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SEAD Member Economy Recent Achievements: Projected Savings from Energy Performance Standards since 2010

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FINAL REPORT

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Introduction

Appliances, lighting and equipment account for the vast majority of global electricity use, and approximately half of global energy consumption (IEA 2009). It is therefore crucial to reduce energy consumption by implementing equipment efficiency policies with a strong record of success. By now, energy efficiency policies are well-recognized as an important tool to limit climate change is well recognized. For example, the International Energy Agency's Redrawing the Climate-Energy Map (IEA 2013) considered a scenario in which energy efficiency contributed to 49% of all energy-related greenhouse gas emissions reductions towards limiting global temperature increases to 2 degrees centigrade. This study attempts to quantify the energy and emissions impacts of some of these programs, focusing on one type of program (minimum energy performance standards) in a specific group of economies (SEAD Initiative members). In doing so, the authors hope to shed some light on the progress made in recent years towards more energy–efficient economies, as well as areas of additional potential. In order to do this, we not only enumerate the number of regulations enacted in recent years, but project energy savings from each regulation studied through 2030. The analysis takes advantage of a modeling capability and database of market and regulatory data accumulated over nearly a decade. Like all such analyses, the current study makes trade-offs between robustness and detail vs. comprehensiveness. The roughly 100 individual regulations studied provide a relatively high degree of detail in a multi-country study. On the other hand, not all major economies are included (China is a notable exception) and only one type of policy is included. Therefore, while we feel that the results are robust, they are by no means comprehensive in terms of energy efficiency policy achievements worldwide. Furthermore, the study considers only new and updated standards over the five year period spanning 2010-2014, therefore omitting substantial accomplishments made before 2010.

Over the past few decades, Energy Efficiency Standards and Labeling (EES&L) programs have been implemented in over 75 countries with a successful track record of reducing energy consumption in the jurisdictions where they are implemented. They have the potential of lowering energy intensity associated with economic growth in developing countries, enhancing energy productivity and addressing global environmental issues such as climate change. As a result of early successes by 'early adopters', the number of programs and countries where they are implemented have proliferated. A recent study found 3604 individual measures were in place around the world, including 1453 energy performance standards (EES 2014) This represents a nearly three-fold growth in the number of measures estimated by a similar study just 10 years earlier (Harrington and Damnics 2004). Even more recently, the International Energy surveyed a number of published evaluations of major programs. The resulting study (IEA 2015) provides an overview of program impacts in multiple dimensions, including impacts on: energy efficiency improvement rates, net financial impacts, equipment prices, innovation, employment and other benefits.

The Super-efficient Equipment and Appliance Deployment (SEAD)[1] initiative recognizes this potential and aims to increase the global pace of efficiency improvement by helping to strengthen, expand and deepen the policies of market transformation in the countries that

[1] As of January 1, 2015 SEAD member governments included: Australia, Brazil, Canada, Chile, European Commission, Germany, India, Indonesia, Japan, Korea, Mexico, Russia, South Africa, Sweden, United Arab Emirates, United Kingdom and the United States. China is currently an observer.

are its members. SEAD was jointly announced by the US and Indian governments at the United Nations Framework Convention on Climate Change (UNFCCC) Conference of Parties in Copenhagen in 2009. It was then launched in July 2010 as an initiative within the Clean Energy Ministerial and task within the International Partnership for Energy Efficiency Cooperation.

Standards Selection and Data Collection

To date, 86 minimum energy performance standards from 10 SEAD member countries and the EU have been analyzed by SEAD[2]. These standards, which became effective or were adopted between January 1, 2010 and December 31, 2014 are a measure of the achievements made by policymakers in SEAD countries in the 5 years since its inception. For the purpose of this study, we count each standard covering a new product and each update of a previously existing standard during the analysis period as one MEPS[3]. The analysis considers only minimum energy performance standards (MEPS). Labels, particularly mandatory categorical labels and voluntary endorsement labels are recognized to be effective in moving markets towards high efficiency. However, a consistent methodology for forecasting the impact of these programs is less certain than for MEPS, though some evidence is provided by several investigations into this area ((Edward Vine, Peter du Pont, and Paul Waide 2001), (Lowenthal-Savy, McNeil, and Harrington 2013), (Zhou and McNeil 2014)). Furthermore, evaluation of labeling programs typically relies on detailed data on per-category market shares, which is either unavailable or expensive. A major exception of this is India, where the 5-star rating system is integrated with MEPS[4] and where market share data collected by the Indian Bureau of Energy Efficiency were available for analysis[5] .

A short summary of SEAD member country programs is provided in Appendix 1. Elements of these programs and those of many other countries are described in published reports (EES 2014). A list of MEPS passed between 2010 and 2014 in SEAD countries is given in Table 1.

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[2] The European Commission is a member of SEAD and the European Union is considered as a single economy. EU equipment minimum energy performance standards apply to all EU member states. EU standards are counted as a single regulation by SEAD, so that the number of standards is smaller than that reported by ((EES) and Maia Consulting, Australia 2014).
[3] In some cases, newly announced regulations were found to constitute only minor changes to earlier standards.
[4] Under the Indian scheme, products not meeting the 1-star criterion are prohibited from sale.
[5] India is not unique in this structure. For example, Australia and New Zealand also use a combined MEPS-comparative labeling system.

Table 1 – Member economy MEPS passed or implemented between from January 1, 2010 through December 31, 2014 and analyzed as part of SEAD's Recent Achievements tracking.

Sector	Residential							Commercial*					Industrial			Grand Total
Country	Appliances	HVAC	Lighting	Electronics	Other	Water Heating	**Subtotal**	HVAC	Lighting	Refrigeration	Other	**Subtotal**	Motors and Pumps	Transformers	Subtotal	
Australia		2		1		1	4		1			1				**5**
Brazil													1		1	**1**
Canada		3		3		1	7			1		1	1		1	**9**
Chile	1		1				2									**2**
European Union	6	3		2	1	1	13						1	1	2	**15**
India	2	2	1				5							1	1	**6**
Japan	1	1		1		1	4			1		1	1		1	**6**
Korea	2			2		1	5			1		1				**6**
Mexico	2	1				1	4						2		2	**6**
South Africa	4	1				1	6	1				1				**7**
United States	6	5		1		1	13	1	1	3	1	6	3	1	4	**23**
Total	**24**	**18**	**2**	**10**	**1**	**8**	**63**	**2**	**2**	**6**	**1**	**11**	**9**	**3**	**12**	**86**

*Commercial sector standards are those specifically targeting equipment classes not commonly used in households. Three standards that cover equipment used in both buildings subsectors are categorized in the residential category.

** Indian MEPS and categorical labeling program are integrated and analyzed as a single regulation.

Keeping track of the number and type of EES&L MEPS implemented or updated provides an important measure of progress made in this important policy area. However, just enumerating standards omits key information, since standards vary widely in both stringency and in base case energy demand, or 'footprint' of the targeted products. In addition, some regulations bundle multiple products, further confounding direct comparison on the basis of the number of regulations. For these reasons, this study attempts to make a methodologically consistent evaluation of the energy each MEPS may be expected to save in the coming decades[6].

In order to compare and aggregate impacts across products and economies, this study collected data on product markets and regulation specifications and fed these parameters into a single model. Establishing a consistent framework in this way allows for identification of remaining gaps and opportunities. Such a comparison provides a means of tracking progress towards achieving energy savings and attendant

[6] Energy efficiency programs generally impact a generation of products and therefore have impacts that are not fully realized for 10-20 years from the year in which they become effective.

benefits for meeting national energy conservation goals of energy security, reduction of capital investments and air pollution and climate goals.

Lawrence Berkeley National Laboratory (LBNL) supports SEAD with tracking the energy savings from standards implemented by its member economies. The first evaluation covered standards with an announcement or effective date[7] between January 1, 2010 and April 1, 2011. This and subsequent updates resulted in a database of standards announced from January 1, 2010 to December 31, 2014 - a total of 5 years, giving a "progress baseline" that characterizes the rate at which member economies are capturing energy efficiency potential. SEAD uses the BUENAS[8] model as its primary tool for quantifying energy efficiency potential and achievements across economies and end uses around the world. The following summarizes the process for standards selection and data collection.

Since its inception, SEAD has queried member country representatives regarding recent standards and labeling activities, including the type of action (test procedure, mandatory or voluntary labels or MEPS), and the stage of development (implemented, announced, drafted, under consideration). Some economy representatives gave quite detailed responses to this request, from which standards definitions and data sources could be determined. However, the level of detail in the responses was not consistent, leaving gaps in the tracking of activities. The following sources were referenced to supplement the information provided by SEAD representatives:

- Economy program pages – Economies with well-documented schedules easily available online include: the US, EU, Mexico and India. Australia and New Zealand?
- Third party summaries of economy programs – These include the Appliance Standards Awareness Project (ASAP) for the US and the European Consortium for an Energy Efficient Economy (ECEEE) for the EU.
- CLASP global S&L database – CLASP maintains a comprehensive database of programs searchable by economy, product and program type.

In addition to program type, a selection is made regarding the stage of standards development. In the first round of standards analyzed for 2010-2011 (Kalavase et al. 2012), we considered standards either

[7] Announcement date refers to the date when the regulation was published in official government documents describing the regulation and setting the date of enforcement
[8] The Bottom Up Energy Analysis System was developed by Lawrence Berkeley National Laboratory. A description is available at https://ies.lbl.gov/research-area/appliance-energy-efficiency.

implemented, announced or 'under consideration'. The latter category ranged from standards with only preliminary studies performed to draft regulations ("Notices of Proposed Rulemakings" in the U.S.) likely to be close to final regulations. Since then, standards in this category were either replaced by finalized 'announced' standards or eliminated.

The first important parameters needed to model the impacts of any regulation are (1) the scope of products covered and (2) the dates of implementation. Analysis of impacts requires projection of market size (sales), baseline energy consumption and the likely per-unit efficiency improvement due to the standard. Baseline energy consumption is defined as the projected energy consumption of new products in the absence of the regulation under consideration, which in some cases takes account of trends in product capacity. The most common source of these are in technical studies performed as part of the regulatory process, the most consistent and well-documented of which include the U.S. DOE's Technical Support Documents and European Commission's Preparatory Studies. In the case where complete studies such as these are absent, data are sourced from secondary sources, such as market research reports, regulation definitions and, in some cases, assumption. Nevertheless, in quite a few cases, the necessary data do not exist to provide a reliable estimate of savings. In cases where a trend toward increasing baseline efficiency is specified in the source documents, these trends are used in BUENAS. Otherwise, the model assumes 'frozen' efficiency in the baseline.

Of the 123 MEPS confirmed by SEAD member economies since 2010, 86 (70%) were analyzed. Of the remaining 37 (30%), 30 (24%) lacked sufficient data for analysis, including standards for CFLs and LEDs that include aspects of quality control to prevent "market spoilage" but have a less direct relationship to energy efficiency than other standards. Finally, 7 (6%) standards were found not to significantly move the market, either because they were determined not to be significantly different from previously issued standards, or because they were determined to be at or below prevailing market efficiency levels.

Analysis Methodology

The impact of standards in SEAD economies is analyzed using the LBNL's Bottom-Up Energy Analysis. The details of the BUENAS methodology have been well-documented in (McNeil et al. 2013).This section describes the basic set of data parameters that must be collected specific to each standard. These variables serve as the primary inputs to BUENAS.

Activity (Stock and Sales) Forecast

A main determinant of energy demand and efficiency-driven savings is the change in equipment stocks over time. The stock in each forecasted year multiplied by average unit energy consumption gives the total energy demand. The rate at which new highly efficient equipment enters the market and lowers the average energy consumption is determined by annual product sales. Stock and sales are strong determinants of one another as market growth increases stocks and replacement of retired stock generates new sales. BUENAS uses multiple methods of determining stock and sales depending on available data, including:

1. Direct sourcing of sales forecasts (preferred) – Unit sales forecasts are taken from existing government documents used to characterize standards, such as U.S. technical support documents (TSDs) or Ecodesign preparatory studies.
2. Third party sales data – Unit sales are taken from recent sales data provided by country representatives, or from purchased data and projections provided by market research firms. Usually these data are extrapolated to the end of the forecast period (2030).
3. Modeled Diffusion – Uptake of residential appliances modeled econometrically as a function of household income and other macroeconomic parameters. The diffusion model used by BUENAS is described in (M. A. McNeil and V. E.Letschert 2010).

Annual Unit Energy Consumption

The projected energy savings of a given standard is driven by average annual unit energy consumption (UEC) that is lower in the policy (standards) case than in the business as usual case. In general, MEPS drive an increase in efficiency, or lowering of energy consumption for products sold after the effective date of the standard. The determination of UEC in each case combines estimates of usage, intensity and efficiency in each case. Methods of determining UEC include:

1. Direct sourcing of UEC estimates (preferred) – UEC are taken from existing government documents used to characterize standards, such as U.S. technical support documents (TDSs) or Ecodesign preparatory studies. Efficiency, Capacity, Intensity and Hours of Use – In many cases,

efficiency definitions must be combined with estimates of intensity and/or usage to determine UEC. For example, air conditioner standards are generally given by an efficiency metric (such as EER) that is combined with assumptions of average cooling capacity (in Watts) and hours of use to yield energy consumption (in kWh). In addition, trends (usually increases) in the average size of appliances sold are included in some cases.

2. MEPS definitions - In some cases (such as refrigerators), MEPS define limits of annual energy consumption for a specific product capacity as determined by test procedures. These limits can be used as an estimate of actual energy consumption. In cases where recent MEPS are updates, the previous MEPS level is sometimes considered to be the baseline.

The key driver of energy savings impacts in the analysis is in the definitions of MEPS issued in the analysis period of 2010-2014, whether as new regulations or updates of old ones. The definition of the regulation is taken as the main indicator of how the market will transform after implementation. MEPS that may be updated in years after 2015 are not considered, as the analysis considers only the impact of the updates issued during the analysis period.

The main parameters determined in this way are documented in Appendix 2. In addition to these inputs, the lifetime of equipment corresponding to each standard are taken from the BUENAS database unless provided specifically. Once all data inputs are assembled, they are fed into the BUENAS model, which calculates annual national energy savings in each year according to the method described in (McNeil et al. 2013).

Results

Not surprisingly, standards in the largest economies save the most energy. Furthermore, countries with the most well-established programs continued to create new and update existing MEPS regulations between 2010 and 2014. The United States leads the pack with 23 standards, followed by the EU with 13.

In terms of numbers of separate regulations, appliances and HVAC are most often addressed by MEPS, and the residential sector still dominates with roughly five times as many standards analyzed than in either the commercial or industrial sector.

Energy savings measured in terms of projected savings from the new regulations and updates tabulated in Table 1 in 2030 are 704 TWh of electricity and 563 PJ of 2030 Oil and Gas. To put this in perspective, 704 TWh is roughly equivalent to typical annual generation of 235 500 megawatt power plants, or 117 GW of installed capacity[9]. This is equivalent to about five times the capacity of the Three Gorges Dam[10], nearly half of the currently installed capacity of India[11] and more than the 2013 electricity consumption of Australia[12]. The savings in terms of gas and oil is equivalent to taking over 8 million cars off the road[13]. These results clearly indicate the power of equipment efficiency standards to have impacts at a global scale. The savings quantified is a subset of overall impacts from equipment energy efficiency programs because it doesn't include information for labels, utility-driven programs or non-regulatory programs. In addition, while SEAD economies represent 61%[14] of global GDP, there are important economies with successful programs that are not included – notably China.

[9] Assuming 3 TWh per year per 500 MW power plant.
[10] Three Gorges Dam Capacity is 22.5 GW (https://en.wikipedia.org/wiki/Three_Gorges_Dam)
[11] Three Gorges Dam Capacity is 22.5 GW (https://en.wikipedia.org/wiki/Three_Gorges_Dam)
[12] 248.96 according to International Energy Agency. Available at http://energyatlas.iea.org/?subject=-1118783123
[13] 1 million cars is 62.5 TBtu http://eetd.lbl.gov/sites/all/files/content/fellowship/equivalencematrix2008.pdf
[14] GDP data from World Bank, in PPP International Dollars, Accessed from https://en.wikipedia.org/wiki/List_of_countries_by_GDP_(PPP) on July 11, 2015.

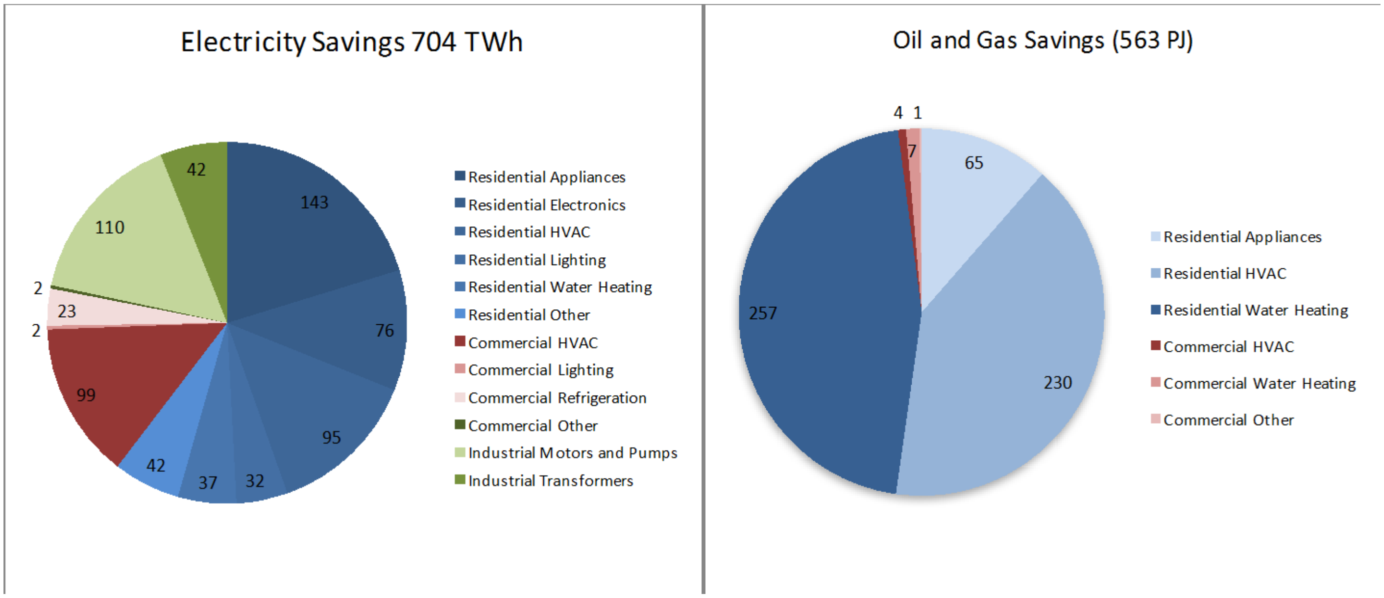

Figure 1 – Projected Annual Final Energy Savings in 2030 for Electricity (left) and Oil and Gas (right)

Figure 1 shows 2030 final energy savings by fuel, sector and end use. Electricity savings are expressed as terawatt hours (TWh), while savings from gas and oil are expressed in petajoules (PJ)[15]. The number of MEPS covering equipment used in commercial buildings is increasing, especially in the U.S. and E.U. In addition, MEPS continue to address losses in electric motors and distribution transformers. In spite of this, more than half of total electricity savings arise from the residential sector, demonstrating the enduring focus on household products as the subject of efficiency standards. Standards for products using gas and oil standards are also most likely to be used in households, and are more or less evenly divided between heating and cooling and water heating, with gas appliances and commercial equipment contributing only a small fraction. Overall, electricity savings dominates in terms of equivalent units of final energy. If energy inputs to electricity production are included (primary energy), the dominance of electricity is even greater.

[15] One terawatt hour is equal to 3.6 petajoules, but electricity energy does not include fuel inputs to produce electricity

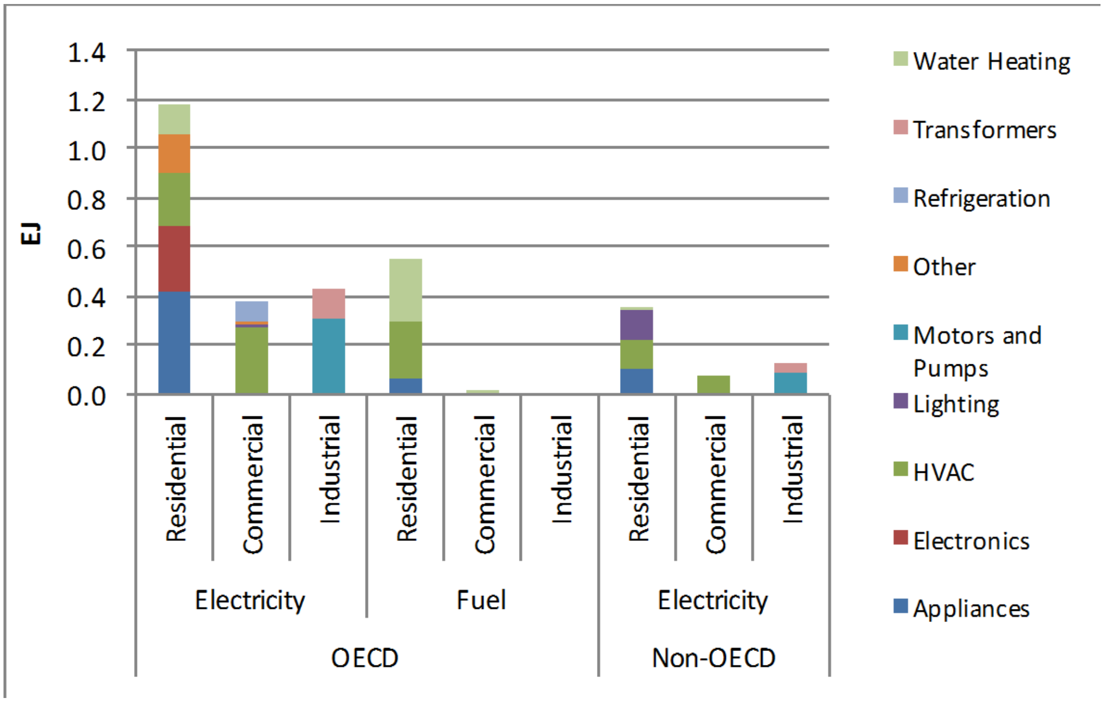

Figure 2 – Final energy savings by OECD membership, fuel and sector

Geographically, savings from standards continues to be dominated by OECD economies[16], although there have been some very important standards passed in developing countries in the past 5 years[17]. Savings in non-OECD countries tends to be distributed by sectors much in the same way as OECD countries, with over half of total savings in the residential sector. However, the significant oil and gas savings are absent in non-OECD countries, which is mostly an effect of warmer climates that require less energy for heating. Electricity consumption in non-OECD countries in 2030 is expected to be on par with those in OECD countries. This indicates a large untapped potential for electricity efficiency programs in developing countries. It is important to note, however, that, since China is not a member of SEAD, savings from Chinese MEPS are not included, potentially significantly suppressing the visible savings from non-OECD countries[18].

[16] SEAD OECD economies include: Australia, Canada, EU, Japan, Korea, Mexico and the US. Non-OECD countries are Brazil, Chile, India, Indonesia and South Africa

[17] Notably refrigerator and air conditioner standards in India, which became mandatory in 2010.

[18] A study by the authors evaluating the impacts of recent MEPS in China is forthcoming.

In terms of greenhouse gas emissions, the minimum energy performance standards are projected to reduce emissions by 376 MT CO2 in 2030, or 4036 MT cumulatively up to that year. Roughly, cumulative emissions savings in the 2010-2015 period are about ten times larger than the 2030 annual emissions. While 2030 annual emissions provide a convenient metric for comparing long-term impacts of MEPS, cumulative emissions provide additional insight in some cases. Specifically, cumulative emissions are particularly important for lighting and electronics. In the first case, the model assumes a high fraction of incandescent lamp substitution by 2030, suppressing annual savings in that year. In the second, the high turnover rate of electronics equipment means a rapid ramp up time to full market substitution of high-efficiency equipment.

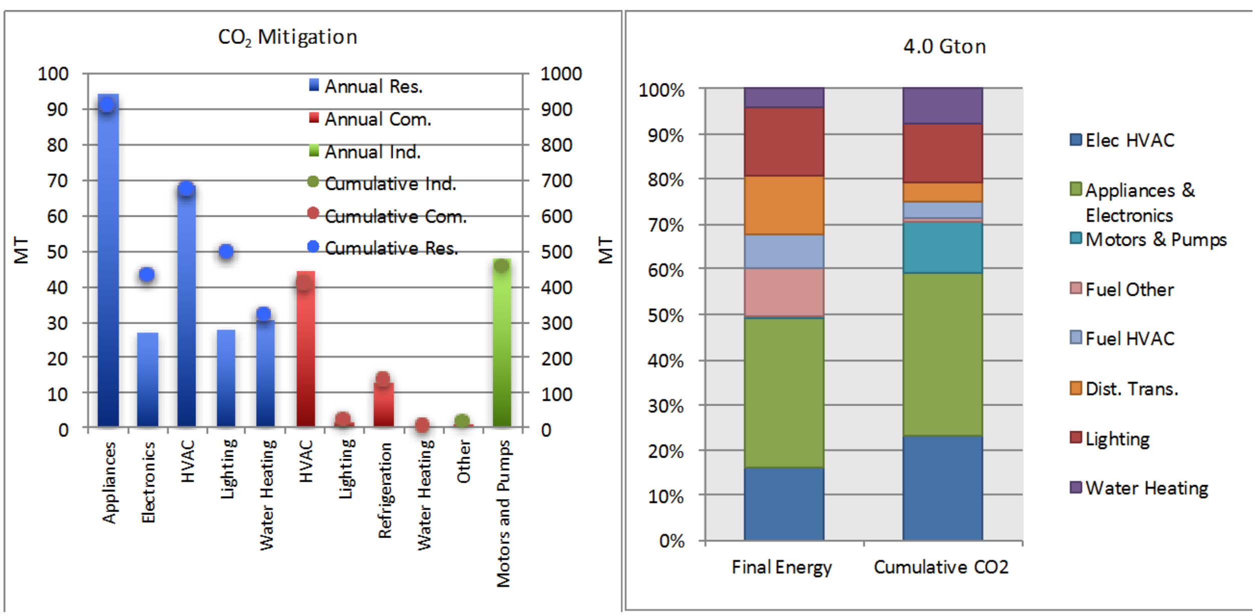

Figure 3 – Projected Annual and Cumulative 2030 Carbon Dioxide Emissions

Similarly, the share of each end use category as a fraction of cumulative emissions reductions follows that of energy savings, with the exception that electricity is more heavily weighted over fuel, and lighting is particularly important for cumulative emissions for the reasons described above.

While the gains made by SEAD economies in the last 5 years are significant and laudable, comparison with a recent study performed by SEAD shows that these represent only a fraction of possible savings. In particular, we can make a comparison to the BUENAS Best Available Technology scenario, (Letschert et al.

2013) which models standards at the highest available efficiency level in 2015. As figure 4 shows, the total potential of adopting best available technologies for the countries studied (not including China) is about 11 EJ of final annual energy savings in 2030, or about 13 gigatons of CO2 cumulative to that year.

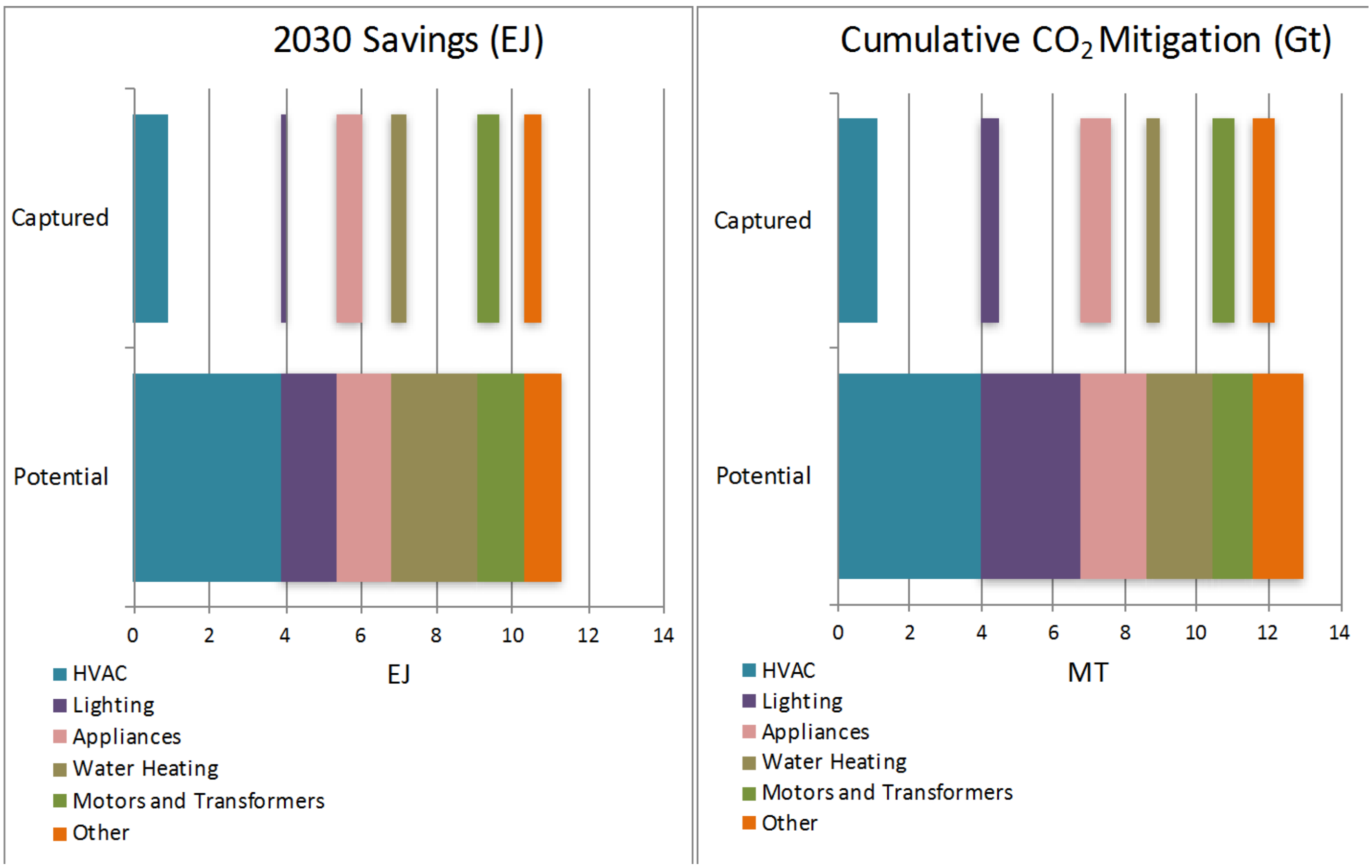

Figure 4 – Projected Annual and Cumulative 2030 Carbon Dioxide Emissions

Savings and carbon dioxide mitigation are summarized in Table 2. Overall, the results show that between a quarter and a third of the potential has been captured.

Table 2 – Captured and Potential Energy Savings and Emissions Reductions from Energy Performance Standards in SEAD economies

Category	Captured	Potential	Gap	% Captured	Captured	Potential	Gap	% Captured
	EJ			%	$Gt\ CO_2$			%
HVAC	0.9	3.9	2.9	24%	1.1	4.0	2.9	27%
Lighting	0.1	1.5	1.4	8%	0.5	2.8	2.3	19%
Appliances	0.7	1.4	0.8	46%	0.9	1.9	1.0	47%
Water Heating	0.4	2.3	1.9	17%	0.3	1.8	1.5	18%
Motors & Transformers	0.5	1.2	0.7	45%	0.6	1.1	0.5	58%
Other	0.4	1.0	0.5	44%	0.6	1.4	0.8	42%
Total	**3.1**	**11.3**	**8.2**	**27%**	**4.0**	**13.0**	**8.9**	**31%**

For both energy and emissions reductions, lighting has the lowest percentage captured and motors and transformers have the highest. The business as usual scenario assumes that the phase out of incandescent lamps will be virtually complete worldwide by 2030. Therefore, while there is some savings from incandescent phase out due to standards passed or implemented within the past 5 years, these are mitigated by a rising baseline. On the other hand, the best available technology sets LEDs as a target for energy performance standards worldwide, a target which is far from realized, though this technology is making rapid gains both in the market and in the attention of policymakers. The high fraction of savings captured for industrial products demonstrates the aggressiveness of MEPS in the large economies, as well as a definition of 'best available technology' that includes only equipment efficiency and does not consider system efficiency improvements, which can be large for motor systems. Finally, it is important to keep in mind for all products in all sectors that the best available technology is generally a moving target and should be updated to reflect recent technological advances driven by markets.

The analysis of recent MEPS in SEAD member economies demonstrates progress in implementing effective equipment efficiency policies over the past five years, implementing standards that will save energy and reduce future greenhouse gas emissions. We find that new and revised MEPS issued between 2010-2014 are projected to save over 700 TWh of electricity and 560 PJ of 2030 Oil and Gas. The electricity savings implies that roughly 235 fewer 500 megawatt power plants will be needed in the next 15 years relative to the case in which no action had been taken. Associated cumulative greenhouse gas mitigation from these regulations total more than 4 billion metric tons of CO2, or more than the annual emissions of the European Union [19].

[19] https://en.wikipedia.org/wiki/List_of_countries_by_carbon_dioxide_emissions

This analysis is limited to energy and greenhouse emission impacts and neglects impacts on health and economic well-being of end-users and general citizens. Avoided capital investments from power plant construction is likely to be in the hundreds of billions. Likewise, since the standards passed generally meet requirements of cost-effectiveness to consumers, delivered economic benefits to households and businesses are also likely to be large. In addition to not including these, some other limitations of the present analysis should be noted. First, energy efficiency is assumed to be frozen in the business as usual case for many regulations, a somewhat unrealistic assumption. On the other hand, regulated markets often 'overshoot' the energy efficiency target, an effect that we do not capture, creating a compensating error. Second, our implicit assumption of full compliance with regulations requires that governments actively encourage compliance and invest in effective monitoring, verification and evaluation (MV&E) processes. Third, the regulations and technology potential considered in this study consider only equipment efficiency. This boundary neglects the significant amount of savings potential in improving systems efficiency, for example, in industrial motors applications or lighting controls. Finally, as mentioned before, in pursuing a high degree of detail, some degree of comprehensiveness was sacrificed. It is the authors' hope that the analysis presented here will provide the basis for expansion to other countries, other policy types and over a longer time period.

Relative to current best available technologies, standards adopted by SEAD economies in the past 5 years capture between a quarter and a third of the total potential, so there are still energy demand reduction opportunities. Recent successes in SEAD countries show that, despite the relatively long history of standards in the United States and Europe, these economies continue to capture additional savings, either by pushing the efficiency envelope further on well-established products such as HVAC, lighting, appliances and motors, or by broadening the scope of covered equipment in the commercial and industrial sectors.

Importantly, however, future opportunities in global energy efficiency gains is more heavily concentrated in developing countries, where momentum for energy efficiency programs is also growing. This important aspect of where the largest potential for energy efficiency gains lies is demonstrated in Figure 5, which shows projected potential energy savings by end use in OECD, vs. non-OECD countries.

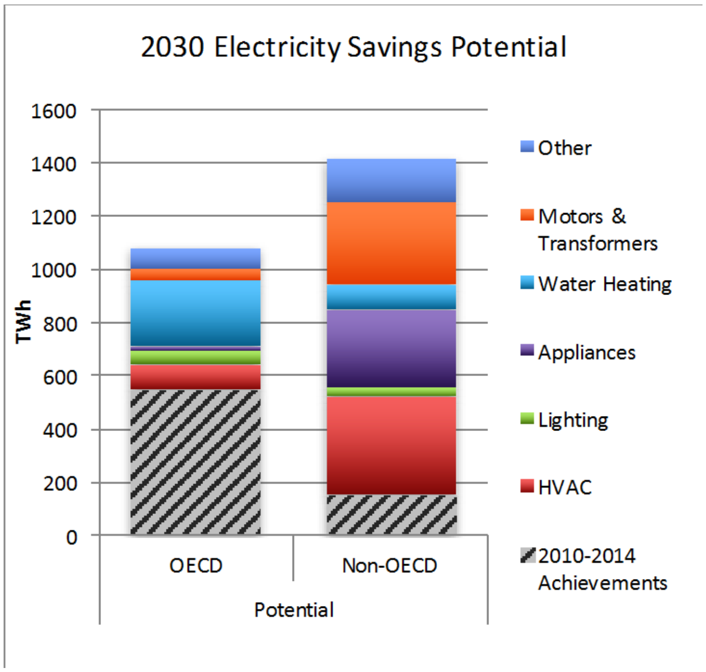

Figure 5 – Electricity Savings Potential by Region and End Use

According to Figure 5, roughly two-thirds of potential electricity savings by 2030 lies in non-OECD countries[20]. The dominance of uncaptured potential in non-OECD countries arises from three main factors. First, population in industrialized is stabilizing and economic growth is moderate compared to rapid GDP growth rates in developing countries. Second, GDP growth in developing countries implies rapid growth in ownership of major energy using equipment such as lighting, refrigerators and televisions, while growth rates in these products in industrialized countries is already high and unlikely to grow much further. Finally, due to many years of programs designed to drive efficiency, OECD countries are operating at a relatively high energy efficiency baseline, whereas there is more opportunity for 'low-hanging fruit' in developing countries. Three main strategies should be followed in order to maximize capture of remaining global energy efficiency potential.

- Expanding the Scope of Existing Programs– Savings of residential electricity is strong, but the potential in commercial buildings and gas and oil end remaining largely untapped, particularly in

[20] As noted before, the analysis excludes China, which may figure prominently in both potential and achieved savings due to its successful energy efficiency policies.

non-OECD countries. The United States and European Union have made strides expanding their programs in recent years, and should continue to do so. Meanwhile, the experience they are gaining should be applied to developing countries at an early stage, allowing those countries to leapfrog into broader programs.

- Extracting Maximum Savings from New Standards and Updates – The main factors contributing to robust standards are robust and credible technical analysis, supported by a stakeholder consultation process that lends integrity to the process. These can be strengthened in developing countries through programs of technical capacity and institution building, potentially funded with resources pledged as part of climate accords and other forms international cooperation.
- Establishing and Strengthening New Programs – Despite the emergence of strong programs in many developing countries, there are still significant gaps. Programs in 'greenfields' countries can be put in place through application of best practices, always considering, however, the particularities and capacity limitations of the countries in questions.

For the developing countries in particular, multiple barriers exist to capturing technologically-feasible energy efficiency potential. Important among these are issues of political support and understanding of national leaders. In order address these, international organizations supporting program development and must improve the evidence base and communication to local leaders in order to secure energy efficiency as a top political priority. This may involve reaching out to government agencies beyond energy ministries, in the areas of finance, industrial development and environmental protection.

Finally, a major barrier to be overcome is the limited technical capacity within governments and their local contractors and partners. Even where programs exist, capacity limitations often result in programs that are weak or lack integrity – in other words, they result in programs and policies that fail to move markets. Fully realizing the contribution of energy efficiency policies therefore merits unprecedented investments in building capacity, including advanced program design, facilitation of data collection, training in analysis and infrastructure to promote effective monitoring, verification and enforcement. Given these conditions, energy efficiency policies like the ones analyzed in this report can help bring a wide-array of benefits to all countries, and contribute strongly to addressing the global climate challenge.

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Appendix 1 – SEAD Country Program Summary

Australia - The standards process in Australia is led by the Equipment Energy Efficiency (E3 2012) Committee, which has a mandate to assess products for possible regulation, engage with stakeholders and complete a Regulatory Impact Statement outlining the economic and environmental effects of the standard. The development of standards is a cooperative process between government and industry, using technical and economic analysis to determine appropriate energy efficiency targets.

Brazil - Brazilian standard regulation was assisted by the National Energy Conservation Program (PROCEL), and the federal government has implemented voluntary and mandatory labels and standards for many domestic, industrial and commercial products. The Brazilian MEPS program is developed and administered by INMETRO.

Chile - Chile began the process of setting up both labeling and Energy Performance Standards programs as early as 1999, with the formulation of MEPS for electric motors. In 2005, Chile created the National Energy Efficiency Program (PPEE), within which lies the Chilean Energy Efficiency Standards and Labelling Program (PNEEE). MEPS were passed for general service lighting in 2013 and refrigerators in 2014. Chile will propose MEPS for industrial electric motors in 2015.

European Union - MEPS were first introduced in the EU in 1994. Under two directives of the European Parliament and of the Council established in 2005 and 2009 (Directives 2005/32/EC and 2009/125/EC respectively), a framework was established to develop MEPS in the EU. Today, the program covers more than 62 appliances and equipment in 14 end-use categories in the residential, commercial, and industrial sectors.

India – The Energy Conservation Act of 2001 provides the basis for India's standards and labeling program. This legislation established the Bureau of Energy Efficiency (BEE), and an Energy Conservation Fund. The legislation enables the provision of both voluntary and mandatory labels and standards. The Indian program uses a combined MEPS and categorical labeling scheme whereby products are labeled on a 5 star rating system and products not meeting the lowest (1 star) level are prohibited from sale.

Indonesia - First implemented in 2000, Indonesia now has mandatory Energy Performance Standards for chillers, commercial lighting systems, packaged terminals, refrigerators and CFLs. More recently, Indonesia was involved in a regional UNDP-GEF project called Barrier Removal to the Cost-Effective Development and Implementation of Energy Efficiency Standards and Labeling (BRESL) to assess MEPS for a number of products. Supported by this program, Indonesia issued a MEPS for lighting in 2014, and a MEPS on AC in early 2015.

Japan - The Japanese Energy Conservation Law, passed in 1979 and revised in 1999, provides the foundation for Japan's energy efficiency policy. Rather than setting MEPS, the law sets a target for the shipment-weighted average efficiency for regulated products. Today the program, known as Top Runner, covers 19 product types in ten end-use categories and is led by the Advisory Committee for Natural Resources and Energy from the Ministry of Economy, Trade and Industry (METI).

Republic of Korea - The Energy Efficiency Standards and Labeling Program in South Korea was launched in 1992 to improve the energy efficiency of common appliances. The program now covers 28 product types in ten end-use categories in the residential, commercial, and industrial sectors. The regulatory process is led by the Korean Energy Management Corporation (KEMCO).

Mexico - The Mexican government updated the new transformers standard, harmonized with the US transformer standard. They also changed the standard definition. However, the preliminary study indicated that there isn't any efficiency improvement for the new standard.

South Africa – Energy efficiency standards and labeling are under the direction of the South African Department Energy National. In 2014, the South African government announced MEPS and mandatory categorical labels for clothes washers, refrigerators, freezers, clothes dryers, dishwashers, ovens, air conditioners and storage tank electric water heaters.

United Arab Emirates - The national energy efficiency conservation program was launched in 2011.The UAE energy efficiency standardization and labeling program is regulated by Emirates Authority for Standards and Metrology (ESMA). ESMA also monitors the market by sampling or testing to make sure the regulated products comply with the existing regulation.

United States - The first federal appliance standards in the United States were enacted in 1987 through the National Appliance Energy Conservation Act (NAECA). Congress set initial federal energy efficiency standards and established schedules for the Department of Energy (DOE) to review these standards. Since then, standards for 47 types of appliances and equipment used in 13 end-use categories of the residential, commercial, and industrial sectors have been established.

Appendix 2 – BUENAS Model Data Inputs and Assumption

Table A2.1 – BUENAS Inputs and Assumptions – Electric Equipment

Sector	Category	Economy	Imp. Year	Product Type	Product Sub-Type	UEC_{BAU}	UEC_{RA}	Reference	% Savings
Residential	HVAC	Australia	2010	Room Air Conditioners	Split - Cooling only	270.1	237.4	(DEWHA 2008b)	12.1%
Residential	HVAC	Australia	2010	Room Air Conditioners	Split – Heat Pump	1545.6	1358.3	(DEWHA 2008b)	12.1%
Residential	HVAC	Canada	2011	Room Air Conditioners	Window - Cooling only	131.6	117.0	(NRCAN 2009)	11.1%
Residential	HVAC	Australia	2012	Central Air Conditioners		430.7	391.4	(DEWHA 2008a)	9.1%
Residential	HVAC	E.U.	2012	Room Air Conditioners	Split – Heat Pump	1496.3	1496.3	(EC 2009a)	0.0%
Residential	HVAC	India	2012	Room Air Conditioners	Split - Cooling only	1385.6	1314.4	(BEE 2015)	5.1%
Residential	HVAC	India	2012	Room Air Conditioners	Window - Cooling only	1520.2	1466.7	(BEE 2015)	3.5%
Residential	HVAC	Japan	2012	Room Air Conditioners	Split – Heat Pump	1209.4	1020.7	(Shah, Waide, and Phadke 2012)	15.6%
Residential	HVAC	Canada	2013	Dehumidifiers	11.8<Cr<=16.6	533.2	426.5	(DEWHA 2008a)	20.0%
Residential	HVAC	Canada	2013	Dehumidifiers	16.6<Cr<=21.3	632.8	514.1	(DEWHA 2008a)	18.8%
Residential	HVAC	Canada	2013	Dehumidifiers	21.3<Cr<=25.5	808.5	618.3	(DEWHA 2008a)	23.5%
Residential	HVAC	Canada	2013	Dehumidifiers	25.5<Cr<35.5	914.0	548.4	(DEWHA 2008a)	40.0%
Residential	HVAC	Canada	2013	Dehumidifiers	Cr<=11.8	539.3	399.5	(DEWHA 2008a)	25.9%
Residential	HVAC	Canada	2013	Dehumidifiers	Cr>=35.5	721.0	648.9	(DEWHA 2008a)	10.0%
Residential	HVAC	U.S.	2013	Furnaces	Electric Furnace	586.0	586.0	(USDOE 2011e)	0.0%
Residential	HVAC	Mexico	2014	Room Air Conditioners	Window - Cooling only	2407.6	2407.6	(Sánchez et al. 2006), (USDOE 2011c)	0.0%
Residential	HVAC	U.S.	2014	Room Air Conditioners	PC1 Window - Cooling only	387.5	342.3	(USDOE 2011c)	11.7%
Residential	HVAC	U.S.	2014	Room Air Conditioners	PC3 Window - Cooling only	598.2	565.1	(USDOE 2011c)	5.5%
Residential	HVAC	U.S.	2014	Room Air Conditioners	PC5a Window - Cooling only	458.5	451.0	(USDOE 2011c)	1.6%
Residential	HVAC	U.S.	2014	Room Air Conditioners	PC5b Window - Cooling only	534.9	530.7	(USDOE 2011c)	0.8%
Residential	HVAC	U.S.	2014	Room Air Conditioners	PC8a Window - Cooling only	473.5	457.6	(USDOE 2011c)	3.4%
Residential	HVAC	U.S.	2014	Room Air Conditioners	PC8b Window - Cooling only	705.9	688.5	(USDOE 2011c)	2.5%
Residential	HVAC	South Africa	2016	Room Air Conditioners	Mini-Split – Heat Pump	476.0	417.0	(Covary, Katzman, and McNeil 2015)(Covary and Lengosa 2015)	12.4%
Residential	HVAC	South Africa	2016	Room Air Conditioners	Mini-Split-Cooling Only	2241.0	1963.4	(Covary, Katzman, and McNeil 2015)(Covary and Lengosa 2015)	12.4%
Residential	HVAC	South Africa	2016	Room Air Conditioners	Window – Heat Pump	482.9	478.3	(Covary, Katzman, and McNeil 2015)(Covary and Lengosa 2015)	1.0%

Sector	Category	Economy	Imp. Year	Product Type	Product Sub-Type	UEC_{BAU}	UEC_{RA}	Reference	% Savings
Residential	HVAC	South Africa	2016	Room Air Conditioners	Window-Cooling Only	2273.5	2251.8	(Covary, Katzman, and McNeil 2015)(Covary and Lengosa 2015)	1.0%
Residential	HVAC	U.S.	2015	Central Air Conditioners	PAC	2147.0	2143.2	(USDOE 2011e)	0.0%
Residential	HVAC	U.S.	2015	Central Air Conditioners	PHP	5304.6	5172.3	(USDOE 2011e)	1.1%
Residential	HVAC	U.S.	2015	Central Air Conditioners	SAC-BC	1895.8	1857.0	(USDOE 2011e)	1.1%
Residential	HVAC	U.S.	2015	Central Air Conditioners	SAC-CO	2015.8	1964.2	(USDOE 2011e)	1.4%
Residential	HVAC	U.S.	2015	Central Air Conditioners	SHP	5028.9	4937.2	(USDOE 2011e)	1.1%
Residential	HVAC	U.S.	2017	Furnace Fans	Electric Furnace	482.3	328.0	(DOE 2013a)	32.0%
Residential	HVAC	U.S.	2017	Furnace Fans	MHEF	297.8	202.5	(DOE 2013a)	32.0%
Residential	HVAC	U.S.	2017	Furnace Fans	MHGFc	605.1	455.2	(DOE 2013a)	24.8%
Residential	HVAC	U.S.	2017	Furnace Fans	MHGFnc	571.3	427.8	(DOE 2013a)	25.1%
Residential	HVAC	U.S.	2017	Furnace Fans	NWGFc	922.6	662.2	(DOE 2013a)	28.2%
Residential	HVAC	U.S.	2017	Furnace Fans	NWGFnc	907.1	572.0	(DOE 2013a)	36.9%
Residential	HVAC	U.S.	2017	Furnace Fans	Oil Furnace	899.2	703.4	(DOE 2013a)	21.8%
Residential	HVAC	U.S.	2017	Furnace Fans	WGF	715.3	535.7	(DOE 2013a)	25.1%
Residential	Lighting	E.U.	2010	General Service Lamps	CFL	5.5	5.5[21]	(EC 2009c)	#N/A
Residential	Lighting	E.U.	2010	General Service Lamps	Incandescent	21.6	21.6[1]	(EC 2009c)	0.0%
Residential	Lighting	India	2010	Linear Fluorescent Lamps		96.0	96.0[1]	(Zhou 2013)	0.0%
Residential	Lighting	U.S.	2012	General Service Lamps	CFL	15.1	15.1[1]	(Letschert et al. 2010)	#N/A
Residential	Lighting	U.S.	2012	General Service Lamps	Incandescent	46.5	46.5[1]	(Letschert et al. 2010)	0.0%
Residential	Lighting	U.S.	2012	Linear Fluorescent Lamps		31.3	31.3[1]	(USDOE 2011b)	0.0%
Residential	Lighting	Chile	2015	General Service Lamps	CFL	20.5	20.5[1]	(Letschert 2010b)	#N/A
Residential	Lighting	Chile	2015	General Service Lamps	Incandescent	97.3	97.3[1]	(Letschert 2010b)	#N/A
Residential	Lighting	Indonesia	2015	General Service Lamps	CFL	21.9	21.9[1]	(EC 2009c)	#N/A
Residential	Appliances	India	2010	Refrigerators	Direct Cool	337.1	337.1	(Michael A. McNeil and Iyer 2009)	0.0%
Residential	Appliances	India	2010	Refrigerators	Frost Free	503.2	489.4	(Michael A. McNeil and Iyer 2009)	2.7%
Residential	Appliances	Japan	2010	Refrigerators		519.0	410.0	(METI 2010)	21.0%
Residential	Appliances	Korea	2010	Rice Cookers		204.1	202.6	(KEMCO 2012)	0.7%
Residential	Appliances	E.U.	2011	Freezers		250.0	228.7	(USDOE 2011a)	8.5%
Residential	Appliances	E.U.	2011	Refrigerators		263.1	252.5	(EC 2008)	4.0%
Residential	Appliances	Korea	2011	Clothes Washers	Horizontal Clothes Washers	119.9	82.0	(KEMCO 2012)	31.7%
Residential	Appliances	Korea	2011	Clothes Washers	Vertical Clothes Washers	28.7	19.6	(KEMCO 2012)	31.7%
Residential	Appliances	E.U.	2012	Dishwashers		341.5	304.0	(EC 2007a)	11.0%
Residential	Appliances	E.U.	2013	Clothes Washers		219.9	216.3	(EC 2007a)	1.6%

[1] Lighting does not involve more efficient product sub-types, but switching to more efficient sub-types.

[2] Gas water heater energy savings from U.S. Clothes Washer and Dishwasher standards considered as a separate product (see gas product table)

Sector	Category	Economy	Imp. Year	Product Type	Product Sub-Type	UEC_{BAU}	UEC_{RA}	Reference	% Savings
Residential	Appliances	United States	2013	Dishwashers		337.5	237.5	(USDOE 2007)	29.6%
Residential	Appliances	U.S.	2016	Cooking Equipment		153.1	151.7	(USDOE 2010l)	0.9%
Residential	Appliances	Mexico	2014	Clothes Washers		74.6	48.5	(Sánchez et al. 2006)	35.0%
Residential	Appliances	E.U.	2014	Dryers	Condenser Dryers	558.0	544.6	(EC 2009b)	2.4%
Residential	Appliances	E.U.	2014	Dryers	Vented Air Dryers	520.8	511.9	(EC 2009b)	1.7%
Residential	Appliances	Mexico	2014	Refrigerators		369.0	369.0	(Sánchez et al. 2006)	0.0%
Residential	Appliances	U.S.	2014	Freezers	Chest	393.8	300.2	(USDOE 2010k)	23.8%
Residential	Appliances	U.S.	2014	Freezers	Upright	671.3	479.4	(USDOE 2010k)	28.6%
Residential	Appliances	U.S.	2014	Refrigerators	Bottom Mount	598.6	532.6	(USDOE 2010k)	11.0%
Residential	Appliances	U.S.	2014	Refrigerators	Others	603.0	568.1	(USDOE 2010k)	5.8%
Residential	Appliances	U.S.	2014	Refrigerators	Side by Side	773.0	612.1	(USDOE 2010k)	20.8%
Residential	Appliances	U.S.	2014	Refrigerators	Top Mount	554.1	403.9	(USDOE 2010k)	27.1%
Residential	Appliances	U.S.	2015	Clothes Washers[2]	Front-Loading - Std Size	245.9	241.4	(USDOE 2012)	1.8%
Residential	Appliances	U.S.	2015	Clothes Washers[2]	Front-Loading - Compact Size	199.0	173.1	(USDOE 2012)	13.0%
Residential	Appliances	U.S.	2015	Clothes Washers[2]	Top-Loading - Std Size	431.3	334.7	(USDOE 2012)	22.4%
Residential	Appliances	U.S.	2015	Clothes Washers[2]	Top-Loading – Compact Size	345.7	232.6	(USDOE 2012)	32.7%
Residential	Appliances	U.S.	2014	Dryers		694.8	676.8	(USDOE 2011d)	2.6%
Residential	Appliances	South Africa	2016	Clothes Washers		192.2	184.7	(Covary, Katzman, and McNeil 2015)(Covary and Lengosa 2015)	3.9%
Residential	Appliances	South Africa	2016	Dishwashers		291.0	258.7	(Covary, Katzman, and McNeil 2015)(Covary and Lengosa 2015)	11.1%
Residential	Appliances	South Africa	2016	Dryers		294.0	274.3	(Covary, Katzman, and McNeil 2015)(Covary and Lengosa 2015)	6.7%
Residential	Appliances	South Africa	2016	Freezers		507.6	423.1	(Covary, Katzman, and McNeil 2015)(Covary and Lengosa 2015)	16.6%
Residential	Appliances	South Africa	2016	Ovens		121.0	110.9	(Covary, Katzman, and McNeil 2015)(Covary and Lengosa 2015)	8.4%
Residential	Appliances	South Africa	2016	Refrigerators	Refrigerator	286.0	248.3	(Covary, Katzman, and McNeil 2015)(Covary and Lengosa 2015)	13.2%
Residential	Appliances	South Africa	2016	Refrigerators	Refrigerator-Freezer	353.0	306.5	(Covary, Katzman, and McNeil 2015)(Covary and Lengosa 2015)	13.2%
Residential	Appliances	E.U.	2016	Microwave Ovens		86.4	71.6	(EC 2011b)	17.1%
Residential	Appliances	U.S.	2016	Microwave Ovens	PC1	24.6	8.7	(DOE 2013c)	64.6%
Residential	Appliances	U.S.	2016	Microwave Ovens	PC2	39.1	19.1	(DOE 2013c)	51.1%
Residential	Appliances	E.U.	2017	Electric ovens		142.1	112.1	(EC 2011b)	19.0%

Sector	Category	Economy	Imp. Year	Product Type	Product Sub-Type	UEC_{BAU}	UEC_{RA}	Reference	% Savings
Residential	Appliances	E.U.	2017	Vacuum Cleaners	Battery/Cordless	20.0	20.0	(EC 2006)	0.0%
Residential	Appliances	E.U.	2017	Vacuum Cleaners	Domestic Canister	93.8	56.3	(EC 2006)	40.0%
Residential	Appliances	E.U.	2017	Vacuum Cleaners	Domestic Upright	93.8	56.3	(EC 2006)	40.0%
Residential	Electronics	E.U.	2010	Set Top Boxes	Simple	56.3	18.6	(EC 2011a)	67.0%
Residential	Electronics	Korea	2010	Standby Power		19.1	5.2	(Jun Choi 2012)	72.7%
Residential	Electronics	Canada	2011	Standby Power		18.4	14.5	(EC 2007b), (Letschert et al. 2010)	21.3%
Residential	Electronics	Canada	2012	External Power Supplies		7.6	6.7		11.0%
Residential	Electronics	Canada	2012	Set Top Boxes	Simple Digital Television Adaptors	62.8	19.0	(PG&E 2006)	69.8%
Residential	Electronics	Japan	2012	Televisions	LCD	62.4	39.3	(Park et al. 2011)	37.0%
Residential	Electronics	Japan	2012	Televisions	Plasma	172.8	108.9	(Park et al. 2011)	37.0%
Residential	Electronics	Australia	2013	Computers	Desktop	199.6	171.3	(E3 2012)	14.2%
Residential	Electronics	Australia	2013	Computers	Notebook	78.6	60.2	(E3 2012)	23.4%
Residential	Electronics	Korea	2013	Televisions	CRT	69.3	31.5	(Park et al. 2011)	54.5%
Residential	Electronics	Korea	2013	Televisions	LCD	86.7	39.4	(Park et al. 2011)	54.5%
Residential	Electronics	Korea	2013	Televisions	Plasma	237.4	107.9	(Park et al. 2011)	54.5%
Residential	Electronics	E.U.	2015	Standby Power		18.4	3.6	(EC 2007b)	80.6%
Residential	Electronics	U.S.	2016	External Power Supplies		4.0	1.2	(USDOE 2014a)	70.5%
Residential	Water Heating	Korea	2012	Drinking Water Heater & Cooler		568.8	383.7	(Jun Choi 2011)	32.5%
Residential	Water Heating	E.U.	2015	Water Heaters	Storage	2160.7	2047.0	(VHK 2007b)	5.3%
Residential	Water Heating	U.S.	2015	Water Heaters	Storage	2490.6	2304.9	(USDOE 2010f)	7.5%
Residential	Water Heating	South Africa	2016	Water Heaters	Storage	810.1	457.5	(Covary, Katzman, and McNeil 2015)(Covary and Lengosa 2015)	43.5%
Residential	Water Heating	Japan	2017	Water Heaters	Heat Pump	475.0	346.8	(IEA 2008), (Lenz 2013)	27.0%
Residential	Other	E.U.	2013	Glandless Circulators	Large Standalone Circulator (450 W)	1730.0	729.8	(Michael A. McNeil, Letschert, and Stephane de la Rue du Can 2008)	57.8%
Residential	Other	E.U.	2013	Glandless Circulators	Small Standalone Circulator (65 W)	212.0	105.2	(Michael A. McNeil, Letschert, and Stephane de la Rue du Can 2008)	50.4%
Residential	Other	Mexico	2014	Water Pumps		167.6	148.3	(CONUEE 2013b)	11.5%
Residential	Other	E.U.	2015	Glandless Circulators	Boiler integrated (90W) circulator	323.0	123.8	(Michael A. McNeil, Letschert, and Stephane de la Rue du Can 2008)	61.7%
Commercial	HVAC	India	2012	Room Air Conditioners	Split - Cooling only	1732.0	1643.0	(BEE 2015)	5.1%
Commercial	HVAC	India	2012	Room Air Conditioners	Window - Cooling only	1900.3	1833.4	(BEE 2015)	3.5%
Commercial	HVAC	E.U.	2013	Ventilation Fans	Axial	2365.0	2300.5	(EC 2011c)	2.7%
Commercial	HVAC	E.U.	2013	Ventilation Fans	Centrifugal	5295.8	5176.1	(EC 2011c)	2.3%
Commercial	HVAC	E.U.	2013	Ventilation Fans	Other	2103.0	1977.9	(EC 2011c)	5.9%

Sector	Category	Economy	Imp. Year	Product Type	Product Sub-Type	UEC_{BAU}	UEC_{RA}	Reference	% Savings
Commercial	HVAC	South Africa	2015	Room Air Conditioners	Mini-Split-Cooling Only	476.0	417.0	(Covary, Katzman, and McNeil 2015)(Covary and Lengosa 2015)	12.4%
Commercial	HVAC	South Africa	2015	Room Air Conditioners	Mini-Split-Heat Pump	2241.0	1963.4	(Covary, Katzman, and McNeil 2015)(Covary and Lengosa 2015)	12.4%
Commercial	HVAC	South Africa	2015	Room Air Conditioners	Window-Cooling Only	482.9	478.3	(Covary, Katzman, and McNeil 2015)(Covary and Lengosa 2015)	1.0%
Commercial	HVAC	South Africa	2015	Room Air Conditioners	Window-Heat Pump	2273.5	2251.8	(Covary, Katzman, and McNeil 2015)(Covary and Lengosa 2015)	1.0%
Commercial	Lighting	Australia	2011	Halogen Lighting	12 V	71.5	67.0	(Melanie Slade 2011)	6.3%
Commercial	Lighting	Australia	2011	Halogen Lighting	240 V	119.5	119.5	(Melanie Slade 2011)	0.0%
Commercial	Lighting	U.S.	2017	Metal halide lamp fixtures	1000W	5116.4	5018.1	(DOE 2013b)	1.9%
Commercial	Lighting	U.S.	2017	Metal halide lamp fixtures	150W	833.2	791.8	(DOE 2013b)	5.0%
Commercial	Lighting	U.S.	2017	Metal halide lamp fixtures	250W	1266.5	1238.4	(DOE 2013b)	2.2%
Commercial	Lighting	U.S.	2017	Metal halide lamp fixtures	400W	2059.2	1990.9	(DOE 2013b)	3.3%
Commercial	Lighting	U.S.	2017	Metal halide lamp fixtures	70W	425.5	391.3	(DOE 2013b)	8.0%
Commercial	Refrigeration	Japan	2010	Refrigerated Vending Machines		1590.0	1051.0	(IEA 2007)	33.9%
Commercial	Refrigeration	Canada	2012	Commercial Refrigeration Equipment	Horizontal Open-Remote Condensing- Low Temperature	14008.7	12034.1	(USDOE 2008) (USDOE 2010i) (USDOE 2010h)	14.1%
Commercial	Refrigeration	Canada	2012	Commercial Refrigeration Equipment	Other Commercial Refrigeration	12976.8	9749.5	(USDOE 2008) (USDOE 2010i) (USDOE 2010h)	24.9%
Commercial	Refrigeration	Canada	2012	Commercial Refrigeration Equipment	Semi-Vertical Open-Remote Condensing- Medium Temperature	15899.4	13264.1	(USDOE 2008) (USDOE 2010i) (USDOE 2010h)	16.6%
Commercial	Refrigeration	Canada	2012	Commercial Refrigeration Equipment	Vertical Closed Transparent-Remote Condensing- Low Temperature	25294.5	14300.7	(USDOE 2008) (USDOE 2010i) (USDOE 2010h)	43.5%
Commercial	Refrigeration	Canada	2012	Commercial Refrigeration Equipment	Vertical Open-Remote Condensing- Medium Temperature	21133.5	17406.9	(USDOE 2008) (USDOE 2010i) (USDOE 2010h)	17.6%
Commercial	Refrigeration	U.S.	2012	Refrigerated Vending Machines	Large Glass-fronted or Fully Cooled Vending Machines	3737.6	1617.0	(USDOE 2010j)	56.7%
Commercial	Refrigeration	U.S.	2012	Refrigerated Vending Machines	Large Other Vending Machines	4511.7	1846.2	(USDOE 2010j)	59.1%

Sector	Category	Economy	Imp. Year	Product Type	Product Sub-Type	UEC_{BAU}	UEC_{RA}	Reference	% Savings
Commercial	Refrigeration	U.S.	2012	Refrigerated Vending Machines	Medium Glass-fronted or Fully Cooled Vending Machines	3350.7	1376.1	(USDOE 2010j)	58.9%
Commercial	Refrigeration	U.S.	2012	Refrigerated Vending Machines	Medium Other Vending Machines	4367.5	1739.6	(USDOE 2010j)	60.2%
Commercial	Refrigeration	U.S.	2012	Refrigerated Vending Machines	Small Glass-fronted or Fully Cooled Vending Machines	3285.0	1275.7	(USDOE 2010j)	61.2%
Commercial	Refrigeration	U.S.	2012	Refrigerated Vending Machines	Small Other Vending Machines	4081.4	1606.4	(USDOE 2010j)	60.6%
Commercial	Refrigeration	Korea	2013	Refrigerators	Freezer	581.4	581.4	(KEMCO 2012)	0.0%
Commercial	Refrigeration	Korea	2013	Refrigerators	Refrigerator-freezer	1286.2	1257.0	(KEMCO 2012)	2.3%
Commercial	Refrigeration	U.S.	2017	Refrigeration Equipment		7945.4	7001.0	(USDOE 2013a)	11.9%
Commercial	Refrigeration	U.S.	2017	Walk in Coolers & Freezers	Display Door - Large	3997.0	2054.7	(USDOE 2013b)	48.6%
Commercial	Refrigeration	U.S.	2017	Walk in Coolers & Freezers	Display Door - Medium	1413.7	557.7	(USDOE 2013b)	60.5%
Commercial	Refrigeration	U.S.	2017	Walk in Coolers & Freezers	Systems	9844.2	6254.1	(USDOE 2013b)	36.5%
Commercial	Electronics	Australia	2013	Computers	Desktop	199.6	171.3	(E3 2012)	14.2%
Commercial	Electronics	Australia	2013	Computers	Notebook	78.6	60.2	(E3 2012)	23.4%
Commercial	Other	E.U.	2014	Vacuum Cleaners	Commercial Canister	206.3	168.8	(EC 2006)	18.2%
Commercial	Other	E.U.	2014	Vacuum Cleaners	Commercial Upright	206.3	168.8	(EC 2006)	18.2%
Commercial	Other	U.S.	2018	Commercial Clothes Washers	Front Loading	581.4	574.3	(USDOE 2010g), (USDOE 2010b)	1.2%
Commercial	Other	U.S.	2018	Commercial Clothes Washers	Top Loading	1018.9	913.9	(USDOE 2010g), (USDOE 2010b)	10.3%
Industrial	Motors & Pumps	Brazil	2010	Large 3-Phase General Purpose	>75kW (121.5kW)	730300.0	718615.2	(Schaeffer 2005)	1.6%
Industrial	Motors & Pumps	Brazil	2010	Medium 3-Phase General Purpose	7.5kW-75kW (23kW)	106642.3	104632.2	(Schaeffer 2005)	1.9%
Industrial	Motors & Pumps	Brazil	2010	Small 3-Phase General Purpose	0.75kW-7.5kW (3.9kW)	14500.0	14137.5	(Schaeffer 2005)	2.5%
Industrial	Motors & Pumps	U.S.	2010	Large 3-Phase General Purpose	> 75 kW (110 kW)	392550.2	389681.9	(de Ameida et al. 2008)	0.7%
Industrial	Motors & Pumps	U.S.	2010	Medium 3-Phase General Purpose	7.5-75 kW (11 kW)	19234.6	18943.5	(de Ameida et al. 2008)	1.5%
Industrial	Motors & Pumps	U.S.	2010	Small 3-Phase General Purpose	0.75-7.5 kW (1.1 kW)	1361.0	1315.4	(de Ameida et al. 2008)	3.3%
Industrial	Motors & Pumps	Canada	2011	Large 3-Phase General Purpose	> 75 kW (110 kW)	392550.2	389681.9	(de Ameida et al. 2008)	0.7%
Industrial	Motors & Pumps	Canada	2011	Medium 3-Phase General Purpose	7.5-75 kW (11 kW)	19234.6	18943.5	(de Ameida et al. 2008)	1.5%
Industrial	Motors & Pumps	Canada	2011	Small 3-Phase General Purpose	0.75-7.5 kW (1.1 kW)	1361.0	1315.4	(de Ameida et al. 2008)	3.3%
Industrial	Motors & Pumps	Mexico	2011	Large 3-Phase General Purpose	> 75 kW (110 kW)	392550.2	389681.9	(de Ameida et al. 2008)	0.7%
Industrial	Motors & Pumps	Mexico	2011	Medium 3-Phase General Purpose	7.5-75 kW (11 kW)	19234.6	18943.5	(de Ameida et al. 2008)	1.5%
Industrial	Motors & Pumps	Mexico	2011	Small 3-Phase General Purpose	0.75-7.5 kW (1.1 kW)	1361.0	1315.4	(de Ameida et al. 2008)	3.3%
Industrial	Motors & Pumps	Mexico	2014	Water Pumps	Vertical Pumps	24075.2	21656.9	(CONUEE 2013a)	10.0%
Industrial	Motors & Pumps	Japan	2015	3-Phase General Purpose		5201.0	4981.0	(Ni 2012)	4.2%

Sector	Category	Economy	Imp. Year	Product Type	Product Sub-Type	UEC_{BAU}	UEC_{RA}	Reference	% Savings
Industrial	Motors & Pumps	U.S.	2015	Small Motors	Polyphase	1934.0	1851.8	(USDOE 2010e)	4.2%
Industrial	Motors & Pumps	U.S.	2015	Small Motors	Single-Phase	1317.3	869.8	(USDOE 2010e)	34.0%
Industrial	Motors & Pumps	U.S.	2016	Large Design AB	> 75 kW (110 kW)	191786.3	190325.5	(USDOE 2015)	0.8%
Industrial	Motors & Pumps	U.S.	2016	Medium Brake	7.5-75 kWH (11 kW)	47334.6	45999.0	(USDOE 2015)	2.8%
Industrial	Motors & Pumps	U.S.	2016	Medium Design AB	7.5-75 kWH (11 kW)	59438.5	58750.7	(USDOE 2015)	1.2%
Industrial	Motors & Pumps	U.S.	2016	Medium Design C	7.5-75 kWH (11 kW)	79210.6	78276.0	(USDOE 2015)	1.2%
Industrial	Motors & Pumps	U.S.	2016	Small Brake	0.75-7.5 kW (1.1 kW)	7632.7	7288.7	(USDOE 2015)	4.5%
Industrial	Motors & Pumps	U.S.	2016	Small Design AB	0.75-7.5 kW (1.1 kW)	8271.2	8113.4	(USDOE 2015)	1.9%
Industrial	Motors & Pumps	U.S.	2016	Small Design C	0.75-7.5 kW (1.1 kW)	8361.9	8206.0	(USDOE 2015)	1.9%
Industrial	Motors & Pumps	E.U.	2017	Large 3-Phase General Purpose	> 75 kW (110 kW)	395664.2	389571.4	(de Ameida et al. 2008)	1.5%
Industrial	Motors & Pumps	E.U.	2017	Medium 3-Phase General Purpose	7.5-75 kW (11 kW)	19773.2	19478.6	(de Ameida et al. 2008)	1.5%
Industrial	Motors & Pumps	E.U.	2017	Small 3-Phase General Purpose	0.75-7.5 kW (1.1 kW)	1481.1	1460.9	(de Ameida et al. 2008)	1.4%
Industrial	Transformers	India	2010	Distribution Transformers	100 kVA	2619.3	1578.9	(McNeil et al. 2005)	39.7%
Industrial	Transformers	India	2010	Distribution Transformers	160 kVA	3756.9	2952.3	(McNeil et al. 2005)	21.4%
Industrial	Transformers	India	2010	Distribution Transformers	200 kVA	4988.9	2210.5	(McNeil et al. 2005)	55.7%
Industrial	Transformers	India	2010	Distribution Transformers	25 kVA	1036.4	812.4	(McNeil et al. 2005)	21.6%
Industrial	Transformers	India	2010	Distribution Transformers	60 kVA	1833.8	1277.7	(McNeil et al. 2005)	30.3%
Industrial	Transformers	E.U.	2015	Distribution Transformers	DER transformers- dry type (2 MVA)	62415.0	53655.0	(EC 2010)	14.0%
Industrial	Transformers	E.U.	2015	Distribution Transformers	DER transformers- oil immersed (2 MVA)	59094.0	50333.0	(EC 2010)	14.8%
Industrial	Transformers	E.U.	2015	Distribution Transformers	Distribution transformers (400 kVA)	7859.0	5634.0	(EC 2010)	28.3%
Industrial	Transformers	E.U.	2015	Distribution Transformers	Industry transformers- dry type (1.25 MVA)	39727.0	30967.0	(EC 2010)	22.1%
Industrial	Transformers	E.U.	2015	Distribution Transformers	Industry transformers- oil immersed (1 MVA)	27168.0	19022.0	(EC 2010)	30.0%
Industrial	Transformers	E.U.	2015	Distribution Transformers	Power transformers (100 MVA)	519272.0	412838.0	(EC 2010)	20.5%
Industrial	Transformers	E.U.	2015	Distribution Transformers	Smaller industrial separation/isolation transformers (16 kVA)	505.0	505.0	(EC 2010)	0.0%
Industrial	Transformers	U.S.	2016	Distribution Transformers		2507.1	1883.5	(USDOE 2010i)	24.9%

Table A2.2 – BUENAS Inputs and Assumptions – Natural Gas and Fuel Oil Equipment

Sector	Category	Economy	Imp. Year	Product Type	Product Sub-Type	UEC_{BAU}	UEC_{RA}	Reference	% Savings
Residential	HVAC	Canada	2010	Boilers		100.3	98.2	(USDOE 2010m)	2.1%
Residential	HVAC	Canada	2010	Boilers		104.8	104.3	(USDOE 2010m)	0.4%
Residential	HVAC	United States	2013	Direct Heating Equipment		20.3	19.5	(USDOE 2010c)	3.5%
Residential	HVAC	United States	2013	Furnaces	MHF	45.5	43.0	(USDOE 2011e)	5.4%
Residential	HVAC	United States	2013	Furnaces	NWGF	37.1	35.9	(USDOE 2011e)	3.4%
Residential	HVAC	United States	2013	Furnaces	OF	69.8	67.3	(USDOE 2011e)	3.6%
Residential	HVAC	European Union	2015	Boilers		43.5	42.5	(VHK 2007a)	2.4%
Residential	HVAC	European Union	2015	Boilers		43.5	41.5	(VHK 2007a)	4.8%
Residential	Appliances	United States	2012	Cooking Equipment		0.9	0.8	(USDOE 2010l)	10.2%
Residential	Appliances	U.S.	2013	Dishwashers – Gas WH Component		0.5	0.4	(USDOE 2007)	20.4%
Residential	Appliances	United States	2015	Clothes Washers	Front-Loading - Std Size – Gas WH Component	1.3	1.2	(USDOE 2012)	2.3%
Residential	Appliances	United States	2015	Clothes Washers	Front-Loading - Compact Size – Gas WH Component	1.0	0.9	(USDOE 2012)	5.7%
Residential	Appliances	United States	2015	Clothes Washers	Top-Loading - Std Size – Gas WH Component	2.3	1.8	(USDOE 2012)	23.6%
Residential	Appliances	United States	2015	Clothes Washers	Top-Loading - Compact Size – Gas WH Component	1.7	1.3	(USDOE 2012)	24.1%
Residential	Appliances	United States	2015	Dryers		2.6	2.6	(USDOE 2010d)	1.4%
Residential	Appliances	European Union	2016	Gas Ovens		0.7	0.6	(EC 2011b))	8.1%
Residential	Water Heating	Mexico	2011	Water Heaters	Instantaneous	9.1	5.6	(CONUEE 2011)	38.5%
Residential	Water Heating	Mexico	2011	Water Heaters	Instantaneous Rapid Recovery	9.1	6.3	(CONUEE 2011)	30.8%
Residential	Water Heating	Mexico	2011	Water Heaters	Storage	20.9	18.9	(Sánchez et al. 2006)	9.8%
Residential	Water Heating	Australia	2012	Water Heaters	Storage	23.5	22.3	(McNeil et al. 2008)	5.0%
Residential	Water Heating	Canada	2013	Water Heaters	Storage	16.8	14.8	(USDOE 2010f)	11.9%
Residential	Water Heating	United States	2013	Pool Heaters		34.5	33.0	(USDOE 2010d)	4.4%
Residential	Water Heating	European Union	2015	Water Heaters	Instantaneous	9.0	8.5	(VHK 2007b)	4.9%
Residential	Water Heating	European Union	2015	Water Heaters	Storage	11.9	11.3	(VHK 2007b)	4.8%
Residential	Water Heating	United States	2015	Water Heaters	Instantaneous	11.3	11.1	(USDOE 2010f)	1.7%
Residential	Water Heating	United States	2015	Water Heaters	Storage	16.8	16.3	(USDOE 2010f)	3.1%
Commercial	HVAC	United States	2012	Boilers	Large Gas-Fired Steam Natural Draft	4335.4	4296.8	(USDOE 2010m)	0.9%
Commercial	HVAC	United States	2012	Boilers	Small Gas-Fired Steam Natural Draft	1171.7	1150.2	(USDOE 2011e)	1.8%

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