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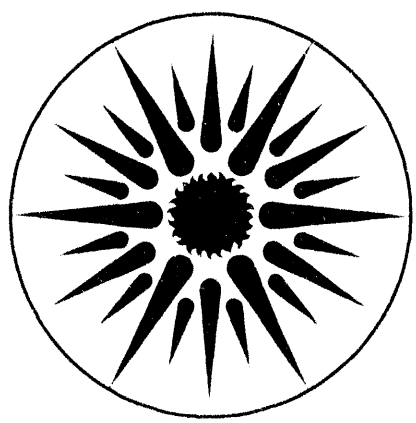
August 1993



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# Household Energy Use in Urban Venezuela: Implications from Surveys in Maracaibo, Valencia, Mérida, and Barcelona-Puerto La Cruz

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## ABSTRACT

This report identifies the most important results of a comparative analysis of household comercial energy use in Venezuelan urban cities. The use of modern fuels is widespread among all cities. Cooking consumes the largest share of urban household energy use. The survey documents no use of biomass and a negligible use of kerosene for cooking. LPG, natural gas, and kerosene are the main fuels available. LPG is the fuel choice of low-income households in all cities except Maracaibo, where 40% of all households use natural gas.

Electricity consumption in Venezuela's urban households is remarkably high compared with the levels used in households in comparable Latin American countries and in households of industrialized nations which confront harsher climatic conditions and, therefore, use electricity for water and space heating. The penetration of appliances in Venezuela's urban households is very high. The appliances available on the market are inefficient, and there are inefficient patterns of energy use among the population. Climate conditions and the urban built form all play important roles in determining the high level of energy consumption in Venezuelan urban households.

It is important to acknowledge the opportunities for introducing energy efficiency and conservation in Venezuela's residential sector, particularly given current economic and financial constraints, which may hamper the future provision of energy services.

## ACKNOWLEDGEMENTS

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## 1. Introduction

Like most Latin American countries, Venezuela has undertaken a profound economic restructuring with the guidance of international monetary agencies. During the late 1980s the country committed itself to fuel price reforms and increased participation by private firms to provide energy services. A volatile political environment — two attempted military coups (February 4, and November 27, 1992) — and other social problems arising from economic stagnation demonstrate the difficulties of implementing reforms in Venezuela. Presently, reforms are at a standstill.

Fuel price reforms and privatization were intended to end subsidies on fuel prices and bring about the end of bureaucratic management in public utility companies. However, new, private utilities have yet to establish pricing policies under the current social circumstances, e.g., an energy price rise sparked a week of rioting in Venezuela in 1989.

Venezuela is not running out of energy resources in an absolute sense. What is running out is the ability to provide a greater energy supply at low cost. A decade of economic constraints due to the reduction of oil prices has significantly restricted the growth of energy services, a growth experienced in other modern industrial nations.

The economic restructuring process must consider how the needs of the population are being fulfilled. Meeting the requirements of Venezuela's development process will require the adoption of innovative approaches to providing more energy services without hampering the country's ability to satisfy demand in the future and the supply of other services to the population. Increasing the efficiency of energy use in Venezuela has an important role to play in this process.

This report identifies the results of a comparative analysis of household energy use in Venezuelan urban cities. Following the methodology of a similar study performed in Caracas, surveys were taken in four major cities encompassing a wide range of climates, income levels, and economic activities. We report on energy use by fuel type for cooking, water heating, and household electricity consumption according to primary end uses in each city. Finally, this report presents a list of areas for further research for the next steps to implementing energy-efficiency programs for the residential sector in Venezuela.

### 1.1 Background

In 1988, a collaborative effort was initiated under the auspices of an international agreement, DOE-MEMV Agreement, Annex XI, between the United States Department of Energy (USDOE) and the Ministry of Energy and Mines of Venezuela (MEMV), aimed at promoting energy conservation. The first study, a survey designed to understand residential energy use, was completed in 1990 and presented a comprehensive analysis for the city of Caracas. Due to the particularities of location and climate in Caracas, it was important in this second study to evaluate how urban size and weather conditions affect household energy use. In pursuing this objective, a project was set up to look at cities with differing climates and households of varying sizes. Based upon the mid-size to large urban populations and diversity of economies and climate, the cities of Maracaibo, Valencia, Mérida, and Barcelona-Puerto La Cruz were selected.

Maracaibo and Valencia are, respectively, the second and third most populous cities in Venezuela; along with Barcelona, they are located in flat lands in the northern part of the country. All the cities' economies have been determined by their proximity to important ports (Valencia), and by their dominant

industrial activities, (oil exploration, refining, and distribution, in Maracaibo and Barcelona-Puerto La Cruz). Valencia is located in a flat and extended valley surrounded by small hills in the central part of the country. Barcelona is close to the northwestern beaches of the Caribbean sea. Maracaibo is located beside Lake Maracaibo, where the core of Venezuela's oil industry is located.

The climate in Maracaibo, Valencia, and Barcelona is warm during most of the year. Popular belief states Maracaibo as Venezuela's hottest city. Valencia and Barcelona are less extreme than Maracaibo.

The fourth city studied, Mérida, is located in a flat terrace approximately 1500 meters above sea level in the Andes Mountains. Its climate is cold for most of the year. The inclusion of Mérida was important for this study to determine whether climate affects the patterns and amounts of energy consumed in Venezuelan households. These four cities, taken together with Caracas, broadly represent the nation's urban population as a whole.

### 1.2 Study Objectives

The primary objective of this study was to gather information about household fuel choices and energy consumption levels in Venezuela. We also look at conditions that affect the choice of fuels used in homes and the policy implications derived from these factors. For each city we produce a structured database that describes urban household energy consumption and determines the effects of income levels on energy consumption. This information is used to ascertain the need for socially targeted energy policies.

The four cities in this study and Caracas together account for more than 50 percent of Venezuela's urban population.[1] One of the most significant aims of this research is to demonstrate the importance of maintaining a consumer database using surveys for understanding the variations on residential energy demand in order to better assess future electricity requirements.

### 1.3 Sampling and Survey Methodology

The study was conducted and coordinated at different levels by the Directorate of Energy Planning, Division of Energy Conservation, Ministry of Energy and Mines (MEM), in Caracas. The International Energy Studies Group, Lawrence Berkeley Laboratory (IES-LBL), Berkeley, California, USA, was a consultant to MEM. Three other Venezuelan institutions developed the field work and surveyed each city: for Maracaibo, Universidad del Zulia (LUZ); for the cities of Mérida and Barcelona, Universidad Simón Bolivar (USB); for Valencia, Universidad Tecnológica del Centro (UNITEC). MEM made the decision to engage three different institutions in the project to aid the transfer of energy-related information between local and international institutions.

The three university teams were asked to gather basic information about the geographic area under study. It was important to establish a close relationship with the respective utility companies in order to define the sample from their customer inventories. Although in each of the cities the survey team consistently tried to involve the utility companies in the work, only the team from LUZ, in Maracaibo, was able to work with the utility company, ENELVEN, to complete the definition of the sample and obtain information to contrast with the survey results.

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[1] Urban areas are defined as those with more than 2500 inhabitants, according to the Census.

The sample in Maracaibo was defined by categories from the utility customer inventory. Four different groups were identified by arranging households by their monthly energy consumption. Other relevant variables for defining the sample were the portion of each group within the universe of customers and the percentage of the population without electricity. The utility provided the latter percentage and data were confirmed through the review of different official sources and surveys. Characteristics of dwellings and field data were also utilized to make the sample comparable to the other cities in the study. Table 1 provides the population and sample sizes of each city surveyed.

Samples from Valencia, Mérida, and Barcelona were geographically stratified by housing type and neighborhood district, both of which were verified in the field. Valencia's research method was to set up a fixed sample size for each stratified segment of population according to a requested ideal level of accuracy. The teams from Mérida and Barcelona made use of maps and direct visits to the field to choose a regular sampling interval for the city and an appropriate number of households to be interviewed from given blocks or neighborhoods.

A model questionnaire and a manual to better manage the questionnaire were prepared based upon the results of the earlier experience in Caracas. The model's intent was to examine issues related to fuel choices, household income, level of energy consumption, and the energy decision-making process. Each university team had the chance to review the questionnaire and introduce modifications to account for the particularities of their city. The principal questions guiding the research were: What are the influences of size and weather conditions on household energy use? How does household energy consumption in other Venezuelan urban areas compare to that of Caracas? How does income level affect energy consumption? What are the implications in terms of energy policy?

**Table 1. Urban Population and Sample Size**

| City | Total population (millions) | Sample size (number of households) |
|---|---|---|
| Caracas[a] | 4.3 | 480 |
| Maracaibo[b] | 1.3 | 537 |
| Valencia[c] | 0.985 | 600 |
| Mérida[d] | 0.268 | 180 |
| Barcelona[e] | 0.307 | 287 |

Sources:
[a] Based on Figueroa et al. for year 1988. Reference No 2.
[b] Based on Conzuplan 2 for year 1989. Reference No 1.
[c] Based on OCEI for year 1990. Reference No 4
[d] Based on UCEP-ULA-MINDUR for year 1989. Reference No 6
[e] Based on OECI for year 1981. Reference No 5

Venezuela's Population in 1990: 19.45 millions of which 85% occupy urban areas. Reference No 23

In undertaking the field work, repeated return visits ensured a low non-response rate. To promote participation, the research teams distributed a booklet edited by MEM with general information about

energy conservation among the surveyed households. The survey was designed with internal consistency checks and ways to confirm key data. Responses on income level and electricity consumption were particularly difficult to obtain in all cases; however, the research teams verified the data by comparing them with reported expenditures and observed household characteristics, such as the condition of the home, furnishings, or clothing of respondents.

For processing the information and creating a commonly organized database, the coordination team defined a set of criteria. The goal was to create a database (using dBase III or Lotus 123) to classify the information acquired from the survey. Four detailed databases constitute one of the main outputs of this project. The final arrangement of the database for each city was aimed at producing output consistent with the earlier reports made for the city of Caracas.

Since an effective comparative analysis by income level was desired as output for the purpose of policy making, and since the arrangement of data by income category proved feasible, the data first compiled by dwelling category were rearranged by processing the income categories found in the survey. Other base income data and information on dwelling categories were used to conform the database for comparative analysis.

## 2. Urbanization and Household Energy Use in Venezuela

### 2.1 General Characteristics of The Survey Cities

The energy situation in Venezuela has been tremendously shaped by the rapid level of urbanization of the country. Alongside urbanization, levels of residential energy demand has grown as has the reliance on modern energy sources, particularly electricity. The cities surveyed encompassed a wide range of living conditions, income levels, economic activities, and local policies.

#### Maracaibo

Maracaibo is Venezuela's second largest city with over 1.3 million residents and an important regional industrial base (Table 1). The city is a specialized center of oil-related activities and services. Maracaibo was the first electrified city in Venezuela after the creation of the first electric utility, the company C.A. Energía Eléctrica de Venezuela (ENELVEN). ENELVEN was formed in 1888 as a private industry. In 1976, the Venezuelan state, through the Venezuelan Investment Fund (Fondo de Inversiones de Venezuela (FIV)) bought a majority of assets in this utility company. Presently, withing the year 1992 the company is expected to be sold back entirely to the private sector.[2]

By 1990, only a small proportion, 2.5%, of Maracaibo's population lacked electricity.[3] This population is related to low-income families which may have an illegal connection to the service.

Two wholly owned subsidiaries of Petróleos de Venezuela S.A., PDVSA, MARAVEN and LAGOVEN, supply fuels to the city. MARAVEN through FIME (Fundación Instituto Municipal de la

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[2] Private Power Reporter. June 1992. A publication of the Office of Energy and Infrastructure. U.S. Agency for International Development on Private Power Activities in Developing Countries.

[3] According to ENELVEN in *Barrios provistos para electrificar en 1991 y 1992.*

Energía)[4] supplies natural gas to part of the city and the rest is covered by LAGOVEN through distributors of LPG (mainly two companies, Regina Gas and VENGAS). Fuels such as gas-oil, bunker, and natural gas for electricity generation are furnished by the same two subsidiaries of PDVSA.

Maracaibo is one of the hottest cities in the country. Annual average temperatures range between 30 and 32 °C with little variations throughout the year. September, October, and November are associated with a higher need for air conditioning because of decreased winds (consequentially, higher temperatures and levels of humidity) during these months.

**Valencia**

Valencia is located 160 kms southwest of Caracas and 500 meters above sea level. It has the third largest population with 1 million inhabitants in 1990 (Table 1). More than 40% of the light manufacturing industry in the country is centered within Valencia.

All households are electrified. Two companies supply electricity to the city, the state-owned Compañía Anónima de Administración y Fomento Eléctrico (CADAFE), and the private Electricidad de Valencia (ELEVAL). The percentage of illegal connections is approximately 17%, although a high percentage shares meters. Natural gas grid infrastructures are not present in Valencia. Ninety-seven percent of all households are supplied by LPG bottles and 3% by LPG tanks.

**Barcelona-Puerto La Cruz**

Located in the northwest region of Venezuela, Barcelona is the seventh most populous city, with a yearly average temperature of 26.5 °C (varying from 35 °C in May to 17 °C in December). The importance of oil activities in the 1940s enabled the development of some industrial branches such as food processing, oil refineries, etc. In the 1970s the city began providing administrative and commercial services. Important investments in the tourist industry in the late 1980s made Barcelona more attractive to foreign visitors. Three nearby ports enhance the area: Puerto de Guanta, Oil Port of Guaraguao, and the Ferris Terminal, which bridges Puerto La Cruz with the island of Margarita, one of the most popular tourist spots in Venezuela.

CADAFE supplies electricity to Barcelona-Puerto La Cruz. According to the company, 98% of the population has electricity (29,434 residential customers in 1989). Illegal connections in Barcelona reached an estimated of 12% by 1989.[5] Gas service (both LPG and NG) is supplied in the city by CORPOVEN through TIGASCO. A grid covering approximately 27% of the existing population allows

[4] Under the present arrangements MARAVEN, a wholly owned subsidiary of PDVSA, supplies gas free of charge to FIME. The responsibility for the operation and maintenance of the distribution system now rests with this institute. FIME is an organization set up under the auspices of the City Council specifically to manage the distribution of gas to domestic and small industrial/commercial users within the city.

[5] According to the survey applied by the local municipality in order to develop the "Local plan for urban development for Barcelona-Puerto La Cruz," in 1987.

the distribution of natural gas.[6] LPG is also distributed in bottles or tanks by a small number of distributors in the city.

**Mérida**

Located 1500 meters above sea level in the Andes Mountains, Mérida's traditional character and cold climate attract tourism all year round. In addition, 20% of the city's 268,270 inhabitants are university students (around 40,000 people), and Mérida's university infrastructures are spread citywide. The annual average temperature is 18.7 °C, with January being the coolest month averaging 17.4 °C and September the warmest with 19.4 °C.

CADAFE supplies electricity to the city of Mérida through two main generating plants, the hydroelectric central José Antonio Páez in Santo Domingo and the thermoelectric alternative source in La Fría. There is no natural gas grid infrastructure in Mérida; LPG is supplied by CORPOVEN through a number of large and small distributors within the city.

## 2.2 The Survey Households: Socio-Economic Characteristics

In the last 30 years, Venezuela has been transformed into a mostly urbanized country. By 1990, 85% of the population lived in urban areas. This transition was brought about by harvesting the revenues of oil export activities. Likewise, oil activities hastened the transition toward the use of modern fuels in Venezuela's urban households.

Venezuela's capital city, Caracas, absorbed the largest share of the nation's public investment in infrastructure. In the last 30 years the city's infrastructure was redeveloped to build freeways, develop public housing projects, and construct the first metro system in the country. Modern fuels were made readily accessible to Caracas's population through the development of a natural gas grid. Electricity was made accessible to even the poorest sectors within the city.

With less modifications to the traditional structure of their cities, Maracaibo, Valencia, Mérida, and Barcelona Puerto-La Cruz have experienced a different urban transition. A large proportion of the traditional types of dwellings remain in each of the four cities and new developments follow the predominant pattern of mixed single-family dwelling structures mixed with local commercial activities.

Single-family dwellings are the most commonly developed structure in the four surveyed cities. Traditional houses consist of halls surrounding an open central patio and rooms with high ceilings and tall windows. The buildings incorporate light materials (asbestos, wood, adobe, etc.) into their design, thus allowing natural ventilation even during the hotter and most humid months of the year.

The newer type of urban single-family dwellings brings a different design that leaves fewer, if any, open areas in the structure and uses more rigid materials, thus requiring the use of a larger number of artificial devices for illumination and ventilation.

Moreover, as cities evolve toward modern stages of physical development, they have abandoned the importance of trees and open space. Such a lack of greenery and space can contribute to exacerbating

[6] According to TIGASCO.

the so-called heat island effect.[7]

Household size and income level have impacts on energy use. Information on income, household sizes, and education help explain why households choose certain fuels, why they use certain amounts of electricity, and why they purchase certain types of appliances. In particular, changes in household incomes and sizes help explain the type and amount of fuel and electricity used in surveyed households.

As presented in Table 2, average income is slightly higher in Caracas than in the other cities. Expressed in terms of purchasing power parity (reference 6), the average income of Caracas's households is almost twice as high as the average level in Mérida. A high rate of inflation (40% in 1990) devalues even further the already low average income of the Venezuelan population.

Considering the number of minimum wage earners in 1990, Caracas's low-income families received on average two minimum wages, whereas in the other cities' low-income families received one minimum wage. Low-income families in Maracaibo and Valencia are worse off than those in other cities. Income distribution is more equitable in Maracaibo, Mérida, and Barcelona, where average income in the highest quintile is about three times that in the lowest quintile. The ratio is eleven to one and seven to one in Caracas and Valencia respectively.

Household size effects the amount of energy used within the household. In all surveyed cities, household sizes decreased at higher income categories. It is expected that a higher number of household members would affect the amount of energy use in the dwelling. However, similar studies (Schipper, 1989) have reported that high levels of saturation of electric appliances within high-income households may cancel the net reduction in energy consumption attributable to smaller family sizes.

As presented in Table 3, average household sizes are markedly distinct among the surveyed cities, ranging from 4.6 in Valencia and Mérida, to 5.4 in Maracaibo and 6.1 in Barcelona. Barcelona shows the highest number of persons per household for almost all income levels. This may be associated with the more traditional and rural mode of life still present in Barcelona's social structure[8].

As a result of poor income distribution and mobility in Maracaibo and Barcelona, income decreases with the growth of household sizes, thus demonstrating that most households in these two cities face more stagnant economic circumstances than in the other cities.

In Caracas, Valencia, and Mérida, household sizes vary little among mid/low-, mid/high- and high-level income categories, contrary to the belief that the higher the income, the lower the number of persons

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[7] The potential of trees and other vegetation to reduce building cooling loads has been recorded in a number of studies (see H. Akbari et al., 1989).

[8] Several factors help to explain the high number of persons in Barcelona households. They may be linked to a strong presence of traditional values within Barcelona's society promted by the Catholic Church. For instance, the role of women in society is defined by motherhood. Young girls often have no other options to marriage, such as higher education or careers, so they marry very early. Early marriage and motherhood prompt women to have more than one child. Extended families living together are common and, among low-income households, even the rule.

per household. This lack of variation is probably linked to the fact that the traditional culture emphasizes closeness of family members and it is considered a positive trait in Venezuelan society. Poverty among the lower and middle classes also causes families to share living quarters.

**Table 2. Monthly Households Incomes**

| | Household Income Level | | | | |
|---|---|---|---|---|---|
| | Low | Mid/Low-Level | Mid/High-Level | High-Level | Average |
| Monthly income (US$)[a] | | | | | |
| Caracas | 362 | 564 | 1092 | 2103 | 545 |
| Maracaibo | 186 | 266 | 482 | 504 | 329 |
| Valencia | 196 | 408 | 508 | 1411 | 412 |
| Mérida | 238 | 265 | 303 | 521 | 294 |
| Barcelona | 254 | 342 | 392 | 786 | 360 |
| Monthly income (PPP)[b] | | | | | |
| Caracas | 517 | 806 | 1560 | 3004 | 779 |
| Maracaibo | 266 | 380 | 689 | 720 | 470 |
| Valencia | 280 | 583 | 726 | 2016 | 589 |
| Mérida | 340 | 379 | 433 | 744 | 420 |
| Barcelona | 363 | 489 | 560 | 1123 | 514 |
| Number of minimum wage earners[c] | | | | | |
| Caracas | 2.0 | 3.1 | 6.0 | 11.6 | 3.0 |
| Maracaibo | 1.0 | 1.5 | 2.7 | 2.8 | 1.8 |
| Valencia | 1.1 | 2.2 | 2.8 | 7.8 | 2.3 |
| Mérida | 1.3 | 1.5 | 1.7 | 2.9 | 1.6 |
| Barcelona | 1.4 | 1.9 | 2.1 | 4.4 | 2.0 |
| Percentages of households in different income groups | | | | | |
| Caracas | 46 | 46 | n/a | 8 | |
| Maracaibo | 11 | 56 | 26 | 7 | |
| Valencia | 16 | 59 | 23 | 2 | |
| Mérida | 12 | 49 | 31 | 8 | |
| Barcelona | 21 | 62 | 10 | 7 | |

[a] Exchange rate 1990: 50 bolivares per U.S. dollar according to *International Financial Statistics Yearbook*, 1991.
[b] Based on reference Summers, B., Heston. 1990 PPP/U.S.$ ratio= 0.7
[c] Minimum wage in mid-1990 estimated in 6.07 $U.S./day
[*] n/a= not applicable

**Table 3. Household Sizes (Persons/Household)**

| | Income Levels | | | | |
|---|---|---|---|---|---|
| | Low | Mid/Low | Mid/High | High | Average |
| Caracas | 5.4 | 4.4 | 4.9 | 4.6 | 4.7 |
| Maracaibo | 6.0 | 5.7 | 4.7 | 4.6 | 5.4 |
| Valencia | 5.2 | 4.5 | 4.4 | 5.4 | 4.6 |
| Mérida | 5.7 | 4.7 | 4.2 | 4.6 | 4.6 |
| Barcelona | 6.2 | 6.3 | 5.9 | 5.0 | 6.1 |

Mérida's average number of persons per household is relatively similar to that in Caracas. This might be associated to the role of Mérida in providing services such as higher education, where almost 20% of its total population are university students.

## 3. Energy Use for Cooking and Water Heating

Cooking is the primary residential energy activity in Venezuela. Water heating tends to be intertwined with cooking, which makes it difficult to disaggregate the amount of energy use for either purpose. The following sections identify the types of fuels used to satisfy each end use, the cost of these fuels, and the amount of energy consumed by the major end-use activities.

### 3.1 Fuel Availability and Cost

As is the case in Caracas, the energy transition in the four cities has already taken place. However, the survey found that in Maracaibo, the use of modern fuels is coupled with a significant utilization of kerosene and fuelwood as secondary options for cooking.

LPG bottles or LPG tanks, natural gas, kerosene, and charcoal are the main fuels available in all urban areas studied. LPG is available practically everywhere. PDVSA's subsidiaries, CORPOVEN, MARAVEN, and LAGOVEN, are in charge of supplying LPG to the main distributors in each city. LPG is distributed in bottles of different weights, ranging from 8 to 45 kilograms. LPG can also be distributed in tanks, although mainly for apartment buildings and high-income households. Valencia and Mérida's households use LPG exclusively, since natural gas is not available.

Three cities have a natural gas distribution infrastructure: Caracas, Maracaibo, and Barcelona. The installation of a natural gas grid in Maracaibo and Barcelona occurred as a consequence of oil development in their regions. Maracaibo has an extensive but poorly maintained natural gas distribution system. Maracaibo's original system was installed in 1937 by Shell, which provided the gas free of charge to users within the city. During subsequent years, the system was expanded to its present size of 2500 to 3000 km, but much of the 1937 distribution system is still in use. A large quantity of natural gas is leaking from the low- and medium-pressure components of the system. The city is currently consuming between 50 and 60 million standard cubic feet a day (MMSCFD) on its residential grid alone. This figure

implies that each household is using around 300 SCFD (as compared to a level of about 32 SCFD/household in Caracas, which has a newer distribution system).

While there are some differences in climatic conditions (Maracaibo is about 30 C in the summer compared to 21°C in Caracas and uses of gas (gas-powered air conditioners are used to some degree in Maracaibo), there is nothing unique to Maracaibo that would account for a 10-fold increase in gas intensity per household.

A combination of economic, institutional, and technological factors have perpetuated this inefficient distribution of gas. Estimates done by FIME and PDVSA, the gas-distribution organizations, suggest that up to 46 MMSCF leak per day. In terms of radiative forcing, this leak rate over the course of a year releases the equivalent of about 6.8 MT $CO_2$, or 10% of Venezuela's total energy-related carbon dioxide emissions in 1990.[9]

**Table 4. Fuel Prices[a] per Gigajoule (GJ)**

| | Natural Gas[b] | LPG | Electricity[c] |
|---|---|---|---|
| 1988 | | | |
| Bls/GJ | 28.7 | 54.3 | 183 |
| U.S.$/GJ | 0.57 | 1.09 | 3.6 |
| 1990 | | | |
| Bls/GJ | 57.47 | 154.3 | 744 |
| U.S.$/GJ | 1.14 | 3.1 | 14.9 |

[a]1 U.S.$ = 50 bolivares in 1990
[b]Regarding natural gas, utilities bill residential customers according to a single fixed value and a predefined unit consumption related to two categories: apartments (25-30 $m^3$/mo, equivalent to 14 GJ/hh/yr) and houses (75 $m^3$/mo, equivalent to 40 GJ/hh/yr).
[c]National average price

Table 4 presents the changes in fuel prices that have occurred in 1988 and 1990 on a dollar per gigajoule basis. The prices roughly apply to all cities in the country. Between 1988 and 1990 there was a 300% increase in the price of LPG and a 200% increase in the price of natural gas. There is a substantial price difference between the two fuels. The price of natural gas is 2.7 times lower than the price of LPG. Natural gas prices are extremely low, even by Venezuelan standards. Moreover, it is a flat rate change. Changing the fuel-pricing tariff structure is particularly problematic in Venezuela for two

[9] During 1993 the Venezuelan government introduced a request for funding to the United Nations Development Program, Global Environmental Facility (GEF), for a project to reduce methane leaks in the Maracaibo natural gas distribution network. The proposal received approval from GEF and is now in the process to be implemented. The participant agencies in Venezuela are the Ministry of Energy and Mines, Petróleos de Venezuela, S.A., (PDVSA), MARAVEN (PDVSA subsidiary), Ministry of Environment and Natural Resources, The government of the state of Zulia and the municipality of Maracaibo.

reasons: first, consumers are unlikely to support higher prices in advance of improvements to the grid. Utilities would find it difficult to invest first and raise rates later because, although the returns on the investment would be attractive, they would be less than the current interest rate (40%) in Venezuela.

Second, the capital and operating costs associated with metering programs in operation in developed countries make them a poor model for a program to introduce metering in urban households in Venezuela. Consequently, there is some concern about proceeding with a pay-for-use tariff structure in advance of some notion of the trade-off between operating costs (e.g., those associated with frequency of reading and the number of meters read) and benefits in terms of incentives for efficient use of energy.

### 3.2 Fuel Choices for Cooking and Water Heating

The transition to the use of modern fuels for cooking and water heating in urban cities in Venezuela is completed. Various factors affected the speed at which the transitions occurred: the availability of fuels, government energy policies oriented to the provision of cheap energy to all sectors of the population, improved income levels, and the influence of modern urban activities on household patterns.

**Table 5. Delivered Fuel Shares (Excluding Electricity)[a] by Income (%)**

| City | LPG | Natural Gas | Kerosene | Other[b] |
|---|---|---|---|---|
| **Maracaibo** | | | | |
| Low income | 60 | 40 | 23 | 27 |
| Mid-low | 33 | 67 | 8 | 12 |
| Mid-high | 2 | 98 | 3 | 2 |
| High income | 6 | 94 | 8 | 0 |
| **Valencia** | | | | |
| Low income | 96 | 0 | 4 | 0 |
| Mid-low | 100 | 0 | 0 | 0 |
| Mid-high | 100 | 0 | 0 | 0 |
| High income | 93 | 0 | 0 | 0 |
| **Mérida** | | | | |
| Low income | 100 | 0 | 0 | 0 |
| Mid-low | 100 | 0 | 1 | 0 |
| Mid-high | 100 | 0 | 0 | 0 |
| High income | 100 | 0 | 0 | 0 |
| **Barcelona** | | | | |
| Low income | 98 | 0 | 0 | 0 |
| Mid-low | 83 | 16 | 0 | 0 |
| Mid-high | 70 | 30 | 0 | 0 |
| High income | 56 | 38 | 0 | 0 |

[a]These numbers represent the percentage of households reporting fuel use.
[b]"Other" mainly refers to the use of fuelwood for cooking.
[c]National gas distribution grid in city

Survey results show that kerosene use has declined to insignificant levels in all of the survey cities. Kerosene and coal use were detected in a significant proportion only in Maracaibo's low-income households (Table 5). The use of these two fuels in Maracaibo's low-income households was reported mostly as a secondary fuel for cooking and water heating.

Where available, households prefer natural gas, as is shown by the high percentage of households using this fuel across income levels in Caracas, Maracaibo, and Barcelona, where distribution grids are present. The availability of fuels affects an urban household's choice of fuels for cooking and water heating. Table 6 shows the percentage of households in the four cities using each type of fuel for cooking.

The percentage of piped gas is higher in mid/high- and mid/low-income households in all cities. Piped gas has a wider presence in multi-family dwellings. The high percentage of multi-family or multi-story structures among mid/high- and mid/low-income categories contributes to this result. Also, the fact that the institution pay for connection costs in multi-family dwellings — as opposed to individuals bearing the cost in single-family dwellings — reinforces this results.

LPG is the fuel of choice of low-income households in all cities except Maracaibo, where a significant 40% use natural gas. This is explained by the fact that most low-income areas comprise *barrios de ranchos*, spontaneous developments on municipal and privately owned lands. The fact that these areas might be subject to eviction prevented the utilities from extending the grid coverage toward them.

Electricity accounts for a significant share of the cooking energy mix for high-income families in all cities. This is not surprising since electric stoves are advertised as modern devices that confer a better social status on the family. More luxurious models of electric stove are offered than gas stoves. In Caracas, the use of electricity for cooking is relevant in all income levels.

The patterns of cooking and the types of food prepared vary little among the cities. In all four cities, the majority of households surveyed indicated that most members ate at least two meals a day in the house. Commercial foods, fast foods, street vendors, and restaurants are regarded as a secondary option, although at least in Caracas, traffic congestion and other difficulties are forcing the population to shift their food habits.

### 3.3 Fuel Choices for Water Heating

The practice of heating water for bathing and laundry is very common in Venezuela's cultural tradition, as reflected in all surveyed cities.[10] Because water heating tends to be intertwined with cooking, households are driven to use the same fuel for either purpose, thus making unit consumption difficult to obtain.

[10] One of the most common routines for bleaching white clothes in Venezuelan households consist of steeping the clothes in soapy boiling water for several minutes. Unit consumption related to this practice is very difficult to estimate.

**Table 6. Percentage of Households Using Each Fuel for Cooking**

| City | Piped gas + Cylinders | Natural Gas | Electricity | Kerosene |
|---|---|---|---|---|
| **Caracas** | | | | |
| Low income | 98 | 0 | 1 | 2 |
| Mid-low | 25 | 65 | 10 | 0 |
| Mid-high | 29 | 44 | 27 | 0 |
| High | 50 | 17 | 33 | 0 |
| Average | 59 | 33 | 7 | 1 |
| **Maracaibo** | | | | |
| Low income | 60 | 40 | 0 | 13 |
| Mid-low | 33 | 67 | 0.3 | 0.6 |
| Mid-high | 2 | 98 | 3 | 0 |
| High | 8 | 94 | 0 | 0 |
| Average | 27 | 74 | 0.8 | 2 |
| **Valencia** | | | | |
| Low income | 96 | 0 | 0 | 5 |
| Mid-low | 100 | 0 | 3 | 0 |
| Mid-high | 100 | 0 | 4 | 0 |
| High | 93 | 0 | 15 | 0 |
| Average | 99 | 0 | 3 | 1 |
| **Mérida** | | | | |
| Low income | 100 | 0 | 8 | 0 |
| Mid-low | 100 | 0 | 1 | 0 |
| Mid-high | 100 | 0 | 0 | 0 |
| High | 100 | 0 | 0 | 0 |
| Average | 100 | 0 | 2 | 0 |
| **Barcelona** | | | | |
| Low income | 98 | 0 | 0 | 0 |
| Mid-low | 83 | 16 | 1 | 0 |
| Mid-high | 70 | 30 | 2 | 0 |
| High | 56 | 37 | 6 | 0 |
| Average | 83 | 15 | 2 | 0 |

Fuel choice for water heating is directly connected to family income. A far larger number of upper-income households rely on electricity for water heating than for cooking in Caracas, Valencia, and Barcelona (Table 7).

In Mérida, households rely on gas as their main water-heating source. This fact also correspond to a higher presence of gas water-heating devices in Mérida's market than in the other surveyed cities. The importation of devices from nearby Colombian markets is probably one of the reasons for such an occurrence.

In Maracaibo the amount of people heating water for different purposes is smaller than in the other cities, probably due to the hot climate in this city.

### 4. Electricity Use for Lighting and Appliances

In recent years, electricity demand has increased rapidly in all the surveyed cities. Higher saturation of appliances and more intensive lighting have spurred this growth. The total demand for household electricity depends on the unit electricity consumption of major electric appliances, appliance ownership, and usage patterns. This section examines the availability and price of electricity in the survey cities; reports on the saturation of electricity end-use lighting, television, refrigerators, water heaters, air conditioners, and washing machines; and analyzes the total amount of electricity consumed by the surveyed households.

### 4.1 Electricity Availability and Cost

In the four surveyed cities, nearly all households had an electricity connection. While most of the households receive their electricity supplies directly from the utility companies, there is a significant number of illegal connections in all four cities, most of which are low-income households. The proportion ranged from 17% in Valencia and Caracas to 12% in Barcelona.

Altering a meter's reading is a common practice for which estimates are impossible to gather or calculate. The quality of the energy supplies varies among cities and income categories within cities. Power outages occur occasionally in the four cities; however, they were markedly reported by low-income households across cities and most probably caused by the great number of illegal connections.

The level of non-metered households registered from the survey was small in all cities. Non-metered households were mostly reported as shared meters rather than as households without the service.

In Caracas (ELECAR) and Maracaibo (ENELVEN), current electricity tariff structures have a pyramid shape. Low- to mid-range customers (using between 130 and 300 kWh/mo) pay the highest prices; lower and higher consumption levels pay lower prices. Electricity use beyond 1000 kWh/mo is priced 44% less than in the low- to mid-range. In the case of Caracas, for instance, mid-range consumers (around 300 kWh/mo) pay the highest average price for electricity, while users at the high end (around 2000 kWh/mo) pay an average price 26% lower (Figure 1).

**Table 7. Percentage of Households Using Each Fuel for Water Heating[a]**

| City | Piped gas + Cylinders | Natural Gas | Electricity |
|---|---|---|---|
| **Caracas[b]** | | | |
| Low income | 0 | 0 | 5 |
| Mid-low | 0 | 0 | 60 |
| Mid-high | 0 | 5 | 75 |
| High | 0 | 13 | 90 |
| **Maracaibo** | | | |
| Low income | 32 | 21 | 0 |
| Mid-low | 18 | 37 | 1 |
| Mid-high | 1 | 46 | 14 |
| High | 3 | 29 | 6 |
| **Valencia** | | | |
| Low income | 25 | 0 | 0 |
| Mid-low | 11 | 0 | 29 |
| Mid-high | 12 | 0 | 63 |
| High | 5 | 0 | 66 |
| **Mérida** | | | |
| Low income | 75 | 0 | 0 |
| Mid-low | 42 | 0 | 17 |
| Mid-high | 51 | 0 | 11 |
| High | 22 | 0 | 0 |
| **Barcelona** | | | |
| Low income | 92 | 0 | 0 |
| Mid-low | 72 | 14 | 7 |
| Mid-high | 56 | 26 | 33 |
| High | 48 | 32 | 38 |

[a]These figures represent the type of fuel households use for water heating and do not reflect the ownership of specific water-heating devices (see Table 10).
[b]Caracas households also use LPG bottles to heat water; however, the share of its use was difficult to define in the survey.

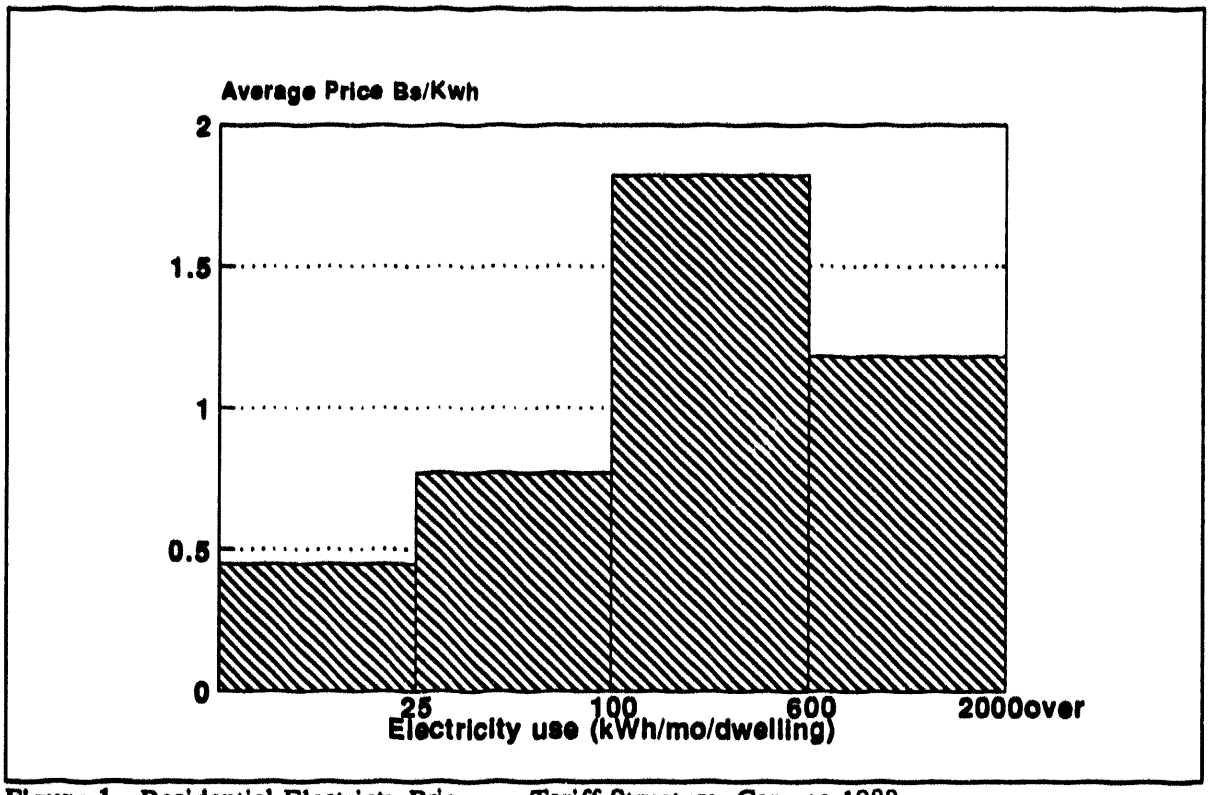


Figure 1. Residential Electricty Prices — Tariff Structure, Caracas 1988

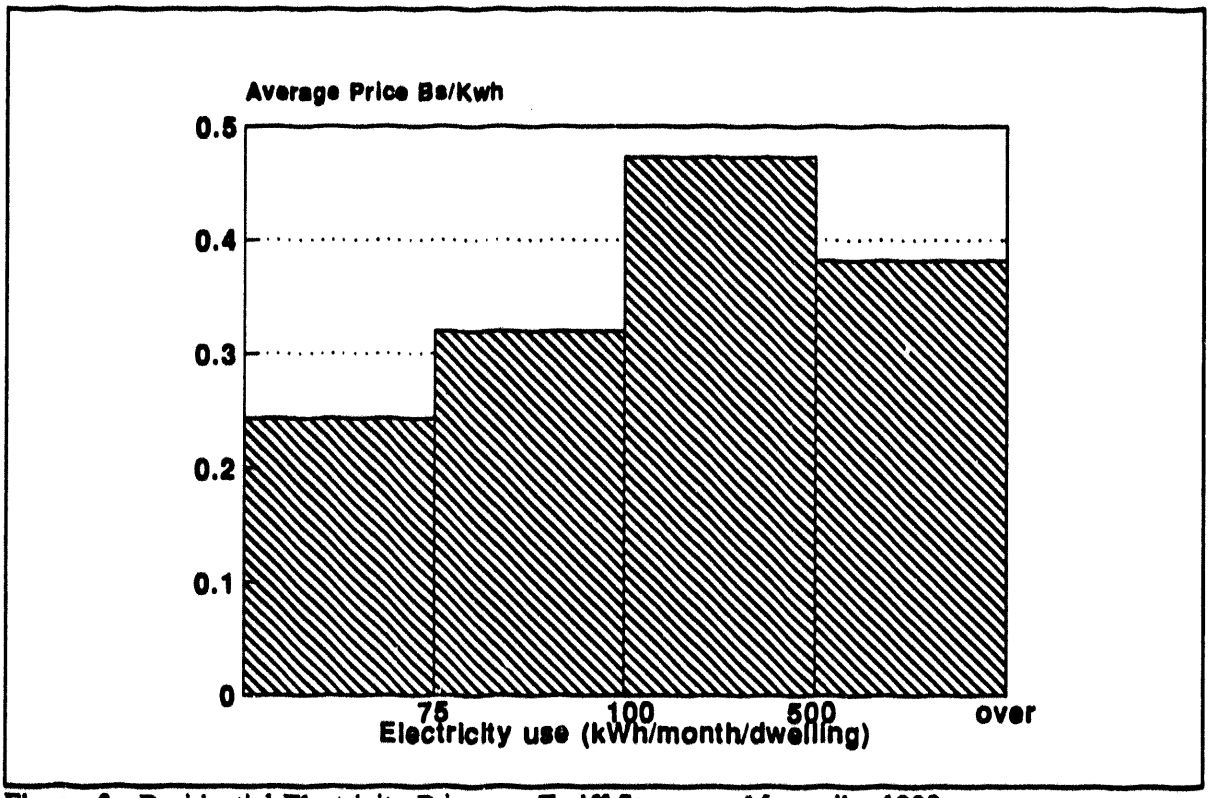


Figure 2. Residential Electricity Prices — Tariff Structure, Maracaibo 1990

This practice also occurs in Maracaibo, where all low-income surveyed families have a level of electricity consumption in the low- to mid-range order (between 131 and 500 kWh/mo, higher than the 100 KWh/mo range pertinent to social tariff), and thus pay more bolivars per kilowatt-hour than mid- and high-income families (Figure 2).

In Valencia, Barcelona, and Mérida, CADAFE and ELEVAL have inverted electric tariffs. The residential electricity tariff increases from 0.35 Bolivars/kWh for consumption levels below 150 kWh per month to 0.99 Bolivars/kWh for consumption levels above 150 kWh per month (Figure 3).

### 4.2 Lighting

The high level of electrification in all surveyed cities and the advantages of electricity's quality and cost ensure its preferred use for lighting in all urban areas. Households predominantly use incandescent bulbs, as shown in Table 8. Fluorescent bulbs are used in a lesser proportion across income categories in all cities.

The penetration of fluorescents increases with income. Low-income families in all four cities reported a minimal use of fluorescents. This result suggests that the initial cost of the tubes prevents their purchase.

The average number of bulbs per household in the four cities varies from 16 to 21 per household. This is a higher number compared to Caracas's average of 11 light points. The large proportion of single-family dwellings might be the driving factor for these results.

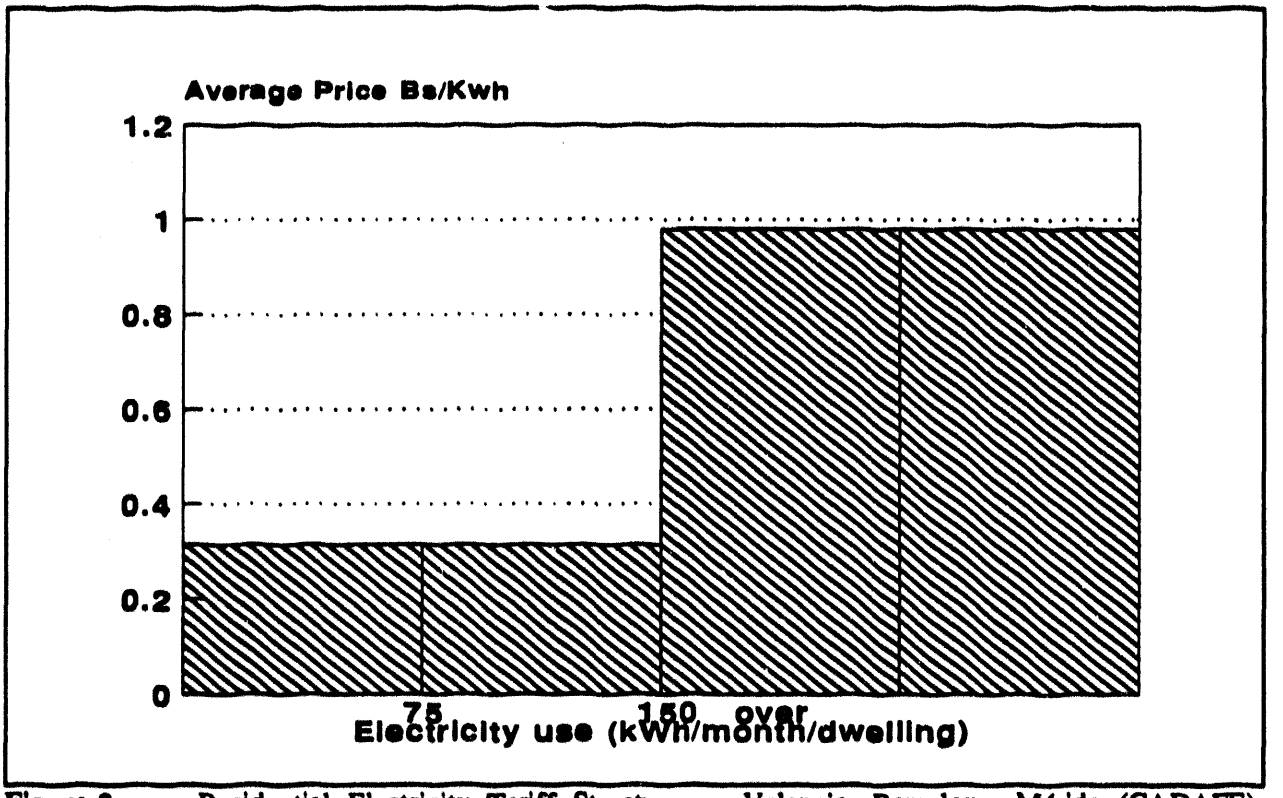


Figure 3. Residential Electricity Tariff Structure — Valencia, Barcelona, Mérida (CADAFE); Valencia (ELEVAL)

**Table 8. Percent of Households with Incandescent and Fluorescent Bulbs**

| | Income Level | | | | |
|---|---|---|---|---|---|
| City | High | Mid-High | Mid-Low | Low | Average |
| **Caracas** | | | | | |
| Incandescent | 97 | 95 | 96 | 95 | 94 |
| Fluorescent | 37 | 46 | 27 | 22 | 26 |
| Light points/dwe. | 32 | 33 | 10 | 8 | 11 |
| **Maracaibo** | | | | | |
| Incandescent | 83 | 88 | 78 | 83 | 82 |
| Fluorescent | 58 | 20 | 25 | 3 | 23 |
| Light points/dwe. | 24 | 22 | 17 | 7 | 17 |
| **Valencia** | | | | | |
| Incandescent | 100 | 90 | 95 | 99 | 94 |
| Fluorescent | 25 | 10 | 8 | 0 | 7 |
| Light points/dwe. | 57 | 28 | 22 | 9 | 21 |
| **Mérida** | | | | | |
| Incandescent | 89 | 82 | 86 | 92 | 86 |
| Fluorescent | 28 | 15 | 23 | 0 | 18 |
| Light points/dwe. | 17 | 17 | 15 | 8 | 15 |
| **Barcelona** | | | | | |
| Incandescent | 88 | 93 | 91 | 95 | 92 |
| Fluorescent | 0 | 10 | 26 | 2 | 18 |
| Light points/dwe. | 31 | 19 | 16 | 12 | 16 |

### 4.3 Electric Appliances

After households obtain lighting, televisions sets, irons, and fans tend to be among the first appliances purchased. Refrigerators are next in line, followed by an array of other minor appliances (a blender is the most commonly found among the cities surveyed). Washing machines, water heaters, and air conditioners follow depending on income level and climate conditions.

### 4.4 Television Sets

The penetration of television sets typically increases along with income (Table 9). Ownership of color television does not vary much among the mid/low-, mid/high-, and high-income categories in all cities.

**Table 9. Percent of Households with Television Sets**

| City | Income Level | | | | |
|---|---|---|---|---|---|
| | High | Mid-High | Mid-Low | Low | Average |
| **Maracaibo** | | | | | |
| Black & white | 20 | 23 | 33 | 48 | 31 |
| Color | 91 | 92 | 76 | 52 | 78 |
| **Valencia** | | | | | |
| Black & white | 18 | 15 | 15 | 36 | 18 |
| Color | 98 | 93 | 85 | 45 | 81 |
| **Mérida** | | | | | |
| Black & white | 33 | 12 | 32 | 42 | 27 |
| Color | 100 | 78 | 76 | 67 | 77 |
| **Barcelona** | | | | | |
| Black & white | 6 | 21 | 17 | 56 | 25 |
| Color | 94 | 79 | 83 | 44 | 75 |

### 4.5 Refrigerators

Consumers in Venezuela tend to purchase large refrigerators. A high percentage of the surveyed houses in all cities owned two-door, manual or frost-free models with volumes of more than 15 cubic feet in size (the percentage of ownership of this type of refrigerator is 64.9% in Valencia, 56% Maracaibo, 41% Barcelona, and 40% in Mérida). Infrequent shopping makes a refrigerator necessary for food storage. The practice of maintaining cold drinkable water in the refrigerator is also widespread and might be linked to the higher ownership of refrigerators even among low-income families (Table 10).

The type of refrigerator varies considerably among income levels. Single-door, manual defrost type refrigerators constitute the more common option for low-income families in all cities (63% Maracaibo, 32% Valencia, 61% Barcelona, and 50% in Mérida).

The survey results also obtained information on second-hand refrigerators. The percentage of used refrigerators increases for low-income households. While almost all high-income households reported new refrigerators, the percentage of used refrigerators in low-income households varied from 50% in Maracaibo, 33% in Valencia, and 20% in Barcelona to less than 1% in Mérida.

**Table 10. Percent of Households with Refrigerators and Electric Water Heaters**

| | Income Level | | | | |
|---|---|---|---|---|---|
| City | High | Mid-High | Mid-Low | Low | Average |
| **Refrigerators** | | | | | |
| Caracas | 100 | 100 | 99 | 91 | 95 |
| Maracaibo | 100 | 99 | 90 | 53 | 89 |
| Valencia | 100 | 100 | 99 | 79 | 96 |
| Mérida | 100 | 98 | 99 | 83 | 97 |
| Barcelona | 100 | 95 | 94 | 78 | 91 |
| **Electric water heaters** | | | | | |
| Caracas | 93 | 83 | 61 | 5 | 37 |
| Maracaibo | 3 | 12 | .3 | 0 | 4 |
| Valencia | 66 | 63 | 29 | 0 | 33 |
| Mérida[a] | 0 | 11 | 17 | 0 | 12 |
| Barcelona | 38 | 33 | 7 | 0 | 10 |

[a] The percent of high-income households using gas water heaters in Mérida is very high reaching 83% contrary to the other cities where gas water heaters were scarcely detected through the survey.

## 4.6 Electric Water Heaters

In all the cities surveyed, heating water for bathing is a common practice. Because of a household's generally low income, consumers tend not to purchase water-heating devices. In the four cities surveyed, the average penetration is low, reaching 33% in Valencia, 10% in Barcelona, and only 4% in Maracaibo (Table 10). Ownership increases along with income. While water heaters are non-existent among low-income families in all cities, they are present in 6 of every 10 high-income families in Valencia.

The situation in Caracas and Mérida is distinct from that in the other cities. Thirty-seven percent of all households have electric water heaters in Caracas, and at high-income levels, half of all households are equipped with two electric water heaters.

In Mérida, a 12% average ownership of electric water heaters, along with an important penetration of gas water heaters ranging from 83% at high-income households to 32% among mid/low-income, leads to the highest average penetration of water-heating devices, 52%, of all the cities surveyed.[11] Still, low-income households in Mérida reported no ownership of water-heating devices. This result suggests that the two major factors driving the penetration of water heaters are income levels and climate conditions.

[11] Ownership of gas water heaters was not detected in Valencia, Barcelona and Maracaibo.

The surveys revealed a significant difference between the penetration of water heaters in Valencia and Barcelona. Climatic conditions do not account for this variation. Barcelona, with essentially the same climate as Valencia, has far fewer electric water heaters. That Barcelona is a less modernized city appears to influence the penetration of water heaters. As income rises and as residents attempt to emulate the lifestyles of their large-city neighbors, water heaters are likely to gain popularity also in Barcelona.

Electric resistance storage-type water heaters almost completely capture the market in Caracas and Valencia, primarily because of their convenience. The use of instant electric showers, which are commonly found in Brazil, is negligent in all cities surveyed. The popular perception of risk when electricity and water mix in a single device appears to prevent their use.

### 4.7 Room Air Conditioners and Fans

The penetration of room air conditioners is highly related to climate conditions in the surveyed cities. While room air conditioners and fans are rarely found in Caracas and Mérida, their penetration is widespread in Maracaibo, Valencia, and Barcelona.

In Maracaibo, Valencia and Barcelona, the penetration of cooling devices corresponds closely with income levels (Table 11). High-income households in these three cities show the greatest penetration of air conditioners. The penetration of fans does not appear to depend on income, remaining high throughout all income categories. Low-income households in all cities surveyed, except Mérida, commonly own electric fans but rarely use air conditioners.

**Table 11. Percent of Households with Air Conditioning**

| City | Income Level | | | | |
|---|---|---|---|---|---|
| | High | Mid-High | Mid-Low | Low | Average |
| **Air Conditioning** | | | | | |
| Caracas | 7 | 12 | 1 | 0 | 1 |
| Maracaibo | 60 | 36 | 23 | 0 | 26 |
| Valencia | 67 | 16 | 5 | 0 | 8 |
| Mérida | 0 | 0 | 0 | 0 | 0 |
| Barcelona | 81 | 38 | 11 | 5 | 17 |
| **Electric Fans** | | | | | |
| Caracas | 27 | 49 | 17 | 28 | 24 |
| Maracaibo | 97 | 99 | 98 | 80 | 96 |
| Valencia | 63 | 69 | 80 | 71 | 75 |
| Mérida | 0 | 0 | 0 | 0 | 0 |
| Barcelona | 50 | 85 | 88 | 90 | 85 |

Among the factors that might have a significant influence on the high penetration of air conditioning in Maracaibo, Valencia, and Barcelona are the housing design, the construction materials, and the construction practices for building houses. Air-conditioner ownership correlates highly with concrete homes, largely because these homes are much more difficult to ventilate than houses built of light wood or other materials.[12]

Concrete construction is common in Venezuela. Even in the *barrios de ranchos* the dominant landscape is one of rather large, solid houses built with industrially produced materials, with concrete-surfaced roads and basic services. Small average room sizes and low average roof heights may also predispose households to higher levels of artificial ventilation and cooling. Finally, inappropriate installation of room air conditioners and lack of maintenance possibly account for a portion of the higher use of electricity attributable to this purpose.

### 4.8 Washing and Drying Machines

In Venezuela, new buildings, houses for rent, and apartment buildings do not ordinarily provide laundry facilities to the prospective owners/occupants. Every family has to either procure its own device, use public facilities, or hand-wash clothes. At the same time clean and very well-ironed clothes are highly prized in Venezuela. For these reasons, a washing machine is often one of the primary appliance purchases.

The penetration of clothes washers and drying machines in Venezuela is closely related to income level. In all cities surveyed, the average penetration of washing machines is more than 55%, reaching saturation among high-income households in Caracas, Valencia, and Barcelona. The penetration of drying machines is fairly low and mostly driven by income (Table 12).

Despite of the high saturation levels of washing machines in all cities, the energy consumption expected for this end use is not relevant since washing machines in Venezuela do not include automatic water heaters. Connecting the washing machine to a hot water faucet in the house is generally done for hot water washes.

Cultural appreciation of cleanliness makes clothes-washing patterns very demanding (and still today, a difficult task for women despite of the use of washing machines). More than half of all households in Maracaibo reported ownership of at least one wringer washer.[13] Within low-income households the share was 100%. The regard of automatic washing machines as less convenient because the duration of the wash cycle cannot be controled may explain such a high percentage. A similar pattern was detected for the other four cities; however, among high-income households, automatic clothes washer were the most commonly found model.

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[12] Tyler, S. 1991. Urban Household Energy Use in Thailand. PhD. Thesis. Energy and Resource Group. University of California. Berkeley.

[13] Is an old electric model of washer which agitates continuously and has a roller.

**Table 12. Percent of Households with Washing and Drying Machine**

| | Income Level | | | | |
|---|---|---|---|---|---|
| City | High | Mid-High | Mid-Low | Low | Average |
| **Washing machines** | | | | | |
| Caracas | 100 | 93 | 88 | 49 | 70 |
| Maracaibo | 81 | 84 | 57 | 23 | 62 |
| Valencia | 100 | 90 | 79 | 29 | 74 |
| Mérida | 89 | 56 | 59 | 17 | 55 |
| Barcelona | 100 | 82 | 66 | 29 | 62 |
| **Dryers** | | | | | |
| Caracas | 77 | 39 | 19 | 1 | 14 |
| Maracaibo | 6 | 20 | 2 | 0 | 7 |
| Valencia | 90 | 26 | 14 | 0 | 16 |
| Mérida | 6 | 2 | 1 | 0 | 2 |
| Barcelona | 44 | 20 | 5 | 0 | 8 |

### 4.9 Household Electricity Consumption

Electricity consumption data were often difficult to obtain because the distribution authorities were unwilling to provide them. The levels of electricity consumption presented in this report are those obtained directly from the survey in each city. Researchers obtained electricity consumption data directly from the information reported in the customer bill. When this information was unavailable, researchers estimated electricity consumption according to reported monthly expenditures on electricity using the tariff in effect at the time of the survey.[14]

Table 13 shows the increases in electricity consumption with income level for each city. In each of the surveyed cities, consumption increases at higher income brackets. Variations in electricity consumption among the cities correspond with levels of appliance ownership and frequency of appliance use.

Low-income households across cities had a similar average level of consumption, except for Barcelona and Maracaibo. The sharpest variations in electricity use among income categories occur in Valencia, Maracaibo, and Caracas; variations remain far less extreme in Mérida, probably because of a more even penetration of appliances in this city.

[14]Appliance consumption estimates from regression analysis were available for the case of Caracas. The same statistical estimates will be reproduced for the four cities in a follow-up report.

**Table 13. Household Electricity Consumption (kWh/year/household)**

| City | Income Level | | | | |
|---|---|---|---|---|---|
| | High | Mid-high | Mid-low | Low | Average |
| Caracas | 11534 | 11534 | 3658 | 1747 | 3520 |
| Index[a] | 6.6 | 6.6 | 2.1 | 1 | |
| Maracaibo | 19775 | 13996 | 7161 | 2509 | 9285 |
| Index | 7.8 | 5.5 | 2.8 | 1 | |
| Valencia | 13694 | 6006 | 6560 | 1332 | 5699 |
| Index | 10.2 | 4.5 | 4.9 | 1 | |
| Mérida | 3970 | 2430 | 2081 | 1218 | 2237 |
| Index | 3.2 | 1.9 | 1.7 | 1 | |
| Barcelona | 13061 | 9016 | 5580 | 3709 | 6054 |
| Index | 3.5 | 2.4 | 1.5 | 1 | |

[a] Indexed so that the low-income type of dwelling, ranchos, are given the value "1" and the other type of dwelling are shown in relative terms.

The average level of electricity consumption of Maracaibo, Valencia, and Barcelona is extremely high, reaching in Maracaibo almost three times the average level of Caracas. These differences appear to be related to the high penetration of air-conditioning devices in the mentioned cities. Even in the case of Mérida, with its cooler climate, the average level of electricity consumption is very high, following closely that of Caracas.

The annual electricity consumption of an average household in Maracaibo (9285 kWh/household/year) appeared even greater than that of an average house in New Orleans, Louisiana, USA, in 1990 average of 8942 kWh/year/household[15].

Among the main factors driving these results are first, large and inefficient appliances available in Venezuela; second, the large proportion of single-family dwellings and the fact that they are built out of concrete without appropriate natural ventilation and illumination. Third, poor installation and maintenance of home equipment. Fourth, as income rises in urban households usage patterns turn more intensive, reflecting little or no concern for energy savings.

## 5 Energy Consumption and Expenditures

Table 14 shows energy expenditures as a percentage of total income per household. Even with relatively low energy prices, Maracaibo's average energy expenditures constitute an important part of total income, accounting for 4% of total private expenditure, comparable to figures for OECD cities with greater space-heating needs. This result is explained by the high level of electricity consumption in this city. Low-

[15] Considering that New Orleans climate conditions are hot and humid as in Maracaibo during great part of the year. The references were taken from the Household Energy Consumption and Expenditures. Residential Energy Consumption Survey (RECS) for 1990. Energy Information Administration.

**Table 14. Energy Expenditures as a % of Total Income per Household**

| | Income Level | | | | |
|---|---|---|---|---|---|
| City | High | Mid- high | Mid-low | Low | Average |
| **Caracas** | | | | | |
| Natural gas | 0.1 | 0.1 | 0.3 | n.a. | 0.3 |
| LPG | 0.3 | 0.3 | 0.6 | 1.2 | 0.7 |
| Electricity | 1.4 | 1.8 | 1.6 | 0.7 | 1.2 |
| Total | 1.8 | 2.2 | 2.5 | 1.9 | 2.2 |
| **Maracaibo** | | | | | |
| Natural gas | 0.2 | 0.2 | 0.5 | 0.6 | 0.4 |
| LPG | 1.2 | 0.6 | 1.0 | 1.1 | 0.9 |
| Electricity | 4.7 | 3.4 | 3.5 | 1.8 | 3.5 |
| Other[a] | 0.0 | 0.3 | 0.2 | 0.9 | 0.3 |
| Total | 6.1 | 4.5 | 5.2 | 4.4 | 5.1 |
| **Valencia** | | | | | |
| Natural gas | n.a. | n.a. | n.a. | n.a. | n.a. |
| LPG | 0.2 | 0.5 | 0.5 | 0.7 | 0.5 |
| Electricity | 1.8 | 2.0 | 1.6 | 0.9 | 1.7 |
| Total | 2.0 | 2.5 | 2.1 | 1.6 | 2.2 |
| **Mérida** | | | | | |
| Natural gas | n.a | n.a | n.a | n.a | n.a |
| LPG | 0.6 | 1.1 | 1.2 | 1.0 | 1.1 |
| Electricity | 1.5 | 1.5 | 1.5 | 0.9 | 1.4 |
| Total | 2.1 | 2.6 | 2.7 | 1.9 | 2.5 |
| **Barcelona** | | | | | |
| Natural gas | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 |
| LPG | 0.2 | 0.6 | 0.7 | 0.8 | 0.6 |
| Electricity | 2.5 | 4.1 | 2.9 | 2.5 | 2.9 |
| Total | 2.8 | 4.9 | 3.8 | 3.5 | 3.7 |

[a] Refers to expenditures for purchasing kerosene and other energy fuels (mainly fuelwood) which were reported in 27% of Maracaibo low-income households in the survey.

households in Maracaibo and Barcelona, as compared to low-income families in the other cities, devote a higher percentage of their income to the purchase of energy services.

In almost all cities surveyed, mid/high- and mid/low-income households devoted a significantly higher percentage of their income to energy purchases than households in the two other extremes. Similarly, the percentage of energy expenditures related to fuel purchases is larger in low-income households than among high-income families.

### 5.1 Final Remarks and Policy Implications[16]

The level of energy consumption of Venezuela's urban households is remarkably high compared with energy use in households of analogous Latin American countries and with households of industrialized nations that confront harsher climates.

The four surveyed cities are in a similar stage of development. Appliance penetration is high in all houses surveyed and across income categories. The appliances available are inefficient, adding to the inefficiency attributable to the wasteful energy-use patterns of the population. Climate conditions and the developed urban-built form also play important roles in determining the far larger level of energy consumption of Venezuelan urban households.

An average household in Maracaibo consume more electricity per year than an average household in the city of New Orleans, Louisiana, U.S. (9285 kWh/year versus 8942 kWh/year) which has a similar climate and a higher saturation of electric appliances per household. When compared with the city of Caracas, the average household in Maracaibo consumes 2.6 times more electricity than that of Caracas. For Barcelona and Valencia, the ratio with respect to Caracas, is 1.7 and 1.6 respectively.

The use of modern fuels is well spread among all cities. The survey documents no use of biomass for cooking; and a negligible use of kerosene. The availability of fuels, their low cost, and convenience of use favors this result. Even though LPG is more expensive than natural gas it is the main fuel for low-income families. In Caracas and Maracaibo, electricity tariff structure leads to a higher cost per kilowatthour to households in the middle and low ranges of electricity consumption. Accordingly, poor families in the four cities surveyed pay more than the rich to purchase the same quantity of energy. The fraction of household income used to buy fuels shows that at lower income brackets the disparity is greater.

The design of modern single-family dwellings does not contemplate natural illumination, ventilation, or the integration of lighter materials, as opposed to the traditional design, leading to a higher necessity for energy devices. The most commonly developed building structure in the four cities is the single-family dwelling (more than 60%).

High appliance penetration resulted from a combination of more affordable equipment and higher households incomes. In almost all cities surveyed, appliances such as televisions and refrigerators have reached saturation.

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[16] Several options for introducing energy efficiency and conservation in Venezuela were discussed in the previous report for the city of Caracas. Reference 2.

Recent studies (Meyers et al., 1990) have demonstrated that the quality of the existing refrigerator stock in developing countries appears far lower than similar vintage equipment in industrialized nations. In Venezuela the market for electric appliances is starting to open to foreign competition. One major policy challenge in this realm would be to ensure that incoming devices, which will account for a considerable share of all appliances sales in the near future, comply with the best available international technologies.

Establishing efficiency standards for imported electric appliances is a policy that could take advantage of the rapidly expanding consumer appliance market. The adoption of new, more efficient technologies by domestic manufacturers will follow if more efficient units are accepted in the market. This is also a way for manufacturers to remain competitive. Labelling and information could stimulate market base competition by creating better conditions for public awareness of the new technologies.

From this study, it is feasible to anticipate that launching a pilot demonstration program (either by a public or a private institution) for a given community within a city could greatly promote the benefits of introducing energy efficiency in Venezuela. For instance, Maracaibo, the city with the highest level of energy consumption per household (both of fuels and of electricity), presents great opportunities for achieving energy conservation and efficiency without hampering the quality of the services.

Implementing building standards at a national level will be an important step for the government. Taking advantage of climate conditions -- i.e. natural ventilation and illumination-- could be required to developers in their designs. At a local level an ordinance requiring the planting of trees would be of foremost benefit to the environment and to reducing the need of artificial air conditioning.

The results of this study raise two questions: whether the traditional perspective that electricity and energy services must be provided through continuously growing investment in new generating capacity can be sustained, or whether improved technology and better management of end uses can lead to higher living standards without the need for enormous increases in energy consumption. The real issue is how to increase living standards, productivity, and participation. Energy is only important as a means of contributing to this objective.

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