Economic and Energy Impact Assessment of Energy Efficiency Standards in México

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ABSTRACT

This paper presents energy and economic impacts from four minimum efficiency appliance standards in effect in México since 1995. The appliances studied are: household refrigerators, room air conditioners, squirrel cage induction motors and clothes washers. We describe the data collected and analytical methodology for each appliance, and calculate energy savings and financial impacts for consumers, utilities, and manufacturers.

This retrospective analysis represents a significant improvement over original forecasts of potential impacts from standards. The evaluation methodology and its results are based on data obtained from manufacturers, testing agencies, utilities, industry groups, and government financial institutions. The applied methodology was validated by the energy efficiency standards working group comprised of Comisión Nacional para el Ahorro de Energía (CONAE) and The Collaborative Labeling and Appliance Standards Program (CLASP) through technical experts at Lawrence Berkeley National Laboratory and the Instituto de Investigaciones Electricas (IIE).

From the analysis of ten years of the standards setting program for these four products, it has been found that a reduction in electric energy consumption for end users equaling approximately 45.8 TWh was realized. This result indicates a significantly higher savings than were originally forecast, largely because manufacturers produced products that exceeded the minimum efficiency mexican requirements in most cases.

The energy saved by these four products over the period 1995-2004 represents almost a third of the electricity generated in Mexico during 2005. We estimate that this savings investments in the energy supply infrastructure equivalent to 2800 MW, which corresponds to about 7% of installed capacity for electrical generation. The main environmental impact of standards was a 30 GTon decrease in CO_2 carbon emissions from fossil fuel power plants.

In addition to the evaluation of overall impacts, the results of this study are significant in demonstrating a detailed methodology for use in analyzing additional products and future standards, and a successful example for market efficiency monitoring programs in other countries.

Introduction

The Mexican energy efficiency standards program began in 1995. It was developed by the National Energy Savings Commission (CONAE) with public and private support, as well as assistance from research organizations, manufacturers and consumers associations. Since 1995, the program has developed more than 20 energy efficiency standards for household appliances, lighting systems and air conditioning equipment.

The first set of minimum efficiency performance standards (MEPS) was developed for four products: household refrigerators, room air conditioners, motors and clothes washing

machines. These standards took effect in 1995. By law, they are updated every five years (with updates almost always resulting in more stringent efficiency requirements)

Assessment Objectives

As a result of the program evolution, new standards have promulgated. Greater manufacturer experience has allowed for faster compliance with standards, with improvements in product quality and decreases in cost. Also, the process has encouraged more stakeholders to become involved in energy efficiency standardization, with the result that technical and economic data for products (generated by these stakeholders) are now easier to obtain. In the same manner, the evaluation method for measuring the impact on national energy savings from implementation of energy efficiency standards programs has improved.

In Mexico the Federal Law of Metrology and Standardization (LFMN) establishes characteristics of a mandatory standard. This legislation requires that any new standard be technically feasible and economically beneficial for those likely to be impacted, as well as for the country as a whole. To address this requirement, the mexican Electric Research Institute (IIE) and CONAE have worked together on the development of an assessment impact methodology for energy efficiency standards.

Assessment Impact Model Validation Project

The methodology used for evaluating the energy efficiency standards setting program provided an estimate of the cost benefit ratio for each participant in the process, and it estimated the energy savings and environmental benefits for the country.

The IIE has collaborated with CONAE since the beginning of the standards setting program. These entities carried out technical and economical studies for this standards setting process in addition to providing technical assistance in developing the methodology for the impact assessment.

The preliminary results from the impact assessment model concerning energy savings spoke to a need to validate the model through the participation of a third party, preferably an international organization specialized in the energy efficiency field. CONAE obtained the support of United States Agency for International Development (USAID) for financing the first part of the project, which consisted of validating the model. In this first phase, PA Consulting Group was assigned as USAID's administrative representative, and Lawrence Berkeley National Laboratory (LBNL) and the IEE were involved in the technical aspects of the effort.

The second phase of this project included using computer models to update the data in order to project the potential impact of implementing the proposed energy efficiency standards for the four products mentioned above. IIE made an analysis of the evaluation methodologies in collaboration with LBNL. In this analysis, the Mexican methodology was compared to those in the US. The result of this phase was a revised, validated model. For the development of the second phase of this project, the input data required to run the evaluation model was updated in order to obtain the energy and economic impacts.

Assessment Methodology

The assessment methodology to estimate the likely economic and energy impacts of implementing energy efficiency standards in Mexico was developed over many years of technical study. This research focused on studying the outcomes from Mexican equipment and appliance standards from 1995 to 2004. This research compares baseline unit energy consumption in 1994 to energy consumption in subsequent years, which are lower due to the impact of standards. National impacts are calculated by scaling unit values according to the number of units entering the stock in each year, according to product shipments.

Stakeholder Perspectives

In this analysis there are 4 different impacts to be evaluated: 1) the impact to the users, 2) the impact to the utility, 3) the impact to the manufacturer, and 4) the environmental impact

Energy savings to end users (households and businesses) are calculated by multiplying per unit annual savings for each product cohort by the total remaining stock in each year. Since the average equipment lifetime for all the products studied is considerably longer than the 10 year impacts period, a turnover accounting model was not necessary. End user operating cost savings equals site energy savings multiplied by per unit energy costs. Tariff structures were used to evaluate marginal per unit energy costs, according to the customer type (residential, commercial or industrial) appropriate to each product. Finally, we calculate the net financial benefit by subtracting additional first costs from operating cost savings. These costs are given by the average increase in retail price from more efficient products, multiplied by the shipments in each year. In order to calculate Net Present Value (NPV) of financial savings, the user viewpoint analysis uses consumer interest rates.

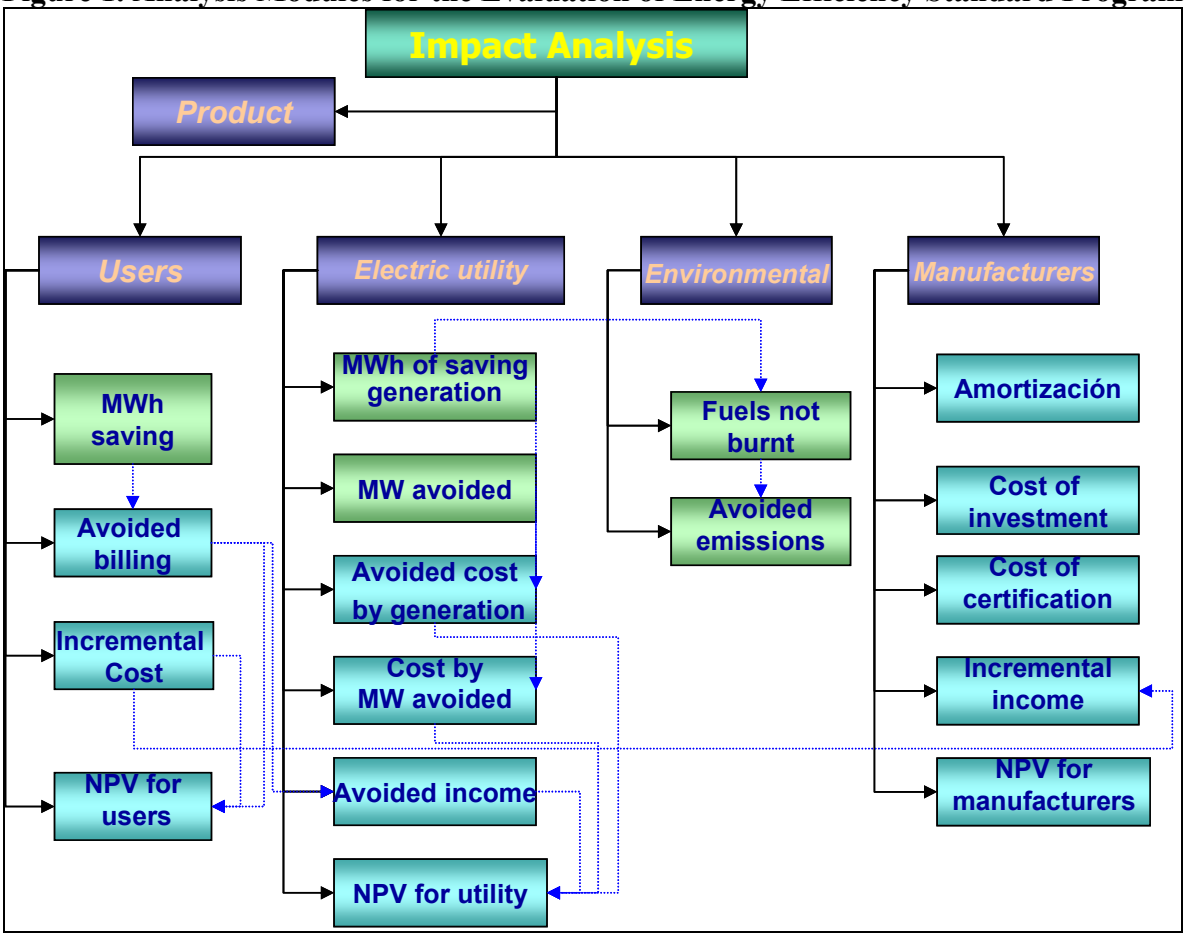
The utility viewpoint differs from that of the end user in two important aspects. First, utility energy savings and operating cost savings are calculated in terms of primary energy, that is, fuel input avoided due to energy savings in the home or business. Second, impacts on generating capacity are estimated by assessing the effect of end use savings on peak load. Financial impacts include the avoided cost of production, revenue losses from lower electric bills, and the avoided capital costs of increasing generation capacity.

The impacts of standards on manufacturers are that they are required to produce products utilizing a higher degree of efficiency technology. This generally increases per-unit costs, in the form of materials and labor. In addition, production of high-efficiency models may involve retooling and redesign costs. On the other hand, high-efficiency products generally demand a higher price in the market, thus increasing revenue to manufacturers.

Finally, the analysis explicitly considers the environmental impacts of standards. These are evaluated in the form of greenhouse gas emissions and other pollutants, namely CO_2, NO_x and SO_x emissions.

The impacts calculated for each viewpoint are summarized in the flow chart in Figure 1. In order to improve the evaluation process of the standards setting program, as well as obtain an international validation of the methodology for energy evaluation, this methodology was revised by the CLASP staff of LBNL and the IIE in a first stage, and then it was run with the revised model equipped with updated information in a second stage.

Figure 1. Analysis Modules for the Evaluation of Energy Efficiency Standard Program



Input Data

The current analysis represents a validation and refinement of the impacts forecast performed in 1997, which necessarily relied on a number of assumptions regarding market trends, prices, etc. Part of the refinement is due to the improved methodology described above. Another significant improvement is that the current analysis gains considerably from the use of data that has become available over the first 10 years of standards in México. These data can now be accessed because of the Mexican government's program of tracking efficiency of certified products. In addition, however, a great deal of data was gathered from stakeholders in the standards setting process, which now participate as part of an efficiency network centered around the standards program.

Efficiency data. The efficiency values correspond to products certified by the Mexican National Electrical Standards and Certification Association (ANCE), the entity authorized by law to expedite the certification of products and its compliance with energy efficiency standards. All products were tested in accredited laboratories. Equipment not having a certificate cannot be sold on the national market. Efficiency values were taken from certification data for 2167 refrigerators models, 620 room air conditioner models, 666 three-phase electrical motors, and 1350 clothes washer models from 1995 until 2004.

Retail prices and shipments data. Retail prices for each product sub-class were collected by a study performed by IIE. Shipments data (units sold) for each product throughout the analysis period were provided by individual manufacturers (Mabe, Vitro, Daewoo LG, Trane, York, Carrier, WEG, etc.), and manufacturer associations (Asociación Nacional de Fabricantes de Aparatos electrodomésticos (ANFAD) and Camara Nacional de Manufacturas eléctricas (CANAME)).

Power sector data. Electricity prices were evaluated in each year according to tariff schedules provided by the Federal Electricity Commission (CFE). Marginal rates were estimated as unit price per kWh for the highest usage block, according to the appropriate schedule: residential for refrigerators and washing machines, commercial for air conditioners, and industrial for motors. CFE also provided transmission and distribution loss rates and heat rates for each year.

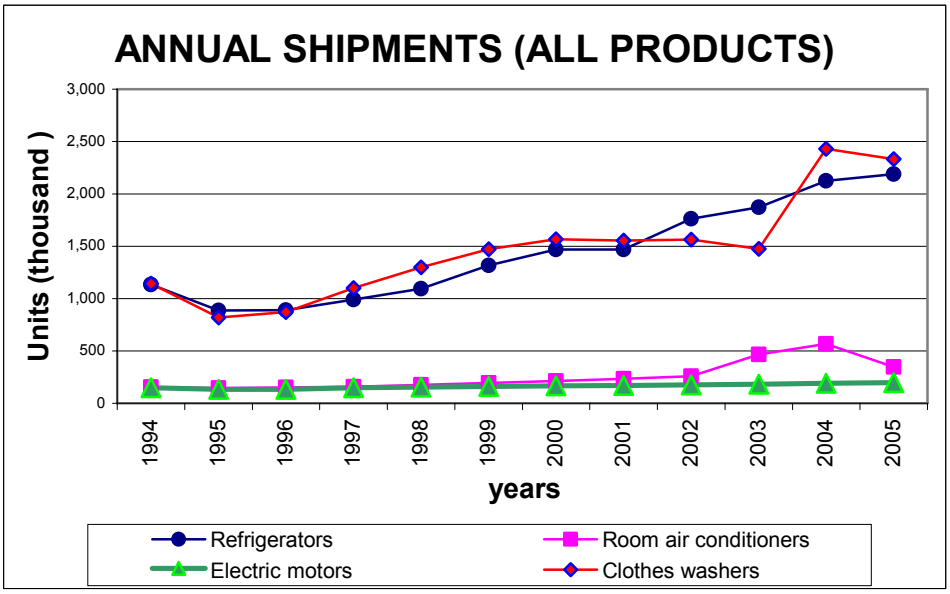
Financial data. Discount rates were calculated separately for end users, utilities and manufacturers. For end users, we used the average interest rate for investments (mutual funds). For utilities, the interest rate on capital investments was used (CFE), and for manufacturers, a typical expected rate of return on investments was used (ANFAD).

Impacts

Annual Shipments

The total number of units entering the Mexican market (shipments) was provided year by year by ANFAD and manufacturers from 1994 to 2005, and the market growth rate, which was provided by manufacturers and associations (ANFAD and manufactures) was 3% for refrigerators, 10% for room air conditioners; 5% for electric motors and 9.85% for clothes washers. These growth rates are quite high. In particular, they show that, while the market for refrigerators is largely saturated, the number of air conditioners and washing machines in homes and businesses is still increasing rapidly in México.

Figure 2. Evolution of Annual Shipments for All Products



Unit Energy Consumption

The basis of efficiency impacts for the four products studied are a series of MEPS and their updates, promulgated between 1994 and 2002. Table 1 summarizes these standards.

Table 1. Original MEPS and Updates 1994-2002

Official Mexican standards	Title
Original NOM-072-SCFI-1994 Update NOM-015-ENER-1997 Update NOM-015-ENER-2002	"Eficiencia energética de refrigeradores y congeladores electrodomésticos" Household Refrigerators and Freezers energy efficiency standard
Original NOM-073-SCFI-1994 Update NOM-021-ENER/SCFI/ECOL-2000	"Eficiencia energética de acondicionadores de aire tipo cuarto" Room air conditioners energy efficiency standard
Original NOM-074-SCFI-1994 Update NOM-016-ENER-1997 Update NOM-016-ENER-2002	"Eficiencia energética de motores de inducción de corriente alterna, tipo jaula de ardilla" AC. Induction motors, squirrel-cage energy efficiency standard
Original NOM-005-ENER-1996 Update NOM-005-ENER-2000	"Eficiencia energética de lavadoras de ropa electrodoméstica" Households electric clothes washers energy efficiency standard

Note: Except electric clothes washers, the energy efficiency values are similar to DOE settings

Mexican MEPS for these products significantly improved the efficiency of the market when they were originally implemented. With the recent updates, they are among the most stringent MEPS in the world. The Mexican government has made an explicit policy to harmonize its efficiency standards with those of the United States, which are generally quite stringent. Some of the initial standards were set to be equal to U.S. standards implemented several years earlier. By 2002, the Mexican standards for these four products were all in line with the current U.S.

standards. Mexican standards use efficiency test procedures identical to those mandated by the U.S. Department of Energy for its standards program.

The baseline for the analysis is given by the energy consumption or efficiency as reported before standards implementation in 1994. We assumed no improvement in base case efficiency over the analysis period. Figures 3 and 4 show the evolution of efficiency values for room air conditioners and refrigerators (the energy efficiency and consumption values before the standards and the evolution of actual test data efficiency).

Figure 3. Evolution of Consumption Values – Household Refrigerators

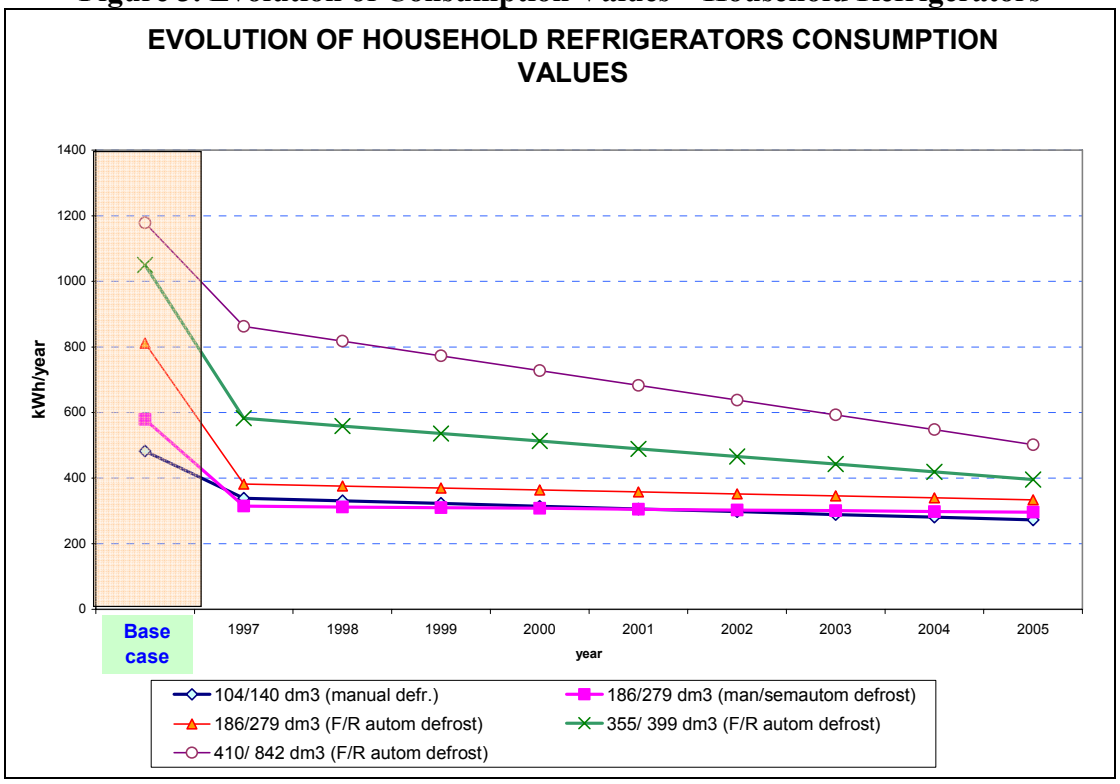
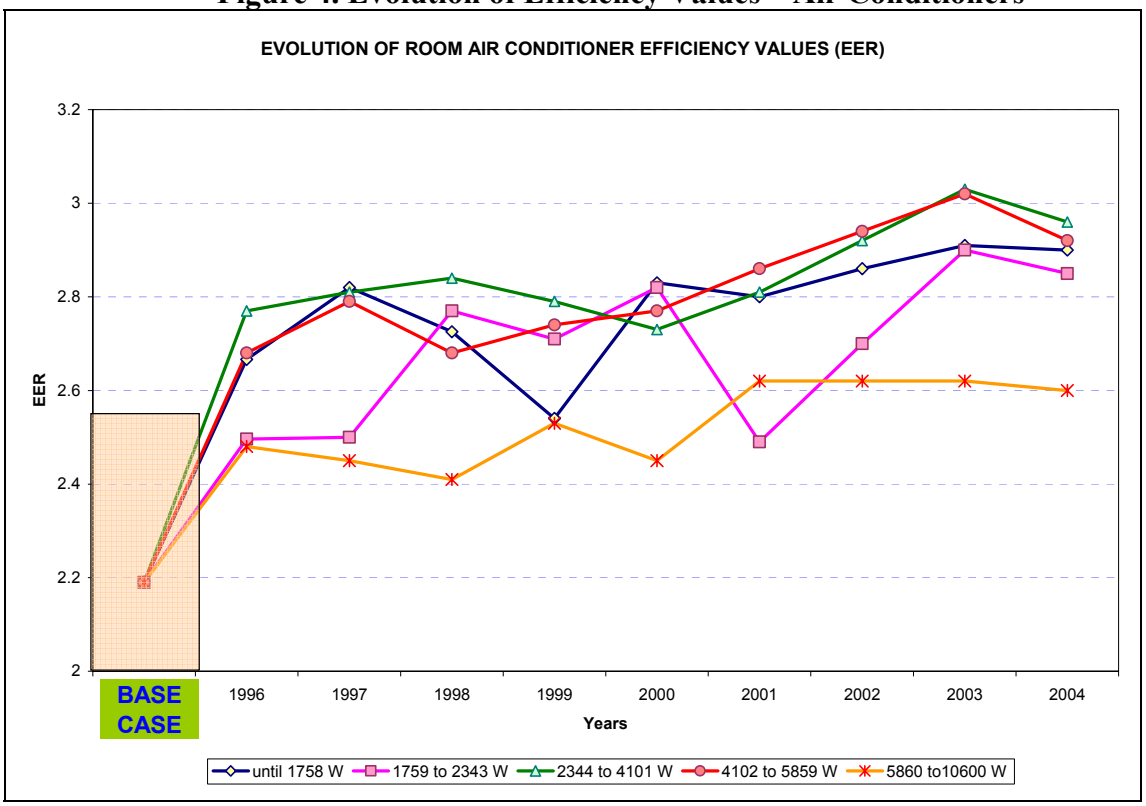


Figure 4. Evolution of Efficiency Values – Air Conditioners

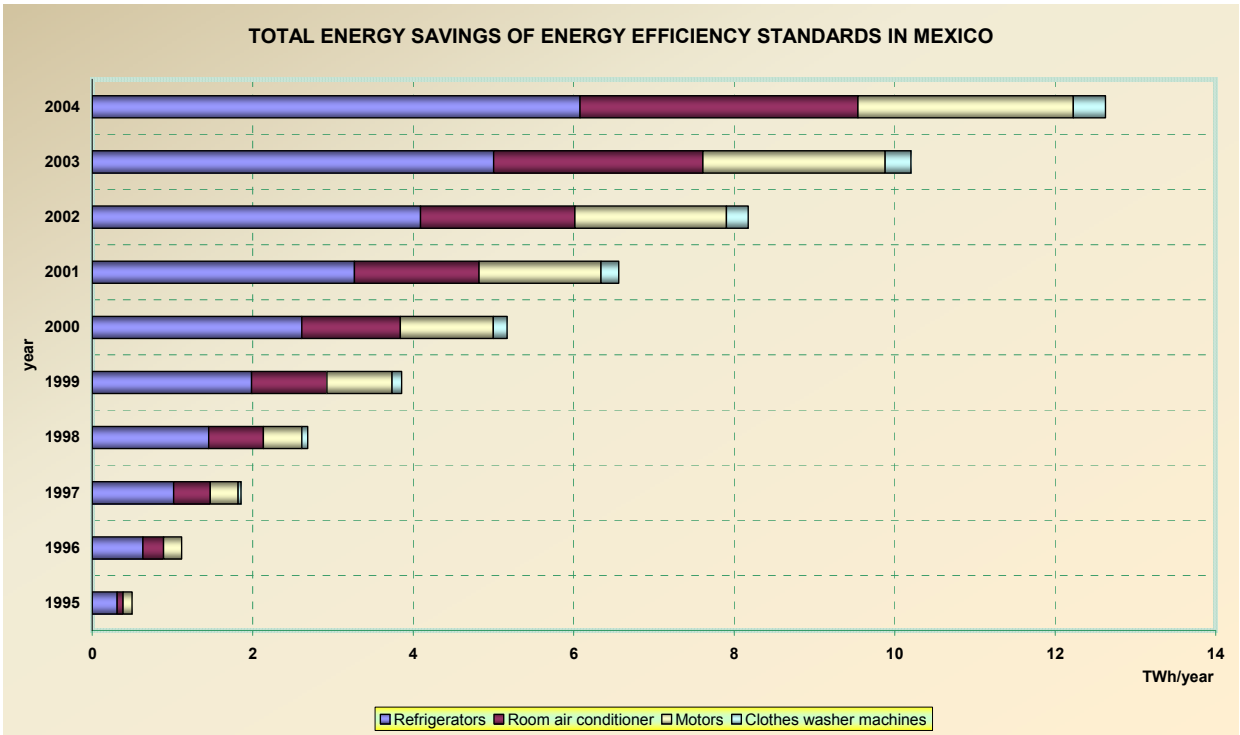


For refrigerators, Figure 3 shows a rapid decline in consumption for high capacity models, resulting in a consumption of up to 62% below the baseline by 2005. Refrigerator standards are particularly stringent – in the most dramatic case, consumption values required by the standard are 58% lower than the baseline (NOM-072-SCFI-1994 vs. NOM-015-ENER-2002). In spite of this stringency, many models currently sold exceed the efficiency requirements of the standards. Likewise, the average air conditioner equipment efficiency in the Mexican market surpasses an EER of 2.8 (W/W), significantly greater than the standard is 2.6. The improvement of efficiency in the market beyond the standards requirements is one of the main reasons why the retrospective analysis finds savings greater than originally projected.

Energy Savings

The product lifetime (period in which the equipment is useful and energy savings are generated) was assumed to be the same value as used in the standard draft for refrigerators, room air conditioners and electric motors (20 years) and 15 years for clothes washers. Therefore, we assume that all of the products entering the market in 1995 or beyond remain in the market in 2005. Electricity savings are calculated for all products as the per unit savings relative to the baseline, multiplied by the stock in each year, as summarized in Figure 5

Figure 5. Cumulative Electric Savings



Refrigerators show the largest energy savings; and electrical clothes washers the smallest Cumulative electricity savings by 2004 is 12.6 TWh. Consumption values required by standards for refrigerators were reduced by 58%, (NOM-072-SCFI-1994 vs. NOM-015-ENER-2002) and the actual average consumption of refrigerators in the market achieved a consumption of 62% lower than the baseline. For room air conditioners and motors, saving are also significant, due to products meeting and exceeding the requirements of the standard.

Financial Impacts

In this study we determined the energy saved and the Net Present Value (NPV) for different sectors of the economy. For end users, net savings is given by utility bill savings minus retail equipment price increases. For utilities, savings included avoided generation and capital costs of capacity increases, but deducted losses in revenue from reduced electricity sales. In order to calculate avoided capacity increases, a coincidence factor was derived relating to the percentage of on-peak use hours. These were 65% for refrigerators, 40% for air conditioners, and 82% for motors. Washing machines were assumed to be an off-peak end use (coincidence factor of 0%). Manufacturer benefits arise from the increases in retail prices, which increase revenues, but material and other incremental production line costs were taken into account as losses.

For each viewpoint analyzed, net financial savings in each year were scaled according to the appropriate discount rates. Average discount rates were 8.5% for users, 12% for utilities, and 17% for manufacturers.

Figure 6. Economic Analysis for Refrigerators

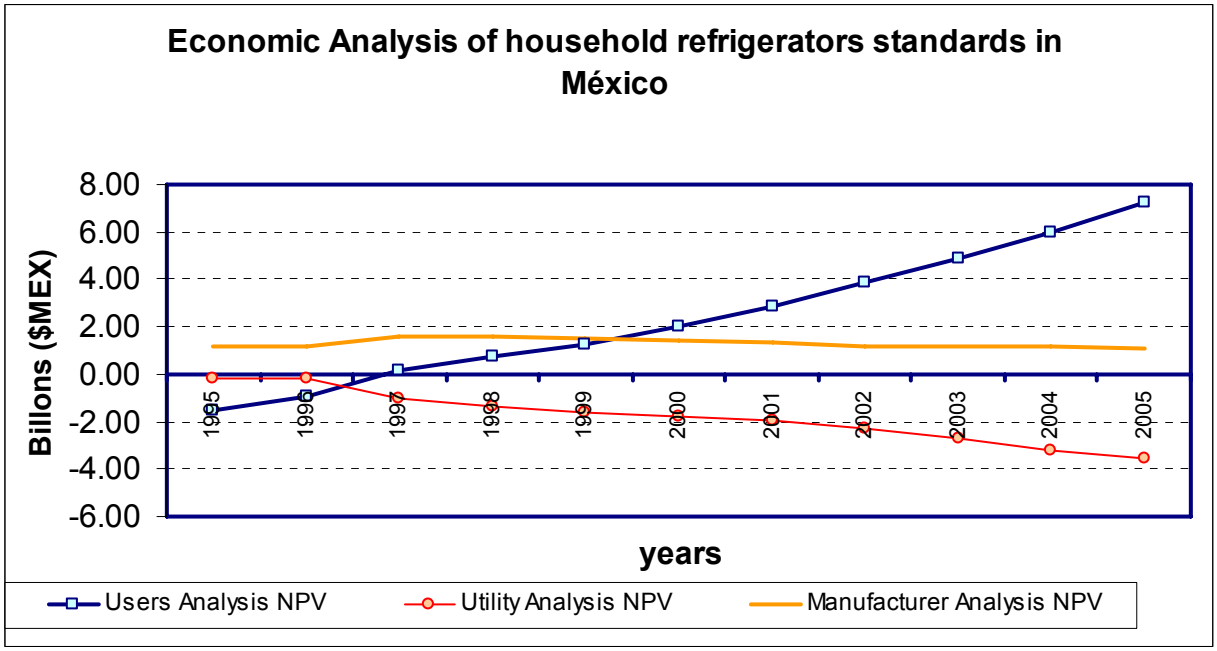


Figure 6 depicts financial impacts for refrigerators over the time period 1995-2005 on manufacturers, end users and Mexican utilities. The economic benefits for end users begin at the third year of the standards setting program and for manufacturers are positive from first year onward, due to the incremental price of products.

Utilities were found not to have direct economic benefits; their benefits are the deferred investment of increasing generation capacity and emission reduction.

Summary of Results

Table 2 shows a summary of the impacts resulting from energy efficiency standards in the Mexican market in the first ten years since standards were introduced.

Table 2. National Energy and Financial Impacts 1995-2005

Energy and Power savings	TOTAL TO 2004				
	Motors	Refrigerators	Room air conditioners	Clothes Washers	Total
TWh Not billed	10.0	23.0	11.5	1.4	45.9
Energy savings in generation TWh	11.5	26.4	13.1	1.6	52,7
MW generation avoided	899	1,266	679	-	2,844

Economic benefits	TOTAL TO 2004				(Millons $MEX)
	Motors	Refrigerators	Room air conditioners	Clothes Washers	Total
Users Analysis NPV	5,588	7,912	7,237	(621)	19,352
Utility Analysis NPV	(828)	(10,738)	(3,913)	(875)	(16,355)
Manufacturer Analysis NPV	702	9,358	1,679	1,208	13,401
Net Total Benefit NPV	5,462	6,532	5,003	(287)	16,398

Note: Parity 11.26$MEX=1$USD [1995]

Conclusions

The methodology of the assessment of the economic and energy impacts by the application of energy efficiency standards in Mexico was developed to evaluate the results of the standards setting program, which began in 1995. This methodology considers the impacts on the product, the manufacturers, the utility, the users, and the country as a whole.

From the analysis of ten years of the standards setting program for these four products, a cumulative reduction in electric energy consumption for end users equaling approximately 45.8 TWh has been achieved. This represents almost a third of electricity generation in Mexico during 2005. In addition, it has reduced investments in the energy supply infrastructure equivalent to 2800 MW, which corresponds to about 7% of installed capacity for Mexican electrical generation. The reduction in energy consumption allowed for a 30 GTon decrease of CO_2 carbon emissions from fossil fuel power plants.

It may be concluded that the standards program, along with other market factors, contributed to improve the level of efficiency of equipment in México due to manufacturers must compete in a market with higher values of efficiency. This, too, has transformed the market.

The results of this analysis are significant for several reasons. First, they represent a concrete and demonstrable example of the effectiveness of standards in the context of a developing country. The extraordinary success of the Mexican program may therefore serve as a useful guide to other countries considering equipment efficiency programs. Second, they demonstrate the use of a well-accepted methodology which has benefited greatly from data provided by a government program, and a variety of stakeholders both public and private. Finally, they show that market actors may respond to standards by capitalizing on the momentum of technological improvement they encourage, thereby improving efficiency beyond the requirements of government regulations and gaining competitiveness in international markets.

Abbreviations

ANFAD: Asociación Nacional de Fabricantes de Aparatos Electrodomésticos
ANCE: Asociación Nacional de Normalización y Certificación del Sector Eléctrico
NOM: Norma Oficial Mexicana
CFE: Comisión Federal de Electricidad (Mexican Utility)
CANAME: Cámara Nacional de Manufacturas Eléctricas
USAID: United States Agency for International Development
CLASP: The Collaborative Labeling and Appliance Standards Program

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