Residential Energy Use in Mexico: Structure, Environmental Impacts, and Savings Potential

Omar Masera, Rafael Friedmann and Odón de Buen
University of California - Berkeley

Introduction[1]

Promoting a more efficient energy use in the Mexican residential sector is important because: (1) residential energy accounts for more than 20% of final energy demand in the country; (2) it has a large potential for growth; (3) residential demand growth represents a significant financial burden for the National Government because of fuel subsidies. Also, the residential sector is responsible for the peak electric load; and (4) access to better energy services could help improve standards of living for the population.

In 1990, residential energy demand was 685 PJ (47 GJ/household), out of 3426 PJ of total demand in Mexico. Residential energy use accounts for 79% of the country's total demand for biomass, 83% of that for liquified petroleum gas, and 21% of the electricity. From 1970 to 1990, residential energy demand grew 175% and domestic electricity demand grew 600%. Prevailing growth rates of electricity and LPG would double residential demand by the year 2000, the former requiring 5 GW of new electric capacity.

The Residential Sector: Structure and Its Change Since 1970

Mexican population reaches 81 million (1990), with a 73:27 percent urban-rural split. There are an estimated 14.7 million households, the average family has 5.5 members. Thirty five percent of total population lives in the five major cities, while the 23 million rural inhabitants are scattered in more than 100,000 villages (86,000 of them have less than 1000 inhabitants). Income is highly concentrated; about 30% of total population lives beyond the poverty line. An important share of total population--particularly in the rural sector--still lacks basic services such as piped water and sewage.

From 1970 to 1990, the following structural changes have occurred in Mexico which have influenced the composition and rate of growth of residential energy demand: (1) a 2.6% average annual population growth; (2) a reduction in family size, which has led to a faster growth in households than that of population; (3) an increase in the urbanization rate from 59% to 72%. Most population growth has occurred in cities larger than 100,000 inhabitants; (4) a re-location of the country's population towards areas where climate considerations lead to a disproportionate increase in energy consumption (i.e., hotter climates requiring air conditioning); and (5) a closer integration of the population to the market economy, reinforced by the present fast liberalization of the country's economy.

Residential Energy Demand

The structural changes listed above have led to a residential energy demand growth of 3.1% per year, significantly larger than the average population growth between 1970 and 1990. In 1990, of the 685 PJ of residential energy demand, 43% was wood, 39% liquefied petroleum gas (LPG), 11% electricity, 5% natural gas, and 2% kerosene.

The average annual rate of growth of residential fuels between 1970 and 1990 has been as follows: electricity 9.2%; LPG 7.9%; natural gas 4.3%; fuelwood 0.4% and kerosene -4.3%. The differences in relative growth rates by fuel have resulted in a growing participation of LPG and electricity as a percentage of total residential energy demand. The demand growth for these fuels have been driven both by the increased access to these resources--through electrification programs and extension of the LPG network--and by the increase in per capita unit energy consumption (see Fig 1).

Demand composition by fuels differs in urban and rural areas. In urban areas, LPG and electricity dominate, while in the rural sector fuelwood accounts for 80% of consumption (see Fig 2). The intense use of fuelwood results in higher per capita energy use in the rural sector than in

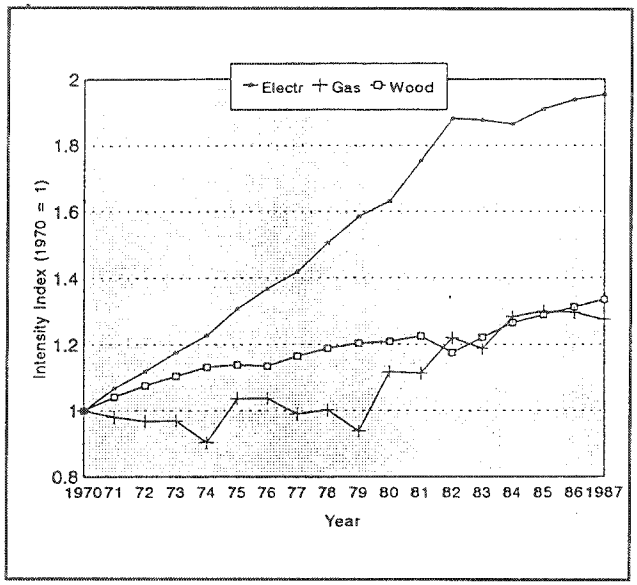

Figure 1. Per Capita Energy Intensity: Mexico 1970-87

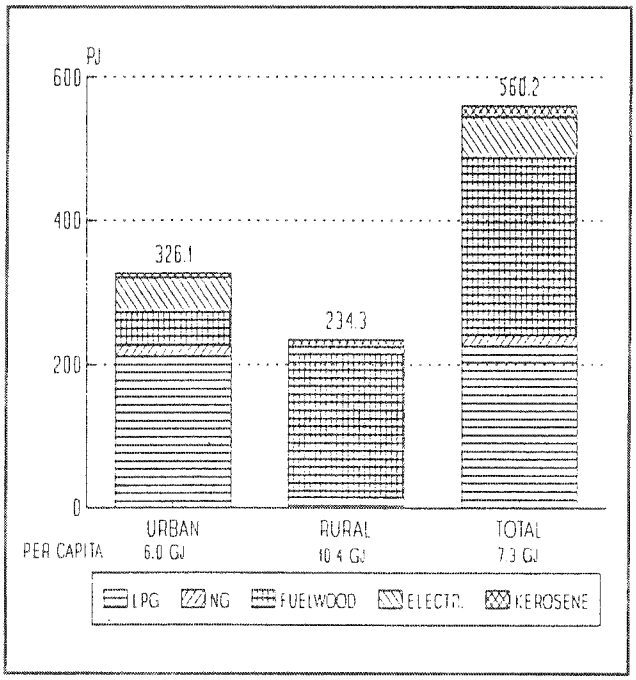

Figure 2. Residential Demand by Fuel: Mexico 1987

urban areas--however, this difference is disappearing with the increasing intensity of modern fuel use in urban households. There has been a substitution of wood and kerosene with LPG for cooking in peri-urban areas and, to a lesser degree, also in rural areas. In the rural sector, kerosene has been increasingly substituted with electricity in lighting.

There are important differences in the amount and composition of energy use by income groups and in the share of energy in total household expenditures. Poorer households tend to rely more on biomass fuels and to spend more of their income in energy purchases. Energy consumption patterns in high-income groups are often comparable to those of the United States.

Major Residential Energy End-Uses

Our analysis suggests that cooking (61%), water heating (27%), lighting (5%), and refrigeration (2.6%), comprise more than 95% of the residential sector's energy use. Wood (50%) and LPG (46%) are the main resources for cooking and water heating. Electricity is mostly used for lighting (35%) and refrigeration (26%). Air conditioning is important in Northern Mexico.

The relative importance of end-use varies between urban and rural areas. In the urban sector, cooking and water heating account for 47% and 38% of total demand, respectively, while in the rural sector the same uses account for 80% and 13%. In the urban sector, cooking is almost exclusively done with LPG, while in the rural sector wood is the major cooking fuel. Appliance saturation is still low compared to some other Latin-American countries (i.e. Venezuela and Brazil). By 1987, about 47% of total population had water heaters (40% gas and 7% fuelwood water heaters); 76% televisions, and 58% refrigerators (see Fig 3). Approximately 11% of the Mexican population still relied on kerosene for lighting.

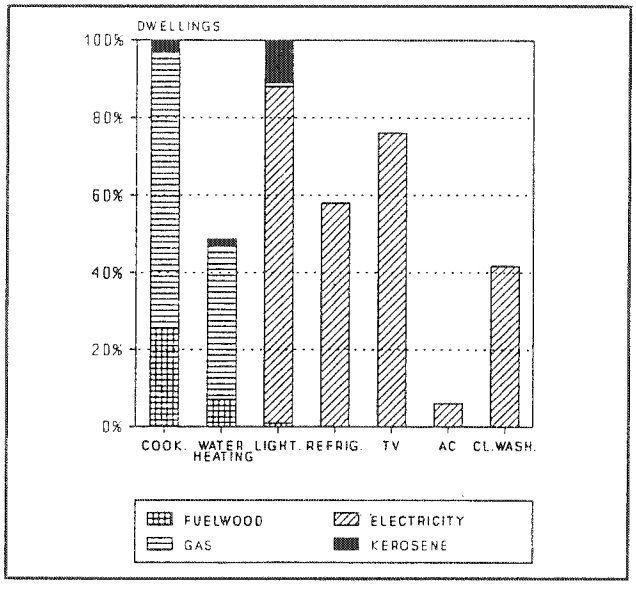

Figure 3. Appliance Saturation Mexico 1987

During the past three years, the rapid liberalization of the country's economy has led to an increase in appliance saturation, mainly due to a boost in appliance imports. High income households are acquiring larger and more energy intensive appliances. Low income households are purchasing cheap and very inefficient models, usually second-hand from Mexican high-income groups and from the U.S. (this phenomena is particularly important in Northern Mexico with air conditioners).

Environmental Impacts

Preliminary estimates based on the current energy resource mix imply that the residential sector is responsible for approximately 5% to 10% of the total particulates, hydrocarbons, and NOx, 14% of SOx, and up to 27% of total CO2 yearly emissions in Mexico. Wood is the primary culprit for particulates; electricity for NOx and SOx; and LPG and electricity for CO_2 emissions. The future planned expansion of the electric capacity using coal-fired power plants will increase emissions significantly.

Potential Energy Savings

Programs to foster a more efficient energy use in Mexican households should include the following measures: (1) improving the conditions of fuel service (e.g., reducing voltage fluctuations, ensuring fuel quality, avoiding gas leaks, installing individual meters); (2) retrofitting the existing equipment and buildings; (3) substituting fuels, particularly traditional with modern ones, including non-renewables with renewables; (4) using more efficient technologies; and (5) changing patterns of energy use (i.e., through education and changes in lifestyles).

Given the current opening of the Mexican economy, and the above mentioned trend towards increasing saturation with inefficient appliances, it is essential that efficiency programs be accompanied by strict regulations on appliance imports--particularly second-hand and junk technology--and on national appliance manufacturing. Financial incentives should be given to low-income customers to acquire efficient models, and financial penalties applied to energy-intensive models oriented to high-income groups. Due to a lack of data for a detailed analysis, below we only identify major areas for pursuing energy savings.

In the urban sector, efforts should stress reducing LPG and electricity use. For LPG, current technical options could reduce unit consumption between 20 to 60% for cooking, and 30 to 70% for water heating (even more if extensive solar water heating were introduced). In lighting, compact fluorescent lamps could reduce electricity use 30% in current market conditions. For most of the major electric appliances the use of the most efficient models could reduce unit consumption by 20 to 80%.

In the rural sector, actions should focus on reducing fuelwood demand for cooking and avoiding the introduction of second-hand inefficient energy technologies. The introduction of improved wood burning cookstoves could lead to fuelwood savings of 30 to 50%. Properly designed, improved cookstoves could significantly improve indoor air quality and public health. Rural electrification should be accompanied by programs to greatly facilitate access to the most cost-effective and efficient technologies.

Conclusions

There is a large potential for improving energy resource use in Mexican households. In the electric sector alone, savings in lighting and refrigeration could amount to 4 GW of deferred peak capacity--or about $ 8 billion--by the year 2000. The yearly electricity subsidies of $750 million to residential customers could also be reduced.

Priority actions to better estimate and to actually achieve potential energy savings include: (1) continuous gathering of both, end use data by region and income levels, and technical and economic characteristics of household energy equipment; (2) setting up new institutional frameworks for the promotion and implementation of energy efficiency; (3) creating human resource training programs; (4) promoting and supporting Mexican R&D in efficient household energy use technologies, including renewable resources; (5) introducing marginal cost pricing, avoiding negative impacts for low-income households--for example through the simultaneous introduction of efficient technologies.

It is essential that appropriate financing schemes be made available, both to households and equipment manufacturers, to help surmount the increased capital investment usually associated with more efficient technologies. Also, every effort should be made so that energy efficiency is integrated into a development process looking at rising the living standards of all the population, securing a sound relationship with the environment, and increasing the country self-reliance.

Acknowledgments

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Endnote

1. This article is largely based on a comprehensive paper on the topic (Masera et al. 1991). Given the space constraints, readers are referred to the original report for details on the methods used to obtained the results presented here.

Reference

Masera, O., O. de Buen, and R. Friedmann. 1991. "Consumo Residencial de Energía en México: Estructura, Impactos Ambientales y Potencial de Ahorro". *Energía y Medio Ambiente en el Sector Residencial Mexicano.* Programa Universitario de Energia, UNAM, Mexico City. (in press).