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Trends in Consumption and Production: Household Energy Consumption

Prepared by
Oleg Dziubinski
Ralph Chipman
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Oleg Dziubinski

Ralph Chipman

The authors are staff members in the Division for Sustainable Development of the Department of Economic and Social Affairs. Contributions to this paper were also made by Alejandro Carpio and Luciana Wegner. Comments should be addressed to the authors, c/o Division for Sustainable Development, Rm. DC2-2284, United Nations, New York, N.Y. 10017, or by e-mail to dziubinski@un.org or chipman@un.org. Additional copies of the paper are available from the same address.

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JoAnne DiSano, Director, Division for Sustainable Development

United Nations

Department of Economic and Social Affairs

Abstract

The household sector accounts for 15 to 25 per cent of primary energy use in developed countries and a higher share in developing countries. A huge gap remains between household energy use in developed and developing countries. Increase in energy-based living standards and more efficient energy use are major opposing trends in developed countries that affect household energy consumption. Diffusion of energy efficient technologies for cooking, heating, lighting, electrical appliances, and building insulation in developing countries has been slow. Governmental policies to influence household energy consumption are often contradictory and have brought mixed results.

Introduction

The work programme of the Commission on Sustainable Development on changing consumption and production patterns, as adopted by the Commission in 1995 (E/1995/32 - E/CN.17/1995/36), includes the element, "identifying the policy implications of projected trends in consumption and consumption patterns." As part of that element, the Secretariat has been analyzing trends relating to sustainable development as a basis for identifying the policy implications of those trends.

In 1997, as part of the five-year review of progress since the United Nations Conference on Environment and Development (Earth Summit), a report on "Critical Trends: Global Change and Sustainable Development" was prepared examining long-term historical trends and future projections in such areas as population, energy and material consumption, agriculture and food supply, water and human development (ST/ESA/255). That review provided a basis for the policy recommendations presented to the Commission on Sustainable Development and the nineteenth Special Session of the General Assembly. A second broad analysis of critical trends is to be prepared for the 2002 ten-year review of progress since the Earth Summit.

For the period 1998-2002, the General Assembly, at its nineteenth Special Session, adopted a work programme with specific themes identified for each year. For the years 1999-2001, a series of reports are planned analyzing trends in selected areas relating to the work programme elements for that year. For 1999, one of the Commission's themes is consumption and production patterns, and the trends analyzed in the present paper and papers on trends in selected minerals and private transportation are related to that theme. Future reports on trends will examine land resources and agriculture (2000) and energy and transport (2001). These analyses will contribute to the broad review of trends for 2002.

As energy is central to any analysis of trends relating to sustainable development, this

paper examines trends in this area from the perspective of private consumption. In particular it considers trends in household energy consumption. This analysis will become part of a broader analysis of trends in energy and transportation in 2001.

This paper analyses current trends in household energy consumption throughout the world. It focuses exclusively on energy consumption within households (i.e., for lighting, cooking, heating, etc.). Energy use for transportation as well as indirect energy consumption (e.g., energy used in manufacturing of consumer goods) is not covered in this study. In addition to examining global and regional trends, the study of household energy consumption also includes analysis of national trends in a number of selected countries. While the global and regional are most indicative of movement toward or away from sustainability with respect to global issues, the national case studies are essential for examining the impact of policies on trends.

Countries were selected for national case studies based on a number of criteria, including their global or regional impact, the extent of active policy interventions, and the availability of consistent long-term data. For example, the Netherlands was selected for study because of both energy policies and the availability of detailed studies of household energy consumption patterns.

As the present paper is a first step toward a more comprehensive review of trends to be prepared for 2002, the Division for Sustainable Development welcomes comments on the data and analyses presented here and contributions toward the reviews planned for future years.

Global Household Energy Use

The household sector is responsible for about 15 to 25 per cent of primary energy use in OECD countries and for a higher share in many developing countries. Average per capita household energy use in developed countries is about nine times higher than in developing countries, even though in developing countries a large share of

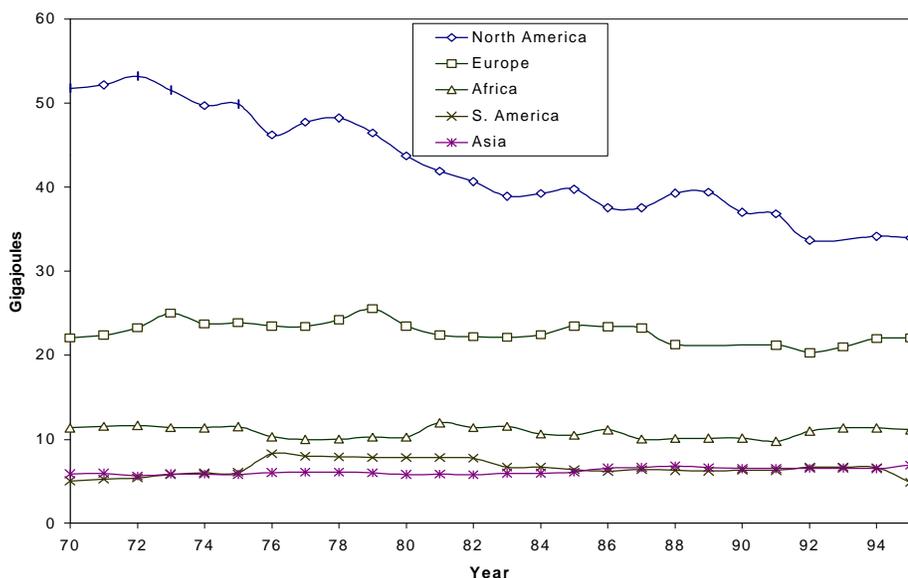


Fig. 1. Per capita household energy consumption in world regions

Source: United Nations Statistics Division

Note: Africa includes North and Sub-Saharan Africa; Asia includes West, South and East Asia

household energy is provided by non-commercial fuels that are often not reflected in official statistics.¹ Historical trends in per capita household energy consumption by

region for the period 1970 to 1995 are represented in Figs. 1 and 2.

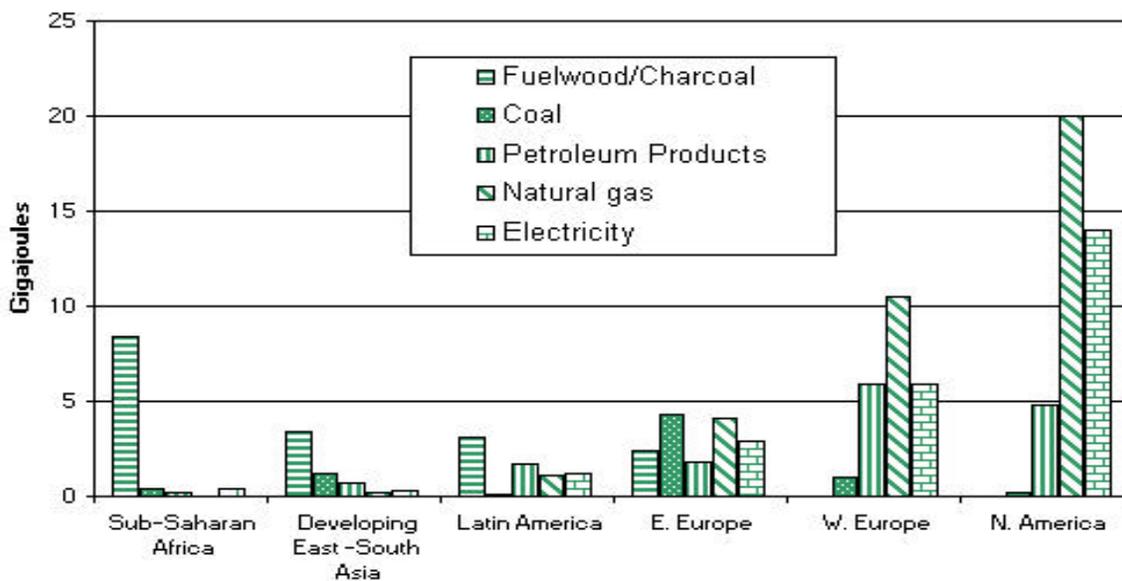


Fig. 2. Per capita household energy consumption by energy type in 1994

Source: United Nations Statistics Division

The most notable trend is the decline in per capita household energy consumption in North America, which in 1970 had much higher household energy consumption than any other region. The difference remains considerable but it decreased substantially. This decline is a result of several factors, including increased energy efficiency and saturation with domestic electrical appliances. Figure 1 also indicates higher household energy consumption in Africa than in other developing regions. This appears to be due to the higher share of fuelwood and other biomass as energy sources in Africa compared to Asia and South America (Fig. 2), and consequently lower energy efficiency.

Disparities in household energy use exist between rural and urban populations, between high and low income groups within a country, and among countries. The major factors contributing to these differences are levels of urbanization, economic development, and living standards. Other factors are country or region specific, such as climate or cultural practices.^{1,2}

Developing countries

Energy efficiency depends both on the type of fuel used and on the characteristics of particular appliances. In many developing countries, particularly in rural areas, traditional fuels, such as fuelwood, charcoal and agricultural waste, constitute a major portion of total household energy consumption. The efficiency of a traditional fuelwood cooking stove is as low as 10 - 12 per cent, compared with a liquefied petroleum gas (LPG) stove efficiency of more than 40 per cent.² Potential energy savings from the use of available efficient technologies for cooking, heating, lighting, electrical appliances and building insulation can reach as high as 75 per cent. Unfortunately, diffusion of these technologies, especially in developing countries, is slow. One of the main reasons for that is their high initial cost to the consumer, particularly relative to the low cash incomes in many rural areas.¹ Other factors include shortages of particular fuels, lack of a distribution network, and failures of the distribution system.

Production and consumption of almost any type of energy have environmental impacts. Harvesting of fuelwood, in particular, contributes to deforestation, soil erosion, and desertification. In Nigeria, harvesting of fuelwood contributes to deforestation at a rate of about 400,000 hectares per year. If this trend continues the country's forest resources could be completely depleted by 2020. Use of fuelwood as an energy source can also contribute to the accumulation of CO₂, the main greenhouse gas, both because burning fuelwood produces CO₂, and because deforestation destroys an important CO₂ sink. In addition, use of biomass in traditional stoves exposes the users, mainly women and children, to high levels of indoor air pollution.^{1,3}

Effects of urbanization and growth in per capita income on household energy consumption

The key determinants of energy demand in the household sector include:

- Prices of fuels and appliances;
 - Disposable income of households;
 - Availability of fuels and appliances;
 - Particular requirements related to each;
- and
- Cultural preferences.

With increasing disposable income and changes in lifestyles, households tend to move from the cheapest and least convenient fuels (biomass) to more convenient and normally more expensive ones (charcoal, kerosene) and eventually to the most convenient and usually most expensive types of energy (LPG, natural gas, electricity). There is also a correlation between the choice of cooking fuels and the value of women's time. Women who enter the formal workforce demand more convenience in their use of household fuels. For example, in Bangkok, that leads to a preference for LPG compared to more traditional fuels.⁴

There is a strong positive relationship between growth in per capita income and growth in

household demand for commercial fuels. For most developing countries, demand for commercial fuels has risen more rapidly than per capita incomes since 1970. This reflects the increasing desire for comfort and discretionary energy consumption.

Urbanization is an important determinant of both the quantity and the type of fuel used in developing countries. In general, urbanization leads to higher levels of household energy consumption, although it is difficult to separate the effects of urbanization from the increases in income levels that generally accompany urbanization. There is also a shift from traditional to commercial fuels. Several factors that contribute to this trend include a decline in access to biomass fuels, inconvenience of transportation and storage, and improvement in availability of commercial fuels in urban areas. Nonetheless, use of traditional fuels in many cities of the developing world remains high among low income groups. Another trend is a decline in the share of energy used for basic requirements such as cooking and lighting as incomes increase, while energy consumption for space heating, water heating, refrigeration, appliances, air conditioning and other modern uses grows.²

Electrification

The difference in per capita electricity consumption between developed and developing countries is greater than the difference for total energy. However, the growth in electricity consumption in most developing countries since 1971 has been faster than that of other fuels. Per capita household electricity use has grown faster than per capita income.

Key factors in the growth of household electricity consumption are the number of households with access to electricity supply, penetration rates of electric appliances, and the size and efficiency of appliances. Access to electricity varies widely among and within developing countries, depending largely on per capita incomes and urbanization. Rapid growth in electrification rates in many countries reflects the impact of urbanization and of rural electrification programmes.

The expected further growth in electricity consumption will have important consequences for power generation systems in developing countries. In some countries, household demand has accounted for a larger share of growth of electricity demand than industry, and in all cases the household sector represents a substantial proportion of the total increase in electricity demand. A particular problem for power systems is that household electricity demand usually adds to peak loads. Growth in electricity demand therefore requires expansion of power generation capacity, for which there are insufficient financial resources in many developing countries under current energy sector policy regimes due to inadequate provision for cost recovery from users.²

Household energy prices

One of the important determinants of household energy demand and fuel mix is the price of various fuels. It is often difficult to estimate the effect of price in developing countries where a major part of energy consumption is met by traditional fuels that are gathered informally with no cash outlays. Non-cash costs consist mostly of time (e.g., for gathering fuelwood) and hence are opportunity costs.

Commercial energy prices are often used as a social policy instrument in developing countries. Among the most common subsidized energy sources for households is electricity, with the aim of making it accessible even to low income households. However, in many cases such programmes result in effectively subsidizing higher income people who live in urban areas and have access to electricity grids. For the rural and urban poor, connection to the electricity supply is often prohibitively expensive or unavailable, even though the price of electricity itself may be low enough to encourage a switch from other fuels. In general, policies that keep energy prices low lead to growth in latent or potential household energy demand. Effective demand may not increase to the same extent if capacity constraints preclude an expansion of supply.²

Case Study 1, India^{5,6,7,8}

Household energy accounts for about half of India's total energy consumption. About 72 per cent of India's population live in rural areas, where biomass is the primary source of energy. In 1995, biomass provided 77 per cent of household energy consumption, liquid fuels 18 per cent, and electricity

5 per cent. Over the previous decade, per capita household energy consumption had increased modestly, mostly due to increases in electricity and liquid fuels, while biomass consumption has remained constant. Solid fuel consumption has declined to less than one per cent (Figs. 3, 4).

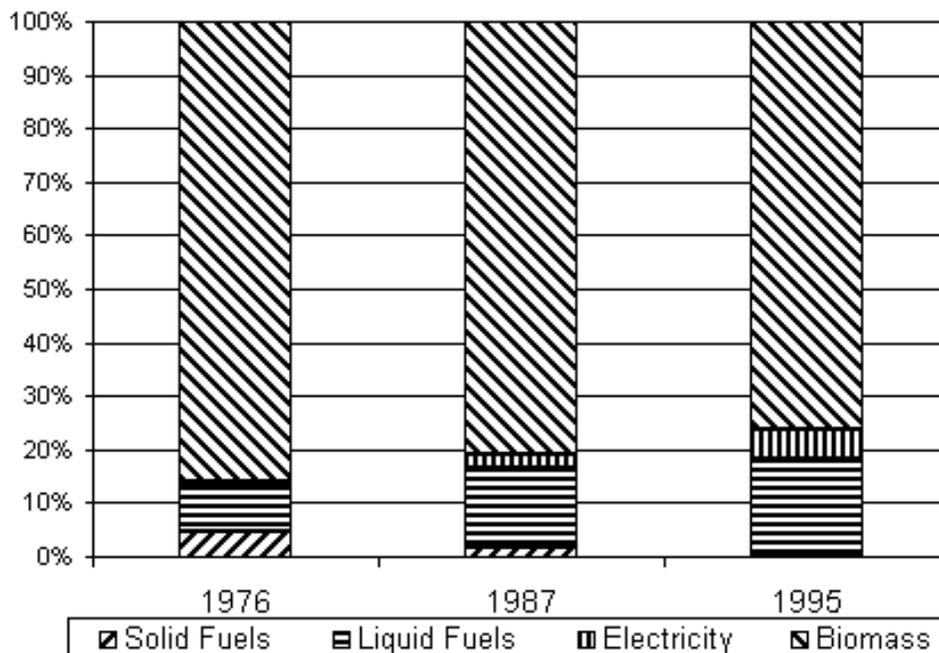


Fig. 3. Fuel mix in household energy use in India
Source: *United Nations Statistics Division*

Cooking and water heating account for about 90 per cent of household energy use. Space heating is not a large component due to India's subtropical and tropical climate, whereas air conditioning is still a luxury confined to a small percentage of households. Biomass dominates cooking fuel (over 90 per cent in the early 1990s). Kerosene is the major fuel for lighting, with about 60 per cent of households using kerosene lamps. Kerosene is also used widely in cooking (about 50 per cent of the commercial cooking fuel supply). With rising incomes, a growing share of household energy is used for lighting and electric appliances, and a decreasing share for cooking. In the early 1990s, only about 40 per cent of all households had access to electricity.

The government's energy policies include large social price subsidies and rural electrification to meet the energy needs of poor people. The electrification policy has been accompanied by both low tariffs and poor collection of payments from rural households. Prices for kerosene and LPG are also subsidized.

Potential for energy efficiency and conservation

Indian households use both commercial and non-commercial energy sources inefficiently, supported in most cases by easy availability and low

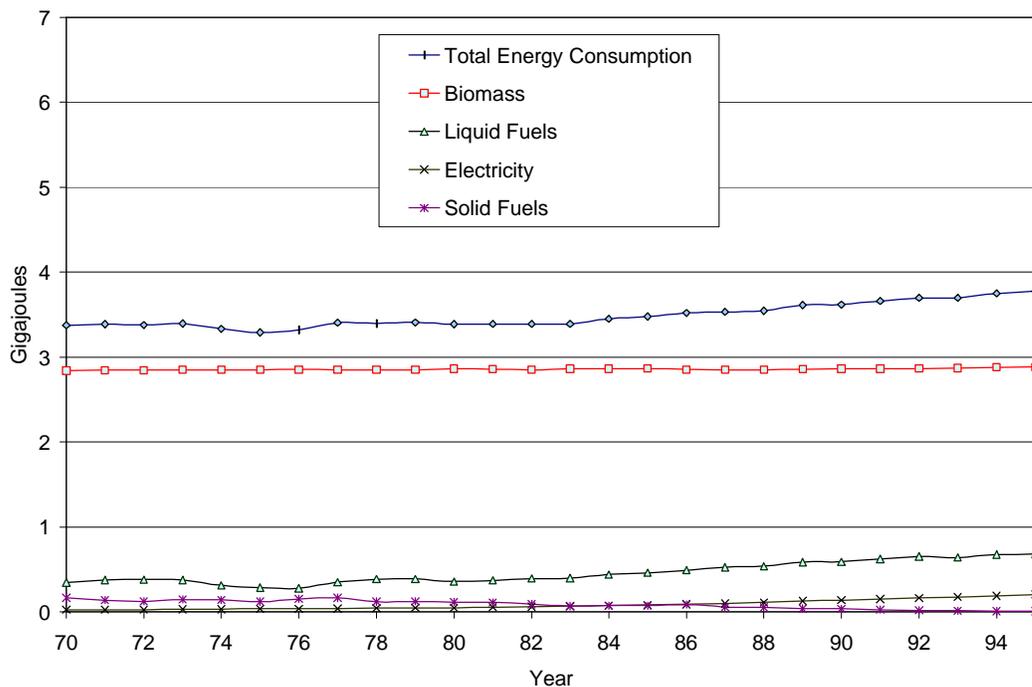


Fig. 4. Per capita household energy consumption in India
Source: *United Nations Statistics Division*

prices for those connected to the grid. Average fuel efficiency for cooking is estimated at 8 per cent for biomass, 18 per cent for coal, 25 per cent for charcoal, 45 per cent for kerosene, and 50 per cent for gas and LPG. A number of opportunities are available to improve household energy efficiency.

Kerosene provides much of the lighting in the rural regions. One third of all household kerosene consumption is for lighting, usually in kerosene wick lamps, although kerosene mantle lamps and candles are also used. These lighting sources provide very low levels of illumination and are very inefficient. A shift from kerosene to electric lighting results in both increased light output and reduced energy use. Fuel use is reduced by nearly 90 per cent, and lighting improved, when a kerosene lamp is replaced by a 16-watt compact fluorescent lamp.

Electric lighting itself offers a large energy conservation potential through a switch from incandescent to fluorescent lamps. The short lifetime of light bulbs would allow such a switch to

occur rapidly. Refrigerators also have a large conservation potential per unit, but because of their longer lives, only modest savings are available in the near future.

For cooking, an energy-efficient Nutan kerosene wick stove has an efficiency of around 60 per cent, compared with about 40 per cent for conventional wick stoves. Since kerosene stoves have relatively short lives, improved stoves could enjoy rapid market penetration. Another energy efficient stove is the Nutan LPG stove. The conservation potential for all hydrocarbon-based cooking fuels is estimated at 1.3 million tonnes. A switch from kerosene to LPG for cooking would provide cleaner air as well as higher energy efficiency.

Firewood and biomass stoves can also be made more efficient. Animal dung, now used in inefficient stoves, could be used to produce biogas, a cleaner fuel with higher utilization efficiency. In addition, an excellent fertilizer can be produced from the slurry from biogas plants. Switching to

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gaseous fuels would bring the greatest gains in terms of both thermal efficiency and cleanliness, but would be more costly.

Case Study 2, Republic of Korea⁵

Household energy accounts for about 30 per cent of total energy consumption in the Republic of Korea. Biomass use is now negligible, with only a 5 per cent share of household energy demand. Because it is a small country with high population density, there are few differences in lifestyles between urban and rural areas.

The climate largely determines household energy consumption patterns. Space heating absorbs almost 70 per cent of total household energy demand, with lighting and appliances accounting for 17 per cent, and cooking for 14 per cent. An

insignificant amount of household energy is used for water heating.

Household energy use has grown more slowly than energy use in other sectors, while there has been a substantial change in the fuel mix. As economic development has raised income levels and living standards, households have switched from cheaper and less efficient fuels, particularly coal and fuelwood, to more convenient and expensive ones, particularly gas and liquid fuels. Household electricity consumption increased at an annual rate of over 20 per cent in the 1970s, when electric appliances were widely adopted. The rate declined to about 10 per cent in the 1990s as the number of new buyers decreased and more efficient models were introduced. For cooking, LPG or town gas is now the most popular choice, with LPG providing more than 50 per cent of cooking fuel in the early 1990s. The trends for different fuels for household energy consumption are shown in Figs. 5 and 6.

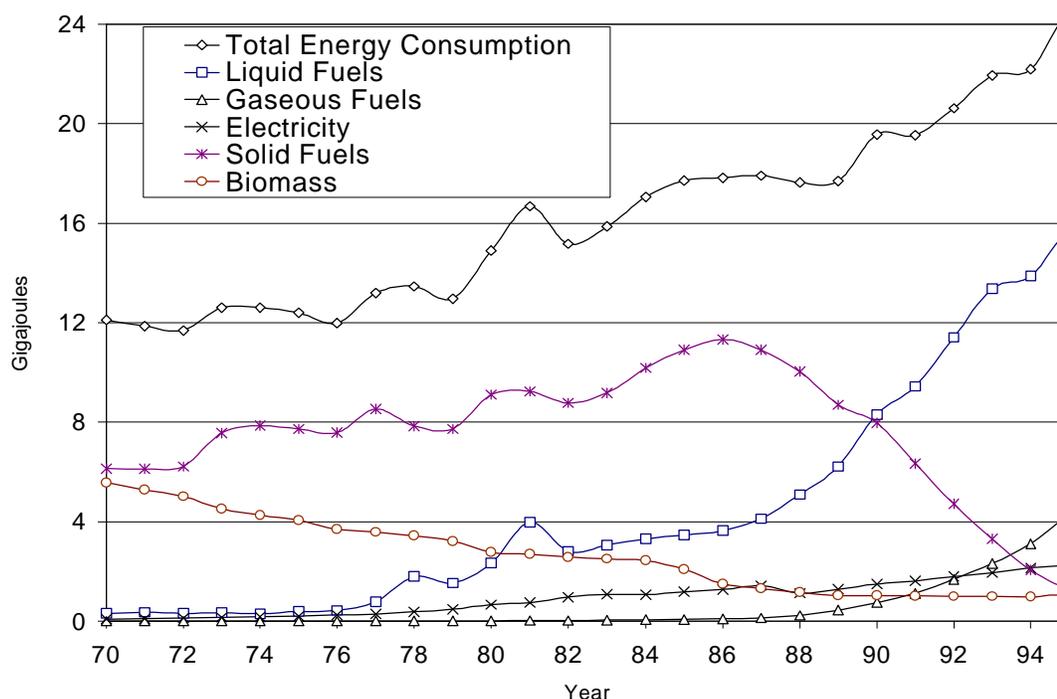


Fig. 5. Per capita household energy consumption in the Republic of Korea

Source: *United Nations Statistics Division*

Now that per capita household energy consumption exceeds European levels, energy conservation has been identified as a key objective

by the government. Energy conservation activities include investments in research and development to improve energy efficiency, financial and tax

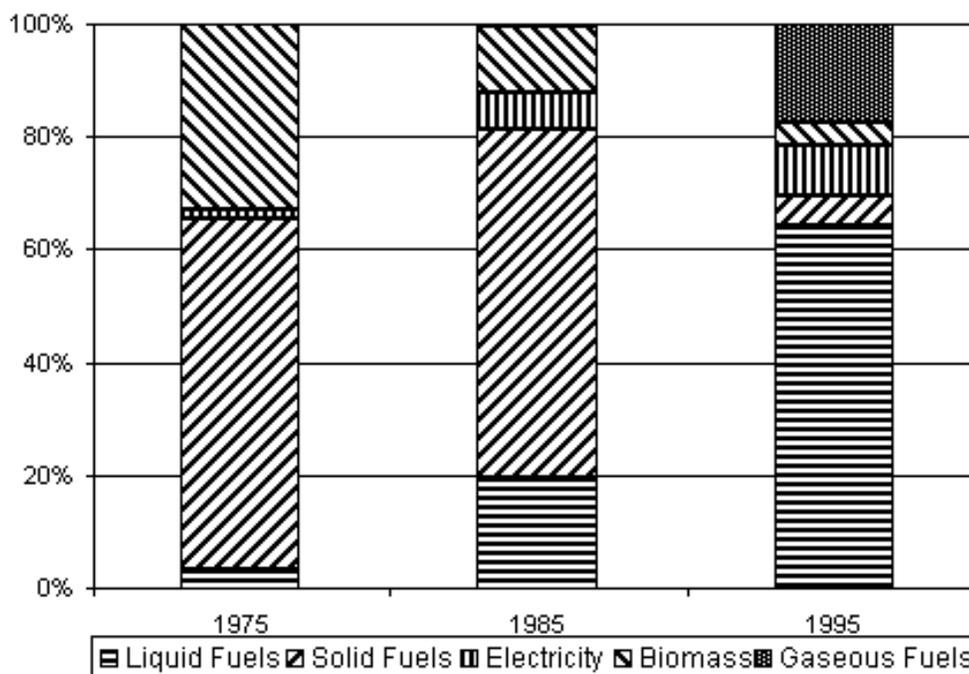


Fig. 6. Fuel mix in household energy use in the Republic of Korea

Source: *United Nations Statistics Division*

incentives for commercial application of energy-saving technologies, and expanded use of heat and power co-generation and district heating. Despite these policy objectives, the government has kept most energy prices low. Price ceilings are set on domestically produced coal (anthracite) that is mostly used for home heating by poor households in remote areas. The government also regulates the price of town gas to promote its use in households as well as in the commercial sector. Electricity is also supplied at a price subject to government approval. These price policies undermine the objective of energy conservation.

Opportunities for improved efficiency and conservation

Since space heating consumes most of the energy used by households in the Republic of Korea, increases in domestic energy efficiency must concentrate in that area. Thermal efficiency for heating devices in the mid-1980s was: firewood stoves 25 per cent, anthracite stoves 30 per cent,

anthracite boilers (small) 60 per cent, oil boilers 70 per cent, and district heating 80 per cent.

District heating systems offer a particularly favorable option in light of the specific local conditions: substantial space heating requirements, high population densities, and a rapid rate of housing construction. District heating based on co-generation of heat and power offers opportunities to improve energy efficiency while using cheaper and lower quality fuels. Better thermal insulation could reduce total heating energy requirements by as much as 39 per cent in existing buildings, and as much as 54 per cent in new buildings.

Thanks to a highly competitive and technologically advanced appliance industry, the Republic of Korea produces electric appliances with high energy efficiency.

Case Study 3, China^{5,9,10,11}

There were about 280 million households in China in 1990, consuming about 200 million tonnes of oil

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equivalent (toe) of biomass, 84 million toe of coal, 14 million toe of electricity (48 billion kWh), and 8 million toe of other types of energy. About 40 per cent of final energy demand (including biomass) occurs in the household sector. Coal and biomass dominate household energy consumption.

About 70 per cent of the population still lives in rural areas and rely on biomass (mainly crop stalks and fuelwood) for about 80 per cent of their fuel. Cooking and space heating account for over 95 per cent of household energy consumption in rural areas and 90 per cent in urban areas.

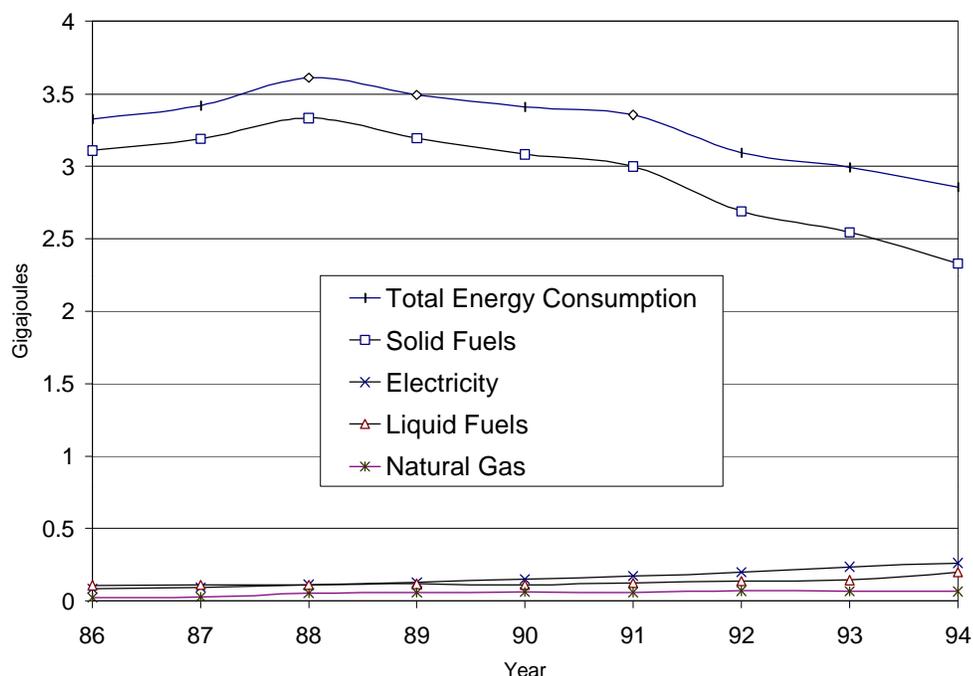


Fig. 7. Per capita household energy consumption in China

Source: *United Nations Statistics Division*

Note: Data on biomass fuels are not included

Official energy statistics in China include coal and petroleum and their products, natural gas, and electricity, but exclude biomass, solar energy, and other low-value fuels. The trends shown in Fig. 7 and 8, although indicative of the changes in the patterns of consumption of commercial energy by households do not present a complete picture, as consumption of fuelwood and other biomass fuels is not reflected.

With rapid economic growth, household electricity demand increased more than four-fold from 1980 to 1990, due to a boom in sales of electric appliances. Growth in electricity consumption continues in the 1990s.

Table 1. Household energy demand by fuel type

(Million tonnes of oil equivalent)

Fuel	1980	1990
Biomass	160	198
Coal	57.9	83.5
Electricity	3	13.6
Gases	1.2	4.6
Kerosene and co-generation heat	2.2	3.2

While urban households have adequate fuel supplies and access to electricity, many rural areas still suffer from fuel shortages, and about 40 million rural households have no access to electricity. Per capita energy consumption in rural areas is higher than in urban areas because of

inefficient use of biomass. Per capita electricity use in urban areas is four times as much as in rural areas because of a much higher rate of appliance use.

Table 2. Household energy demand by end-use in 1990

Use	Rural	Urban
Cooking	54%	55%
Space-heating	44%	36%
Lighting	1%	3%
Appliances	1%	6%

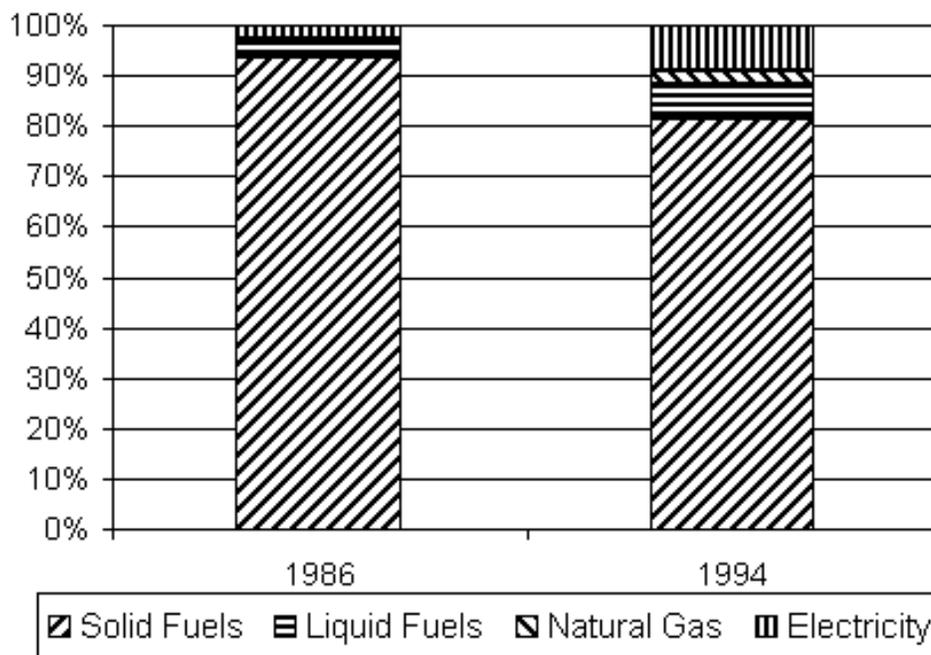


Fig. 8. Fuel mix in household energy use in China
Source: *United Nations Statistics Division*
Note: Data on biomass fuels are not included

Opportunities for energy efficiency and conservation

China has great potential for fuel savings in cooking and water heating. Promoting efficient firewood and coal stoves has been a priority of the government since the early 1980s. By the end of the 1980s, about 50 per cent of all rural households were equipped with firewood stoves with a high thermal efficiency of 25 to 30 per cent. The goal is to install efficient firewood or coal stoves in every rural household by the end of this century. Promoting sustainable biomass use is an important element of rural energy policy and is being advanced by government-sponsored planting of trees and the development of more efficient stoves.

In southern areas, the government is promoting the generation and use of biogas.

In urban areas, emphasis has been placed on increasing the share of gaseous fuels for cooking in order to reduce the air pollution caused by household use of coal. Honeycomb briquettes are also being promoted as a relatively cheap alternative for saving energy.

Space heating is provided mostly by stoves (100 per cent in rural areas, 75 per cent in urban areas) which can be very efficient but cause severe indoor air pollution. Central heating is available only in urban areas, accounting for 25 per cent of heated urban households. Efficient district heating facilities (either large boiler stations or co-generation plants) serve about 5 per cent of heated

households. Central heating facilities commonly use small boilers with an energy efficiency of about 50 per cent.

Electrical appliances offer a substantial potential for energy saving. Although refrigerators and TV sets are common in urban households, they are still rare in rural areas. Current electricity use of refrigerators averages about 400 kWh/year, while newer models from the Republic of Korea consume 240 kWh/year.

Conservation of lighting energy may not present a large potential for energy savings. Ordinary Chinese families already use electricity frugally because of relatively high prices. While small fluorescent lamps are now popular in urban areas, low wattage incandescent lamps (15-25 W) are still widely used. Introducing compact fluorescent lamps to replace low wattage lamps may not be cost-effective, but lighting quality would improve greatly. In the long run, as income increases, so will lighting demand, and compact fluorescent lamps will offer economic and environmental benefits.

The following conservation programs are in operation or in the planning stages:

- More efficient firewood and coal stoves for rural households, with sustainable firewood supply;
- More efficient briquette stoves for urban households with improved distribution of anthracite briquettes;
- Increasing the supply of LPG, natural gas, and coal gas;
- Efficient central heating systems;
- Promoting compact fluorescent lamps in the long run;
- Energy efficiency standards for appliances;
- Improving the thermal integrity of buildings; and
- Mandatory energy efficient building standards.

Developed countries

In developed countries, two opposing trends have determined household energy consumption since the 1970s. One is the increase in energy-based living standards due to increases in household income. This trend by itself would have led to a growth in household energy consumption ranging from about 30 to 70 per cent in different countries. The opposing trend had several components. Most important was more efficient energy use and a slight lowering of indoor temperatures. Energy savings occurred primarily due to reduced space and water heating intensity and improvements in the thermal properties of residential buildings. As a result, household energy use increased no more than by 30 per cent by 1991 and even fell in some countries. The share of household spending on energy generally declined, even when it grew in absolute terms with increasing income.¹²

An important factor that influences growth in household energy consumption is saturation in the ownership and use of appliances. The growth in household energy use due to increases in appliance ownership is slowing because of this saturation.

Dramatic increases in energy efficiency of new appliances occurred during the years of high energy prices (1973-1985), and when prices went down there was no reverse trend in energy efficiency. Energy prices had an impact on both total energy consumption and the fuel mix in particular countries. Sweden and Norway had the least reaction to higher household energy prices due to the availability of low-priced electricity and substantial quantities of free firewood. In the United States and the United Kingdom, where there are substantial natural gas resources, real prices in the 1990s are close to or below those in the early 1970s.

National conservation policies also played their role in reducing household energy consumption. The most measurable effects were a result of strengthened building codes and boiler standards in Europe and appliance efficiency standards in the United States. The sharp reductions in energy intensities after 1979 were due initially to cutbacks in energy services. Continued and more

permanent reductions were due to technical improvements to buildings, electric appliances, and other equipment. It is often difficult to distinguish between the measures undertaken in response to the higher energy prices and those within the framework of various energy-saving programmes.

Space heating remained the most important final energy use for households followed by the water heating. Cooking and lighting consume relatively minor proportions of final energy. There was a significant growth in the number, size and features of electric appliances, but also increased efficiency of appliances, resulting in little change in total energy consumed by appliances.

In most developed countries, space heating intensities fell or at least remained constant since early 1970s primarily as a result of better insulation of buildings. Additional savings were achieved in some countries through lower indoor temperatures, more careful heating practices, and improvements in equipment efficiency.

There were major changes in the fuel mix for household energy consumption from the early 1970s to the early 1990s. Fuel conservation, fuel substitution, and the proliferation of electric appliances were the major reasons for these changes. By the early 1990s there was a significant reduction in oil consumption due to both reduced energy consumption and large declines in the share of buildings using oil, particularly in France and Sweden. Only in Japan are petroleum products still the dominant form of household energy, with more than 60 per cent of households using kerosene as their main source of heat.

In most developed countries, there has been a substantial increase in the number of households using natural gas for space and water heating, due both to new construction and conversions of buildings previously heated by oil or coal. The growth of natural gas consumption was moderated by the greater energy efficiency of new dwellings and new heating equipment. Except in coal-rich areas, use of coal has greatly diminished, with other major fuels replacing it. In the United

States and Northern Europe there was some increase in use of biomass (mainly wood), typically half as a main fuel and half as a supplement to oil or electricity. Electricity use grew significantly. In some countries, the increase was caused by conversion to electric space and water heating, and in most others by increases in appliances and electric cook stoves.

Case Study 4, The Netherlands^{13,14,15}

Households consume about 20 per cent of the total energy used in the Netherlands. Household energy consumption in the Netherlands can be divided into two components: (1) heat for space heating, water heating and cooking; and (2) electricity for lighting and appliances.

There have been major changes in the fuel mix for heating and cooking since the 1950s. Coal, which was the major heating fuel in the 1950s and 1960s, virtually disappeared from households by the mid-1970s. It was replaced by oil in the late 1960s, which has been replaced in turn by natural gas since the development of North Sea natural gas in the early 1970s.

After the discovery and development of the domestic natural gas reserves, the government invested heavily in the gas distribution grid and used price policies to encourage conversion to gas from other fuels. These policy incentives, together with market-related developments, resulted in a great increase in the use of natural gas and discouraged energy savings. The oil crises and price increases of 1973 and 1979 led to introduction of government policies promoting energy conservation. As a result, household consumption of heating fuel, both total and per household, declined sharply to 1990 and has remained relatively stable since then. Savings due to greater energy efficiency have been partly offset by increasing use of hot water in recent years.

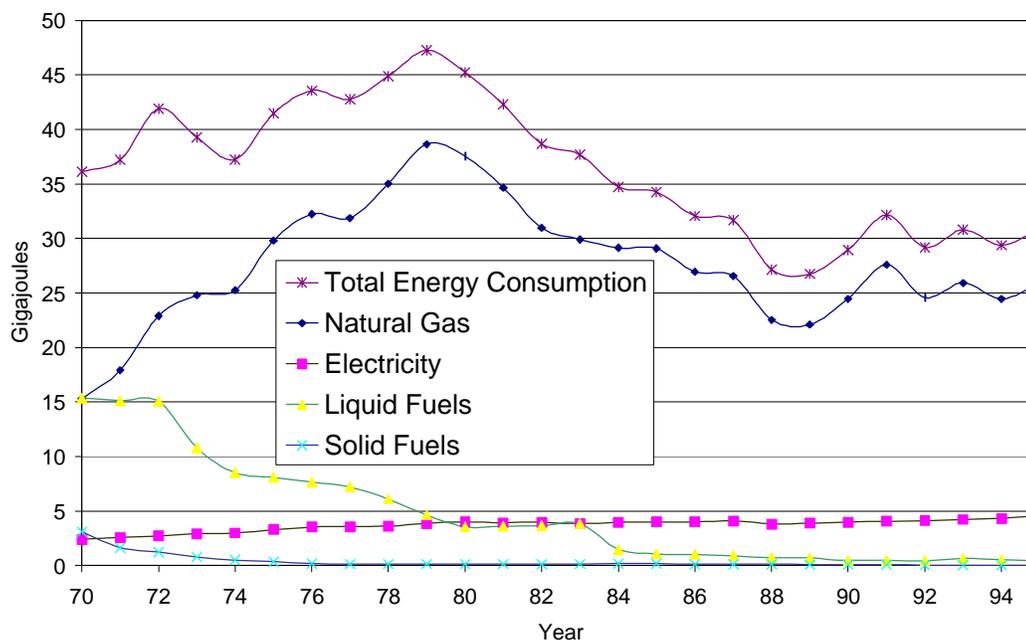


Fig. 9. Per capita household energy consumption in the Netherlands
Sources: *United Nations Statistics Division; Green Households*¹⁵

Household electricity consumption increased steadily until 1980. There was a short decrease in the early 1980s following the oil crises, but since 1985 electricity consumption has risen at an average rate of 3 per cent per year. Electricity consumption has increased from 2.4 GJ (gigajoules) per capita in 1970 to 4.6 GJ in 1995. Before 1973, purchases of domestic appliances were stimulated by rapidly rising incomes and the decreasing real price of electricity. From 1974 to 1981, rising electricity prices reduced the growth in electricity use, as well as leading to improved efficiency of electrical appliances.

By the early 1980s, the penetration rates of some appliances, such as refrigerators, washing machines and TV sets, were at saturation levels. A small reduction in electricity consumption in the early 1980s appears to be due to this saturation combined with improved efficiency. The main reason for the renewed growth in electricity consumption after 1985 is the introduction of new appliances.

Trends in per capita household energy consumption in the Netherlands are presented in Fig. 9 and 10.

Primary energy consumption by households is higher than household energy consumption mainly due to the energy requirement for generating and transmitting electricity. Currently, it takes approximately 2.9 MJ of primary energy to deliver 1 MJ of electricity to the household. This is significantly less than past values (5.25 MJ/MJ) due to efficiency improvements in electricity production, but still much higher than for natural gas and other primary energy sources. In terms of primary energy, the share of electricity is approximately 40 per cent of total household energy consumption.

Environmental and conservation policies in the Netherlands

In 1980, the Netherlands government launched the "National Insulation Programme" to improve

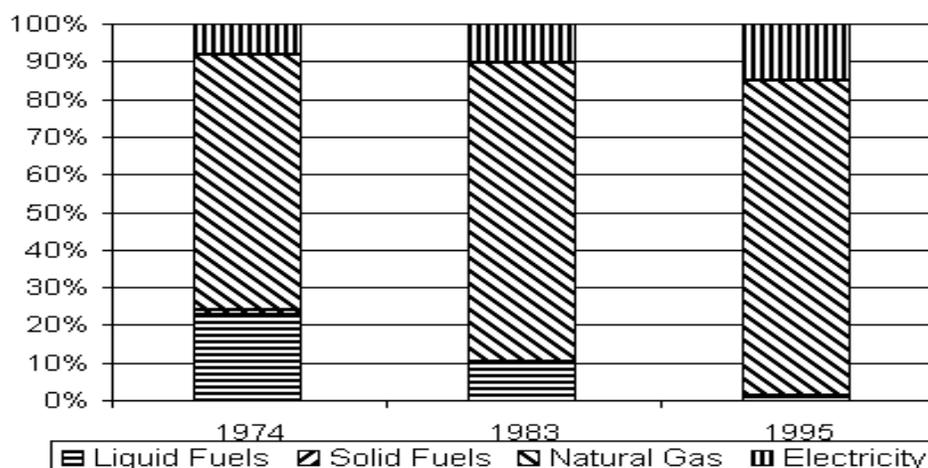


Fig. 10. Fuel mix in household energy use in the Netherlands

Sources: *United Nations Statistics Division; Green Households*¹⁵

energy efficiency in the existing housing stock. Housing corporations and municipalities gave subsidies for renovations and energy efficiency measures. From 1980 to 1993, approximately 3.5 million houses were insulated. As noted above, this contributed to a significant decline in energy consumption in the 1980s. Further improvements are still possible, as indicated, for example, by the fact that only 60 per cent of the houses built before 1965 have double glazing.

Beginning in 1989, a series of National Environmental Policy Plans have been developed, with energy conservation as an important component, and households as one of the target-groups. Energy conservation is to be achieved through greater energy efficiency and the promotion of alternative energy sources. One of the goals of NEPP2 (1993-1998) was to reduce CO₂ emissions by households by 23 per cent compared to energy use in 1989 through an improvement of energy efficiency.

As a result of the various insulation programmes and the public information campaigns on energy saving organized by government since 1991, 140 000 houses have been equipped with double glazing each year, 80,000 with wall insulation, 95,000 with roof insulation, and 60,000 with floor insulation. The estimated effect of all these programmes has been a yearly average saving

of 800 m³ of gas per house. Natural gas consumption for space heating declined from 87 GJ per household in 1980 to 51 GJ in 1995. The percentage of houses fully insulated rose from 2 per cent in 1981 to 23 per cent in 1995. By 1995, only 8 per cent of the housing stock had no form of insulation. Double glazing is the most common form of insulation, in 75 per cent of all houses, followed by wall insulation (63 per cent) and roof insulation (59 per cent). During the period from 1981 to 1993 the energy efficiency for household heating improved by almost 40 per cent, of which 20 per cent was achieved by improving insulation in existing houses, 12 per cent by building new houses with better energy standards, 8 per cent through introduction of condensing boilers.

Energy efficiency standards for new buildings have been steadily tightened and are more stringent than those in most other European countries. The standard for energy use for new houses was lowered to 950 m³ of gas for household space warming in July 1992 and further to 850 m³ in October 1995. In 1992, a voluntary agreement between the government and the housing associations was signed, in which the associations committed themselves to giving subsidies to their members to achieve certain insulation norms. Several experiments on new sustainable buildings are studying the potential for energy saving, the

costs of energy efficient construction, and the willingness of people to pay for energy efficiency and to change their life-styles. In 1990, the Sustainable Construction program was launched, in which corporations, municipalities and construction companies worked together to improve the "environmental quality" of new buildings.

In 1995, the system of financing housing construction, which had previously discouraged investment in energy-saving measures, was changed. Prior to 1995, all investments in social housing were charged to the state budget, discouraging extra spending on energy-saving measures, even when they were highly cost-effective. Under the new system, the extra costs of energy-saving measures are charged to the housing associations, which can recover them through higher rents.

The Condensing Boiler Program, financed by the government in cooperation with utilities, was implemented from 1991 to 1993, resulting in the replacement of 100,000 boilers by condensing boilers. Subsequently, these low-emission and energy-saving heating boilers were commercialized, and the subsidy for them was abolished in 1993.

The Directive on Energy Saving Appliances prescribes energy labeling of products and minimum efficiency standards for appliances, encouraging high efficiency refrigerators, washing machines, central heating pumps, condensing

boilers, and other equipment.

Other activities encouraging household energy saving include:

- Information campaigns and subsidies for fluorescent lamps; in 1992, 2.2 million new fluorescent lamps were sold, with annual subsidies of \$12 million;
- Organization of a national debate in 1996 on sustainable lifestyles; and
- Introduction of the Personal Environmental Test in 1994 by a consumer organization to improve environmental awareness and to promote changes in lifestyles.

Case Study 5, Japan^{12,16,17,18}

Japan has long had relatively low per capita household energy consumption compared to other developed countries. In 1988, annual energy use per household in Japan was approximately one-half of that in France, United Kingdom, and Germany, and about one-third of that in the United States. That gap has been steadily closing, and now its household energy consumption is similar to average of European countries though still

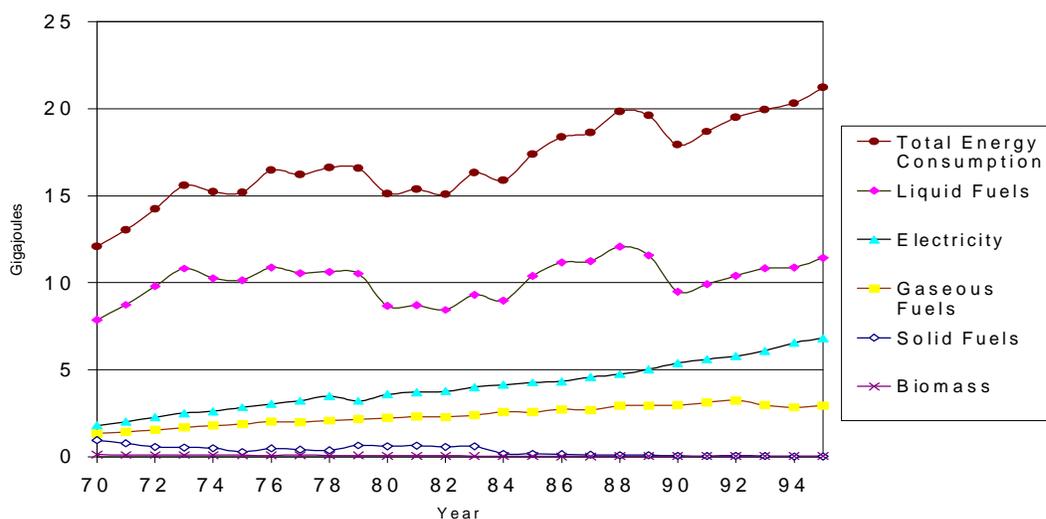


Fig. 11. Per capita household energy consumption in Japan
Source: United Nations Statistics Division

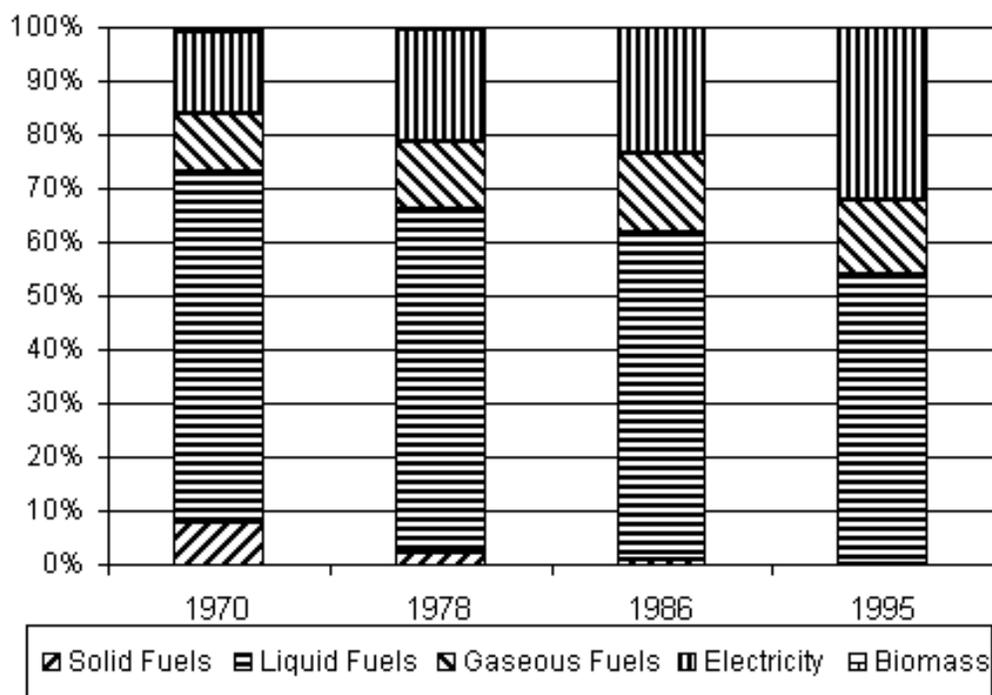


Fig. 12. Fuel mix in household energy use in Japan
Source: *United Nations Statistics Division*

significantly lower than in the United States. Household energy consumption has increased steadily with increasing household incomes (Fig. 11).

The source of many differences in household energy use between Japan and other developed countries are unique housing situations, lifestyles and customs. Taking climatic differences into account, Japan uses substantially less energy for space heating, as houses are commonly maintained at about 15-16 degrees C in winter. Space heating intensity has remained roughly constant since the 1970s as increased heating in winter has been compensated by modest improvements in insulation and increased use of heat pumps. Less than 10 per cent of households have central heating, and small kerosene space heaters and fan heaters, supplemented by electric heaters under tables ("kotatsu") are commonly used.

Bathing commonly includes a shower for cleaning, followed by soaking in a tub for relaxation. The tub water is often reheated and

reused by other household members, and sometimes transferred afterwards to the washing machine for washing clothes.

Significant changes have occurred in recent years both in the fuel mix for household energy consumption (Fig. 12) and in the end use. In 1972, space heating accounted for 39 per cent of household energy, lighting, appliances and cooking for 33 per cent, water heating for 30 per cent, and cooling for 0.5 per cent. Twenty years later, in 1992, the largest category was water heating at 37 per cent, followed by lighting, appliances and cooking at 35 per cent, space heating at 27 per cent, and cooling at 1.5 per cent.

Average household energy consumption per household grew at 2.2 per cent from 1974 to 1992. The rates for different energy types were 3.9 per cent for electricity, 2.9 per cent for city gas (included in gaseous fuels in Fig. 11 and 12), 1.7 per cent for LPG, and 1.4 per cent for kerosene (both included in liquid fuels in Fig. 11 and 12). Energy consumption grew fastest for cooling, followed by water heating, and lighting, appliances

and cooking. Japan is the only country besides the United States that uses considerable amounts of energy for cooling.

The government has been actively involved in setting and implementing policies related to household energy consumption and housing construction. After the oil shocks of the 1970s, development of energy-saving appliances proceeded quickly, particularly low-energy refrigerators, air conditioner, television sets, and washing machines. Not all efforts were successful, however. Development of a central heating system that would be more comfortable, more convenient, and safer than kerosene space heaters was suspended.

The Energy Conservation Law adopted in 1979 proposed standards for thermal integrity of houses and efficiency of air conditioners. The

Housing Corporation began to make low-interest loans for insulated house construction in 1979 and for solar water heaters in 1980. Due to the second oil shock in 1979, there was a continuing focus on energy-efficient appliances.

With the decline in energy prices after 1985, work on energy-efficient appliances diminished somewhat. However, from the early 1990s, development of energy-efficient technologies has again been encouraged as a response to global environmental issues.

Currently, ownership of electrical household appliances, except for dishwashers and clothes dryers, has largely reached saturation, while ownership of heating and air conditioning systems is still growing. Most heating and cooling equipment is still of the single-room type.

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