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Impacts Evaluation of Appliance Energy Efficiency Standards in Mexico since 2000
Technical Report

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Impacts Evaluation of Appliance Energy Efficiency Standards in Mexico since 2000

FINAL REPORT

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Summary of Results

Since its launch in 1994, Mexico's national energy efficiency standards and labeling (S&L) program has expanded to include regulations for 26 major appliances, equipment, and building components[1] in the residential, commercial, and industrial sectors. This program evaluation aimed to analyze the impacts on Mexican consumers and the national economy from energy efficiency standards on residential refrigerators and window air conditioners that were aligned, or "harmonized" with U.S. standards in the early 2000s. The impacts of a standard on mini-split air conditioners that was implemented in 2011 were also analyzed and quantified. A clear improvement in the average efficiency as a result of the standards was observed over the period analyzed: the average efficiency of Mexican refrigerators increase by 17% or 27% depending on product class, about 4% for window air conditioners, and over 7% for split system air conditioners. As a result of these standards, we estimate savings of about 5 TWh of electricity per year in 2014, roughly equivalent to two 500 MW power plants. Given the electricity generation mix during this period, we estimate that about 23 million metric tons of CO2 were avoided through 2014.

The impacts from Mexican energy efficiency standards go beyond energy savings and carbon emissions avoided, and encompass economic benefits to Mexican consumers and industry. Electricity saved by the standards resulted in roughly 40 billion[2] Mexican pesos saved (about 3 billion[3] US dollars at 2015 exchange rates) by Mexican consumers between 2002 and 2014. Mexico's retail electricity tariffs are subsidized however, so that the savings in actual production and delivery costs of electricity may be significantly higher. Meanwhile, at the aggregate level, equipment prices for refrigerators and air conditioners showed to be level or dropping compared to the overall rate of inflation, suggesting that, while efficiency increased during this time period, Mexican consumers did not see a negative price impact.

Representatives from the private sector interviewed for this study acknowledged the introduction of standards as a positive regulatory mechanism that creates a level playing field where manufacturers can compete under similar conditions and sends a clear signal to industry that investments to upgrade

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[1] Standards for building components include thermal insulation and building envelop.

[2] 40,000 million

[3] 3,000 million

technology and product manufacturing processes are worthwhile. The introduction of standards and associated energy labels has also led to an increased awareness of energy efficiency among Mexican consumers. For example, according to the latest market intelligence report from Mabe, energy efficiency is now one of the five most important factors considered by consumers when purchasing a refrigerator.

Background and Introduction

In 1989, Mexico's newly founded National Commission on Energy Savings (CONAE) established a program of minimum energy performance standards (in Spanish, Normas Oficiales Mexicanas or NOMs). The first three standards promulgated in 1994 covered two important household appliances - domestic refrigerators and air conditioners - as well as three-phase electric motors, which are a workhorse of industry across many sub-sectors.

This first set of NOMs was based on standards for the same products already implemented in the United States by that time. In fact the standards intentionally matched both the measurement specifications (test procedures) for rating energy efficiency and level of stringency. In an era of increasing economic integration among the countries of North America, this alignment minimized barriers to the import and export of domestic appliances and industrial equipment in both directions. Trade data reported in the COMTRADE database indicates that the value of refrigerator exports from Mexico to the US in the period 2000 – 2014 increased 9 fold from 401 million US dollars to about 3.7 billion US dollars[4].

Energy demand impacts from this first set of standards were significant. A study carried out by LBNL, CONAE and the Electric Research Institute (IIE) (Sanchez, McNeil, Pulido et al.) in 2006 estimated that these regulations reduced electricity consumption by 13.3 TWh in 2005, accounting for roughly 9.6% percent of total electricity demand. The Mexican standards resulted in this high percentage of savings because of a relatively low efficiency baseline, and household energy demand[5] that was concentrated in a few major household appliances and lighting.

[4] COMTRADE data at: http://comtrade.un.org/data/

[5] The reduced electricity demand of 13.3 TWh corresponds to 15.3 TWh of gross generation. Mexico's total gross generation in 2005 was 160 TWh.

Since then, CONAE and its successor agency the National Commission for the Efficient Use of Energy (known by its Spanish acronym CONUEE) have expanded the appliance efficiency standards program, which now covers 23 product classes[6] and has updated standards twice (for some products). In 2014, CONUEE requested that the Super-Efficient Appliance Deployment (SEAD) Initiative[7] support an updated study of the impacts of appliance energy efficiency standards in Mexico. SEAD partners, Lawrence Berkeley National Laboratory (LBNL) and CLASP, commenced the study to quantify the impacts of subsequent updates of the refrigerator and window air conditioner standards, and the expansion of air conditioner standards to cover mini-split units. The SEAD team contracted IIE of Mexico to coordinate other major data inputs. The impact analysis of these regulatory updates is presented in this Technical Report.

The following sections describe the selection of NOMs included in the study, data inputs needed for the calculation of energy and financial savings, and the approach and methodology for impacts analysis. This study also aimed to assess other related impacts on the private sector from the introduction of the NOMs under analysis. Interviews with representatives from certification bodies and industry were conducted and their opinions and views are documented. Finally, we provide the results of the study and draw conclusions.

Selection of NOMs

Due to resource and time constraints and the large volume of NOMs implemented by the Mexican government over the past two decades, the SEAD team decided to focus on refrigerators and air conditioners, two important consumer products suggested for prioritization by CONUEE. Most of the standards for refrigerators and air conditioners have been revised from the time they were first implemented. The current study considered the effects of the first standard and its subsequent revisions up until 2012. In this way, this study was an update of the impacts analysis that was previously referenced above, and utilizes a similar methodology as well as data inputs.

[6] The total number of regulations is 26, including building components.
[7] SEAD is an initiative of the Clean Energy Ministerial, and sponsored the research presented in this report. More information about SEAD and its activities can be found at superefficient.org

Initial findings after NOMs review

Once the NOMs for evaluation were identified, the SEAD team undertook a comprehensive review of the NOMs within the scope, identifying standards coverage and key dates for the evaluation. Furthermore, the team reviewed the stringency of standards, compared to previous versions and also made comparisons to international benchmarks where appropriate. The following table lists the applicable regulations (NOMs) evaluated:

Table 1 – Mexican standards (NOMs) for refrigerators and air conditioners

Type	NORMA	Recent[8]	Previous 1	Previous 2
Ref 1	NOM-015-ENER-2012 Energy efficiency of refrigerators and freezers. Limits, test methods and labeling.	2012	2003[9]	1997
AC 1	NOM-023-ENER-2010 Energy efficiency of ductless split-system air conditioners. Limits, test methods and labeling.	2010/11		
AC2	NOM-021-ENER/SCFI-2008 Energy efficiency and user for room air conditioners. Limits, test methods and labeling.	2008	2000[10]	1994/5

As Table 1 shows, there have been updates to all classes of residential refrigerators and air conditioners in the period 2008-2014. However, efficiency parameters for the refrigerator standard of 2012 and the room air conditioner standard of 2008 are virtually identical to the specifications laid out in the previous regulation. Exceptions to this are:

1) The addition of product classes in the refrigerators standard (NOM-015-ENER-2012), including:

a) Class 5A: refrigerator-freezer with bottom-mounted freezer with automatic through the door ice dispenser

b) Class 10A: chest freezer with automatic defrost

[8] Recent NOMs documents can be found at: http://www.conuee.gob.mx/wb/Conuee/normas_de_eficiencia_energetica_vigentes

[9] Available at http://www.clasponline.org/en/Resources/Resources/StandardsLabelingResourceLibrary/2006/~/media/Files/SLDocuments/2006-2011/2006-07_MEPSLabelTestProcedureForRefrigeratorsAndFreezers.pdf

[10] Available at http://legismex.mty.itesm.mx/normas/ener/ener021.pdf

2) The introduction of a voluntary 'high efficiency' refrigerator class for an appliance having an energy consumption < 90% than the maximum allowed by the standard.

The SEAD team concluded that, with the exception of the introduction of a voluntary 'high efficiency' class of refrigerators[11], there has been no significant update for refrigerators since 2002/3, a period of 11-12 years[12]. Furthermore, we observed no significant update for room air conditioners since 2000, a period of 14 years. On the other hand, the standards implemented in 2002/3 for refrigerators and 2000 for room air conditioners were relatively stringent standards for the time period, corresponding generally to minimum energy performance standards (MEPS) issued only a few years earlier in the United States.

Finally, CONUEE implemented a split-system room air conditioner standard in 2010/11. This standard was defined independently from the U.S., which includes mini-split in its central air conditioning regulations. The impact of this standard on the Mexican market was therefore unknown before undertaking the study, although ex ante analysis by CONUEE was performed. Therefore, the study was defined to concentrate on (1) the refrigerator standard of 2002/3, (2) the window air conditioner standard of 2000 and (3) the split-system air conditioner standard of 2010/11.

Approach and Methodology for Impact Analysis

The analysis of impacts of Mexican standards in this study followed a bottom-up approach. While the impacts of such a national appliance energy efficiency program can be significant in terms of overall electricity demand, the multitude of drivers of this "macro" parameter makes it difficult to isolate effects of the program. Instead, we decided to attempt the measurement of concrete observed effects for specific product classes affected by regulations, such as changes in average energy consumption, and calculate impacts to date as well as future impacts according to projections of electricity demand.

A significant amount of data and variables were required to characterize the market and the usage for the period of analysis. The data needed to execute the current study are largely the same as those used for

[11] The new "high efficiency" class identified in the NOM should not be confused with the Sello FIDE, a voluntary label for high efficient products awarded by the Fideicomiso para el ahorro de energía eléctrica (FIDE).

[12] Additional impacts from the introduction of the high efficiency classes were not accounted in this study.

the previous study carried out by LBNL, CONAE and IIE (Sanchez, McNeil, Pulido et al.). These data are summarized in the Appendix of that report. Variables collected by IIE are summarized in Table 2 according to type.

Market overview of products under analysis

Table 2 – Data collected for financial and power sectors, and product specific market, energy and financial variables

Variable	Source	Variable	Source
Financial Variables		Product Specific Market Variables	
Interest Rate	Banco de México3	Product Lifetime	Manufacturer Assumption/ international reference
Discount Rate	SHCP, CFE	Annual Sales	Manufacturers
Exchange Rate	Banco de México	Market Growth Rate	ANFAD
Power Sector Variables		Product Specific Energy Variables	
Marginal Electricity Cost	CFE	Use Factor	Assumption IIE-CONUEE/ Manufacturers /CFE
Marginal Demand Cost	CFE	Coincidence Factor	Assumption IIE-CONUEE/ Manufacturers /CFE
Transmission and Distribution Losses	CFE	Unit Energy Consumption / Efficiency	ANCE
Capacity Losses in Peak Period	CFE	Product Specific Energy Variables	
		Equipment Prices	IIE
		Manufacturing Costs	Manufacturers
		Equipment Certification Costs	ANCE

The refrigerator market in Mexico more than doubled in size in the period 2000 – 2014, from 10,593 million Mexican pesos in 2000 to 23,405 million Mexican pesos in 2014[13]. About 90 – 95% of refrigerators

[13] Euromonitor 2014.

sold in Mexico are manufactured domestically. Assembled products (imported parts and local assembly) account for the remainder and are mostly high-end products with larger capacities. Figure 1 shows sales in thousands of units for the two main types: refrigerators and refrigerators-freezers. Mexico also exports part of its domestic production. Mabe, a major refrigerator manufacturer, with 35% of the domestic market, exports to more than 60 economies in Europe, the Middle East, Latin America and North America (under various brand names).

The market for split and window air conditioners grew eight-fold in the same period, from 744 million Mexican pesos in 2000 to 6,127 million Mexican pesos in 2014[14]. Almost all of the air conditioners sold in Mexico are imported. Sales in thousands of units for the two main types - windows and split air conditioners - are also shown in Figure 1.

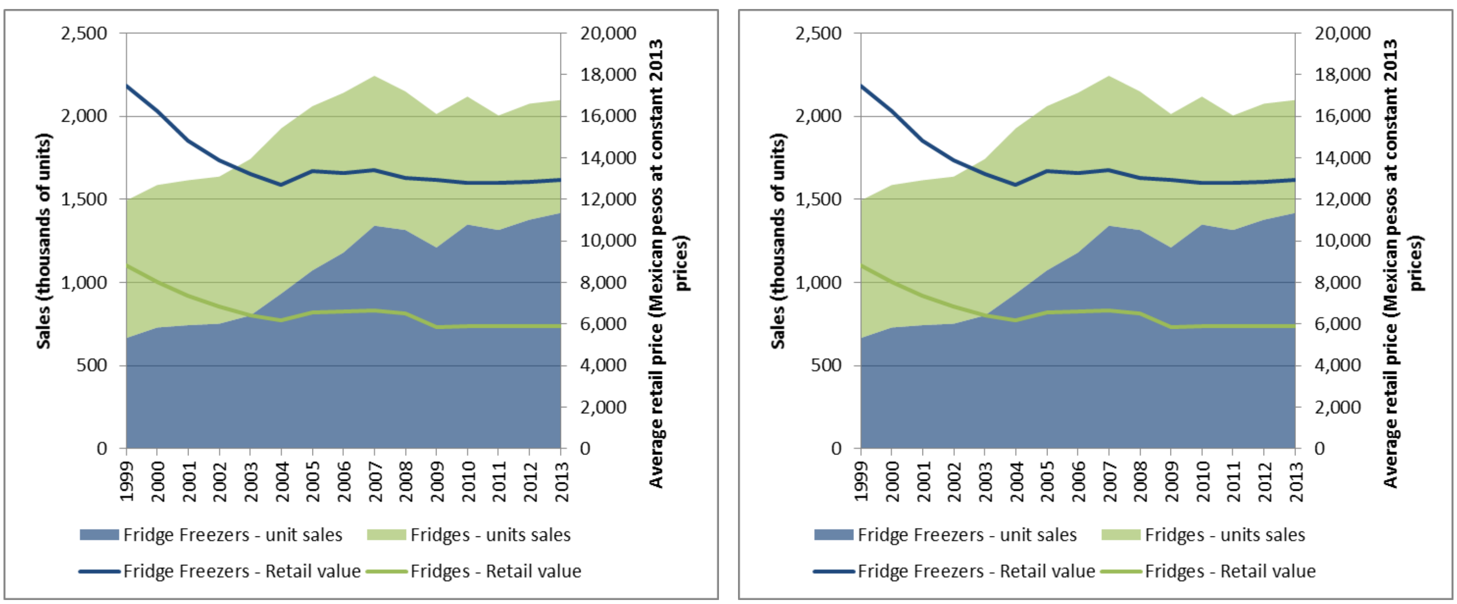

Figure 1 – Annual sales and average retail price for Refrigerators (left) and Air Conditioners (right)[15]

[14] Euromonitor 2014.

[15] Euromonitor 2014.

Determination of Efficiency Improvement

The method followed for calculation of energy savings relies on determination of a several basic parameters. Key among these is an assessment of the average energy consumption of new equipment entering the market each year. The regulation forbids the sale of products that do not meet the minimum requirements, but does not impact equipment already operating, commonly referred to as existing stock. From a data availability perspective, evaluation of base line efficiency of appliances sold in a given market and the impact that regulations have on them is one of the main challenges of performing an impacts analysis. Fortunately, Mexico's government requires that manufacturers register all products to be sold with its main certification agency, the Association for Standardization and Certification (known by its Spanish acronym ANCE). ANCE maintains a database of all products registered, with the date of registration, the efficiency metric according to defined test procedures, and other technical parameters of the product, such as capacity. The ANCE database can therefore be used to provide a time series of annual "snapshots" of the efficiency of the market for specific products, and it was used in this analysis to calculate the baseline and the average unit energy consumption. However, ANCE's database provides the energy consumption / efficiency of each model for sale, but gives no information on the market share of each model.

Refrigerators and Refrigerator-Freezers – As in the United States, the refrigerator category is broken down into a number of product classes for the purposes of energy efficiency determination. The Mexican NOM for 2002 defined 10 product classes; the most popular classes and their market shares are shown in Table 3.

Table 3 – Market share of main refrigerator product classes[16]

Class	Description	Market share in 2014
1	Refrigerator manual defrost or semi-automatic	8%
3	Refrigerator-freezer with automatic defrost (top mounted)	80%
5	Refrigerator-freezer with automatic defrost (bottom mounted)	4%

[16] Data gathered by IIE in support of the project

7	Side by side refrigerator-freezer	3%
11	Compact refrigerator or refrigerator-freezer with manual defrost	5%

However, two product classes account for 88% of the total Mexican market:

- Product Class 1 – Refrigerators and Refrigerator/Freezers with manual, or semi-automatic defrost.
- Product Class 3 – Refrigerator/Freezers with automatic defrost and top-mounted freezers with no through-the-door ice, and all refrigerators with automatic defrost.

These product classes have a high degree of correlation with the general categorization of refrigerator-only vs. refrigerator/freezers, but the mapping is not exact due to the presence of side-by-side and bottom-mount freezer units and, to a lesser extent, the presence of auto-defrost refrigerator-only units. Freezer-only units constitute less than 4% of the market and are not included in the analysis. According to a purchased market research database (Euromonitor 2014), the market share of refrigerator/freezers is growing steadily, from 46% in 2000 to 64% in 2010.

Unfortunately, the ANCE database does not record the exact product class of each model. However, the two product classes were found to be well-separated in terms of energy consumption. More precisely, it is unlikely that refrigerators in Product Class 3 (Auto-Defrost Refrigerator + Refrigerator/Freezer) meet the MEPS for Product Class 1 (Manual Defrost Refrigerator Only), so all refrigerators meeting the standard were assumed to belong to the Product Class 1 category, others being categorized as Product Class 3. While this method risks introducing some bias in the measurement, the energy regimes of the level of overlap was judged to be small.

Figure 2 shows the results of taking the average of the energy measurement of each category considering the above assumptions (solid markers). The solid lines represent the baseline and post-standard efficiency as a simple average over all years before and after standard implementation in 2003. In this representation, we have assumed that efficiency is constant both before and after standard implementation. This is a somewhat crude assumption, however, the statistical sample is not sufficient to establish this definitively, and there is no visible trend in either direction. Still, a drop in energy consumption is clearly visible in both product classes. Manual Defrost Refrigerators (Product Class 1) show average efficiency improvement of 17% and Auto-Defrost Refrigerators/Refrigerator-Freezers (Product Class 3) show average efficiency improvement of 27%. These levels of improvement correlate well with the expected reduction based on comparison of parameters defined by the 2003 standard relative to the 1997 standard. In other words, while there are significant uncertainties on the measurement, the best discernable observation indicates that standards impacted the market more or less in the way that they were designed to.

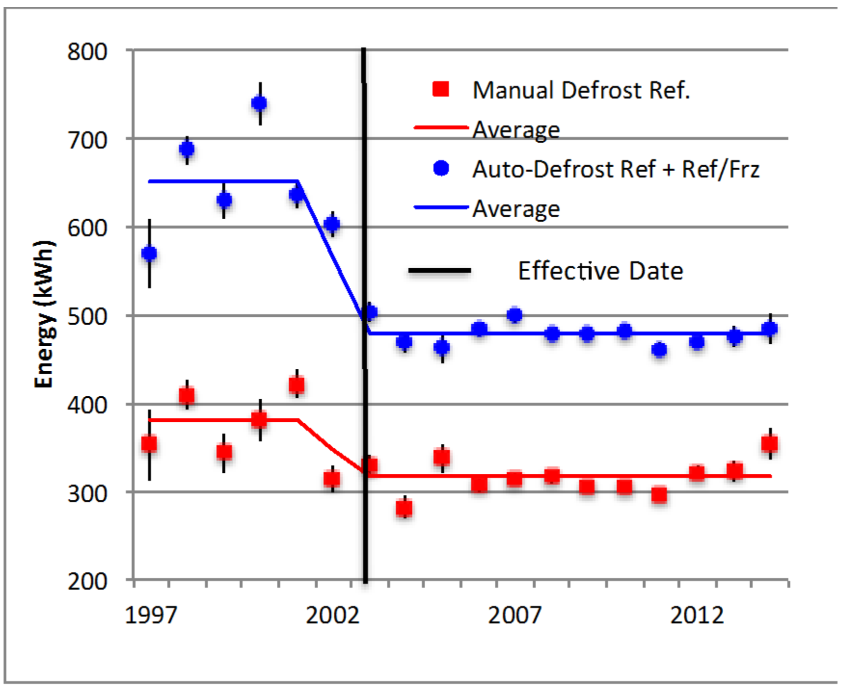

Figure 2 – Market Average Efficiency for Refrigerators

Window Air Conditioners – As in the case of refrigerators, the ANCE dataset does not clearly define the product classes for air conditioners. Product classes for window air conditioners are primarily defined by cooling capacity. However, there are separate product classes for units without louvered sides, and for reversible-mode capable units that provide heating as well as cooling. Both of these product classes are believed to be small in Mexico. Table 4 shows only the main type of window units (with louvered sides, and without reversible-mode) and the various classes considered under the scope of this analysis.

Table 4 – Window ACs main product classes

Type	Class	Description
with louvered sides, and without reversible-mode	1	CC < 1758t
	2	1759t < CC < 2343t
	3	2344t < CC < 4101t
	4	4102t < CC < 5859t
	5	5860t < CC < 10600t

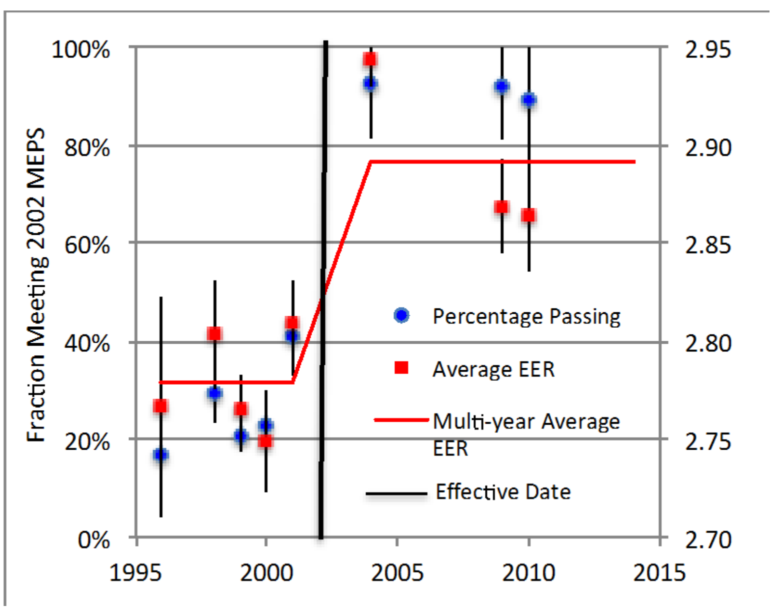

Figure 3 – Market Average Efficiency for Window Air Conditioners

Figure 3 shows that, similar to the refrigerator case, the air conditioner timeline shows a clear 'signal' for improvement of efficiency (after standard adoption), but little evidence of a trend on either side of the implementation year. It should be noted, however, that statistics are quite poor in the window air conditioner case. Figure 3 shows two parameters for a dataset of combined product classes. First, the apparent percentage of compliance with the new standard is shown in blue. Compliance is 40% or below in each year before the standard implementation date of 2000. After that date, compliance is close to 100%. Because of the presence of minor product classes with less stringent standards, compliance rates below 100% do not necessarily imply non-compliance. A resulting shift in the average efficiency of AC products in the market due to the standard is also visible, with the energy efficiency ratio (EER[17] in W/W) improving from 2.78 to 2.89, or 4% between 2002 and 2014. However, this improvement is relatively small compared to the refrigerator case. Again, the market performance roughly tracks the change in requirements of the standards, since window AC standards were expected to provide about 7% efficiency improvement[18].

Split-System Air Conditioners – This type of unit has in recent years become the norm for residential cooling applications throughout the world, with the exception of the North American market. In Mexico, split systems have gained significant ground, from less than 100,000 units in 2000 to more than 400,000 in 2013, as shown in Figure 1. As a result of this rapid growth in market share, CONUEE implemented the first standard for split system air conditioners in 2011. Because certification is required only for products already subject to standards, there were no data in the ANCE database pre-dating the standard, making an assessment of the baseline difficult for this period. Therefore, estimates of unit reduction in energy consumption for split systems were taken from CONUEE's own cost-benefit assessment analysis[19]. These estimates showed an average improvement of 7.3% over all capacities.

Annual Energy Consumption

In the case of refrigerators, the efficiency metric is an estimated annual consumption according to the approved test procedure. However, actual field energy consumption of refrigerators is not the same as that estimated by the test procedure (Greenblatt, Hopkins, Letschert et al. 2013). Nonetheless, since actual usage in Mexico is unknown, the test procedure estimate is taken as a proxy. For air conditioners,

[17] The EER is the ratio of cooling heat transfer to power input, measured at full cooling capacity.

[18] Phase II of the 1997 NOM requires EER of 2.637 W/W for units between 2344 and 4101 W cooling capacity, while the 2000 standard requires EER of 2.87 W/W for units of this size without louvered sides. This is believed to be the largest product class for window air conditioners.

[19] Provided by Mexico's Federal Commission on Regulatory Improvement (COFEMER) Available at http://www.cofemer.gob.mx/

the efficiency metric is energy efficiency ratio (EER). This parameter provides a measurement of efficiency[20], but does not fully determine energy consumption, which is crucially dependent on hours of use. Data on air conditioner use patterns are scarce, and therefore assumptions for hours of use present the main uncertainty for energy consumption. Anecdotal evidence suggests that the use of window air conditioners is still uncommon in the central highland areas of Mexico, but is concentrated in hot coastal areas and near the northern areas of Mexico – along the border with US, where climatic conditions drive high hours of use. CONUEE's own cost benefit analysis assumes 2880 hours per year, corresponding to usage of 8 hours per day throughout the year. We made a somewhat more conservative assumption of 6 hours per day, or 2180 hours per year. Energy consumption is calculated using these assumptions, coupled with cooling capacity market shares provided by CONUEE.

Energy consumption estimates are subject to several caveats, including the deviation between test measurements and field usage and the uncertainty of usage effects. Rebound effects are also neglected, although we acknowledge they may be important. In the case of refrigerators, usage-driven rebound is unlikely, since the refrigerator is generally operating at all times. Refrigerator rebound effects could include consumer decision to buy larger units. Trends in refrigerator capacity show no evidence of that, however. For air conditioners, rebound effects in usage could be more pronounced if consumers have a clear perception that they are using high-efficiency air conditioners and that these are much less expensive to operate.

In addition, a critical assumption in this type of impact analysis is the construction, implicit or explicit, of a counterfactual. Guided by the Figures 2 and 3, which do not clearly show a trend in efficiency either before or after the standard, we assumed that efficiency would have remained constant in the absence of a standard. While this assumption seems justified in light of the data, we recognize that multiple effects could drive the market toward higher or lower efficiency. Factors towards higher efficiency include consumer demand for high efficiency products and labeling programs. On the other hand, addition of energy-consuming features could reduce overall efficiency. The observed data suggests that any such

[20] EER is also not an accurate metric for variable-speed air conditioners, which optimize efficiency by operating at partial load

effects did not dramatically pull the market in either direction during the time period studied. In general, such assumptions and observations should be made on an ad hoc basis for each program evaluated. Finally, the calculation of average market efficiency did not use a weighted average of each model's efficiency with its market share, as ANCE's database does not provide information on market share. While the model-based average surely deviates from this ideal, the degree of deviation is unknown.

Sales Tracking and Stock Turnover

National energy savings from efficiency standards is calculated under the premise that the average product sold each year after the standards implementation was more efficient than it would have been in the absence of standards. Therefore, in the first year of the standard, energy savings is equal to the total number of products sold multiplied by the average annual energy saved by each product. In the second year, a new cohort of higher efficiency products enters the stock, increasing savings while the first cohort continues to save energy. In general, projections of energy savings calculated in this way must take account of products removed from the stock. In the case of the standards considered here, savings are calculated through 2014, 12 years after implementation for refrigerators, fourteen years after implementation for window air conditioners and only 3 years after implementation for split system air conditioners. Since this time period is less than the expected product lifetime of 15 years, product retirements are neglected. Market sales for the period (implementation dates to 2014) for refrigerators and air conditioners are provided by (Euromonitor 2014).

National Impacts Results

Figure 4 shows the resulting electricity savings in TWh from refrigerator and air conditioner standards in Mexico (left axis), through 2014. In addition, reduction in peak load is calculated using product-specific use factor, coincidence factor and system transmission and distribution losses (right axis). This calculation, and the parameters used are detailed in (Sanchez, McNeil, Pulido et al. 2007).

The theory of cost-benefit analysis of efficiency standards holds that standards may raise the overall prices that consumers pay for appliances and equipment because they eliminate inefficient and generally cheaper products from being sold. On the other hand, more efficient appliances and equipment use less energy and therefore reduce operating costs and consumer utility bills. If standards are implemented effectively, additional capital costs for the purchase of appliances are at least compensated by utility bill reductions, thereby providing a net positive benefit to consumers. This is the case for the Mexican standards program. As detailed above, efficiency standards have contributed to increase the average efficiency of Mexican refrigerators by 17% or 27% depending on product class. Efficiency improved about 4% for window air conditioners, and over 7% for split system air conditioners. All told, these gains in efficiency have saved Mexican households 34 TWh since 2002. This level of avoided electricity use corresponds to 40 billion pesos[21].

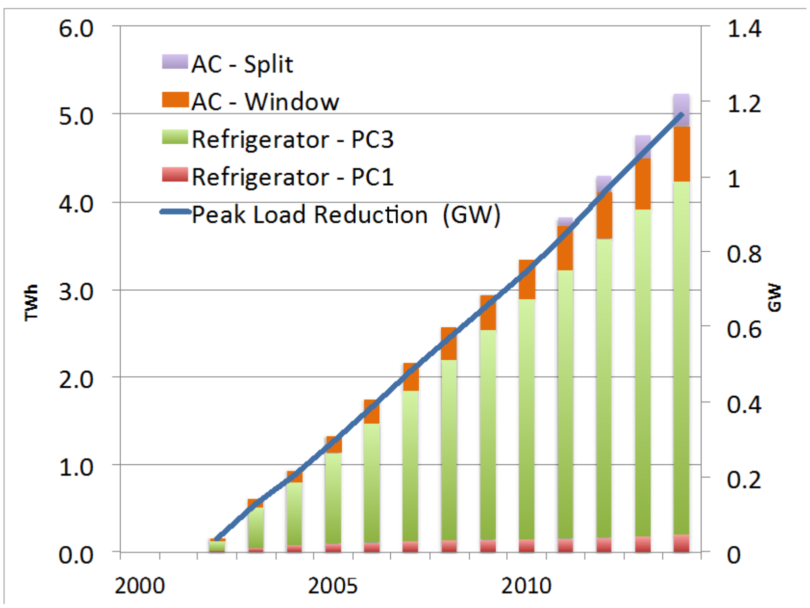

Figure 4 – Annual Energy Savings and Peak Load Reduction for Refrigerators and Air Conditioners

Interestingly, appliances retail prices tracked over the period between 2000 and 2013 do not show a detectable increase in the costs for refrigerators and air conditioners, as shown in Figure 1. In fact, one observes an overall price drop in the early years of the forecast, followed by a leveling. In real terms, prices for these products have been pretty constant in the recent past. A possible explanation for this observation is that manufacturers traded off appliance features in order to implement expensive efficiency options. This seems unlikely, however, since appliances features seem to be constantly increasing and

[21] In 2014 pesos

there is little evidence that durability and quality have been adversely affected by efficiency improvements over the years, as reported by interviews with manufacturers. A more likely explanation seems to be that manufacturers, domestic and international trade partners, quickly adapted to efficiency requirements and took advantage of economies of scale and other general improvements in manufacturing processes to keep prices down. Whatever the cause, historical evidence suggests that Mexican consumers have benefitted from standards on these two products without a significant penalty in the form of increased appliance prices.

Non-Energy Benefits

End users of the regulated equipment were not the only part of Mexican society to benefit from efficiency standards. We estimate that the implementation of the standards analyzed reduced peak generation capacity needs in Mexico by 1.2 GW, equivalent to saving the need for $160 million USD in capital investment[22]. Furthermore, retail electricity is still highly subsidized in segments of Mexican society. Therefore, in addition to the savings to ratepayers, efficiency standards benefit the national treasury by reducing overall residential electricity consumption and, thereby the amount of money the government spends on electricity subsidies.

In addition to the energy savings impacts quantified in the previous sections, this study aimed to document other related impacts on the private sector from the introduction of the standards under analysis. Interviews with representatives from certification bodies and appliance manufacturers were conducted in order to document their opinions on the standards development process, impacts on product development and commercialization, competitiveness of Mexican-made appliances in the global market, and compliance infrastructure (testing laboratories). The organizations interviewed represent 35% of the refrigerators market[23] (Mabe) as well as the largest certification body in Mexico (ANCE). Views and opinions expressed in those interviews are documented in the following sections.

[22] Using a capital cost of $133/kW from (Sanchez, McNeil, Pulido et al. 2007)

[23] Refrigerators are manufactured in Mexico while most air conditioners are imported.

Stakeholder participation in the NOMs development process

Mexican law requires public bodies to be inclusive in their regulatory exercises; this means stakeholders are encouraged to participate through various mechanisms. CONUEE's regulatory process for developing NOMs includes an advisory committee[24] with participation from stakeholders from both the public and private sector, representing a broad range of interests from industry, government, academia and civil society.

According to interviewed stakeholders, NOMs development is considered by the private sector to be an open and transparent process, where enough information is made available by CONUEE, and manufacturers' voices are heard. In particular, a MABE representative commented that: "CONUEE is an organization recognized for being inclusive in the regulatory process. The advisory committee has also been characterized by its full transparency and inclusiveness"[25]. The manufacturing sector also believes that CONUEE is doing a good job with developing the necessary impact studies, specifically the cost-benefit studies, to achieve a better balance between efficiency and competitiveness.

Impacts of NOMs on product development and commercialization

In general, the introduction of NOMs is seen as positive by those interviewed: it creates a level playing field where manufacturers can compete under similar conditions, sending a clear signal to industry that investments in energy efficiency to upgrade technology and product manufacturing processes are worthwhile while inefficient products are eliminated from the market.

The announcement or publication of NOMs has often resulted in technology changes, as manufacturers asserted they have worked to improve products by including new components or more efficient parts. For instance, the cooling system in refrigerators has become more efficient.

[24] Comité Consultivo Nacional de Normalización para la Preservación y Uso Racional de los Recursos Energéticos - CCNNPURRE

[25] Pablo Moreno, MABE representative.

According to a certification body, "standards and regulations are essential for innovation, as they provide a solid base for product improvement without sacrificing performance and with consideration of efficiency parameters that are especially important in the current context"[26].

Manufacturers are concerned about developing more efficient products. Since the introduction of the first NOM for refrigerators in 1995, energy consumption has improved by over 35%. Today, a Mexican consumer can purchase a better, more efficient product according to those interviewed.

The introduction of NOMs has also led to an increased awareness of energy efficiency among Mexican consumers. According to the latest market intelligence report from MABE, energy efficiency is now one of the five most important factors considered by the Mexican consumer when purchasing a refrigerator. The energy efficiency levels displayed on the energy label have helped by making this information more readily available and by facilitating comparison among products.

Impacts of NOMs on competitiveness of Mexican products in the global market

An important outcome of the introduction of NOMs has been preventing that repaired and/or rebuilt products enter the Mexican market. On the other hand, some technologies in the global market are substantially different and the Mexican consumer is not willing to pay yet for that same quality or efficiency. According to a representative from a certification body, as Mexican standards become more aligned with international standards, these barriers will be removed resulting in increased access to those technologies by the Mexican consumers.

Regarding exports, the platform (production lines) for local consumption or exports is not the same in most cases. Refrigerators that are exported to North America must comply with the most recent version of the standard which requires improvements up to 30% higher than the current efficiency levels in Mexico. The cost associated with this shift in technology can only decrease with economies of scale (i.e., larger sales). In the US, middle class families (and higher income families) account for a significant market share, thus creating a large demand. This is not the case in the Mexican market, where most of the sales are driven by

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[26] Abel Hernandez, ANCE's Director General.

the base of the pyramid composed of lower income families. This means that consumer preferences and requirements in terms of capacity are different; in Mexico, average refrigeration capacities are in the range of 9 to 14 cubic feet, which are lower than the average capacities of units sold in the US. Consumers of large capacity refrigerators can more easily absorb an impact in price due to a shift in technology, whereas consumers of the smaller capacities are potentially affected by this price differential, according to manufacturers.

A solution for this problem in Mexico is to find ways to increase demand in order to reduce price differentials by creating economies of scale. CONUEE has been sensitive to these challenges, and it is supporting industry in its efforts to develop a NAMA[27] for refrigerators that will "introduce on a nationwide scale and at an accelerated pace the newest more energy efficient technologies"[28], same way an incentives program will do.

According to manufacturers, exports to Central America have been affected negatively after the introduction of the NOMs, as most countries in the region do not require compliance with energy efficiency standards and conformity assessment processes are not in place. Products manufactured in Mexico, complying with NOMs requirements, are not currently competitive in a region where products coming from markets in Asia are offered at a lower price (at the expense of efficiency and other characteristics). The industry is very proud of the achievements resulting from energy efficiency regulations in Mexico, as stated during the interviews: a very robust regulatory framework, a conformity assessment process in place, and a proper laboratory infrastructure. But, in a region where this is not the common denominator in most economies, Mexican manufacturers are at a competitive disadvantage.

There are ongoing efforts in the Central American region to develop a unified approach towards energy efficiency regulations, and existing product testing infrastructure in Mexico, Costa Rica and Colombia could

[27] National Appropriated Mitigation Actions, NAMAs, refer to any action that reduces emissions in developing countries and is prepared under the umbrella of a national governmental initiative.

[28] http://www.thepmr.org/system/files/documents/Mexico_MRP_Final_Refg_19-02-2013.pdf

be useful in avoiding the need for expensive infrastructure to support appliance efficiency compliance activities.

Impacts of NOMs on conformity assessment infrastructure

Mexico's current infrastructure for the evaluation of conformity of all NOMs includes 56 testing laboratories, 7 certification bodies and 1 accreditation agency.

The introduction of NOMs has mostly positive impacts to the conformity assessment infrastructure, according to those interviewed. In general, a new regulation or a new or revised test method translates into time and resources for developing the testing capacity and evaluation of performance according to the requirements. As such, investments in response to these infrastructure and capacity needs result in certifying bodies and testing laboratories modifying their strategies.

Mexico's largest certification body, ANCE, did not have any laboratory capacity at the beginning of the period of analysis (1995) and today it has the largest testing capacity in the country. It currently provides services to the Mexican market for the three products covered in this analysis, in addition to responding to testing requests from international bodies in Central America and Asia, with the same infrastructure and equipment.

Conclusions

This study found that the first update of refrigerator and air conditioner standards in the early 2000s saved approximately 5.2 TWh in 2014, equivalent to roughly two power plants. This savings represents approximately 2 percent of national electricity demand in 2012[29]. These standards were based on similar U.S. regulations at that time and were considered particularly stringent, especially the U.S. refrigerator standard that took effect in 2001. When introduced to the Mexican market, standards for refrigerators in general reduced the energy consumption of the main product class by 27%. Efficiency improvements from the secondary refrigerator product class and air conditioner standards were less in percentage terms, but

[29] Mexico's electricity consumption in 2012 was 246 TWh according to the IEA see http://www.iea.org/publications/freepublications/publication/keyworld2014.pdf

still significant. In particular, the recent standard on mini-split air conditioners may yet have strong impacts, as the market for this high-energy intensity equipment is growing in Mexico. For the specific standards studied, therefore, we can make the following conclusions:

- Minimum energy performance standards (MEPS) in Mexico seemed to have an impact on the market to a degree roughly corresponding to the expected impact of the standard, that is, the standard was successfully implemented.
- Past alignment of Mexican standards with those of the United States has been a successful policy for Mexico, allowing it to move the efficiency of its domestic markets significantly, while providing a benefit to Mexican manufacturers seeking to compete in a wider North American market.
- While refrigerator and air conditioner standards passed in the early 2000s moved the market significantly, those of the past few years were virtually identical to the previous version. Therefore, there may be further opportunities for energy savings and related benefits to aligning Mexico's NOMs with current US MEPS.
- The introduction of NOMs has created a robust regulatory framework and laboratory infrastructure that facilitates Mexican manufacturers' participation in the global market.

Energy efficiency standards, which originated in the 1970s as a response to the global energy crisis, were created primarily to bolster energy security. By now, however, it has become clear that countries reap multiple benefits from efficiency programs such as Mexico's appliance standards. Mexico's experience shows high levels of energy savings at low cost, providing economic benefits to consumers, increasing access to energy services, increasing the treasury's coffers through reduction of electricity subsides, and providing a competitive edge to its industry. While Mexico's experience with efficiency standards is exemplary, it is by no means unique. Many countries can benefit in much the same way as Mexico has. In particular, Mexico may serve as an inspiration and best practice particularly for developing countries in Latin America that do not yet have efficiency programs, or are just now embarking on them.

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