast moving product groups, manufacturers can make running improvements on a product line even as the products are being shipped out – which allows them a greater potential to adapt as MEPS and labelling requirements are introduced. Source: "High quality super-efficient lighting products: the SEAD Global Efficiency Medal", Gallinat, Karpay Weyl et al, eceee Summer Study Proceedings 2015

markets. This may divert innovation efforts from other areas such as resource efficiency, styling, design, functionality and accessibility.

The stringency of agreed MEPS or labels is the most important influence on the innovation impact: It is necessary to strike a good balance between the ambition (stringency) of requirements and their timing. Companies whose products do not currently meet the globally harmonised requirements will require time to innovate their products to meet any new requirements.

When markets open up, and become more integrated on a world-wide level, the pace of technological innovation accelerates. As technologies and markets evolve, the regulatory landscape addressing the energy efficiency of products requires revision. There is a dynamic interplay between innovation and regulation. Often, innovation paves the way for regulation, but in some cases regulation creates the stimulus for innovation (e.g. Ecodesign regulation on pumps). This section explores the potential impacts of globally harmonised MEPS on technology innovation.

Investments in innovation

Implementation of globally harmonised MEPS will require product improvements by some manufacturers. In particular, firms operating in previously unregulated markets will be required to improve their products to meet the new (higher) requirements. The impact per firm will vary on the basis of a few factors, including:

- Whether their existing product range includes products that meet the requirements: If so, the firm will be able to shift production to these products and discontinue the now obsolete models, potentially writing off some of their investment. Those without products that meet the requirements will be required to invest in innovation to redesign their products using more efficient components / designs.
- The ambition of the requirements: Stricter requirement levels increase the innovation effort needed, as would a short timescale for implementation. In economies with existing MEPS the impact on innovation investment is likely to be minimal, assuming the change in requirements is relatively small.

Labelling requirements have been shown to be more motivating for innovation investment by firms - if not in terms of total investment, then in terms of investment focus (see below). This is particularly the case for products where consumers are influenced by a label either persuading them either to take into account product energy efficiency in their buying decisions or to perceive higher labelling class as an indicator of increased product quality. Design of the labelling classes is key. Globally harmonised labels, set with stretching upper thresholds, can drive innovation across all firms by creating a level playing field for them to compete on energy efficiency performance. This then becomes a key competitive factor between firms in addition to classic factors such as price, quality and functionality. Appropriate levels of labelling class ambition and timing, are essential. Upper classes that are significantly above current market and/or best available product levels, or are open ended, are necessary for label effectiveness and longevity, and can provide significant incentives to firms to innovate. However, if the upper labelling classes are unaffordable to achieve on reasonable timescales, labelling may fail to influence investment in energy efficiency innovation.

Box 13: Innovation impact of EU Ecodesign regulation

The EU Ecodesign Directive and its implementing measures is an example of the type of MEPS requirements that are modelled in the scenarios in this study. Sector specific research has found the following impacts of Ecodesign on firms innovation activities:

- Electric motors and pumps: induced process innovation and radical restructuring of production lines, although not radical impacts on product innovation.
- White goods: little innovation impact at high-end of market, but can help support process innovation and have a significant innovation impact when a change, i.e. refrigerant type is mandated.
- Consumer electronics: Ecodesign helped to keep energy efficiency on the innovation agenda but the sector is already innovative and in some cases it was felt Ecodesign could be counterproductive.
- Lighting: Ecodesign had a radical impact on the sector, by removing incandescent bulbs from the market, but the innovation significance was low as all firms already had other products.
- Air conditioning: Ecodesign increased the speed with which firms pursued their innovation activities.
- Heating: impacts were greatest on companies serving the lower ends of the market, or less developed markets in Southern and Eastern Europe, where innovation was needed to bring existing product ranges up to the new requirements.

Firms in the above sectors quite consistently reported that Energy Labelling was a bigger driver for innovation as this was an area in which they could compete within the market, rather than a simple requirement to fulfil (at the bottom of their product range). Therefore innovation benefits would be most likely to increase if harmonisation were to also include EU-type performance scoring energy labels.

Innovation speed

Firms already invest in innovation. This results in year-on-year product developments, and often improvements in energy efficiency. Increasing the speed of innovation, to achieve improvements faster, at higher rates each year, is an important goal of energy efficient product policy. The timescale of implementation of global requirements will play a crucial role in determining the impact on innovation speed.

A requirement implemented in a short period of time is effectively more ambitious than the same requirement implemented over a longer period. In implementing MEPS or energy labels it is important that the regulator gives industry enough time to develop solutions that are energy efficient but that can be achieved within reasonable product innovation cycles whist still meeting important user and other legislative requirements.

A short implementation period requires rapid technical solutions, acting as a catalyst for an increased rate and speed of innovation. There is a risk that SMEs and firms in currently unregulated regions struggle to adapt quickly enough to comply and remain competitive at the same time. Other problems can also arise, such as innovative firms being discouraged if there is not sufficient time to recoup the costs of their previous innovation efforts, and innovation moving too fast for consumers to adapt or afford. Meeting global requirements could be facilitated through technology transfer, which would accelerate global deployment of best practice in product design.

A longer implementation period postpones the time for more efficient (innovative) technologies to be adopted, reducing the immediate innovation impact of a measure, but providing space for firms to adapt their innovation strategy within normal investment cycles. In either case innovation activity tends to be most concentrated in the immediate run up to the introduction of a requirement.

Using a tiered approach to global MEPS and harmonised labels, similar to the system used internationally for electric motors, could provide a balanced way to address this issue of timing. Structured tiers that are clearly communicated to manufacturers allows them to set clear medium term goals, appropriately plan research and innovation, and align product changes with standard investment cycles, keeping costs down. Tiers could also be differentiated across economies, at least in the short term, to support unregulated economies by gradual harmonisation with global requirements.

Innovation focus

Evidence from regulated markets shows that energy performance increasingly becomes a point of competition between firms as consumers become increasingly aware and influenced by energy labels and firms seek to differentiate their products[41]. Therefore introducing globally harmonised requirements is likely to encourage this trend at global level, incorporating previously unregulated markets.

The extent to which this effect persists is related to the benefit that firms derive from competing on energy performance. The most innovative firms tend to have an efficiency culture embedded in their organisation seeing this as not only a consumer demand and differentiating criteria, but also as part of their company mission. For products that are mature, where main functionalities are relatively fixed, for example washing machines, innovation focuses on energy (or other environmental) performance to a greater extent than other functionalities. For products undergoing greater functional development and change, for example, consumer electronics, the focus of innovation on energy performance is less as it is only one of a variety of dimensions on which firms compete and on which consumers base their purchase decisions. Lighting is an example of a sector that was, until around the last 10 years, relatively mature in this sense. The phase-out of incandescent bulbs in many countries, plus the development of LED-bulbs has transformed the market, with innovation now heavily focused on the LED sector. While part of the rationale for this switch is the much better energy performance of LED bulbs, the innovation focus of firms is not only to develop LEDs in the first place but also to ensure that the functionality, i.e. light colour, warmth, timing, compatibility with fittings and other aspects; also matches consumer needs.

Regulation can incorporate innovation incentives by providing additional allowances to encourage specific energy efficient features to be brought to market. Such features could be, for example, presence sensors to enter low power modes when the user is not present, provision of energy use information to the user, or provision of feedback on use to service providers.

Other considerations

Innovation needs to be protected by a proper regulatory process. Failure to enforce compliance can put innovation at risk. A recent study[42] on the impact of Ecodesign and energy labelling on R&D and innovation concluded that *"… the lack of market surveillance activity reduced the motivation for companies to innovate in order to comply, especially as it was evident that non-compliant products were still visible in the market place." (p.95).* Mitigations include strengthened market surveillance, stakeholder involvement in MEPS and label design. Other important considerations to

[41] Sibylle Braungardt, Edith Molenbroek, Matthew Smith, Rob Williams, Sophie Attali, Catriona McAlister (2014) Impact of Ecodesign and Energy/Tyre Labelling on R&D and technological innovation- Final Report, http://www.ecofys.com/en/publication/impact-of-ecodesign-and-energy-labelling-on-rd-and-innovation/
[42] S. Braungardt et al (2014)

avoid barriers to innovation include; ensuring procedural clarity; coordinating with other legislation; protection of intellectual property; and timely impact assessment.

3.3 Impact on citizens

3.3.1 Affordability impacts

Key points:

Affordability is already a key consideration in setting MEPS requirements in most countries and/or regions: the US and the EU explicitly take this into account, ensuring that requirements are set at the levels that impose the least life-cycle costs for the average end-user. A similar approach is often, but not always, applied in China.

There is little empirical evidence of significant price increases from MEPS: empirical work on the subject finds little evidence of real product price increases due to MEPS, but there is significant evidence of reduced life cycle costs producing net savings for end-users over the full product lifetime. Price increases are thought to be kept low due to:

- Manufacturers are find cheaper ways to improve product efficiency than projected.
- Scale economies and increased competition between suppliers of higher efficiency components reduces unit costs following MEPS.
- Manufacturing systems are increasingly flexible, reducing the fixed costs of switching production lines to higher efficiency products.
- Introduction of MEPS is often taken as an opportunity to upgrade production lines and tooling and to negotiate new supplier arrangements which can help suppress cost increases.
- Advance notice of MEPS of 2-6 years is typically given, reducing the costs of switching.
- Learning effects increasingly apply as production volumes of higher efficiency products increases.

Few affordability problems are anticipated for products produced for global markets: for example consumer electronics and ICT goods, which are already only produced in a few places (often with existing MEPS) for global markets. Products whose costs are strongly linked with material costs, such as electric motors, LEDS or transformers, would see some (likely small) cost increase from additional material requirements. Locally tailored products of relatively small production volumes may see larger price increases.

Some affordability impacts may be experienced, particularly in countries with low energy prices, low disposable incomes and/or low usage patterns: the empirical work flagged above has primarily been carried out in developed countries, the impact can be different in poorer developing countries. Energy prices, product prices and disposable income levels and usage patterns can all have an important influence on the life-cycle costs and benefits of higher efficiency. In countries with low energy prices the efficiency level at which least life-cycle cost is achieved will be lower than in countries with relatively high energy prices as the economic value of each unit of energy saved is lower. Similarly for the other variables.

An approach based on levels of requirements could mitigate affordability concerns: levels could differentiate per product or related to relative national incomes/prices. Such an approach would address short term product affordability concerns while contributing to greater harmonisation.

As noted in section 3.2.1 on economic impacts, a move towards globally harmonised MEPS at current maximums would be expected to lead to both increases in product prices for consumers and longer term energy savings. Considering the balance and timing of these impacts is important to analysing the potential impacts.

The affordability of higher efficiency products is one of the aspects that energy efficiency regulators analyse prior to introducing MEPS and to a lesser degree energy labels. The USA has long enshrined the principle that MEPS should be set at levels that reduce overall life cycle costs (by lowering energy and operating costs more than they increase product purchase costs) and result in acceptable payback periods to end-users. The EU's Ecodesign Directive enshrines the same principle in basing MEPS requirements at the efficiency level that produces the least life cycle cost for the average end-user. China has often set MEPS on a similar basis although this approach is not institutionalised within the Chinese regulatory framework. In practice then all existing MEPS help to lower overall lifecycle costs for consumers and end-users and thus help ensure value for money while only having a modest or negligible impact on purchase prices.

In theory, requiring the removal from the market of less energy efficient products should necessitate the adoption of designs that are likely to have a higher material, component and/or design cost. If this increase in cost is passed on to the consumer then average prices would be expected to rise. Some studies[43] have examined this effect to see if the projected increase in prices that were postulated when the regulations were introduced have produced the expected increase in product prices. Generally, these retrospective analyses have found little or limited evidence for product price increases stimulated by the adoption of higher efficiency requirements and in some cases the reverse[44], that prices continue to decrease as efficiency improves. There are several potential explanations for this:

1. Manufacturers are likely to find cheaper ways to improve product efficiency than projected in the regulatory support analyses.
2. The incremental cost of higher efficiency components is related to the volume of demand for those components, so as demand increases due to a regulatory development, the cost of the component declines as competition among suppliers helps decrease unit costs.
3. Manufacturers that are used to responding to energy efficiency (and or other) regulations will tend to develop more flexible manufacturing systems that lower the fixed tooling and process costs associated with producing a new series of higher efficiency products.
4. A regulatory stimulus to upgrade a range of product models will often be taken as an opportunity to upgrade production lines and tooling and to negotiate new supplier arrangements which can help suppress cost increases.
5. Any incremental production costs due to MEPS will also be sensitive to how much advance notice is given before the regulatory measures take affect – usually this is between 2 and 6 years.

[43] Reference studies for the affordability analysis are included in the References section at the end of this report

[44] IEA4E (2015) Achievements of appliance energy efficiency standards and labelling programs: a global assessment

As a result, while most product life cycle cost assessments a priori will project end-user payback periods of within about a third of a product's life time from reasonably ambitious MEPS (leaving two thirds where there is a net benefit), the actual payback periods seem to be considerably shorter and the period of net benefits longer. In fact, this phenomena is well known in technology learning curve theory wherein the price of a technology with a given performance level declines by the learning rate each time the volume of units produced is doubled. This has been empirically observed for many energy supply technologies, such as solar photovoltaic panels, whose costs have declined by an average of 18% each time the volume of panels installed has doubled over many decades, and has also been observed for the efficiency of many energy using technologies.

Overall, there is little evidence of real product price increases due to MEPS although there is ample evidence of reduced life cycle costs. Over the medium term these net savings will reduce expenditure burdens for end-users and increase their ability to spend in other areas of economic activity.

However, it is important in this global analysis to consider whether adoption of the world's most stringent MEPS or highest energy label thresholds would be of economic benefit to all end-users and/or if it would make products unaffordable for some end-users. Affordability is contextual in that end-users with more disposable income can more easily afford to purchase more expensive products than those that haven't. This varies both within economies and across economies and affects expenditure patterns for all product types regardless of their energy efficiency. Before considering the impact of potential price increases it is important to appreciate that life cycle costs are sensitive to energy prices, product usage profiles and product prices. The efficiency level for which a product's life cycle cost is minimised will be higher for economies with relatively high energy prices and high usage levels than for those with cheap energy and low usage profiles. For this reason, adoption of common minimum efficiency levels for all economies would not be economically optimal for all.

However, as today's a priori life cycle cost estimates have been proven to be systematically conservative in that they tend to overestimate actual product price increases due to higher efficiency requirements, it is likely that broad international adoption of current most stringent MEPS would not result in very significant increases in product prices, at least for some product types. Those products that are already manufactured for a global market in a small number of product centres such as Consumer Electronics and ICT products would likely have very little change in price. Those that are produced for mostly global markets but have a strong link with material costs, such as electric motors, LEDS or transformers, would be expected to reflect the incremental bill of material costs but little extra production costs. Those products that are more localised and produced in smaller series would be expected to have the largest increase in price.

For these reasons it may be appropriate for regulators to consider development of a menu or ladder of internationally harmonised energy efficiency thresholds from which each economy can chose requirement levels which are consistent with local needs but which help maximise international harmonisation. Such an approach would give sufficient flexibility to regulators to mitigate any near term product affordability concerns while supporting greater harmonisation, thereby building markets and accelerating the technology learning rate, which in turn will improve affordability.

3.3.2 Functionality and usability of energy related products

Key points:

Functionality and usability considerations relating to international harmonisation of energy efficiency requirements and labelling include:

- **Regional variations in functionality:** Regulations should ensure that global requirements do not result in manufacturers neglecting regional user needs in favour of cutting costs to supply a one-size-fits all solution. Allowing for modular design approaches and software customisation can facilitate regionally tailored solutions at low cost, based on a standardised foundation product.
- **Consumer confusion of power characteristics with performance:** There have been some cases of consumers interpreting the phase out of inefficient products as limiting product functionality available to them for purchase. This is usually due to a misconceived association between the power characteristics of the product being regulated and its performance. This often arises from power being a key product attribute in marketing material and pricing scales. The reality is that a well-performing product will be able to execute its core function effectively whilst using the minimum necessary power. Negative consumer attitudes to phase-out regulations can reduce or be forgotten as: i) the market adapts to promote products in terms of their true functional performance ii) consumers shift to more efficient products, they may find have improved functionality due to innovation.
- **Functionality improvements as a result of MEPS:** In some cases, efficiency improvements instigated by mandatory requirements result in additional positive impacts on product usability, reliability and features. E.g. efficient power supplies that generate less heat (safer) and are smaller and lighter weight (less copper), so easier to transport.
- **Balancing functionality and user needs:** Consumer demands for functionality and price are likely to be lower in areas that have not previously been regulated. In these countries the majority of the market may initially be focused upon lower quality, less efficient models that may be phased out under mandatory requirements. It is important that MEPS and labels provide sufficient allowance for efficient products with basic features, whilst at the same time ensuring that allowances for extra features are proportionate.

Regional variations in functionality

Global harmonisation of MEPS and energy labelling to be applied to products would need to be specified and timed with appropriate impact assessment to ensure that functionality from the end-user's perspective is not adversely affected. This will be particularly important for products where there are regional variations in functionality. For example, air conditioning functionalities failing to meet the varying needs of different climatic zones, or TV automatic brightness adjustments failing to adapt appropriately for variations in ambient lighting conditions when viewing TV in different regions. Sensitive design of regulations and labels is important to ensure that global requirements do not result in regional user needs being neglected in favour of cutting costs to supply a one-size-fits-all solution. Provided that the potential of modular design and custom software is appropriately exploited, low cost customisation should be possible based on a standardised foundation product. There may need to be some degree of customisation in labelling approaches to ensure that product classes result in representative efficiency ratings taking into account the differences in regional use profiles, conditions and functionality.

Consumer confusion of power characteristics with performance

The Ecodesign framework directive (2009/125/EC) makes some clear statements with regards to functionality of products addressed by Ecodesign implementing measures:

- *"there shall be no significant negative impact on the functionality of the product, from the perspective of the user"*
- *"The choice of a specific design solution will achieve a reasonable balance between the various environmental aspects and between environmental aspects and other relevant considerations, such as safety and health, technical requirements for functionality, quality, and performance, and economic aspects, including manufacturing costs and marketability, while complying with all relevant legislation."*

Such considerations are taken into account in the preparatory studies that assess the potential for regulation. The foundation MEERP methodology for example, defines functionality as one of the boundary conditions where there should be no negative impacts. However, despite such precautions being taken, sometimes consumers interpret the phasing out of inefficient products as limiting product functionality available to them for purchase. This is usually due to them misconceiving a link between the power characteristics of the product being regulated and its performance. The reality is that a well-performing product will be able to execute its core function effectively whilst at the same time as being energy efficient and using the minimum necessary power. Confusion can arise partly due to the way in which products are marketed and priced, as power ratings can provide an easy means of differentiating products. However, such a focus can create a barrier to moving toward energy efficiency as a central driver in product design.

Confusion over the link between power ratings and core product functionality has resulted in some consumer controversies over the minimum energy performance requirements introduced in Europe. For example:

- Vacuum cleaners: Minimum efficiency requirements introduced for vacuum cleaners in Europe, mean that (as well as requirements for minimum dust pick up) there is now an upper limit to the power rating of these products. One of the key performance indicators on which vacuums were historically marketed was their power (wattage). The average power of a vacuum on the market in Europe at the time of the proposal was 1800 watts, with the legislation introducing an initial limit of 1600 watts, reducing to 900 watts from 2017. Therefore some consumer and media reactions to the introduction of the requirements (in 2014) claimed that the "best" (meaning most powerful) vacuums on the market would be banned. In fact, a well performing vacuum cleaner will be able pick up dust effectively whilst using the minimum necessary power. European vacuum cleaner manufacturers finding themselves unable to focus on ever-increasing power ratings in the wake of the EU power cap, are likely to shift to promoting their products on the basis of their true functionality – the ability to pick up dust effectively.
- Televisions: Similar concerns were raised with the phase out of inefficient TVs in Europe, where consumers equating power (high wattage plasma screens) with screen size panicked that they would no longer be able to buy large screen TVs. In fact other technologies (LED LCD, quantum dot UHD etc.) progressed to enable more efficient, better resolution and larger screens.

Negative consumer attitudes to the phasing out of products due to regulation can reduce or be forgotten as the market adapts to promote products in terms of their true functional performance, and as consumers shift to alternative products that they may find have improved functionality (see box 6). In order to successfully design and implement ambitious harmonised MEPS and labelling schemes, management of consumer perceptions regarding impacts on product choice is key.

Box 14: Functionality case study on domestic light bulbs

Traditional incandescent light bulbs have been phased out in Europe under Ecodesign legislation. Prior to the introduction of minimum performance requirements for light bulbs, consumers purchased light bulbs by power rating (wattage) rather than brightness (lumens / candelas). The alternatives available to consumers at the time of the incandescent phase out included halogens, compact fluorescent light bulbs (CFLs) and light emitting diodes (LEDs). The phase out, combined with subsidy and incentive programmes, had a profound impact on the market. Whilst much of the market moved to CFLs, there was also a greater than expected shift to halogens, due to consumer-perceived disadvantages of CFLs, and the relative infancy of LED technology at the time.

Consumer complaints about the relative inadequacy of the functionality of the CFL bulbs that were being promoted as an alternative included:

- Lower brightness and colder light colour of comparable CFL substitutes to traditional incandescent bulbs.
- The need for a 'warm up' time for CFLs to reach full brightness.
- Incompatibility with dimmer switches and for specialist applications.
- Incompatibility with existing light fittings and dimmer switches.
- Presence of toxic mercury vapour contained in each CFL bulb.
- Health concerns around the impact of high-frequency 'flickering' of CFLs.

The shift in the market toward alternative lighting technologies enabled CFLs to overcome these challenges through technology developments, drove halogens toward improved efficiency and led to huge innovation in the LED market. The regulation in fact provided a crucial driver for this change, and the transition to more efficient lighting solutions with equally satisfactory and often improved quality. Some LEDs now entering the market as a result of demand for more efficient light sources have advanced capabilities that can even allow users to change the colour temperature of a bulb to their specific preference. A 2011 survey in the United States found that consumer attitudes in the lighting area had become much more positive than previously expected toward efficient lighting alternatives such as LEDs in the run up to phase out of less efficient options, but stressed the need for consumer education in advance of the introduction of such measures.[45]

Natural improvement in functionality as a result of efficiency

Due to the efficiency drive instigated as a result of MEPS, labelling initiatives, and subsidy schemes, technology improvements can actually result in products that provide additional user benefits in terms of improved functionality, reliability, usability and performance whilst meeting energy efficiency goals. For example, improvements

[45] Wimberly, J., EcoPinion / Ecoalign (March 2011), Lighting the Path Forward for Greater Energy Efficiency - Survey Report • Issue 10

in power supply efficiencies over recent years have resulted in power supply units that generate less heat (safer) and are smaller and lighter weight (less copper), so easier to transport. Likewise, set top boxes (typically located in poorly ventilated areas) with improved efficiency have become smaller and by generating less heat have lower failure rates.

Balancing functionality and user needs

In a scenario of harmonised mandatory product requirements, the consumers most likely to be impacted by changes in product ranges would be those in areas that have not previously been regulated – often in poorer areas where consumer demands in terms of functionality and price are likely to be lower. These consumers may only be able to choose from the lower quality, less efficient models at the bottom of the market, that may be phased out under mandatory requirements. This would have consequent impacts on product affordability and access for consumers.

These impacts can be managed through careful design of harmonisation initiatives. Often regulatory requirements take the form of a baseload allowance covering power required for basic functionality, plus additional allowances for greater functionality or product sizing. If baseload allowances are insufficient, it is the lower functionality, low-cost products that are most likely to be impacted. It is therefore important to ensure sufficient baseload allowances to enable efficient but basic products to achieve the harmonised levels. For example, too low a baseload allowance for TV energy efficiency requirements may make it harder for small screen TVs to comply with the requirements, pushing prices up and reducing choice, and therefore impacting the ability for consumers to affordably purchase products in smaller sizes.

Likewise, if allowances for additional functionality are set which allow a level of power demand higher than necessary for these features, less-efficient products with unnecessary features not demanded by the user may become commonplace on the market. For example, in the area of refrigeration there have been discussions around the appropriateness of energy labelling correction factors for additional product features such as ice makers and water chillers. It was considered that these could have resulted in "misleadingly high energy efficiency ratings" considering the additional impact these features have on total energy use and running costs[46].

There are also concerns regarding the way in which the design of energy classes may mislead consumers in terms of the absolute energy impacts of products. For example, a large TV or refrigerator may have a higher (better) energy class than a smaller TV or fridge. Whilst these products may be efficient for their larger size, they are likely to consume more energy overall. Consumers interested in reducing absolute energy consumption may make inappropriate purchasing decisions due to not fully understanding the relation of the energy classes to the size of the device.

Therefore it is important that the design of harmonised regulations and labels ensures appropriate allowance is made for smaller, lower cost, or lower featured but efficient products to comply, and that such products are not compared unfavourably with larger or higher-featured products.

[46] Consumer Focus (December 2012) Under the influence? Consumer attitudes to buying appliances and energy labels http://www.consumerfocus.org.uk/files/2012/12/Under-the-influence.pdf

4 Barriers to harmonisation

Key points:

The world does not yet enjoy the benefits of harmonisation described in this report. This is due to a number of barriers to achieving global harmonisation of (firstly) technical standards and then MEPS and labels. The barriers can be grouped into the following three types:

- **Regional barriers:** Real and perceived needs for differences between regions, which stem from differences in climate, culture and market structure, user needs, tangential regulations (such as food safety), simple historical accident and efforts to protect local markets.
- **Barriers to the process of change (harmonisation) itself:** These include; a lack of motivation to change (when standards can suffice as they are for existing trade); a lack of available time and technical resource on the working committees and for policy-makers; uncertainty during change; the costs of re-testing or developing new products; the investment in new facilities to build or test new products; the practicality that update cycles are 'out of sync' between regions and so agreements cannot be struck at crucial times. There is also a disconnect between high level policies aimed at improving comparability and the activities of the technical committees that must make it happen but have other priorities.
- **Perceived barriers and risks:** These could include potential damage to local industry from exposure to increased competition; disappearance of familiar products; discontinuity of trend data as test methods change. Some issues seen as barriers are actually insignificant in practice: examples include language and units of measurement – translation for both is straight-forward and introduces little or no technical uncertainty.

An aspiration for complete global harmonisation is neither realistic nor essential - a core requirement for harmonisation is simply the coherence and comparability of test standards and policy approaches, and the transparency necessary to identify and spread best practice standards and policies (including MEPS and energy labels).

The foregoing sections have highlighted many benefits of harmonisation of global standards and MEPS. A significant amount of alignment does already occur since technical standards, MEPS and labels are too costly and time-consuming for every nation to develop separately: those needing such approaches tend to adopt or adapt those of trading partners and/or near-neighbours. Globally, there are a handful of countries that lead these processes, including the USA, EU, China and Japan. These leader countries tend to be followed by neighbouring countries that base their standards on those of the leader, often with some adaptation.

However, there still remains a disparity of approaches at a global level. This section examines why the world does not, in reality, enjoy the transparency of product performance and higher energy savings that might follow from global harmonisation.
The barriers examined in this section concern the differences between the countries leading the development of standards, MEPS and energy labelling schemes, the regional level implementation of requirements, and the potential to re-align the MEPS and labels of whole groups of countries.

When assessing the political priority and feasibility of harmonisation, the relative strength and applicability of the following barriers must be set in perspective for each case:

1. Why there are, or might need to be, distinct differences between regions for some products

From a legal standpoint, ISO and WTO recognise three main justifications for a region to impose its own technical regulation, rather than adopting or adjusting an already existing or imminent international regulation for that product. These are noted in the WTO agreement on Technical Barriers to Trade[47] as:

i. fundamental climatic differences;
ii. geographical factors; and
iii. fundamental technical problems.

In practical terms, there are other more specific factors that have acted to cause or perpetuate differences between regions. Although these WTO factors lie behind several in this longer list, any of those not considered as within scope of the WTO factors could be challenged via WTO. In approximate descending order of significance:

a. **Local climate:** important differences occur due to the local climate. For example, air conditioners in South East Asia are optimised for efficiency with high ambient temperatures and humidity for much of the year; units in Northern Europe are optimised differently. Regulatory and labelling requirements therefore need to be developed to take account of local climate. The EU energy labels for air conditioners are implemented in this way, being allocated according to 4 distinct climate zones. Most types of cooling appliance are similarly affected by climate. Even if efficiencies could be compared easily between tropical and temperate climate products, the products would perform poorly (or at least differently) if transferred to the other region and so there is little incentive to resolve such differences. Thus, it is considered justifiable to have non-comparable requirements across climate zones for equipment for which performance is affected by ambient conditions. However, it would be possible to harmonise requirements defined within similar climate zones if compromise on rating temperatures could be agreed – for example for cooling equipment between EU and much of North America.
b. **Local technical infrastructure and other market conditions, culture and service needs:** some inevitable differences arise from these factors and the set-top box (STB) is a good example. The built-in functionality of these devices varies enormously depending on: the local media industry (business models used); signal delivery infrastructure (cable, terrestrial, satellite etc.); and consumer demand (built-in recording, multiple tuners etc.). Comparison of regulatory requirements for STBs between regions is extremely hard to achieve on a fair basis, except at the most basic level of standby power[48]. Another example is where local food types affect the internal design and storage temperatures of domestic fridges (fridges specifically for storing 'Kimchi' pickled cabbage that are almost unique to Korea are one extreme example of that). Also, the actual efficiency achievable by products that include an electric motor depends upon the frequency of electrical supply (50Hz or 60Hz).
c. **Differences in tangential regulations:** regulations not directly associated with energy use may affect design of products and lead to necessary differences in regulatory requirements and labelling schemes. For example, local food safety law dictates storage temperatures for domestic and commercial food refrigerating

[47] See https://www.wto.org/english/tratop_e/tbt_e/tbt_e.htm
[48] This was shown in analysis of STB products and markets by IEA 4E Mapping and Benchmarking in 2014, see http://mappingandbenchmarking.iea-4e.org/matrix?type=product&id=14.

equipment, which directly affects energy consumption. Similarly local building regulations affect the nature of energy efficiency requirements for many HVAC products, including performance metrics and types of losses taken into account. In these cases, however, if other aspects of testing and policy requirements are harmonised then comparison of relative stringency of policy requirements can be achieved by empirical or theoretical adjustment factors.

d. **Historical accident:** some differences exist due to historical accident, such as: the particular experience of those involved in developing the MEPS or labelling scheme; when and where it started, or due to the context in which products are used or sold in that region. This applies to some differences in the metric used which can make requirements problematic to compare. It also applies to terminology and ways in which products are defined and segmented by type. For example, efficiency for vertical glass door chilled cabinets in the US is expressed as kWh per unit internal volume, whereas efficiency of these in the EU is measured as kWh per unit display area visible to the customer. Whilst awkward to change for reasons noted below, such differences could in theory be resolved and harmonised.
e. **How product types are segmented:** this will affect the stringency of policies that can be applied and differences can make comparison misleading. For example India segments its policy thresholds for televisions by display technology (CFL backlit LCD with plasma screens in one category; LED backlit LCD in another), whereas other countries force all technologies to compete in the same category. Commercial refrigeration standards have many such anomalies which mean that stringency is hampered for some policies that group products in particular ways and comparisons between policy levels in different economies can be misleading. This troublesome but not insurmountable challenge for comparison and alignment often arises through historical accident or preferences of local manufacturers and policy-makers.
f. **Protectionism:** any one of these or other barriers could be exploited by industry and/or policy-makers to achieve some level of protection for local manufacturing industry, through raising the effective cost of entry to the market. This could result in larger differences between regions than might technically be justified.

Box 7: Why test methods and policy standards for packaged liquid chillers are so different in the EU compared with the rest of the world (case study).

The IEA 4E mapping and benchmarking initiative recently analysed why EU seasonal performance metrics are so different and non-comparable with those of the rest of the world for packaged liquid chillers, as used for central air conditioning and process cooling applications. The August 2015 report49 compares policy thresholds for cooling mode seasonal efficiency (IPLV) of chillers across USA, Canada, Australia and China, and presents separately the proposed 2017 seasonal efficiency (SEER) thresholds for the EU. The seasonal IPLV widely used throughout the world cannot be compared on a fair basis with the EU metric due to fundamentally different assumptions including annual usage profile, climatic temperatures, built-in assumptions about efficiency of pumps and fans within the system and how to account for low power modes.

As expected, reasons for differences include different dominant technologies markets, typical capacity range of chillers, climate conditions and cooling demand profiles. But other factors are also important in this case: The EU approach is embedded in product policy and so products are assessed in isolation, whereas the

[49] IEA 4E Policy benchmarking for Packaged Liquid Chillers and evaluating the lack of comparability between economies, 4 August 2015, available from http://mappingandbenchmarking.iea-4e.org/matrix?type=product&id=17.

IPLV (USA) policy is embedded in building/system policy - this changes the reference framework and explains the fan/pump assumption differences; but also the USA is dominated by large centrifugal cooling only chillers used throughout the year whereas the EU has systems used part-year based on chilled water which are often reversible to circulate hot water for heating in winter. The EU policy thus integrates cooling and heating performance.

Whilst this raises major challenges for harmonisation, policy-makers could make standards significantly easier to compare through changing some of the assumptions, but an easier route to achieving comparability is through manufacturers' chiller selection software: This could easily deliver data in the different metrics and in standard formats alongside each other. From that data the policies could be compared.

2. Barriers to the process of to the process of change and alignment of standards, MEPS and labels

In approximate descending order of significance:

a. **Lack of motivation to change:** when policy requirements suffice for intra-regional trade as currently specified, there is limited direct benefit to manufacturers from wider alignment (unless larger businesses are developing inter-regional trade). Policy makers have historically not prioritised such steps and consumers do not demand such alignment.
b. **Lack of available time and technical resources:** Development of test methods relies largely on volunteer effort from industry and so the focus is on producing a workable standard within the required (often long) timescale. Review of standards and MEPS from other regions and negotiation of changes would require technical resources that are not available to the committees.
c. **Uncertainty whilst new MEPS are developed:** It takes at least two years after embarking down that route until test results are available and policy requirements are set - when manufacturers finally know how their products compare, this creates significant uncertainties for businesses.
d. **Costs of re-testing:** There is a substantial cost to industry of re-testing products according to a new method. The retest of even a small appliance will cost around € 1,000 per test per product type, with costs rising steeply as complexity and test duration increases.
e. **Difference in regulatory and test cycles:** Regulatory and test method update cycles are 'out of sync' between regions and internally. This can mean discussions between the right expert groups are hard to organise at the crucial times for each region. This could result in impacts on trade when policy requirements for one region are fundamentally changed whilst those for another remain as they were for several years. Co-ordinated changes would work best for global industry.
f. **Apparent disconnect between policy and action:** the few high-level policy statements that call for alignment[50] are not translated into direct guidance to the committees of experts charged with actually writing and modifying policy requirements, and when those committees meet they often have other priorities.

3. Perceived risks from harmonised or aligned MEPS and labelling schemes

In approximate descending order of significance:

[50] Examples of policy statements supporting closer alignment include the 'Annual Union work programme for European standardisation' (COM(2013) 561 final) and the draft Transatlantic Trade and Investment Partnership (TTIP).

a. Damage to local industry through increased competition as technical barriers to trade are reduced, see also section 3.2.4.
b. Concern on reduced availability of familiar products after changes, if new policies or test requirements mean old approaches can no longer be used and product design has to evolve. Often product design is significantly shaped by local policy requirements that have existed for many years, see also section 3.3.2.
c. A change of test method can lead to discontinuity of historical performance data so that performance trends cannot easily be tracked for the benefit of policy-makers and experts.
d. Changes can require investment in testing and enforcement infrastructure necessary to implement the changes.

4. Insignificant barriers
Some potential barriers do not pose a problem in practice, such as those listed below:
a. **Language:** The need for different languages is obvious, but is not relevant to technical specifications and test methods – standards are translated between languages without significant problems.
b. **Units:** Use of different units of measurement, as not all regions use SI units. Applying simple factors to convert metrics that are fundamentally identical but use different units is straight forward and is not an aspect that is necessary to harmonise. For example, kWh per cubic foot for the US can easily be converted into kWh per litre for the EU.
c. **Variations in stringency between coherent testing and policy approaches:** It is important to recognise that policy requirements can be harmonised as coherent and comparable, even if they are not set at the same level of stringency: level of stringency is a separate decision to the test method that underpins it. Policy requirements in India can be directly compared with those in the US if the underlying test method gives comparable results. It is a matter for local economic justification, policy ambition, technology availability, industrial policy etc. to influence a decision on stringency.
d. **Lack of formal mechanisms:** There is no lack of formal mechanisms for policymakers, experts and industry to co-operate between regions towards alignment, even if these are not widely exploited for the purpose. IEC and ISO exist for this reason; policy makers meet through IEA, SEAD, ASEAN and other international frameworks. There are proposals to create additional formal mechanisms for this purpose in the proposed Transatlantic Trade and Investment Partnership (TTIP) between the EU and the US[51]: TTIP affirms a desire for EU and US regulators to work more closely together to develop new regulations. It proposes to do this internationally through setting up a Regulatory Co-operation Body.

In conclusion on barriers to harmonisation: whilst many barriers exist, harmonisation is only necessary up to the point where there is coherence and comparability of policy approaches and standards between economies. If harmonisation is given appropriate political priority that results in availability of necessary technical resources, many of these barriers can be overcome.

[51] See "Regulatory cooperation in TTIP: Cutting red tape for EU firms – without cutting corners", EU fact sheet on TTIP, available from http://trade.ec.europa.eu/doclib/press/index.cfm?id=1230, accessed 25 February 2015.

5 Overall merits of harmonisation

The previous chapters explored the potential impacts of greater global harmonisation of technical standards and product energy efficiency requirements, and the barriers to achieving greater harmonisation in practice. On the basis of the analysis we conclude that:

- **Significant global energy saving benefits can be achieved - for example 13% gross global energy savings in 2030:** if global MEPS were agreed at current most stringent levels and implemented by 2020. Savings would be experienced across all countries and regions and across a large range of product groups.
    - Savings would remain significant even taking a likely rebound effect into account – estimated from literature review at 20%.
    - Consumer electronics and ICT, lighting and (thermal) heating and hot water products offer the highest relative and absolute energy saving potential.
    - If the highest current MEPS were already applied globally, then gross energy savings would be 21%, or 34% if highest label requirements were also applied. This demonstrates that energy savings can be increased if alignment also included energy labels.
- **Reducing energy use would also have important GHG mitigation and environmental benefits:** these impacts would fall proportionally with the energy savings, i.e. 13-14% reductions in all impacts in the CoNW MEPS 2030 scenario. Benefits to global emissions are estimated at reduction of 4,450 MtCO2e in this scenario, or 7% of 2030 total global BAU[52] emissions. Important benefits to air quality (reduction in particulate emissions) and environmental quality (reduction in acidifying emissions) would also result from lower energy use.
- **Improved efficiency would bring economic benefits to end-consumers and the wider economy:** this applies to end-consumers in the residential, tertiary and industrial sectors where products in these sectors are regulated. Economic benefits will arise from the increased consumption and production opportunities granted by energy savings and also the indirect economic impact of the savings being re-spent elsewhere in the wider economy. The benefits already take into account the additional costs of more efficient products, assessed to typically be no more than 25% of the value of the total energy savings. The value of potential energy savings are assessed to be €280-410 billion per year globally, or savings of 8-13% compared to a 2030 BAU, assuming today's energy prices.
    - Reduced energy use would result in structural economic change, reducing the relative size of the energy sector, while increasing the size of other sectors, including the appliance manufacturing industry.
    - Appliance manufacturers in the EU would be particularly likely to benefit from increased global energy efficiency requirements due to a leading position in energy efficiency.
    - Trade impacts would also occur, with reductions in energy imports anticipated, particularly gas for heating and other fuels for electricity generation. This would be beneficial for the trade balances of net energy

[52] BAU = Business as usual, i.e. continuing current trends, policies and practices

importers such as the EU, also contributing to increased energy security.
    - Economic savings will also be experienced by implementing agencies and policymakers as costs and information are shared and inefficiencies and parallel or duplicate processes reduced.
- **Economic savings will have a positive net employment impact:** while jobs may be lost in the energy sector as energy consumption is reduced the re-spending of economic savings will create more jobs in other economic sectors. The balance of these changes is positive due to the relatively low labour requirement per unit of turnover of the energy sector in comparison to the wider economy. The global impact in the CoNW MEPS 2030 scenario is estimated to result in 1.7-2.5 million additional jobs compared to the 2030 BAU.
    - Changes in skills requirements will go hand-in-hand with the changes in employment. It is likely that some highly skilled jobs would be lost in the energy sector, with the new jobs being created having a broader range of skills needs, particularly in the services sector.
- **Harmonising requirements would reduce trade barriers:** which increasingly take the form of non-tariff or technical barriers, such as product standards and performance requirements including MEPS and labels. Reducing these barriers could be of particular benefit to EU firms which export these products. Negotiations at the WTO or on free trade agreements could already be used to start the harmonisation process.
- **Competitiveness impacts are relatively low and can be mitigated:** the impacts on manufacturing costs, compliance costs, product prices and markets are assessed to either be beneficial or generally low, although impacts differ within the various markets. Impacts are least for international Original Equipment Manufacturers (OEMs), but greater for large manufacturers and SMEs operating at a national level in previously unregulated markets, which will need to adjust to the new situation. To mitigate these issues it is crucial therefore that firms are given adequate time to adjust to any new harmonisation of requirements.
- **Harmonised requirements could positively influence investment in innovation, innovation speed and its focus on energy efficiency:** the extent to which these influences occur is a factor of the ambition (stringency) of the requirements. Although it is also important to strike a balance between stringency and competitiveness, as more stringent requirements are likely to require greater innovation efforts (reducing competitiveness), particularly from large manufacturers and SMEs operating at a national level in previously unregulated markets. A combination of MEPS and labelling can provide a good way to raise efficiency at the bottom of the market and incentivise innovation at the top.
- **Consumers will benefit from efficiency savings over time, although affordability may be an issue in some countries:** particularly where low energy prices, low usage and/or low incomes are present, as each of these act to reduce the financial savings from greater efficiency compared to the increased product cost. Nevertheless existing evidence finds that product price increases have actually been significantly lower than anticipated due to a variety of factors. Affordability impacts are therefore understood to be generally low, but could be mitigated by adopting a tiered approach to requirements (see below).
- **Product functionality can benefit from harmonised requirements:** for example increased efficiency can, in some cases, result in additional positive impacts on product usability, reliability and features. E.g. efficient power supplies that generate less heat (safer) and are smaller and weigh less (less

materials used). At the same time requirements must be designed with sensitivity to regional or national needs for functionality and also to clearly communicate the benefits of any core changes in function to avoid consumer confusion and/or opposition.

- **Barriers to harmonisation exist but can be overcome:** this work identified three important types of barriers to harmonisation.
    - Regional barriers: based on real and perceived needs for differences between regions, stemming from differences in climate, culture and market structure, user needs, tangential regulations (such as food safety), simple historical accident and efforts to protect local markets.
    - Barriers to the process of change (harmonisation) itself: these include a lack of motivation to change, a lack of time and technical resources, uncertainties, costs of re-testing or developing new products, investment costs, update cycles being 'out of sync' between regions and disconnect between high-level policy and activities in technical committees where foundations must be laid for harmonisation.
    - Perceived barriers and risks: including potential damage to local industry from exposure to increased competition, the disappearance of familiar products, discontinuity of data as test methods change. Some issues seen as barriers are actually insignificant in practice: examples include language and units of measurement – translation for both is straight-forward and introduces little or no technical uncertainty.

  In relation to barriers, aspiring for complete global harmonisation is neither realistic nor essential - a core requirement for harmonisation is simply the coherence and comparability of test standards and policy approaches, and the transparency necessary to identify and spread best practice standards and policies (including MEPS and energy labels).

It is clear that there are multiple overall benefits to global harmonisation of product MEPS (and energy labels), and barriers, while important, can be overcome. The benefits are experienced differently per country/region, depending on a variety of factors, including their starting point, energy consumption patterns, prices, climate, culture, energy system and industry. The EU is relatively well positioned to benefit from such changes, particularly its appliance manufacturing industries. Although EU benefits may be proportionally lower than other countries/regions, given its relatively high starting point, there still remain significant economic and environmental benefits that can be achieved, for example in helping to reduce the need for energy imports.

The scale of the benefits (and any costs) will vary with the stringency of any global requirements, therefore this question remains important. International agreement to implement MEPS at less stringent requirement levels may be easier, but will produce fewer benefits. Given the disparity in current requirements a tiered approach should be considered, e.g. offering variations in MEPS per region and that these are introduced over a reasonable timeframe, as this would help to overcome the concerns and barriers that remain.

In any case, this work has demonstrated the huge global potential benefits in energy use, GHG emissions, environmental impacts and economically from greater alignment to more stringent MEPS and energy labels for energy-related products. It is clear that further work in this area by the EU and other countries could be valuable in actually achieving these benefits.

While the main purpose of this work lies not in an investigation how harmonisation could be achieved, the pathway to this should involve at least, in broad terms:

- Greater alignment of technical standards (test procedures, product groupings and efficiency metrics);
- More engagement in international dialogues and fora; and
- Capacity building in countries without existing standards and MEPS.

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Annex I: Description of model and modelling methodology

This annex discusses the modelling methodology and scenarios used for the quantitative analysis presented in-depth in Annexes I and II.

Model design and structure

The model logic is a hybrid top-down linked to a quasi-bottom up approach:

- Bottom up: To help analyse the impacts of higher-efficiency equipment scenarios a bottom-up model of equipment energy use was developed. The model is established to separately analyse energy consumption and the impact of changes in equipment energy efficiency in each of China, the EU, India, the Republic of South Africa and the USA.
- Top down: The model takes top down data on energy use by sector (residential, tertiary, industrial) and fuel (electricity, oil, gas) from the IEA's World Energy Outlook for 2010, 2020 and 2030 for the Current Policies scenario. This is assumed to be the base case (Business as Usual) scenario as it has been developed through a careful and extensively reviewed analysis of macroeconomic and econometric trends linked to a scrutiny of the on-going impact of policies and measures which have already been adopted.

The model treats equipment energy use separately in each of the residential, tertiary and industrial sectors. In the residential and tertiary sectors it models all final energy forms (electricity, gas, oil) whereas in the industrial sector it only treats electricity as used in motive power applications (~70% of industrial electricity use) and in transformers. It does not model other fuels, process heat or other electricity uses (such as arc furnaces) in the industrial sector, nor does it deal with district heating in the residential or tertiary sectors.

Bottom-up energy consumption

For each of the principal economies analysed (China, EU, India, South Africa and the USA) bottom-up data is assembled on the share of energy consumption by end use within each primary sector (residential, tertiary and industrial) and applied using an attribution approach to proportion that energy by specific equipment end-use for each principal sector and fuel (electricity, gas/LPG or oil). In most cases for the five economies analysed in depth this attribution is based on existing studies of the breakdown of energy consumption by end-use and most notably from the sources in the footnote.[53] In cases where there is no available data on the consumption by an

[53] Opportunities for Success and CO2 Savings from Appliance Energy Efficiency Harmonization, Waide P. et al, (2011) http://www.clasponline.org/en/Resources/Resources/PublicationLibrary/2011/Opportunities-for-appliance-EE-harmonization.aspx
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CNIS. (2012). White paper for the energy efficiency status of China energy-use products. Beijing: China Standards Press.
Development and implementation of energy efficiency standards and labelling programs in China: Progress and challenges, Zhou, Nan, Nina Khanna, David Fridley, and John Romankiewicz, LBNL China Energy Group, (2013), https://china.lbl.gov/publications/development-and-implementation-energy
Report On "Verified Energy Savings with the Activities of "Bureau of Energy Efficiency" For the year 2009-10, Bureau of Energy Efficiency, http://www.beeindia.in/content.php?page=miscellaneous/energy_savings_achieved.php
BUENAS Scenarios Estimate Cost-Effective and Technical Savings Potential for MEPS in 13 Major World Economies, Mc Neil et al, CLASP, (2012),

end-use in one of these economies the share taken by the end-use is approximated by assuming it accounts for the same share as in a proxy economy where the share is known. In the case of the Rest of the World this proxy economy approach is used, typically by weighting the share of the top down sector level fuel consumption estimates taken by the end use by a weighted blend of the shares taken in the five economies analysed in depth.

In this way, estimates of the energy consumed by end use in the base year (2010) are determined for the equipment types shown in Table A53 in each principal economy and the Rest of the World.

http://www.clasponline.org/en/Resources/Resources/PublicationLibrary/2012/BUENAS-Scenario-BAT-CEP.aspx
For the USA a variety of resources at the USDOE site http://energy.gov/eere/buildings/appliance-and-equipment-standards-program , the Appliance Standards Awareness Program site http://www.appliance-standards.org/reports and the Energy Information Administration's Annual Energy Outlook http://www.eia.gov/forecasts/aeo/

Table A53: Equipment types for which energy end-use is modelled in-depth (bolded) or indirectly (plain text)

Sector	Lighting	Electronics	White goods	Industrial products[54]	Air conditioning	Heat supply
Residential	**Omni-directional socket lamps (GLS, Halogen, CFL, LED)** Directional socket lamps (GLS, Halogen, CFL, LED) **Linear fluorescent lamps**, **ballasts**	**Consumer electronics – TVs, decoders/set-top boxes,** HiFi, **external power supplies,** VCR/DVD players, game stations **ICT – Desktops, notebooks,** tablets, **monitors,** printers, **Multi-function devices,** routers	**Refrigerators, freezers, clothes washers, dishwashers, dryers** Cooking appliances – hobs (gas/electric), ovens (gas/electric), microwaves, combination ovens, range hoods		Ventilation – ceiling fans, extractor fans, others **Air conditioning – room air conditioners, central air conditioners**	**Boilers and furnaces – gas** **Boilers and furnaces – oil** **Boilers and furnaces – electric (resistance, heat pump)** Boilers – circulation pumps Water heaters – electric (storage, instantaneous) Water heaters – gas (storage, instantaneous)
Tertiary	**Omni-directional socket lamps** (GLS, Halogen, CFL, LED) Directional socket lamps (GLS, Halogen, CFL, LED) **Linear fluorescent lamps, ballasts** **High intensity discharge lamps** (Mercury vapour, sodium, metal halide and ceramic metal halide lamps, ballasts) Note, in the tertiary sector indoor and outdoor lighting applications are treated independently	ICT – **Servers, Desktops, notebooks, monitors,** printers, **Multi-function devices**, routers	**Refrigeration** – self-contained, remote Laundry – clothes washers, dishwashers, dryers Cooking appliances – gas, electric		Ventilation – Air handling units (AHU), other Air conditioning – **room air conditioners, central air conditioners**, chillers	Boilers – gas Boilers – oil Boilers – electric (resistance, heat pump) Boilers – circulation pumps Water heating – electric Water heating – gas
Industrial				**Electric motors** – AC (0.75-375kW, <0.75kW, >375 kW), special motors, VSDs **Industrial ventilation** **Compressors** **Pumps** **Transformers – distribution, power**		

Note: Bolded equipment are those that were fully analysed for the results presented in this report

[54] Motors, pumps, fans, compressors

In total a 102 specific-end uses that are treated within the model. This division by end-use is adopted because it broadly matches the breakdown of energy efficiency regulations by product type applied in the economies considered. In a few specific cases, energy consumption data was not identified for the end-uses indicated above. This situation is most common for South Africa where the data sources are less abundant, but also in some instances for India and China. By contrast data in the EU and USA was comprehensive for all the above end uses. Whenever data on a specific end-use was not available, the same proportion of energy use as in a peer economy was assumed for the economy where the data is missing. Professional judgement was used in the few cases where it was necessary to apply such matching between the economies.

Once the energy consumption by equipment type is known in the base year (2010) it was then projected forwards in time (up to 2035 depending on the scenario considered). The approach taken for the analysis was to assume that the end-use takes the same share of its specific fuel consumption (gas, oil, or electricity) for the sector it operates in (residential, tertiary or industrial) in future years as it does in the base year. Under the base case scenario the total fuel consumption by fuel type and sector is assumed to match that forecast in the IEA's Current Policies scenario; thus, the consumption for the specific equipment is assumed to be the same proportion of the total in any future year in question as it takes in 2010. E.g. if domestic refrigerators took 15% of residential electricity consumption for an economy in 2010 under the base case scenario it is assumed they take the same proportion of residential electricity consumption in any given future year. This approach is a necessary simplification of actual stock dynamics, required in order for the analysis to be completed within the available resources. In some instances where clear projections of stock dynamics are known these are taken into account. For example, the EU and US scenarios are based on the projections made in studies conducted for the European Commission and US Department of Energy respectively and are integrated into the scenarios used in this model. Many of the most important Chinese energy end-use projections also take account of projected stock dynamics from recently published analyses.

Estimating efficiency levels

The information on equipment efficiency levels is drawn from a variety of sources including those mentioned in the previous footnote. In practice it was not feasible within the available project resources to gather data and conduct a detailed analysis of all the 102 end-uses for which energy consumption data is gathered. Accordingly, the approach taken was to select a sub-set of product types for a full analysis and then to apply proxy efficiency assumptions for the remaining product types. For example, the products in bold in Table A53 are analysed in depth and those not in bold are assumed to follow the same efficiency trends as proxy products or to have a simplified analysis applied based on differences observed in a subset of the economies.

The efficiency data used included the efficiency (efficiency unit varying by product group) of:

- the average of the stock in 2010;
- the average of new products in 2010;
- the minimum MEPS levels (broken down into up to four tiers whenever the application of MEPS is specified in tiers);
- the maximum energy label threshold; and,
- the annual autonomous energy efficiency improvement rate.

The data was first gathered using the locally applied energy efficiency metric (i.e. using the units of energy efficiency adopted in that economy and as measured using the locally applied test procedures).

In order to facilitate comparison of the efficiency levels across economies these local efficiency levels were then mapped onto a common international scale. The approach taken varies considerably by product type. In some cases, such as electric motors and lamps, the efficiency test procedures and metrics applied internationally are directly comparable and thus the local units are essentially the same as the international ones. In other cases, such as for domestic refrigerators or seasonal energy efficiency metrics for air conditioners, there can be substantial local differences. Derivation of common international comparisons then requires a conversion algorithm to be applied to convert the local efficiency levels into common international levels. This has been possible building upon a substantial body of work conducted to facilitate such international benchmarking - most notably in a variety of studies done by CLASP, SEAD and the IEA 4E. The present analysis draws heavily upon these and in particular from the synthesis of such work reported in the studies listed in the footnote[55].

Nonetheless, these benchmarking studies are not comprehensive in that they do not cover all end-uses. For the products analysed, this was found to be the case for space heating and water heating. As a result a different approach is taken for these end-uses as described further below. All other products either use common international efficiency metrics or were converted to common levels using benchmarking conversion formulae.

In the specific cases of space and water heating there is considerable variation by economy in the technologies deployed and the test procedures and performance metrics used. This makes comparability of product efficiency across economies much more challenging. As previously mentioned, there are no existing benchmarking studies for space and water heating and thus the detailed technical work which would be needed to enable comparison of efficiency levels across economies to be considered has not been undertaken. It was not within the scope of this work to undertake such work. The approach taken to resolve this issue is to make an assumption of a level of direct comparability between the performance levels reported via the different test procedures but then to temper this based on professional knowledge and experience. This was then translated into a framework of comparable efficiency ratings per heating technology type and applied to each country/region on the basis of an analysis of the share of each technology type used. In this way comparable starting points, the potential impact of requirements and improvement potentials could be calculated.

Treatment of the scenarios considered

The four scenarios that were modelled are as follows:

Business as Usual (BAU) scenario

The BAU scenario considers how much energy would be used by each product type in each economy if energy efficiency policies which have currently been adopted are implemented but no new policies are adopted and implemented thereafter. In the

[55] CLASP and The Policy Partners Compare Global Appliance Energy Efficiency Standards and Labels, http://www.clasponline.org/en/Resources/Resources/PublicationLibrary/2014/CLASP-Report-Compares-Global-Standards-and-Labels.aspx
Opportunities for Success and CO2 Savings from Appliance Energy Efficiency Harmonization, Waide P. et al, (2011) http://www.clasponline.org/en/Resources/Resources/PublicationLibrary/2011/Opportunities-for-appliance-EE-harmonization.aspx

event no product efficiency policies have been adopted this scenario projects the energy consumption as would be expected due to autonomous energy efficiency improvements, i.e. due to unregulated market forces.

Cost of Non World MEPS 2015 scenario
This scenario considers how much energy would be consumed were the average efficiency of products used today (2015) to be at the level equal to the most ambitious currently promulgated minimum energy performance standards (MEPS). This Cost of Non World scenario is completely hypothetical in that it is now too late for it to actually happen; however, it is informative in indicating the magnitude of savings that would have been delivered today had the most ambitious minimum energy performance standards policies been adopted in the recent past on an internationally harmonised basis.

Cost of Non World MEPS + High Label 2015 scenario
This scenario considers how much energy would be consumed were the average efficiency of products used today (2015) to be either at the level equal to the most ambitious currently promulgated minimum energy performance standards (MEPS) or at the level equal to the most ambitious currently promulgated energy label threshold (i.e. the so-called "High Label" requirement), whichever is most ambitious. This Cost of Non World scenario is purely hypothetical in that it is now too late for it to actually happen; however, it is also informative in indicating the magnitude of savings that would have been delivered today had the most ambitious minimum energy performance standards and labelling policies been adopted in the recent past on an internationally harmonised basis.

Cost of Non World MEPS 2030 scenario
This scenario is different to the two 2015 Cost of Non World scenarios in that it is a plausible scenario that could yet be actualised. It projects how much energy would be consumed in 2030 were the average efficiency of products sold in the future to be at the level equal to the most ambitious currently promulgated minimum energy performance standards (MEPS). It explicitly takes into account the minimum realistic period it would take for all economies to adopt and implement these regulations (typically assumed to be about 5 years i.e. from 2020 onwards) and of the degree to which the stock of equipment in 2030 would be influenced by these regulations. Thus, it takes into account the fact that only a proportion of the equipment stock in 2030 would be affected by these regulations as some proportion of the equipment stock would have been sold prior to the regulations coming into effect i.e. would not have been retired from service by 2030. This scenario gives an indication of how much energy could be saved by 2030 were there to be broadly based international agreement to adopt the world's most demanding MEPS from 2015 by circa 2020.

Energy savings for each of the three policy scenarios are derived by comparison with the relevant Business as Usual scenario. The BAU in 2015 is calculated by projecting the 2010 equipment stock efficiency levels to 2015. This is done by taking the 2010 stock efficiency levels for each equipment type and applying the estimated annual autonomous energy efficiency improvement estimates for the intervening years (i.e. for the 5 years from 2010 to 2015). The energy savings are then estimated by comparing the efficiency of the stock projected to 2015 with the efficiency of the most ambitious currently promulgated MEPS for the CoNW 2015 MEPS scenario or with the currently promulgated high energy label thresholds (or MEPS if there are no high label requirements) for the CoNW MEPS + High Label 2015 scenario. The sectoral (i.e. residential, tertiary or industrial) level energy consumption under the BAU scenario matches the consumption by fuel (electricity, gas or oil) of the IEA's Current Policies scenario from the World Energy Outlook. The IEA scenario takes account of macro level drivers such as GDP, population, energy prices, income and price elasticity of demand as well as other policies such as fiscal measures and incentives.

The two Cost of Non World 2015 scenarios are only partially time dynamic as they do not require a simulation of the replacement of the stock in response to higher efficiency requirements being set for new products as old products are steadily retired. Real world scenarios are time dynamic, however, and therefore the Cost of Non World MEPS 2030 scenario takes account of this by including a proper treatment of time dependent effects. Specifically, it considers the likely delay necessary for other economies to adopt the world's most stringent MEPS as promulgated in 2015 and generally assumes there is a five year delay before they come into effect in other economies. Secondly, it simulates the effect of time on the proportion of the stock which will be affected by the adoption of these MEPS by 2030 by assuming the product stock follows a typical S-curve survival function. If a product type has a short life average life expectancy, e.g. of typically less than a few years for incandescent lamps, then most or all of the stock in 2030 would be expected to be replaced by products that comply with the MEPS requirement (assuming they come into effect in 2020). However, for most product types considered the average life expectancy is longer, i.e. from 7 to 30 years depending on the product type, and in these cases only a proportion of the stock in 2030 would be purchased after the regulatory requirements come into effect. The model estimates this proportion for each product type. Furthermore, even without new policy measures the efficiency of products is unlikely to be static as market forces will still tend to act to improve energy efficiency, albeit at a lower rate of improvement than achieved by the highest 2015 MEPS. This is captured in the BAU scenario and thus for all these reasons the relative energy savings in 2030 under the Cost of Non World MEPS 2030 scenario will be less than they are in the purely hypothetical Cost of Non World MEPS 2015 scenario.

Proxy data for rest of world

Beyond the five economies analysed in-depth the rest of the world region is treated as if the efficiency of products sold there and their relative importance to overall energy consumption are similar to the cases found among the five economies. With respect to product efficiency levels in actuality the Rest of the World encompasses a blend of economies that have quite extensive energy efficiency MEPS and labelling requirements, such as found in Australia, Brazil, Canada, Japan, Jordan, Korea, Mexico, New Zealand, Russia, Turkey for example, those economies that have some requirements but the number of products covered is intermediate and those that have no requirements. In total there are 164 countries within the Rest of the World group and generally the efficiency of products sold there is considered for modelling purposes to be an average of that sold in India and South Africa.

The share of energy consumption by product type will also vary among these 164 economies. The approach adopted in the model takes account of the major differences by sector and fuel type through aligning with the IEA's Current Policies scenario projections at this level for the BAU scenario (i.e. through alignment of energy consumption by fuel (electricity, gas/LPG and oil) and sector (residential, tertiary, commercial). The sub-division of consumption by energy end use within these constraints is determined by attribution. The model assumes the ROW group has a proportion of energy consumption by end-use that is a blended share of the within OECD economies (e.g. the EU and USA) and the beyond OECD economies (e.g. China, India, South Africa). In this way a plausible estimate of the division of consumption by end-use is derived without recourse to individual modelling of each economy, which was beyond the means of this study.

Model outputs

The model produces results with respect to the final energy consumption of each equipment type and fuel considered for the residential, tertiary and industrial sectors. Although 102 end-uses are simulated in some level of detail the results are reported in a more aggregate format for usability in Annexes II and III.

Annex II: Country / region results

This annex presents the results for the four energy scenarios described in section 2.1 for each of the five economies analysed in depth and for the rest of the world.

EU

The break down in the proportion of EU final energy consumption by end use (residential and tertiary uses combined) under the BAU scenario in 2015 is shown in Figure A1.

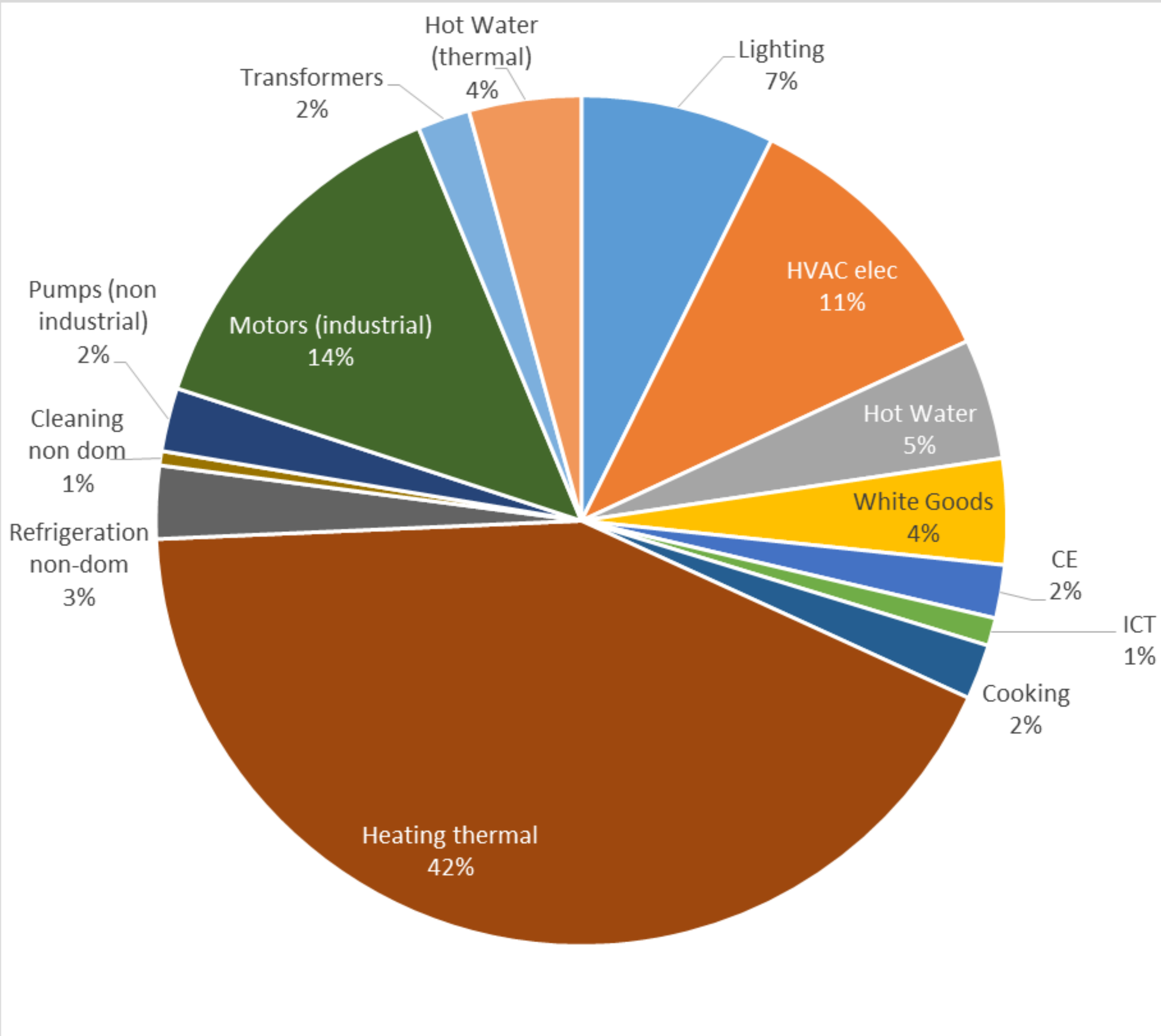

Figure A1: Share of EU final energy consumption by end-use – BAU in 2015 (excludes transport, energy losses in production or transmission and non-motive power industrial energy uses).

Tables A1 to A3 show the final energy consumption by end-use for the EU residential, tertiary and industrial sectors respectively under the Business as Usual, Cost of Non-World in 2015 and Cost of Non-World in 2030 scenarios (see explanations in section 2). The Cost of Non-World 2015 scenarios are differentiated according to whether the world's most stringent MEPS are considered (the CoNW 2015 MEPS scenario) or both the most stringent MEPS and the most demanding energy label requirement (the CoNW 2015 MEPS + HL scenario). The Cost of Non-World MEPS 2030 scenario is also shown, which indicates the savings that would be expected in 2030 were today's most stringent MEPS to be adopted under a plausible timeframe from today and allowing for expected autonomous efficiency improvements plus the time it would take for the stock of energy using equipment to be replaced. Table A4 shows the aggregate energy consumption and savings expected from all the sectors and end-uses considered under each scenario.

Table A1: EU residential sector final energy use

Product group	BAU[1] 2015	CoNW MEPS 2015[2]		CoNW MEPS + HL 2015[3]		BAU 2030	CoNW MEPS 2030[4]	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving
Electric end-uses								
Lighting	125	72	43%	40	68%	94	62	34%
Electric (resistance/HPs)	178	168	6%	168	6%	178	171	4%
Circ. Pumps	58	26	55%	26	55%	66	35	48%
Ventilation	16	12	27%	12	27%	18	15	18%
AC	33	26	22%	13	60%	49	42	14%
Electric	127	118	7%	53	58%	130	122	6%
Refrigerators	126	110	13%	59	53%	127	113	11%
Clothes Washers	42	41	2%	37	13%	33	33	1%
Clothes Dryers	29	20	30%	6	79%	33	25	26%
Dishwashers	27	27	2%	21	23%	36	36	1%
CE/TVs	113	34	70%	25	78%	98	39	60%
ICT/PCs	27	19	31%	13	52%	22	16	27%
Electric	40	36	9%	35	10%	44	40	8%
Total	941	709	25%	508	46%	930	749	19%
Thermal end-uses								
Heating	1686	1367	19%	1021	39%	1410	1231	13%
Hot Water	169	130	23%	103	39%	218	184	16%
Cooking	26	24	10%	24	10%	22	21	6%
Total	1881	1521	19%	1148	39%	1650	1435	13%

[1] BAU = Business as Usual scenario, [2] = CoNW MEPS 2015 is the Cost of Non World MEPS in 2015 static scenario, [3] CoNW MEPS + HL 2015 is the Cost of Non World MEPS and High Label static scenario in 2015, [4] = CoNW MEPS 2030 is the Cost of Non World MEPS in 2030 time dynamic scenario

Table A2: EU tertiary sector final energy use

Product group	BAU[1] 2015	CoNW MEPS 2015[2]		CoNW MEPS + HL 2015[3]		BAU 2030	CoNW MEPS 2030[4]	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving
Electric end-uses								
Lighting	286	264	8%	245	14%	211	199	6%
Resistance/HPs	182	148	18%	148	18%	182	155	15%
AHU/Other	94	68	27%	68	27%	114	89	22%
Central/RAC/Chillers	94	79	16%	79	16%	108	89	17%
Hot water systems	129	125	4%	54	58%	132	129	3%
Refrigeration	155	141	9%	130	16%	183	170	7%
Cleaning	30	29	5%	24	20%	31	30	4%
ICT	32	24	26%	21	35%	26	20	21%
Cooking	40	40	0%	40	0%	45	45	0%
Pumps	77	62	19%	62	19%	87	74	15%
Total	1119	980	12%	872	22%	1119	999	11%
Thermal end-uses								
Heating	685	568	17%	442	35%	573	507	11%
Hot Water	69	54	21%	44	35%	88	76	14%
Cooking	11	11	0%	11	0%	16	16	0%
Total	765	634	17%	497	35%	678	600	12%

[1] BAU = Business as Usual scenario, [2] = CoNW MEPS 2015 is the Cost of Non World MEPS in 2015 static scenario, [3] CoNW MEPS + HL 2015 is the Cost of Non World MEPS and High Label static scenario in 2015, [4] = CoNW MEPS 2030 is the Cost of Non World MEPS in 2030 time dynamic scenario

Table A3: EU industrial sector final energy use

Product group	BAU[1] 2015	CoNW MEPS 2015[2]		CoNW MEPS + HL 2015[3]		BAU 2030	CoNW MEPS 2030[4]	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving
Electric end-uses								
Mechanical movement	291	277	5%	281	3%	469	469	0%
Fans	122	100	18%	102	17%	198	179	9%
Compressors	191	181	5%	183	4%	309	307	1%
Pumps	161	149	7%	151	6%	259	254	2%
Total	765	708	8%	717	6%	1234	1209	2%
Transformers								
Energy losses	111	79	29%	52	53%	192.8	165	14%

[1] BAU = Business as Usual scenario, [2] = CoNW MEPS 2015 is the Cost of Non World MEPS in 2015 static scenario, [3] CoNW MEPS + HL 2015 is the Cost of Non World MEPS and High Label static scenario in 2015, [4] = CoNW MEPS 2030 is the Cost of Non World MEPS in 2030 time dynamic scenario

Table A4: All sectors EU final energy use (i.e. sum of Energy use from Tables A1 to A3)

	BAU[1] 2015	CoNW MEPS 2015[2]		CoNW MEPS + HL 2015[3]		BAU 2030	CoNW MEPS 2030[4]	
Total	5471	4511	18%	3720	32%	5612	4969	11%

[1] BAU = Business as Usual scenario, [2] = CoNW MEPS 2015 is the Cost of Non World MEPS in 2015 static scenario, [3] CoNW MEPS + HL 2015 is the Cost of Non World MEPS and High Label static scenario in 2015, [4] = CoNW MEPS 2030 is the Cost of Non World MEPS in 2030 time dynamic scenario

USA

The break down in the proportion of US final energy consumption by end use under the BAU scenario in 2015 is shown in Figure A2.

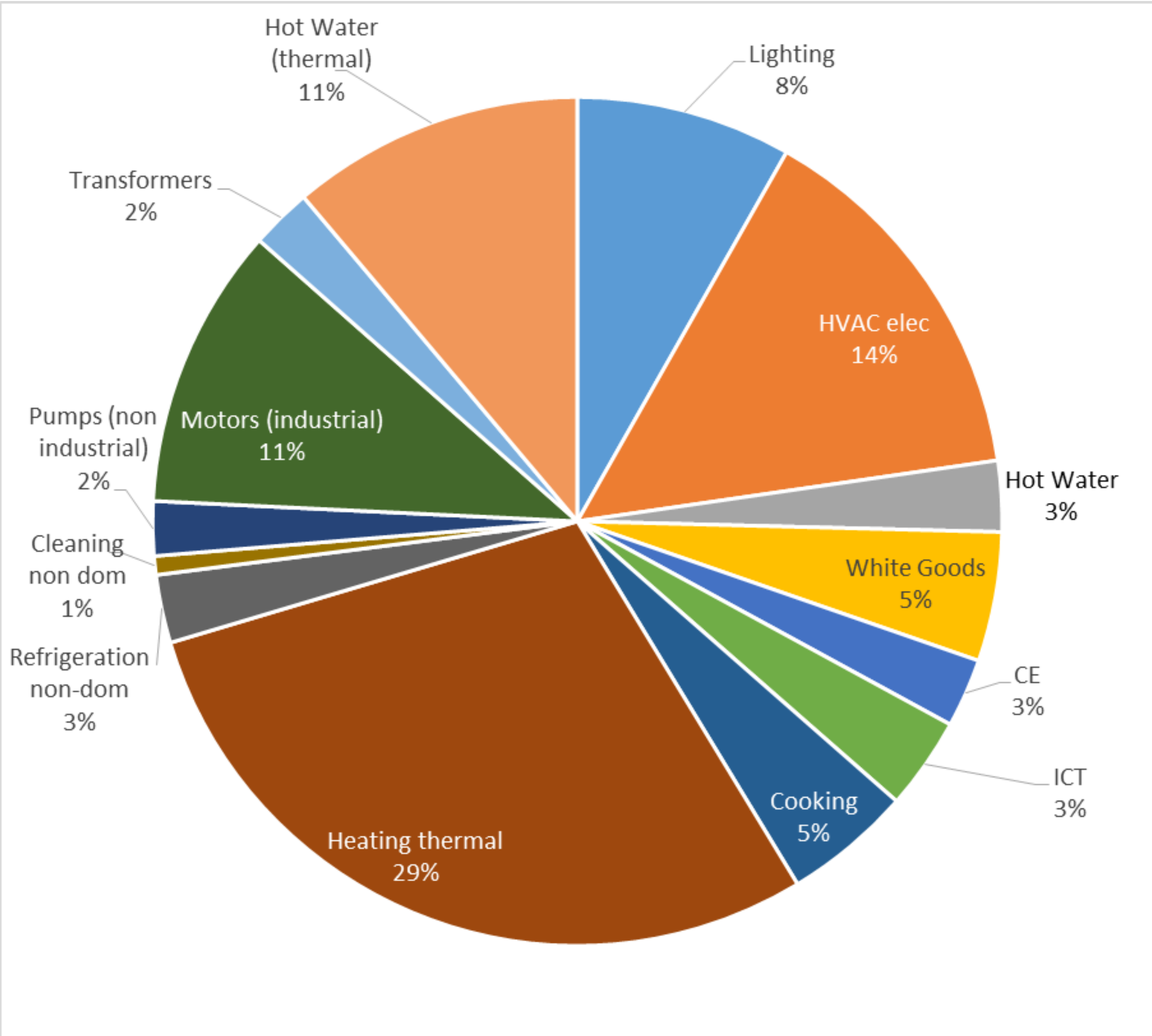

Figure A2: Share of US final energy consumption by end-use – BAU in 2015 (excludes transport, energy losses in production or transmission and non-motive power industrial energy uses).

Tables A5 to A7 show the final energy consumption by end-use for the US residential, tertiary and industrial sectors respectively under the Business as Usual, Cost of Non-World in 2015 and Cost of Non-World in 2030 scenarios (see explanations in section 2). The Cost of Non-World 2015 scenarios are differentiated according to whether the world's most stringent MEPS are considered (the CoNW 2015 MEPS scenario) or both the most stringent MEPS and the most demanding energy label requirement (the CoNW 2015 MEPS + HL scenario). The Cost of Non-World MEPS 2030 scenario is also shown, which indicates the savings that would be expected in 2030 were today's most stringent MEPS to be adopted under a plausible timeframe from today and allowing for expected autonomous efficiency improvements plus the time it would take for the stock of energy using equipment to be replaced. Table A8 shows the aggregate energy consumption and savings expected from all the sectors and end-uses considered under each scenario.

Table A5: US residential sector final energy use

Product group	BAU[1] 2015	CoNW MEPS 2015[2]		CoNW MEPS + HL 2015[3]		BAU 2030	CoNW MEPS 2030[4]	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving
Electric end-uses								
Lighting	185	60	68%	33	82%	207	95	54%
Electric (resistance/HPs)	109	94	14%	94	14%	97	88	9%
Circ. pumps	20	9	55%	9	55%	24	13	48%
Ventilation	65	47	27%	47	27%	67	55	18%
AC	229	199	13%	176	23%	282	259	8%
Electric	133	125	6%	55	58%	139	131	5%
Refrigerators	136	106	22%	57	58%	140	114	19%
Clothes Washers	67	46	31%	36	47%	69	50	27%
Clothes Dryers	60	50	18%	15	75%	67	57	15%
Dishwashers	28	18	36%	13	55%	32	22	31%
CE/TVs	155	48	69%	35	77%	166	66	60%
ICT/PCs	90	61	32%	43	53%	101	73	28%
Electric	73	66	9%	65	10%	70	64	8%
Total	1348	928	31%	677	50%	1462	1088	26%
Thermal end-uses								
Heating	1120	917	18%	678	39%	1059	931	12%
Hot Water	460	359	22%	278	39%	435	370	15%
Cooking	83	75	10%	75	10%	79	74	6%
Total	1663	1351	19%	1032	38%	1573	1375	13%

[1] BAU = Business as Usual scenario, [2] = CoNW MEPS 2015 is the Cost of Non World MEPS in 2015 static scenario, [3] CoNW MEPS + HL 2015 is the Cost of Non World MEPS and High Label static scenario in 2015, [4] = CoNW MEPS 2030 is the Cost of Non World MEPS in 2030 time dynamic scenario

Table A6: US tertiary sector final energy use

Product group	BAU[1] 2015	CoNW MEPS 2015[2]		CoNW MEPS + HL 2015[3]		BAU 2030	CoNW MEPS 2030[4]	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving
Electric end-uses								
Lighting	299	217	27%	217	27%	323	309	4%
Resistance/HPs	44	32	27%	32	27%	36	30	15%
AHU/Other	205	149	27%	149	27%	232	182	22%
Central/RAC/ Chillers	205	183	11%	183	11%	233	209	10%
Hot water systems	26	26	3%	11	58%	24	24	2%
Refrigeration	153	146	5%	133	13%	157	150	4%
Cleaning	42	41	3%	34	20%	55	54	2%
ICT	117	84	28%	75	36%	159	123	23%
Cooking	59	59	0%	59	0%	76	76	0%
Pumps	103	84	19%	84	19%	135	115	15%
Total	1255	1021	19%	979	22%	1430	1271	11%
Thermal end-uses								
Heating	596	504	15%	396	34%	617	554	10%
Hot Water	199	162	19%	132	34%	206	180	13%
Cooking	72	72	0%	72	0%	96	96	0%
Total	867	738	15%	600	31%	919	830	10%

[1] BAU = Business as Usual scenario, [2] = CoNW MEPS 2015 is the Cost of Non World MEPS in 2015 static scenario, [3] CoNW MEPS + HL 2015 is the Cost of Non World MEPS and High Label static scenario in 2015, [4] = CoNW MEPS 2030 is the Cost of Non World MEPS in 2030 time dynamic scenario

Table A7: US industrial sector final energy use

Product group	BAU[1] 2015	CoNW MEPS 2015[2]		CoNW MEPS + HL 2015[3]		BAU 2030	CoNW MEPS 2030[4]	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving
Electric end-uses								
Mechanical movement	241	234	3%	237	2%	368	368	0%
Fans	102	85	17%	86	16%	155	140	9%
Compressors	159	153	4%	155	3%	242	241	1%
Pumps	133	125	6%	127	5%	204	199	2%
Total	635	597	6%	604	5%	969	949	2%
Transformers								
Energy losses	137	102	26%	65	53%	238.8	208	13%

[1] BAU = Business as Usual scenario, [2] = CoNW MEPS 2015 is the Cost of Non World MEPS in 2015 static scenario, [3] CoNW MEPS + HL 2015 is the Cost of Non World MEPS and High Label static scenario in 2015, [4] = CoNW MEPS 2030 is the Cost of Non World MEPS in 2030 time dynamic scenario

Table A8: All sectors US final energy use (i.e. sum of Energy use from Tables A5 to A7)

	BAU[1] 2015	CoNW MEPS 2015[2]		CoNW MEPS + HL 2015[3]		BAU 2030	CoNW MEPS 2030[4]	
Total	5767	4635	20%	3893	33%	6353	5513	13%

[1] BAU = Business as Usual scenario, [2] = CoNW MEPS 2015 is the Cost of Non World MEPS in 2015 static scenario, [3] CoNW MEPS + HL 2015 is the Cost of Non World MEPS and High Label static scenario in 2015, [4] = CoNW MEPS 2030 is the Cost of Non World MEPS in 2030 time dynamic scenario

China

The break down in the proportion of China's final energy consumption by end use under the BAU scenario in 2015 is shown in Figure A3.

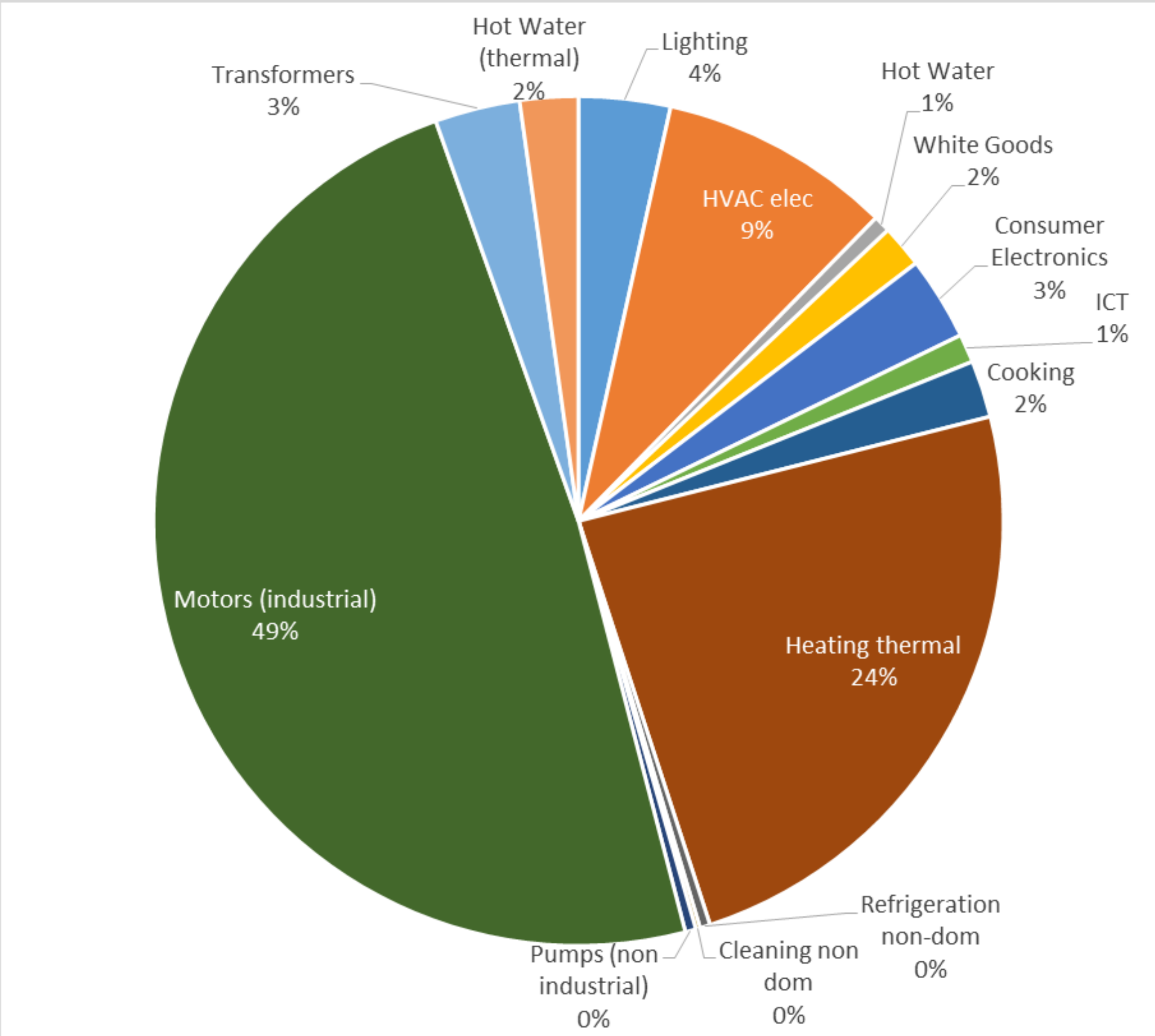

Figure A3: Share of China's final energy consumption by end-use – BAU in 2015 (excludes transport, energy losses in production or transmission and non-motive power industrial energy uses).

Tables A9 to A11 show the final energy consumption by end-use for the Chinese residential, tertiary and industrial sectors respectively under the Business as Usual, Cost of Non-World in 2015 and Cost of Non-World in 2030 scenarios (see explanations in section 2). The Cost of Non-World 2015 scenarios are differentiated according to whether the world's most stringent MEPS are considered (the CoNW 2015 MEPS scenario) or both the most stringent MEPS and the most demanding energy label requirement (the CoNW 2015 MEPS + HL scenario). The Cost of Non-World MEPS 2030 scenario is also shown, which indicates the savings that would be expected in 2030 were today's most stringent MEPS to be adopted under a plausible timeframe from today and allowing for expected autonomous efficiency improvements plus the time it would take for the stock of energy using equipment to be replaced. Table A12 shows the aggregate energy consumption and savings expected from all the sectors and end-uses considered under each scenario.

Table A9: China's residential sector final energy use

Product group	BAU[1] 2015	CoNW MEPS 2015[2]		CoNW MEPS + HL 2015[3]		BAU 2030	CoNW MEPS 2030[4]	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving
Electric end-uses								
Lighting	153	73	52%	41	73%	274	160	42%
Electric (resistance/HPs)	79	64	19%	64	19%	260	226	13%
Circ. Pumps	2	1	55%	1	55%	2	1	48%
Ventilation	35	25	27%	25	27%	76	62	18%
AC	284	236	17%	119	58%	395	352	11%
Electric	43	40	7%	18	58%	92	86	6%
Refrigerators	83	46	45%	25	71%	94	57	39%
Clothes Washers	27	18	34%	14	49%	61	43	30%
Clothes Dryers	1	1	30%	0	79%	9	7	26%
Dishwashers	2	1	43%	1	60%	12	7	37%
CE/TVs	223	60	73%	43	81%	371	135	64%
ICT/PCs	45	25	43%	16	64%	99	62	37%
Electric	50	45	9%	44	10%	91	84	8%
Total	1027	635	38%	412	60%	1836	1283	30%
Thermal end-uses								
Heating	1235	947	23%	748	39%	1390	1172	16%
Hot Water	115	94	18%	69	39%	161	141	12%
Cooking	79	71	10%	71	10%	89	83	6%
Total	1428	1112	22%	889	38%	1640	1397	15%

[1] BAU = Business as Usual scenario, [2] = CoNW MEPS 2015 is the Cost of Non World MEPS in 2015 static scenario, [3] CoNW MEPS + HL 2015 is the Cost of Non World MEPS and High Label static scenario in 2015, [4] = CoNW MEPS 2030 is the Cost of Non World MEPS in 2030 time dynamic scenario

Table A10: China's tertiary sector final energy use

Product group	BAU[1] 2015	CoNW MEPS 2015[2]		CoNW MEPS + HL 2015[3]		BAU 2030	CoNW MEPS 2030[4]	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving
Electric end-uses								
Lighting	91	78	15%	73	20%	204	179	12%
Resistance/HPs	152	124	18%	124	18%	261	222	15%
AHU/Other	14	10	27%	10	27%	24	19	22%
Central/RAC/ Chillers	57	33	41%	33	41%	97	84	14%
Hot water systems	2	2	4%	1	58%	4	4	3%
Refrigeration	28	26	7%	23	15%	47	45	6%
Cleaning	11	11	5%	9	20%	29	28	4%
ICT	31	22	29%	19	39%	54	41	23%
Cooking	1	1	0%	1	0%	2	2	0%
Pumps	27	22	19%	22	19%	46	39	15%
Total	415	329	21%	316	24%	767	663	14%
Thermal end-uses								
Heating	444	351	21%	287	35%	500	430	14%
Hot Water	41	34	16%	27	35%	58	52	11%
Cooking	23	23	0%	23	0%	26	26	0%
Total	508	408	20%	336	34%	584	507	13%

[1] BAU = Business as Usual scenario, [2] = CoNW MEPS 2015 is the Cost of Non World MEPS in 2015 static scenario, [3] CoNW MEPS + HL 2015 is the Cost of Non World MEPS and High Label static scenario in 2015, [4] = CoNW MEPS 2030 is the Cost of Non World MEPS in 2030 time dynamic scenario

Table A11: China's Industrial sector final energy use

Product group	BAU[1] 2015	CoNW MEPS 2015[2]		CoNW MEPS + HL 2015[3]		BAU 2030	CoNW MEPS 2030[4]	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving
Electric end-uses								
Mechanical movement	1295	882	32%	879	32%	2165	2165	0%
Fans	545	319	41%	318	42%	911	825	9%
Compressors	852	578	32%	576	32%	1424	1420	0%
Pumps	716	473	34%	472	34%	1196	1172	2%
Total	3408	2253	34%	2245	34%	5696	5582	2%
Transformers								
Energy losses	227	114	50%	75	67%	417	359	14%

[1] BAU = Business as Usual scenario, [2] = CoNW MEPS 2015 is the Cost of Non World MEPS in 2015 static scenario, [3] CoNW MEPS + HL 2015 is the Cost of Non World MEPS and High Label static scenario in 2015, [4] = CoNW MEPS 2030 is the Cost of Non World MEPS in 2030 time dynamic scenario

Table A12: All sectors China's final energy use (i.e. sum of Energy use from Tables A9 to A11)

	BAU[1] 2015	CoNW MEPS 2015[2]		CoNW MEPS + HL 2015[3]		BAU 2030	CoNW MEPS 2030[4]	
Total	6786	4736	30%	4198	38%	10522	9431	10%

[1] BAU = Business as Usual scenario, [2] = CoNW MEPS 2015 is the Cost of Non World MEPS in 2015 static scenario, [3] CoNW MEPS + HL 2015 is the Cost of Non World MEPS and High Label static scenario in 2015, [4] = CoNW MEPS 2030 is the Cost of Non World MEPS in 2030 time dynamic scenario

India

The break down in the proportion of India's final energy consumption by end use under the BAU scenario in 2015 is shown in Figure A4.

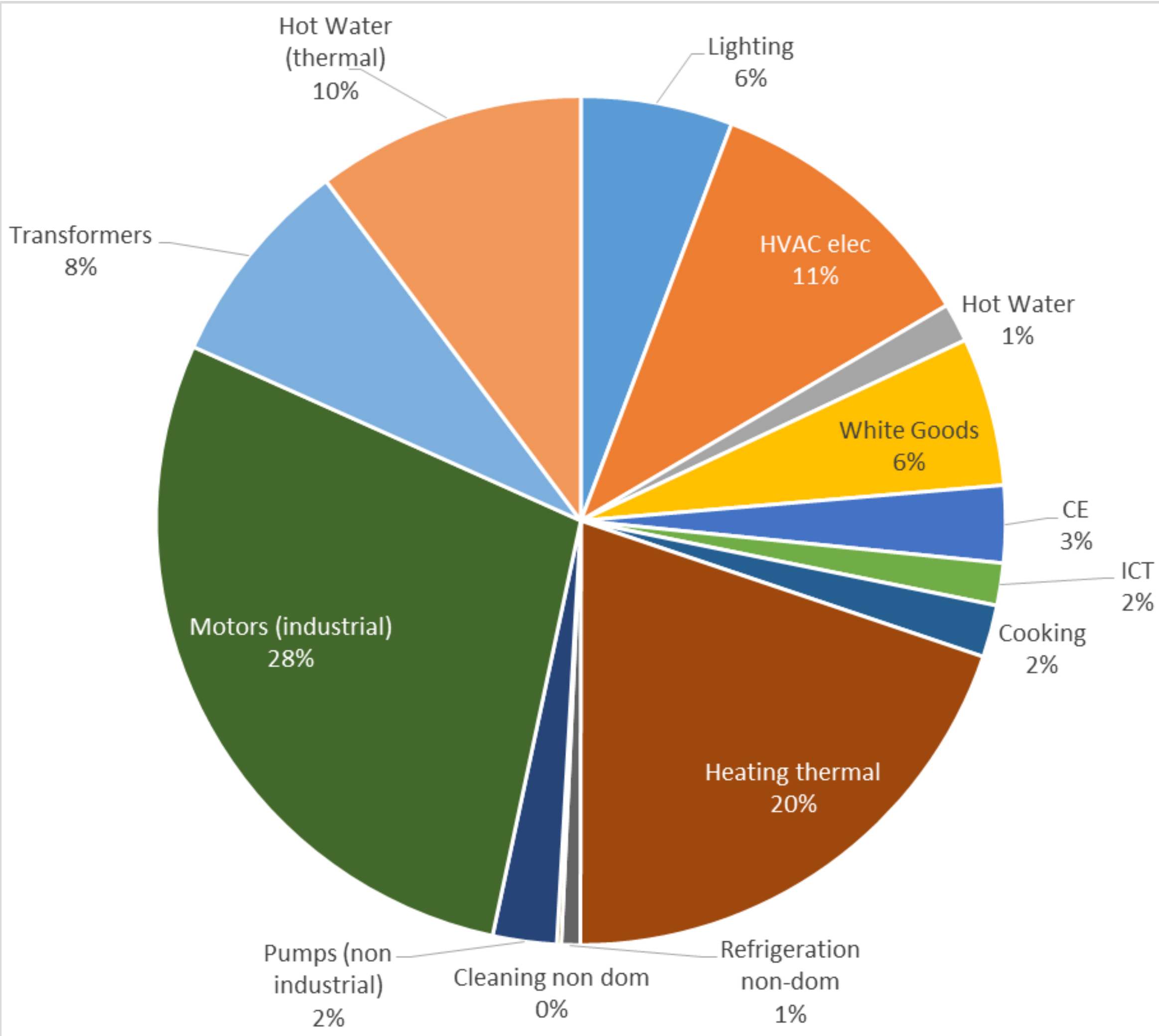

Figure A4: Share of India's final energy consumption by end-use – BAU in 2015 (excludes transport, energy losses in production or transmission and non-motive power industrial energy uses).

Tables A13 to A15 show the final energy consumption by end-use for the Indian residential, tertiary and industrial sectors respectively under the Business as Usual, Cost of Non-World in 2015 and Cost of Non-World in 2030 scenarios (see explanations in section 2). The Cost of Non-World 2015 scenarios are differentiated according to whether the world's most stringent MEPS are considered (the CoNW 2015 MEPS scenario) or both the most stringent MEPS and the most demanding energy label requirement (the CoNW 2015 MEPS + HL scenario). The Cost of Non-World MEPS 2030 scenario is also shown, which indicates the savings that would be expected in 2030 were today's most stringent MEPS to be adopted under a plausible timeframe from today and allowing for expected autonomous efficiency improvements plus the time it would take for the stock of energy using equipment to be replaced. Table A16 shows the aggregate energy consumption and savings expected from all the sectors and end-uses considered under each scenario.

Table A13: India's residential sector final energy use

Product group	BAU[1] 2015	CoNW MEPS 2015[2]		CoNW MEPS + HL 2015[3]		BAU 2030	CoNW MEPS 2030[4]	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving
Electric end-uses								
Lighting	53.0	23.3	56%	12.9	76%	65.0	35.9	45%
Electric (resistance/HPs)	0.0	0.0	NA	0.0	NA	0.0	0.0	NA
Circ. Pumps	0.0	0.0	NA	0.0	NA	0.0	0.0	NA
Ventilation	41.5	30.2	27%	30.2	27%	55.7	45.6	18%
AC	31.6	22.8	28%	11.5	63%	137.2	113.1	18%
Electric	15.5	14.0	10%	6.5	58%	57.1	52.1	9%
Refrigerators	49.9	25.5	49%	13.7	73%	96.0	55.3	42%
Clothes Washers	11.5	7.3	36%	5.7	50%	23.1	15.9	31%
Clothes Dryers	0.1	0.1	30%	0.0	79%	0.6	0.4	26%
Dishwashers	0.1	0.1	47%	0.1	62%	0.6	0.3	40%
CE/TVs	32.0	8.1	75%	6.0	81%	62.2	21.9	65%
ICT/PCs	8.2	4.4	46%	2.8	66%	40.3	24.4	40%
Electric	5.0	4.5	9%	4.5	10%	11.5	10.5	8%
Total	248	140	44%	94	62%	549.3	375.5	32%
Thermal end-uses								
Heating	216.1	165.7	23%	130.9	39%	332.8	280.6	16%
Hot Water	31.3	24.6	21%	19.0	39%	47.7	40.8	14%
Cooking	13.2	11.9	10%	11.9	10%	20.3	19.0	6%
Total	261	202	22%	162	38%	400.8	340.4	15%

[1] BAU = Business as Usual scenario, [2] = CoNW MEPS 2015 is the Cost of Non World MEPS in 2015 static scenario, [3] CoNW MEPS + HL 2015 is the Cost of Non World MEPS and High Label static scenario in 2015, [4] = CoNW MEPS 2030 is the Cost of Non World MEPS in 2030 time dynamic scenario

Table A14: India's tertiary sector final energy use

Product group	BAU[1] 2015	CoNW MEPS 2015[2]		CoNW MEPS + HL 2015[3]		BAU 2030	CoNW MEPS 2030[4]	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving
Electric end-uses								
Lighting	10.0	8.4	15%	8.0	20%	60.9	53.5	12%
Resistance/HPs	0.0	0.0	NA	0.0	NA	0.0	0.0	NA
AHU/Other	8.5	6.2	27%	6.2	27%	14.9	11.7	22%
Central/RAC/ Chillers	35.7	21.1	41%	21.1	41%	62.8	48.9	22%
Hot water systems	0.6	0.6	5%	0.2	58%	1.0	1.0	4%
Refrigeration	7.8	6.9	12%	6.3	19%	13.8	12.4	10%
Cleaning	1.8	1.8	5%	1.5	20%	3.8	3.6	4%
ICT	9.4	6.5	31%	5.2	44%	16.5	12.4	24%
Cooking	0.9	0.9	0%	0.9	0%	1.6	1.6	0%
Pumps	26.5	21.6	19%	21.6	19%	46.6	39.7	15%
Total	101	74	27%	71	30%	221.9	184.9	17%
Thermal end-uses								
Heating	0.0	0.0	NA	0.0	NA	0.0	0.0	NA
Hot Water	80.3	64.8	19%	51.8	35%	19.9	17.3	13%
Cooking	2.5	2.5	0%	2.5	0%	6.2	6.2	0%
Total	83	67	19%	54	34%	26.1	23.5	10%

[1] BAU = Business as Usual scenario, [2] = CoNW MEPS 2015 is the Cost of Non World MEPS in 2015 static scenario, [3] CoNW MEPS + HL 2015 is the Cost of Non World MEPS and High Label static scenario in 2015, [4] = CoNW MEPS 2030 is the Cost of Non World MEPS in 2030 time dynamic scenario

Table A15: India's industrial sector final energy use

Product group	BAU[1] 2015	CoNW MEPS 2015[2]		CoNW MEPS + HL 2015[3]		BAU 2030	CoNW MEPS 2030[4]	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving
Electric end-uses								
Mechanical movement	117.6	112.1	5%	109.6	7%	362.8	362.8	0%
Fans	49.5	40.6	18%	39.7	20%	152.7	138.3	9%
Compressors	77.3	73.1	5%	71.5	8%	238.7	237.3	1%
Pumps	65.0	60.1	7%	58.8	10%	200.5	196.4	2%
Total	309	286	8%	280	10%	954.6	934.8	2%
Transformers								
Energy losses	88	62	29%	41	53%	272.8	233	14%

[1] BAU = Business as Usual scenario, [2] = CoNW MEPS 2015 is the Cost of Non World MEPS in 2015 static scenario, [3] CoNW MEPS + HL 2015 is the Cost of Non World MEPS and High Label static scenario in 2015, [4] = CoNW MEPS 2030 is the Cost of Non World MEPS in 2030 time dynamic scenario

Table A16: All sectors India's final energy use (i.e. sum of Energy use from Tables A13 to A15)

	BAU[1] 2015	CoNW MEPS 2015[2]		CoNW MEPS + HL 2015[3]		BAU 2030	CoNW MEPS 2030[4]	
Total	1002	770	23%	661	34%	2153	1859	14%

[1] BAU = Business as Usual scenario, [2] = CoNW MEPS 2015 is the Cost of Non World MEPS in 2015 static scenario, [3] CoNW MEPS + HL 2015 is the Cost of Non World MEPS and High Label static scenario in 2015, [4] = CoNW MEPS 2030 is the Cost of Non World MEPS in 2030 time dynamic scenario

South Africa

The break down in the proportion of South Africa's final energy consumption by end use under the BAU scenario in 2015 is shown in Figure A5.

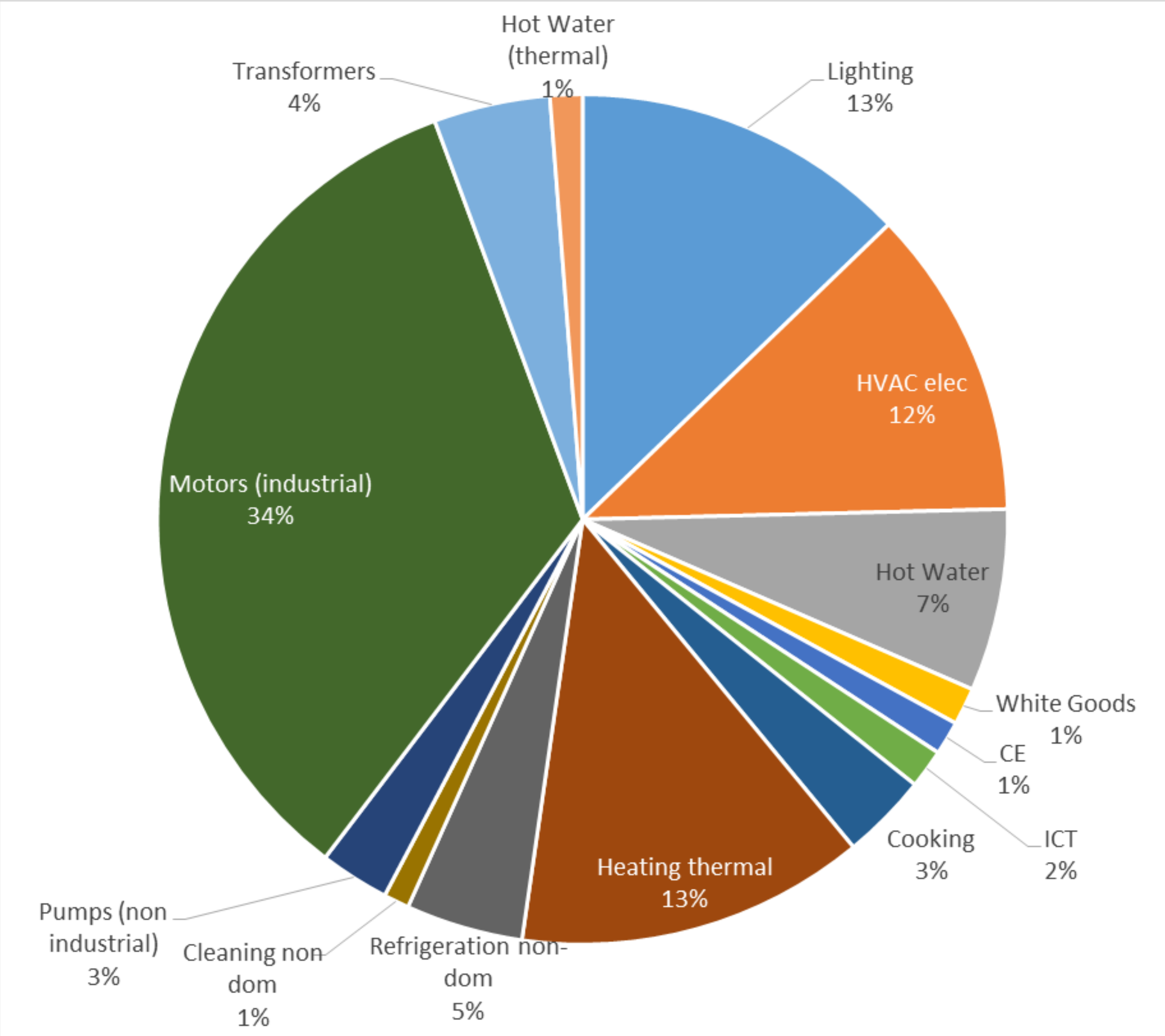

Figure A5: Share of South Africa's final energy consumption by end-use – BAU in 2015 (excludes transport, energy losses in production or transmission and non-motive power industrial energy uses).

Tables A17 to A19 show the final energy consumption by end-use for the South African residential, tertiary and industrial sectors respectively under the Business as Usual, Cost of Non-World in 2015 and Cost of Non-World in 2030 scenarios (see explanations in section 2). The Cost of Non-World 2015 scenarios are differentiated according to whether the world's most stringent MEPS are considered (the CoNW 2015

MEPS scenario) or both the most stringent MEPS and the most demanding energy label requirement (the CoNW 2015 MEPS + HL scenario). The Cost of Non-World MEPS 2030 scenario is also shown, which indicates the savings that would be expected in 2030 were today's most stringent MEPS to be adopted under a plausible timeframe from today and allowing for expected autonomous efficiency improvements plus the time it would take for the stock of energy using equipment to be replaced. Table A20 shows the aggregate energy consumption and savings expected from all the sectors and end-uses considered under each scenario.

Table A17: South Africa's residential sector final energy use

Product group	BAU[1] 2015	CoNW MEPS 2015[2]		CoNW MEPS + HL 2015[3]		BAU 2030	CoNW MEPS 2030[4]	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving
Electric end-uses								
Lighting	5.0	1.8	64%	1.0	80%	7.9	3.9	51%
Electric (resistance/HPs)	2.6	2.1	18%	2.1	18%	4.1	3.6	12%
Circ. Pumps	0.5	0.2	55%	0.2	55%	0.5	0.3	48%
Ventilation	0.1	0.1	27%	0.1	27%	0.2	0.1	18%
AC	0.9	0.6	27%	0.3	63%	1.6	1.3	17%
Electric	7.7	6.8	12%	3.2	58%	12.2	10.9	10%
Refrigerators	3.4	1.7	49%	0.9	73%	5.3	3.0	42%
Clothes Washers	0.5	0.4	34%	0.3	49%	0.8	0.6	30%
Clothes Dryers	0.0	0.0	30%	0.0	79%	0.0	0.0	26%
Dishwashers	0.02	0.01	47%	0.01	62%	0.0	0.0	40%
CE/TVs	3.6	0.4	88%	0.2	93%	14.3	3.4	76%
ICT/PCs	1.2	0.6	53%	0.3	73%	6.7	3.6	46%
Electric	3.2	2.9	9%	2.8	10%	5.0	4.6	8%
Total	29	18	38%	12	60%	58.6	35.4	40%
Thermal end-uses								
Heating	30.9	23.7	23%	18.7	39%	34.2	28.8	16%
Hot Water	2.9	2.2	21%	1.7	39%	4.0	3.4	14%
Cooking	2.0	1.8	10%	1.8	10%	2.2	2.0	6%
Total	36	28	22%	22	38%	40.4	34.3	15%

[1] BAU = Business as Usual scenario, [2] = CoNW MEPS 2015 is the Cost of Non World MEPS in 2015 static scenario, [3] CoNW MEPS + HL 2015 is the Cost of Non World MEPS and High Label static scenario in 2015, [4] = CoNW MEPS 2030 is the Cost of Non World MEPS in 2030 time dynamic scenario

Table A18: South Africa's tertiary sector final energy use

Product group	BAU[1] 2015	CoNW MEPS 2015[2]		CoNW MEPS + HL 2015[3]		BAU 2030	CoNW MEPS 2030[4]	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving
Electric end-uses								
Lighting	30.4	25.2	17%	23.6	22%	51.5	44.3	14%
Resistance/HPs	12.4	10.1	18%	10.1	18%	28.4	24.2	15%
AHU/Other	8.3	6.1	27%	6.1	27%	23.1	18.0	22%
Central/RAC/ Chillers	8.3	4.0	52%	4.0	52%	22.0	17.2	22%
Hot water systems	11.5	10.8	6%	4.8	58%	26.8	25.6	5%
Refrigeration	12.4	10.9	12%	10.0	19%	36.1	32.7	10%
Cleaning	2.7	2.6	5%	2.2	20%	6.3	6.1	4%
ICT	2.9	1.9	36%	1.4	52%	5.2	3.7	28%
Cooking	3.6	3.6	0%	3.6	0%	9.1	9.1	0%
Pumps	6.8	5.5	19%	5.5	19%	17.7	15.1	15%
Total	99	81	19%	71	28%	226.2	195.9	13%
Thermal end-uses								
Heating	5.9	4.6	21%	3.8	35%	6.5	5.6	14%
Hot Water	0.5	0.4	19%	0.4	35%	0.8	0.7	13%
Cooking	0.4	0.4	0%	0.4	0%	0.5	0.5	0%
Total	7	5	20%	5	34%	7.8	6.8	13%

[1] BAU = Business as Usual scenario, [2] = CoNW MEPS 2015 is the Cost of Non World MEPS in 2015 static scenario, [3] CoNW MEPS + HL 2015 is the Cost of Non World MEPS and High Label static scenario in 2015, [4] = CoNW MEPS 2030 is the Cost of Non World MEPS in 2030 time dynamic scenario

Table A19: South Africa's industrial sector final energy use

Product group	BAU[1] 2015	CoNW MEPS 2015[2]		CoNW MEPS + HL 2015[3]		BAU 2030	CoNW MEPS 2030[4]	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving
Electric end-uses								
Mechanical movement	35.8	33.9	5%	33.4	7%	53.0	53.0	0%
Fans	15.1	12.3	19%	12.1	20%	22.3	20.2	9%
Compressors	23.5	22.1	6%	21.8	8%	34.8	34.6	1%
Pumps	19.8	18.2	8%	17.9	10%	29.3	28.7	2%
Total	94	86	8%	85	10%	139.4	136.5	2%
Transformers								
Energy losses	12.3	8.7	29%	5.8	53%	18.3	15.7	14%

[1] BAU = Business as Usual scenario, [2] = CoNW MEPS 2015 is the Cost of Non World MEPS in 2015 static scenario, [3] CoNW MEPS + HL 2015 is the Cost of Non World MEPS and High Label static scenario in 2015, [4] = CoNW MEPS 2030 is the Cost of Non World MEPS in 2030 time dynamic scenario

Table A20: All sectors South African final energy use (i.e. sum of Energy use from Tables A17 to A19)

	BAU[1] 2015	CoNW MEPS 2015[2]		CoNW MEPS + HL 2015[3]		BAU 2030	CoNW MEPS 2030[4]	
Total	265	218	18%	195	26%	472	409	13%

[1] BAU = Business as Usual scenario, [2] = CoNW MEPS 2015 is the Cost of Non World MEPS in 2015 static scenario, [3] CoNW MEPS + HL 2015 is the Cost of Non World MEPS and High Label static scenario in 2015, [4] = CoNW MEPS 2030 is the Cost of Non World MEPS in 2030 time dynamic scenario

Rest of World

The breakdown in the proportion of the Rest of the World (ROW) final energy consumption by end use under the BAU scenario in 2015 is shown in Figure A6.

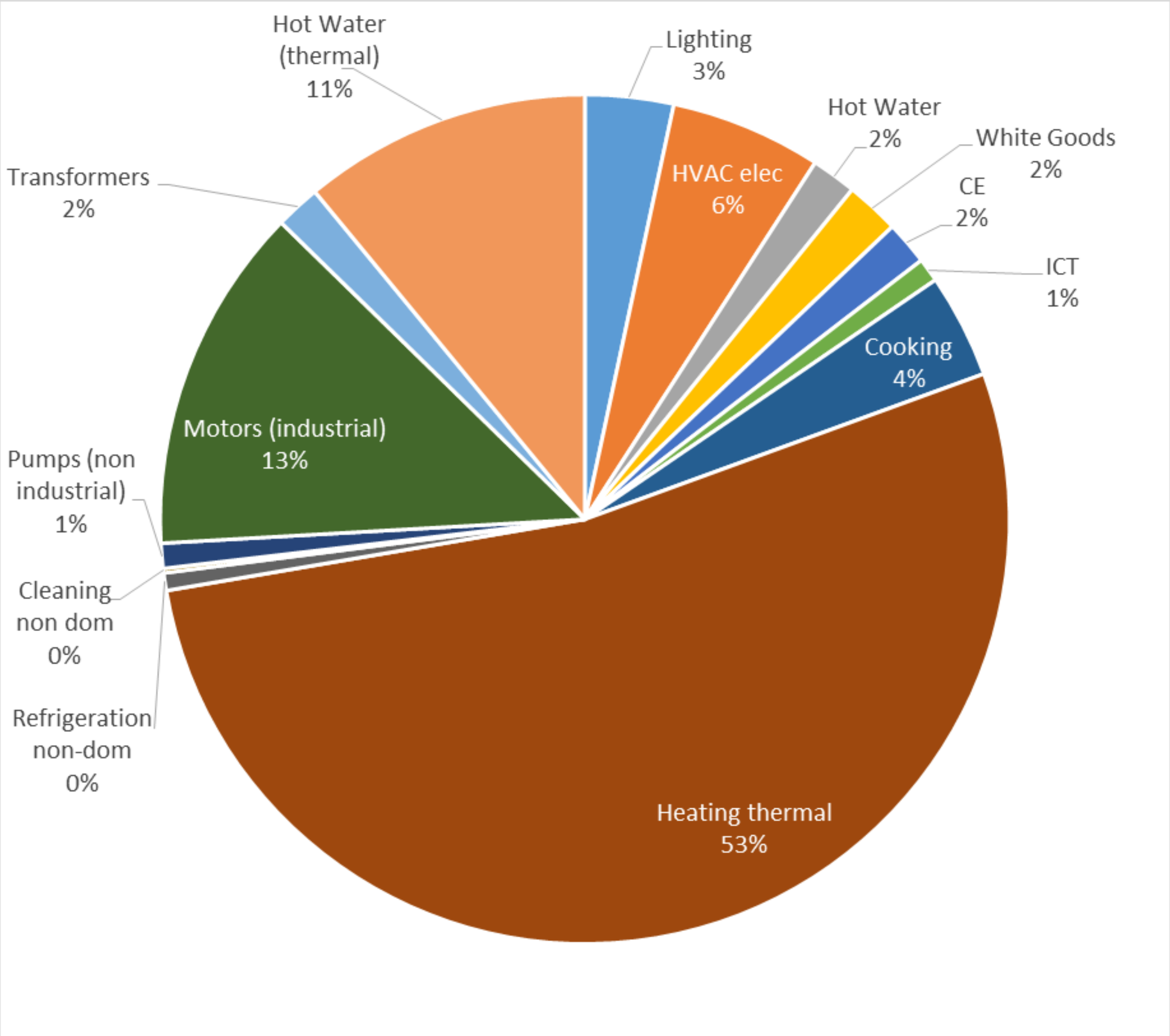

Figure A6: Share of ROW final energy consumption by end-use – BAU in 2015 (excludes transport, energy losses in production or transmission and non-motive power industrial energy uses).

Tables A21 to A23 show the final energy consumption by end-use for the ROW residential, tertiary and industrial sectors respectively under the Business as Usual, Cost of Non-World in 2015 and Cost of Non-World in 2030 scenarios (see explanations in section 2). The Cost of Non-World 2015 scenarios are differentiated according to whether the world's most stringent MEPS are considered (the CoNW 2015 MEPS scenario) or both the most stringent MEPS and the most demanding energy label requirement (the CoNW 2015 MEPS + HL scenario). The Cost of Non-World MEPS 2030 scenario is also shown, which indicates the savings that would be expected in 2030 were today's most stringent MEPS to be adopted under a plausible timeframe from today and allowing for expected autonomous efficiency improvements plus the time it would take for the stock of energy using equipment to be replaced. Table A24 shows the aggregate energy consumption and savings expected from all the sectors and end-uses considered under each scenario.

Table A21: ROW residential sector final energy use

Product group	BAU[1] 2015	CoNW MEPS 2015[2]		CoNW MEPS + HL 2015[3]		BAU 2030	CoNW MEPS 2030[4]	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving
Electric end-uses								
Lighting	463	169	64%	94	80%	528	260	51%
Electric (resistance/HPs)	209	171	18%	171	18%	351	308	12%
Circ. pumps	40	18	55%	18	55%	66	34	48%
Ventilation	165	120	27%	120	27%	181	148	18%
AC	371	269	27%	136	63%	630	521	17%
Electric	337	297	12%	141	58%	483	433	10%
Refrigerators	356	182	49%	98	73%	433	249	42%
Clothes Washers	96	63	34%	49	49%	132	93	30%
Clothes Dryers	28	19	30%	6	79%	50	37	26%
Dishwashers	19	10	47%	7	62%	41	24	40%
CE/TVs	405	48	88%	27	93%	680	160	76%
ICT/PCs	115	54	53%	31	73%	294	160	46%
Electric	156	141	9%	140	10%	204	187	8%
Total	2760	1562	43%	1037	62%	4073	2614	36%
Thermal end-uses								
Heating	10465	8023	23%	6340	39%	10920	9208	16%
Hot Water	1451	1140	21%	879	39%	1731	1481	14%
Cooking	604	547	10%	547	10%	633	593	6%
Total	12520	9709	22%	7766	38%	13285	11282	15%

[1] BAU = Business as Usual scenario, [2] = CoNW MEPS 2015 is the Cost of Non World MEPS in 2015 static scenario, [3] CoNW MEPS + HL 2015 is the Cost of Non World MEPS and High Label static scenario in 2015, [4] = CoNW MEPS 2030 is the Cost of Non World MEPS in 2030 time dynamic scenario

Table A22: ROW tertiary sector final energy use

Product group	BAU[1] 2015	CoNW MEPS 2015[2]		CoNW MEPS + HL 2015[3]		BAU 2030	CoNW MEPS 2030[4]	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving
Electric end-uses								
Lighting	354	293	17%	275	22%	603	520	14%
Resistance/HPs	240	196	18%	196	18%	336	287	15%
AHU/Other	132	96	27%	96	27%	199	156	22%
Central/RAC/ Chillers	283	135	52%	135	52%	378	295	22%
Hot water systems	79	74	6%	33	58%	117	112	5%
Refrigeration	162	142	12%	131	19%	252	228	10%
Cleaning	42	40	5%	34	20%	70	67	4%
ICT	105	68	36%	51	52%	140	100	28%
Cooking	36	36	0%	36	0%	58	58	0%
Pumps	191	155	19%	155	19%	257	219	15%
Total	1624	1236	24%	1142	30%	2411	2041	15%
Thermal end-uses								
Heating	2382	1881	21%	1537	35%	2470	2121	14%
Hot Water	1214	980	19%	784	35%	1171	1019	13%
Cooking	168	168	0%	168	0%	425	425	0%
Total	3764	3029	20%	2488	34%	4067	3566	12%

[1] BAU = Business as Usual scenario, [2] = CoNW MEPS 2015 is the Cost of Non World MEPS in 2015 static scenario, [3] CoNW MEPS + HL 2015 is the Cost of Non World MEPS and High Label static scenario in 2015, [4] = CoNW MEPS 2030 is the Cost of Non World MEPS in 2030 time dynamic scenario

Table A23: ROW industrial sector final energy use

Product group	BAU[1] 2015	CoNW MEPS 2015[2]		CoNW MEPS + HL 2015[3]		BAU 2030	CoNW MEPS 2030[4]	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving
Electric end-uses								
Mechanical movement	1220	1155	5%	1137	7%	1736	1736	0%
Fans	514	418	19%	411	20%	731	662	9%
Compressors	802	754	6%	742	8%	1142	1136	1%
Pumps	674	619	8%	610	10%	959	940	2%
Total	3210	2946	8%	2901	10%	4569	4474	2%
Transformers								
Energy losses	417	296	29%	196	53%	615.8	527	14%

[1] BAU = Business as Usual scenario, [2] = CoNW MEPS 2015 is the Cost of Non World MEPS in 2015 static scenario, [3] CoNW MEPS + HL 2015 is the Cost of Non World MEPS and High Label static scenario in 2015, [4] = CoNW MEPS 2030 is the Cost of Non World MEPS in 2030 time dynamic scenario

Table A24: All sectors ROW final energy use (i.e. sum of Energy use from Tables A21 to A23)

	BAU[1] 2015	CoNW MEPS 2015[2]		CoNW MEPS + HL 2015[3]		BAU 2030	CoNW MEPS 2030[4]	
Total	23879	18482	23%	15334	36%	28404	23977	16%

[1] BAU = Business as Usual scenario, [2] = CoNW MEPS 2015 is the Cost of Non World MEPS in 2015 static scenario, [3] CoNW MEPS + HL 2015 is the Cost of Non World MEPS and High Label static scenario in 2015, [4] = CoNW MEPS 2030 is the Cost of Non World MEPS in 2030 time dynamic scenario

Annex III: Product group results

This annex presents the results for the four energy scenarios described in section 2.1 for each of the product groups analysed in depth and for each economy considered. Under each product group heading it begins by presenting a table that indicates which economy has currently the most ambitious MEPS and energy labels promulgated. Then it presents the results showing the energy consumption expected by the product group (residential and tertiary sector combined) for each economy under each scenario and the expected savings, expressed as a percentage, compared to the Business as Usual (BAU) scenario.

Lighting

Table A25: Economy with highest MEPS and labelling requirements for lighting

Product / sub-product	Country with Highest MEPS	Country with Highest Label
Household lamps		
Non-directional	EU	EU
Directional	EU	EU
Tertiary sector lamps/ballasts		
Ballasts	EU	India/China
Fluorescent lamps	EU	EU
Mercury vapour lamps	EU	EU
High pressure sodium lamps	EU	EU
Metal halide lamps	EU	EU

Table A26: Total Energy consumption and savings for lighting per economy by scenario

Country	BAU 2015	CoNW MEPS 2015		CoNW MEPS + HL 2015		BAU 2030	CoNW MEPS 2030	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving on BAU
China	244	158	35%	118	52%	478	349	27%
EU	411	336	18%	285	31%	306	261	15%
India	63	34	46%	22	65%	126	92	27%
South Africa	35	27	23%	25	30%	59	48	18%
USA	484	299	38%	263	46%	530	423	20%
Rest of World	817	478	42%	378	54%	1131	795	30%
Total	2055	1332	35%	1091	47%	2630	1968	25%

HVAC electric

Table A27: Economy with highest MEPS and labelling requirements for HVAC

Product / sub-product	Country with Highest MEPS	Country with Highest Label
Air Conditioners		
Room AC	EU	EU
Household ducted	USA	USA
Heat-pumps		
Ground-source	EU	EU
Air-source	EU	EU
Fans/AHU		
<125W	EU	EU
>125W	EU	EU

Table A28: Total Energy consumption and savings for HVAC per economy by scenario

Country	BAU 2015	CoNW MEPS 2015		CoNW MEPS + HL 2015		BAU 2030	CoNW MEPS 2030	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving on BAU
China	622	493	21%	377	39%	1113	966	13%
EU	597	501	16%	488	18%	649	562	13%
India	117	80	32%	69	41%	271	219	19%
South Africa	33	23	30%	23	31%	79	64	19%
USA	856	705	18%	681	20%	947	823	13%
Rest of World	1400	987	29%	854	39%	2075	1714	17%
Total	3625	2789	23%	2492	31%	5134	4348	15%

Hot water (electric)

Table A29: Economy with highest MEPS and labelling requirements for electric water heaters

Product / sub-product	Country with Highest MEPS	Country with Highest Label
Electric water heaters		
Household (storage or instantaneous)	EU	EU
Non-domestic	EU	EU
Heat-pump (only)	EU	EU/China

Table A30: Total Energy consumption and savings for electric water heaters per economy by scenario

Country	BAU 2015	CoNW MEPS 2015		CoNW MEPS + HL 2015		BAU 2030	CoNW MEPS 2030	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving on BAU
China	45	42	7%	19	58%	95	90	6%
EU	256	243	5%	107	58%	262	250	4%
India	16	15	10%	7	58%	58	53	9%
South Africa	19	18	8%	8	58%	39	36	7%
USA	159	151	6%	66	58%	163	155	5%
Rest of World	417	371	11%	174	58%	601	545	9%
Total	912	839	8%	380	58%	1218	1129	7%

White goods

Table A31: Economy with highest MEPS and labelling requirements for white goods

Product / sub-product	Country with Highest MEPS	Country with Highest Label
Refrigerators and freezers	USA	EU
Washing Machines	EU	EU
Dishwashers	EU	EU
Clothes-dryers	EU	EU

Table A32: Total Energy consumption and savings for white goods per economy by scenario

Country	BAU 2015	CoNW MEPS 2015		CoNW MEPS + HL 2015		BAU 2030	CoNW MEPS 2030	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving on BAU
China	114	65	42%	40	65%	176	114	35%
EU	224	199	12%	123	45%	230	207	10%
India	62	33	46%	20	68%	120	72	40%
South Africa	4	2	47%	1	69%	6	4	41%
USA	291	220	24%	121	59%	308	243	21%
Rest of World	498	274	45%	160	68%	655	403	38%
Total	1193	793	33%	464	61%	1497	1043	30%

Consumer electronics

Table A33: Economy with highest MEPS and labelling requirements for Consumer Electronics

Product / sub-product	Country with Highest MEPS	Country with Highest Label
Televisions	EU	EU/RSA
Complex Set-top Box	EU	NA
External Power Supply	EU	EU/USA

Table A34: Total Energy consumption and savings for consumer electronics per economy by scenario

Country	BAU 2015	CoNW MEPS 2015		CoNW MEPS + HL 2015		BAU 2030	CoNW MEPS 2030	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving on BAU
China	223	60	73%	43	81%	371	135	64%
EU	113	34	70%	25	78%	98	39	60%
India	32	8	75%	6	81%	62	22	65%
South Africa	4	0	88%	0	93%	14	3	76%
USA	155	48	69%	35	77%	166	66	60%
Rest of World	405	48	88%	27	93%	680	160	76%
Total	932	198	79%	137	85%	1392	426	69%

ICT

Table A35: Economy with highest MEPS and labelling requirements for ICT

Product / sub-product	Country with Highest MEPS	Country with Highest Label
Desktop computer	EU	China/EU/USA
Notebook computer	China	China/EU/USA
Monitors	EU	EU/RSA
Domestic Imaging Products	NA	China/EU/India/RSA/USA
Non-domestic Imaging Products	NA	China/EU/India/RSA/USA
Servers	NA	USA

Table A36: Total Energy consumption and savings for ICT per economy by scenario

Country	BAU 2015	CoNW MEPS 2015		CoNW MEPS + HL 2015		BAU 2030	CoNW MEPS 2030	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving on BAU
China	76	48	37%	35	54%	153	104	32%
EU	59	42	28%	34	43%	47	36	24%
India	18	11	38%	8	54%	57	37	35%
South Africa	4	2	41%	2	58%	12	7	38%
USA	208	145	30%	118	43%	260	196	25%
Rest of World	220	122	45%	81	63%	434	260	40%
Total	584	371	37%	278	52%	963	640	34%

Cooking

Table A37: Economy with highest MEPS and labelling requirements for Cooking

Product / sub-product	Country with Highest MEPS	Country with Highest Label
Rice cookers	China	China
Electric ovens	EU	EU
Gas ovens	EU	EU
Electric cooktops (hobs)		
Gas cooktops (hobs)	EU	India/China
Extractor fans (range hoods)	EU	EU

Table A38: Total Energy consumption and savings for cooking per economy by scenario

Country	BAU 2015	CoNW MEPS 2015		CoNW MEPS + HL 2015		BAU 2030	CoNW MEPS 2030	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving on BAU
China	152	140	8%	139	8%	207	194	6%
EU	117	111	5%	110	6%	128	123	4%
India	22	20	8%	20	8%	40	37	6%
South Africa	9	9	5%	9	6%	17	16	3%
USA	287	272	5%	272	5%	321	310	3%
Rest of World	965	892	8%	891	8%	1320	1263	4%
Total	1552	1444	7%	1441	7%	2032	1943	4%

Space heating (thermal)

Table A39: Economy with highest MEPS and labelling requirements for non-electric space heating equipment

Product / sub-product	Country with Highest MEPS	Country with Highest Label
Gas boilers	EU	EU
Oil boilers	EU	EU

Table A40: Total Energy consumption and savings for non-electric space heating equipment per economy by scenario

Country	BAU 2015	CoNW MEPS 2015		CoNW MEPS + HL 2015		BAU 2030	CoNW MEPS 2030	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving on BAU
China	1679	1298	23%	1035	38%	1890	1602	15%
EU	2371	1936	18%	1463	38%	1983	1738	12%
India	216	166	23%	131	39%	333	281	16%
South Africa	37	28	23%	23	39%	41	34	15%
USA	1716	1422	17%	1075	37%	1677	1484	11%
Rest of World	12846	9904	23%	7877	39%	13391	11329	15%
Total	18865	14754	22%	11603	38%	19314	16468	15%

Water heating (thermal)

Table A41: Economy with highest MEPS and labelling requirements for non-electric water heating equipment

Product / sub-product	Country with Highest MEPS	Country with Highest Label
Gas storage water heater	EU	EU
Gas instantaneous water heater	EU	EU
Solar water heater	EU	EU

Table A42: Total Energy consumption and savings for non-electric water heating equipment per economy by scenario

Country	BAU 2015	CoNW MEPS 2015		CoNW MEPS + HL 2015		BAU 2030	CoNW MEPS 2030	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving on BAU
China	156	128	18%	96	38%	219	193	12%
EU	238	184	23%	147	38%	306	260	15%
India	112	89	20%	71	37%	68	58	14%
South Africa	3	3	21%	2	39%	5	4	14%
USA	658	520	21%	411	38%	641	551	14%
Rest of World	2666	2119	20%	1663	38%	2902	2500	14%
Total	3833	3044	21%	2389	38%	4141	3566	14%

Refrigeration (non-domestic)

Table A43: Economy with highest MEPS and labelling requirements for non-domestic refrigeration equipment

Product / sub-product	Country with Highest MEPS	Country with Highest Label
Reach-in display cabinets	USA	China
Beverage coolers	USA	USA
Professional storage cabinets	NA	NA

Table A44: Total Energy consumption and savings for non-domestic refrigeration equipment per economy by scenario

Country	BAU 2015	CoNW MEPS 2015		CoNW MEPS + HL 2015		BAU 2030	CoNW MEPS 2030	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving on BAU
China	28	26	7%	23	15%	47	45	6%
EU	155	141	9%	130	16%	183	170	7%
India	8	7	12%	6	19%	14	12	10%
South Africa	12	11	12%	10	19%	36	33	10%
USA	153	146	5%	133	13%	157	150	4%
Rest of World	162	142	12%	131	19%	252	228	10%
Total	517	472	9%	434	16%	689	638	7%

Cleaning

Table A45: Economy with highest MEPS and labelling requirements for non-domestic cleaning equipment

Product / sub-product	Country with Highest MEPS	Country with Highest Label
Non-domestic washing machines	USA	USA
Non-domestic clothes-dryers	USA	USA
Non-domestic dishwashers	USA	USA

Table A46: Total Energy consumption and savings for non-domestic cleaning equipment per economy by scenario

Country	BAU 2015	CoNW MEPS 2015		CoNW MEPS + HL 2015		BAU 2030	CoNW MEPS 2030	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving on BAU
China	11	11	5%	9	20%	29	28	4%
EU	30	29	5%	24	20%	31	30	4%
India	2	2	5%	1	20%	4	4	4%
South Africa	3	3	5%	2	20%	6	6	4%
USA	42	41	3%	34	20%	55	54	2%
Rest of World	42	40	5%	34	20%	70	67	4%
Total	131	125	4%	104	20%	196	189	4%

Pumps (non-industrial)

Table A47: Economy with highest MEPS and labelling requirements for non-industrial pumps

Product / sub-product	Country with Highest MEPS	Country with Highest Label
Circulation pumps	EU	EU
Water pumps	China	China
Pool and aquarium pumps	USA	USA

Table A48: Total Energy consumption and savings for non-industrial pumps per economy by scenario

Country	BAU 2015	CoNW MEPS 2015		CoNW MEPS + HL 2015		BAU 2030	CoNW MEPS 2030	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving on BAU
China	29	23	21%	23	21%	48	40	16%
EU	135	88	34%	88	34%	154	109	29%
India	26	22	19%	22	19%	47	40	15%
South Africa	7	6	21%	6	21%	18	15	16%
USA	122	92	25%	92	25%	159	127	20%
Rest of World	231	173	25%	173	25%	323	253	22%
Total	551	404	27%	404	27%	748	584	22%

Motors (industrial) and related applications

Table A49: Economy with highest MEPS and labelling requirements for industrial electric motors and related applications

Product / sub-product	Country with Highest MEPS	Country with Highest Label
AC induction motors >0.75kW	USA/EU	China/EU/India/RSA/USA
Other motor types	Mostly USA	NA
Industrial fans	EU	NA
Industrial compressors	China	China
Industrial pumps	NA	NA

Table A50: Total Energy consumption and savings for industrial electric motors and related applications per economy by scenario

Country	BAU 2015	CoNW MEPS 2015		CoNW MEPS + HL 2015		BAU 2030	CoNW MEPS 2030	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving on BAU
China	3408	2253	34%	2245	34%	5696	5582	2%
EU	765	708	8%	717	6%	1234	1209	2%
India	309	286	8%	280	10%	955	935	2%
South Africa	94	86	8%	85	10%	139	136	2%
USA	635	597	6%	604	5%	969	949	2%
Rest of World	3210	2946	8%	2901	10%	4569	4474	2%
Total	8421	6875	18%	6831	19%	13563	13286	2%

Transformers

Table A51: Economy with highest MEPS and labelling requirements for transformers

Product / sub-product	Country with Highest MEPS	Country with Highest Label
Distribution transformers	USA	SEAD system (informal)
Power transformers	EU	NA

Table A52: Total Energy consumption and savings for transformers per economy by scenario

Country	BAU 2015	CoNW MEPS 2015		CoNW MEPS + HL 2015		BAU 2030	CoNW MEPS 2030	
	TWh	TWh	% saving	TWh	% saving	TWh	TWh	% saving on BAU
China	227	114	50%	75	67%	417	359	14%
EU	111	79	29%	52	53%	193	165	14%
India	88	62	29%	41	53%	273	233	14%
South Africa	12	9	29%	6	53%	18	16	14%
USA	137	102	26%	65	53%	239	208	13%
Rest of World	417	296	29%	196	53%	616	527	14%
Total	992	663	33%	435	56%	1756	1508	14%

Annex IV: Emission factors used for environmental impact analysis

Table 15: Environmental impact per TWh

Country / region	Fuel	Source / assumption	Climate change	Ozone depletion	Terrestrial acidification	Photochemical oxidant formation	Particulate matter formation	Natural land transformation	Water depletion	Metal depletion
			$MtCO_2e$	kg CFC-11 eq	Mt SO_2 eq	t NMVOC	t PM_{10} eq	ha	million m^3	t Fe eq
China	Electricity	From Ecoinvent	1.148	7	0.0100309	4 409	3 129	7	3	3 787
EU	Electricity	From Ecoinvent	0.487	23	0.0019337	1 016	622	6	4	3 542
India	Electricity	Same as China	1.148	7	0.0100309	4 409	3 129	7	3	3 787
RoW	Electricity	Same as USA	0.755	21	0.0048174	1 909	1 193	5	2	5 017
RSA	Electricity	Same as China	1.148	7	0.0100309	4 409	3 129	7	3	3 787
USA	Electricity	From Ecoinvent	0.755	21	0.0048174	1 909	1 193	5	2	5 017
China	Heavy fuel oil	From Ecoinvent	0.320	59	0.0006738	436	191	11	-1	3 976
EU	Heavy fuel oil	From Ecoinvent	0.320	59	0.0006738	436	191	11	-1	3 976
India	Heavy fuel oil	From Ecoinvent	0.320	59	0.0006738	436	191	11	-1	3 976
RoW	Heavy fuel oil	From Ecoinvent	0.320	59	0.0006738	436	191	11	-1	3 976
RSA	Heavy fuel oil	From Ecoinvent	0.320	59	0.0006738	436	191	11	-1	3 976
USA	Heavy fuel oil	From Ecoinvent	0.320	59	0.0006738	436	191	11	-1	3 976
China	Natural gas	From Ecoinvent	0.276	34	0.0004655	389	159	4	0	3 852
EU	Natural gas	From Ecoinvent	0.260	15	0.0008022	350	194	3	-2	3 367
India	Natural gas	From Ecoinvent	0.276	34	0.0004655	389	159	4	0	3 852
RoW	Natural gas	From Ecoinvent	0.276	34	0.0004655	389	159	4	0	3 852
RSA	Natural gas	From Ecoinvent	0.276	34	0.0004655	389	159	4	0	3 852
USA	Natural gas	From Ecoinvent	0.276	34	0.0004655	389	159	4	0	3 852
China	LPG	From Ecoinvent	0.107	81	0.0007576	510	221	16	0	2 262
EU	LPG	From Ecoinvent	0.107	81	0.0007576	510	221	16	0	2 262
India	LPG	From Ecoinvent	0.107	81	0.0007576	510	221	16	0	2 262
RoW	LPG	From Ecoinvent	0.107	81	0.0007576	510	221	16	0	2 262
RSA	LPG	From Ecoinvent	0.107	81	0.0007576	510	221	16	0	2 262
USA	LPG	From Ecoinvent	0.107	81	0.0007576	510	221	16	0	2 262

Annex V: Relevance of global harmonisation for the EU within existing trade frameworks

1. Global trade initiatives via WTO

Ensuring that national and regional regulations do not obstruct trade is the main aim of agreements of the World Trade Organisation (WTO): the WTO is the only international organization dealing with the global rules of trade between nations and ensures that 'trade flows as smoothly, predictably and freely as possible'.

WTO agreements present a double edged sword for harmonisation of Ecodesign regulations: on one hand they provide high level policy drivers for harmonised standards to facilitate free trade and establish mechanisms for cooperation between nations (such as through ISO). But on the other hand, WTO agreements constrain some aspects of technical regulations and standards within a legal framework which could hamper some efforts towards harmonisation.

The most relevant and important WTO agreement for Ecodesign and energy labelling is that on Technical Barriers to Trade[56] (TBT), which established principles such as treating suppliers from all WTO member countries equally (the so-called 'most favoured nation' principle), equality within national borders ('national treatment') and reducing barriers to trade through negotiation. The TBT deals with voluntary standards by means of a Code of Good Practice[57], which member country governments are obliged to accept and comply with[58].

Constraints to harmonisation efforts on Ecodesign and labelling that arise trade rules include[59]:

a) The principle established in a GATT dispute that Mexico raised against the US in 1991: this dispute was about protecting dolphins in tuna fisheries, but established that one country cannot take trade action (such as embargoes) to force another country to adopt environmental regulation in line with its own.

b) Environmental labelling schemes are recognised under WTO as useful and necessary as long as they do not discriminate between trading partner countries and do not favour locally produced products over imports.

c) One area that is not yet resolved by the WTO Trade and Environment Committee is whether regulations or a label are allowed to specify whether the method of manufacture is environmentally friendly, especially when the method is not evident in the final product (labels are certainly allowed to specify environmental properties of the product itself). This could result in blocking aspects of an Ecodesign or labelling regulation that constrains methods of manufacture.

2. The draft bilateral EU / US Transatlantic Trade and Investment Partnership (TTIP)

The EU is negotiating a trade and investment deal with the US - the Transatlantic Trade and Investment Partnership - or TTIP[60]. The draft text recognises the potential impact of environmental regulation on trade and aims to make better use of ISO standards in common with the US; reduce burdensome procedures for checking products; and notably to 'improve cooperation between EU and US standardisation bodies when they draw up new standards'. The TTIP has a specific chapter on regulatory co-operation which would set up ways for regulators to work together

[56] See https://www.wto.org/english/tratop_e/tbt_e/tbt_e.htm

[57] Code of good practice for the preparation, adoption and application of standards, Annex 3 of the TBT agreement

[58] According to Article 2 of the TBT

[59] See https://www.wto.org/english/thewto_e/whatis_e/tif_e/bey2_e.htm accessed 25 Feb 2015

[60] See http://ec.europa.eu/trade/policy/in-focus/ttip/ accessed 25 February 2015

closely on a particular area; initiate work with the US to promote international cooperation on regulatory issues and internationally agreed approaches to regulation; and, create a Regulatory Cooperation Body. Once established, the TTIP should provide a co-operative framework to facilitate harmonisation or alignment of technical regulations and standards both with the US and more widely.

3. Trade negotiations with China

China is the EU’s largest trading partner in Asia. Negotiations of a comprehensive EU-China investment agreement were launched at the EU-China Summit of November 2013 with the aim to remove market access barriers to investment. Perhaps more relevant to Ecodesign, however, are negotiations to upgrade the 1985 Trade and Economic Cooperation Agreement which began in 2007 but have stalled since 2011 due to divergent mandates and expectations of the parties.

4. Trade negotiations with Japan

Japan is the EU’s second biggest trading partner in Asia, after China. Negotiations for a free trade agreement were launched in April 2013 with four rounds of talks since then. A number of non-tariff barriers operating in Japan are of concern to these negotiations; links and similarities on Ecodesign type regulation with Japan are few.

5. The bilateral Canada EU Trade Agreement (CETA)

A substantial Canada / EU trade agreement was agreed in October 2014 which affirms adoption of large parts of the WTO agreement on TBT for trade between Canada and the EU. In 2012, Canada was the 12th most important trading partner of the EU. Canadian energy efficiency regulations for appliances and equipment are largely harmonised with the US.