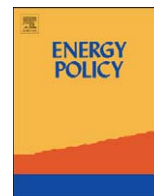




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Electric energy saving potential by substitution of domestic refrigerators in Mexico

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ABSTRACT

We evaluate the potential for electric power saving in Mexico that would follow the substitution of old, low efficiency domestic refrigerators with modern, high efficiency ones. Our results indicate that a total substitution of domestic refrigerators would save 4.7 TWh/year, which represents 33% of the annual total consumption of 14.1 TWh. Assuming an average daily use of 14 h for domestic refrigeration, 900 MW of electricity would be saved. An annual substitution of 20% over 5 years would save approximately 1 TWh a year and almost 180 MW would be released. It is recommended that this program of replacement should be supported by the Federal and State governments, beginning with the States (which have more direct influence), and with the oldest, least efficient refrigerators along the lines followed in programs that introduced fluorescent compact lamps.

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1. Introduction

In Mexico, refrigeration is responsible for around 29% of the electricity consumption in the homes located in temperate climates and for 14% in those of warm climates where air conditioning is used. This situation produces problems for Mexican families so serious and complex that it is necessary to extensively subsidize the domestic electric rates. From 1997, the Mexican Official Standard (*NOM in Spanish*) of energy efficiency for domestic refrigerators has been implemented (*Norma Oficial Mexicana, 1997, 2002*). Recently, the NOM-015-ENER-2002 standard went into effect making currently marketed refrigerators 30% more efficient than the ones sold previously. Nevertheless, the substitution rate is slow and the change of the current total of more than 23 million refrigerators will take many years at the current sales rate of approximately 1.6 million refrigerators a year.

In this study, we have evaluated the composition of the total current domestic refrigerators in the country and states in order, later on, to carry out an estimate of the current consumption of electric power and the evaluation of the electric energy saving potential by means of the substitution of low efficiency old refrigerators with high efficiency modern ones. The achievement of this potential is very distant since the substitution of old for

new models follows a very slow curve, first, because most Mexican households do not have the economic capacity to buy new refrigerators and second, because the technological durability of the refrigerators they already own – some more than 30–40 years old – makes the purchase of new ones unnecessary.

Hence, we propose the organization of a government program that will rapidly substitute old and inefficient refrigerators for new and efficient ones. In support of such a program, information is needed about the relative magnitudes of electricity consumption of the old and the new refrigerators (*Arroyo-Cabañas, 2002*).

For this purpose, statistical information on the total make-up of domestic refrigerators was gathered from census and population counts, sales, national production and imports and surveys of domestic expenditures. The results for individual States and the nation as a whole appear in *Table 1* below. There the major user States are shown. It would be to them that the policy of intensive refrigeration substitution would be first applied. On the basis of the labels of energy efficiency as defined according to the Mexican Official Standard (*NOM*), it is estimated that refrigerators sold between 1995 and 2000 consumed 30% more electricity than those of the same size sold between 2001 and 2007, while those sold before 1980 consumed 60% more.

2. Aggregate estimate of refrigerators in México

To evaluate the electric energy consumption of domestic refrigeration at both the national and state levels it is fundamental

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Table 1
Existing refrigerators in Mexico; State and national totals.

State	2007	%
Aguascalientes	241,110	1.05
Baja California	736,122	3.21
Baja California sur	122,822	0.53
Campeche	151,708	0.66
Coahuila	651,065	2.84
Colima	147,982	0.64
Chiapas	663,390	2.89
Chihuahua	869,284	3.79
Distrito Federal	2,435,687	10.61
Durango	352,760	1.54
Guanajuato	1,021,254	4.45
Guerrero	610,450	2.66
Hidalgo	428,638	1.87
Jalisco	1,669,255	7.27
México (State of)	3,018,929	13.15
Michoacán	864,763	3.77
Morelos	384,062	1.67
Nayarit	228,276	0.99
Nuevo León	1,107,544	4.82
Oaxaca	583,352	2.54
Puebla	935,517	4.07
Querétaro	323,393	1.41
Quintana Roo	222,532	0.97
San Luis Potosí	489,062	2.13
Sinaloa	667,566	2.91
Sonora	622,772	2.71
Tabasco	396,453	1.73
Tamaulipas	752,051	3.28
Tlaxcala	177,673	0.77
Veracruz	1,426,164	6.21
Yucatán	360,440	1.57
Zacatecas	300,509	1.31
Total	22,962,584	100.00

Source: National Institute of Statistics, Geography and Computing (INEGI) and ANFAD.

to know the number and age of the refrigerators in Mexico, together with the models and their individual consumption rates. With this information, it is possible to estimate the saving in the electrical energy consumption if old, inefficient refrigerators were replaced with modern efficient ones in most of the Mexican homes.

To determine the approximate number of refrigerators existing in the homes of each of the 32 States of the country, information was obtained from population and housing census. Refrigerator sales for 2001–2007, as given by the National Association of Manufacturers of Domestic Devices (ANFAD), were set beside the census data. The results are shown in Table 1 (INEGI, 1990 and 2000; ANFAD, 2000–2007).

The key observations are the total number of refrigerators existing in Mexico (23 million), their principal concentrations in the States of Mexico (13.15%) and the Distrito Federal (10.61%), that seven States take up 53% of the whole, that the distribution of refrigerator ownership is not homogeneous, and that on the basis of a total population of about 105 million there is approximately one refrigerator for every five persons.

In Table 2, the number of houses with electricity, and the number of refrigerators per house can be analyzed for each State of the Mexican Republic. In States like Oaxaca, Chiapas and Tlaxcala, the number of refrigerators for housing is almost 0.7, which means that in many Mexican homes this household appliance still is not affordable. By contrast, there is one refrigerator per home in the States to the north of the country (Chihuahua, Coahuila, Nuevo León, Tamaulipas, Sonora and Baja California). The national average of refrigerator ownership for

Table 2
State and National figures for houses with electricity and refrigerators.

State	2005		
	Refrigerators	Houses with electricity	EH/F ^a
Aguascalientes	216,712	238,639	0.91
Baja California	674,903	660,170	1.02
Baja California sur	111,476	123,466	0.90
Campeche	133,567	171,236	0.78
Coahuila	597,206	605,490	0.99
Colima	135,649	141,454	0.96
Chiapas	551,985	832,257	0.66
Chihuahua	800,067	775,503	1.03
Distrito Federal	2,252,187	2,184,909	1.03
Durango	318,303	338,912	0.94
Guanajuato	904,573	1,008,367	0.90
Guerrero	534,180	641,867	0.83
Hidalgo	370,204	524,071	0.71
Jalisco	1,519,358	1,500,244	1.01
México (State of)	2,689,715	3,038,513	0.89
Michoacán	771,060	870,040	0.89
Morelos	347,504	380,164	0.91
Nayarit	206,824	230,584	0.90
Nuevo León	1,017,498	976,487	1.04
Oaxaca	493,302	728,248	0.68
Puebla	799,594	1,142,154	0.70
Querétaro	285,257	336,696	0.85
Quintana Roo	195,541	240,160	0.81
San Luis Potosí	431,007	518,227	0.83
Sinaloa	610,288	604,998	1.01
Sonora	570,955	580,076	0.98
Tabasco	348,245	452,319	0.77
Tamaulipas	685,349	734,495	0.93
Tlaxcala	150,518	226,225	0.67
Veracruz	1,253,827	1,664,756	0.75
Yucatán	316,525	409,864	0.77
Zacatecas	268,358	313,920	0.85
Total	20,561,737	23,194,511	0.89

^a EH/F = Ratio of electrified housings/refrigerators.

houses with electricity is 0.89, which means that the ratio of 1 refrigerator per home has yet to be reached. The ideal situation would be having at least one refrigerator in each home (INEGI, 1995 and 2005).

This information is a good indicator of the socioeconomic conditions of the Mexican population. The north zone of the country has the major purchasing power and because of its rigorous climate, the greatest need of refrigeration for the conservation of food and personal comfort. In this region a major quantity of electrical energy is consumed, which has influenced the establishment of electrical preferential tariffs.

3. Aggregates of domestic refrigerators by age

Another important parameter to consider in the current electricity consumption of domestic refrigerators is their age, since recent models present major energy efficiencies. Starting with information about the number of refrigerators per State from census data on Population and Housing for the year 2000 (INEGI) and the proportionate data about sales from ANFAD for the corresponding period, the number of existing refrigerators was calculated for each State. Fifty-eight percent of the aggregate of domestic refrigerators is 1–10 years old, 29% from 11 to 20 years old and 13% more than 20 years. It is necessary to emphasize that in previous works refrigerators of 30 and 40 years of age have been noted still operating in Mexican homes. Table 3 suggests that while 10 years might usually be the effective life of a refrigerator the majority of the families maintain them appropriately and the

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