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July 1987

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**Residential Energy Demand in Six OECD Countries:
Historic Trends and Future Directions**

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We acknowledge the kind cooperation of individuals and institutions who provided information in the countries we have studied, and the collaboration and guidance of Lee Schipper, currently on leave at Shell International.

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Notes on Terminology

Energy units. In keeping with international practice, we use SI units in this report. $1 \text{ MJ} = 10^6 \text{ joules} = 0.948 \text{ MBtu}$, $1 \text{ GJ} = 10^9 \text{ joules} = 0.948 \text{ MMBtu}$, $1 \text{ PJ} = 10^{15} \text{ joules} = 0.948 \text{ Trillion Btu}$ ($1000 \text{ PJ} = 0.948 \text{ quads}$).

Final energy (delivered energy) refers to the energy consumed at the home.

Primary energy includes losses in electricity generation and district heat production accounted for by the residential sector. For electricity, we multiply delivered electricity consumption by 3.28 for all countries. This value is the average for the OECD countries for the 1970-82 period. For district heat, we multiply delivered consumption by 1.33 for all countries.

Useful energy excludes the approximate combustion losses of fuels. It thus reflects changes independent of the increasing electricity share of the heating market. We approximate useful energy as 66% of delivered energy for gas and oil, and 55% of delivered energy for solids.

Climate correction. All energy consumption data that include consumption for space heating have been adjusted to reflect the normal climate for each country. We correct by dividing actual space heating consumption by the ratio of actual degree-days base 18°C to the long term average (long term average degree-days values are presented in Appendix I). Due to lack of appropriate data, climate for Italy is assumed to be normal after 1978. Different indices were used for the U.S. to adjust oil and electricity consumption, reflecting the particular regions of the country where these fuels are most heavily used.

Solids includes coal, coke, and wood.

Oil includes LPG, except in Germany where it is included with gas. For the U.K., oil heated dwellings include homes with district heating, almost 70% of which is produced with oil in that country.

Central heating refers to a system which is able to heat the entire home, and in which the heat is usually distributed from a central furnace. We include in this category the dwellings heated by a system sized for a district, a complex, a building, or the dwelling itself.

Single-family dwellings include row houses and townhouses.

Conversion to Common Currency. Current local currencies were converted to 1981 US dollars by deflating the currency by the appropriate Consumer Price Index (base 1981), and then applying 1981 exchange rates published by the International Monetary Fund.

1. Introduction

This report describes trends in residential energy consumption for the six largest OECD countries: the United States, France, Germany, Italy, Japan, and the United Kingdom. The focus is on how and why the demand for the different fuels -- oil, gas, solids, and electricity -- has been changing, and where the trends are leading residential energy use.

To address these points, we examine the structural changes that have occurred and are occurring in the residential sector of each country. The structural elements are the characteristics of the residential buildings and the energy-using equipment in them. Some of the structural changes have pushed upward on energy consumption, and others have pushed downward. Also important are behavioral changes -- the way people use the energy-using equipment.

The body of the report has four chapters. Chapter 2 describes how overall energy demand and consumption of the different fuels has changed, and identifies the basic forces that have pushed upward and downward on energy demand. The changes in aggregate energy demand, of course, result from changes in the major end-uses. In Chapters 3 to 5 we look at changes in fuel choice and energy intensity for space heating, water heating and cooking, and electric appliances. In Appendix I we provide summary tables of the data and indicators presented in this report. Appendix II (in progress), contains scenarios of future energy demand for each country, based on the analysis contained in this report.

2. The Evolution of Residential Energy Demand Since 1973

Energy consumption by the residential sector in the six countries has undergone considerable change since 1973. In the early 1970s, the structure of the residential sector was becoming more energy-intensive as the penetration of central heating and various electric appliances increased. This was less so for the U.S. than for the other countries, where there was less room for growth in penetration. After the 1973 oil price shock, natural gas and electricity displaced oil in the market of new heating systems, and consumer awareness limited the most wasteful use of energy in the homes. When energy prices experienced a second major increase in 1979 and 1980, demand was curbed by consumer's short term behavior as well as by conservation investments. Fuel switching was accelerated, mainly with gas and electricity substituting for oil. By this time also, the growth in the structural energy intensity of the residential sector was slowing. This was due in part to the higher level of penetration of central heating and appliances already reached in earlier years, and in part to slower growth in consumer income. By 1984, with real oil prices stabilizing, the stock of houses and the saturation of fuels in them was very different from the condition of 1973.

An important factor to bear in mind when comparing the U.S. experience to that of the other OECD countries is that the U.S. residential sector was more "advanced" in 1970. By this we mean that some of the structural changes that pushed upwards on energy demand in other OECD countries had already taken place in the U.S. in the 1960s. The most important of these was growth in penetration of central heating. Penetration of major home appliances was also relatively advanced in the U.S. by 1970. By 1984, the structure of the residential sector in the other countries was much closer to the U.S. than was the case in 1970, though there are still significant differences, most of which are related to size of homes and appliances.

2.1. Energy Consumption Trends

Despite the increase in the number of households -- which grew between 1% and 2% per year in the 1973-83 period, final energy consumption¹ has declined or grown moderately in all of the six countries except Japan, where average growth rate has been higher than 3% per year. (See Figure 2-1.)

Average final energy consumption per home declined the most in the U.S. and France. (See Figure 2-2.) Only in Japan did it increase. A factor pushing downward on final energy consumption has been the displacement of coal and wood by other fuels and the increased penetration

Figure 2.1
Index of
Residential Final Energy Consumption

Figure 2.2
Residential Final Energy Consumption
per Home

¹ Final energy consumption is a better quantity to compare among countries than primary demand because differences in electricity demand growth are not magnified.

Figure 2.3
Index of Residential
Primary Energy Consumption

of electricity in the home heating market (discussed in Section 3). In both cases, a fuel that in actual practice has lower combustion losses at the building takes the place of one that has higher losses. The effect of electricity penetration is particularly evident in France and, to a lesser extent, the U.S. The replacement of coal and wood by oil, gas, or electricity was significant in Europe, but not in the U.S., where this already had occurred in the 1960s. (Indeed, wood use as a secondary and even as a primary heating fuel has grown substantially in the U.S. since 1973.)

The increased penetration of electric heating and various electric appliances has led to more of an increase in primary energy consumption than was the case for final energy consumption because primary energy consumption includes losses in electricity production and transmission. (See Figure 2-3.) The magnitude of residential primary energy consumption in 1973 and 1983 is shown in Chart 2-1.

Chart 2-1
Residential Primary Energy Consumption

2.2. Different Growth for Different Fuels

Energy consumption as described above represents an aggregate of the different fuels, the demand for which has changed considerably in the six countries.

Figure 2.4
Index of Residential
Oil Consumption

- Oil consumption has declined in all of the six countries except Japan. (See Figure 2-4.) Most of the decline in oil consumption took place after the 1979/80 jump in oil prices. The largest decline relative to 1973 (46% between 1973 and 1983) occurred in the U.S., where there was greatest potential for efficiency improvement. The U.K. also experienced a considerable decrease (40% in the same period) although the oil share of demand was never significant there, followed by France (36% through 1984), Italy (26% between 1972 and 1984), and Germany (12% between 1973 and 1983). In Japan, consumption grew by 37% through 1984.

Figure 2.5
Index of Residential
Gas Consumption

- Gas consumption grew considerably in all of the six countries except the U.S., where demand in 1984 was 8% lower than in 1973. (See Figure 2-5.) In the period observed, gas demand more than tripled in Italy, grew two and a half times in Germany, doubled in France and the U.K., and increased by more than half in Japan. Gas use did not increase in the U.S. as it did in Japan and Europe because it was already firmly established in the U.S. residential sector in 1973.

Figure 2.6
Index of Residential
Electricity Consumption

- **Electricity** consumption has grown substantially in all of the six countries except the U.K., where it has been stagnant. (See Figure 2-6.) The U.S. has seen the slowest growth, resulting in a 29% increase. The highest growth (9% per year) was in France, where demand doubled as a result of the aggressive promotion of electric heating. Consumption increased by around 50% in Germany, Italy, and Japan, with an annual average growth between 4.5% and 6%.

Figure 2.7
Index of Residential
Solid Fuel Consumption

- **Coal and wood** consumption declined rapidly in all the countries except the U.S., where wood became popular heating fuel. (See Figure 2-7.) In absolute terms, this trend was most significant in Germany, the U.K., and France where coal was an important fuel in 1973. France however, experienced an upturn in wood use as secondary heating fuel. The sharp decline in Japan and Italy reveal the rapid disappearance of the use of solids from urban households.
- **District heating** is present in France, Germany, and to a very small extent in Italy and the U.K., but its contribution did not change markedly in the period analyzed.

The result of the differential growth rates is that the contribution of the alternative fuels to total energy demand was changed. (See Figures 2-8-1 through 2-8-6.)

- The share of *oil* has declined considerably in all of the countries except Japan, where some decline occurred after 1981. By 1984, oil still accounted for between 37% and 47% of final energy consumption in continental Europe and Japan, while its share was less than 16% in the U.S. and only around 6% in the U.K.
- The share of *gas* has increased considerably in Europe, and particularly in the U.K., but has remained at about the same level in Japan and the U.S. (where it continues to dominate the sector).
- The share of *electricity* has increased everywhere except in the U.K. By 1984, its contribution was between 15% and 19% in Europe, while around 27% in both the U.S. and Japan.
- The share of *coal* and *wood* has declined in all countries except the U.S., where growth in use of wood has more than offset the decline in use of coal. The contribution of solid fuels remain significant in France and the U.K. (more than 15%), and to a lesser extent in Germany and the U.S. (7% and 10% respectively), while their role is only marginal in Italy and Japan.

Figure 2.8.1
FRANCE
Residential Final Energy Consumption
by Fuel Type (Climate Corrected)

Figure 2.8.2
GERMANY
Residential Final Energy Consumption
by Fuel Type (Climate Corrected)

Figure 2.8.3
ITALY
Residential Final Energy Consumption
by Fuel Type (Climate Corrected)

Figure 2.8.4
JAPAN
Residential Final Energy Consumption
by Fuel Type (Climate Corrected)

Figure 2.8.5
UNITED KINGDOM
Residential Final Energy Consumption
by Fuel Type (Climate Corrected)

Figure 2.8.6
UNITED STATES
Residential Final Energy Consumption
by Fuel Type (Climate Corrected)

2.3. An Overview of Factors Affecting Energy Demand

By factors affecting energy demand we mean the structural and behavioral forces that have pushed upwards or downwards on energy demand. Here we simply highlight the forces that will be discussed more in the later sections.

The main factors that have pushed upward on final energy consumption since 1973 have been: (1) Increase in the number of dwellings; (2) Growth in penetration of central heating;² and (3) Growing penetration of electric appliances.

Figure 2.9
Index of Number of Occupied Dwellings

Growth in the number of homes has been a somewhat more important factor in the U.S. than in the other countries. (See Figure 2-9.) The U.S. and Japan had the highest population growth rate. But in the U.S. there has been a more significant growth in the number of homes per capita (i.e. decrease in the number of persons per dwelling). Since a smaller household is likely to have many similar demands for energy services as a larger one, growth in the number of homes per capita pushes upward on energy demand even though use per home decreases.

The main factors that have pushed downward on energy demand since 1973 have been: (1) Improvements to thermal performance of existing homes; (2) Penetration of new homes with better thermal performance than the existing stock; (3) Substitution of energy-using devices with new ones with higher energy efficiency; (4) Lowering of winter indoor temperatures, and other maintenance activities.

The importance of the factors has varied among the countries. But in all cases, the factors that pushed upwards on energy demand became less significant after 1978, as all countries reached high levels of comfort and an economic crisis was felt throughout the industrialized countries. On the other hand, the factors pushing downward became more important in the wake of the 1979/80 oil price increase, leading to slower growth or even decline in final energy consumption.

² The increased penetration of electric heating has pushed upward on primary energy demand, but has pushed downward on final energy demand.

Other factors have shaped the different growth rates for the fuels. These include: (1) Fuel choices for replacement equipment for heating, water heating, and cooking; (2) Fuel choices for equipment for heating, water heating, and cooking in new homes; (3) Growth in saturation of electric-specific uses; and (4) Differential change in intensity of use.

In Chapters 3, 4, and 5, we describe these and other changes for each of the main end-uses. Before proceeding to this discussion, we describe the evolution of the economic factors that have shaped the changes in the residential sectors of the six countries, and illustrate the relative importance of the different end-uses.

2.4. The Economic Context

The changes in the structure of the residential sector and in behavior in the home are shaped by the economic setting in each country. The key economic factors affecting residential energy use are *disposable income*, which allows consumers to purchase energy and energy-using capital goods, and *energy prices*, which shape decisions related to manufacture and purchase of energy-using capital goods and to use of those goods.

Figure 2.10
Disposable Income per Capita

Two features stand out when comparing the U.S. experience to that of the other countries. First, disposable income per capita in the U.S. is much higher than in any of the other countries examined. Second, the average prices of gas, electricity, and to a lesser extent, oil, have been (and still are) lower in the U.S. than in the other countries.

Disposable income

Although disposable income per capita remains between 10 and 30% higher in the U.S. (with the exception of Italy,³ where per capita income is 50% of the U.S. level), there was more growth relative to the 1970 level in the other countries than in the U.S. (See Figure 2-10.)

For all six countries, the trend in income per capita shows a marked stagnation in the period after 1979. This came at the same time as (and in part because of) the large increase in oil prices, and probably contributed to the "belt-tightening" of the period.

³ The growing importance of the grey economy, in Italy as well as in other European countries, hampers the use of this factor to explain the differences in energy use level among countries.

Energy prices

The period since 1970 has seen considerable increase in the delivered price of fuels used by households. This change has affected each country differently, as the relative importance of each fuel varies among countries. In all cases though, the use of oil became much less favorable relative to the alternatives.

Figure 2.11
Residential Oil Prices

Figure 2.12
Residential Gas Prices

- The price of *fuel oil* to households in real terms increased approximately two-fold between 1970 and 1980 in the six countries. (see Figure 2-11.) The decline in the real price of residential oil since 1982 has been greater in the U.S. and Japan than elsewhere.

- The real price of *gas* to households has risen modestly since 1974 in all six countries. (See Figure 2-12.) This increase has been less than that of oil. Thus, the ratio of gas to oil prices has declined.

- The real price of *electricity* to households declined through 1973, and has been fairly stable or somewhat increased since in the U.S. and most of Europe. (See Figure 2-13.) In Italy and Japan there has been a more significant increase since 1979. Electricity prices in the U.S. have historically been much lower than in most of the other five countries (largely due to the lower dependence on oil for electricity generation).

These changes in prices have altered the competitiveness between fuels.⁴ By 1980, gas was cheaper than fuel oil in all countries except Japan; In Italy and Great Britain it reached that competitive edge which favored gas over oil in North America since the early seventies. (See Figure 2-14.) The increasing price of residential fuel oil also increased the competitiveness of electricity use for space heating purposes, although the recent drop in oil prices is reversing this trend.⁵ (See Figure 2-15.) Electricity also gained somewhat with respect to natural gas, (See Figure 2-16.) particularly for new dwellings if the lower cost of installation is taken into account. Below, the analysis of the changing penetration of fuels in new dwellings illustrates the significant impact of changing prices on the space heating stock.

⁴ The heavy line in Figures 2-14 to 2-16 indicates the equivalence of prices when accounting for furnace efficiency, assuming oil burned at 80% efficiency, gas at 70%, and electricity at 100%.

⁵ Consumer prices of electricity for space heating purposes is somehow lower in several countries, but consistent data is not available at the stage of the analysis.

Figure 2.13
Residential Electricity Prices

Figure 2.14
Relative Fuel Prices:
GAS to OIL

Figure 2.15
Relative Fuel Prices:
ELECTRICITY to OIL

Figure 2.16
Relative Fuel Prices:
ELECTRICITY to GAS

Legend

- FRANCE
- GERMANY
- ITALY
- × JAPAN
- UNITED KINGDOM
- △ UNITED STATES

2.5. End Uses of Energy

Energy is used in the residential sector for four main purposes: space heating, water heating, cooking, and electric-specific appliances. The relative importance of these end-uses has changed somewhat since 1973. (See Figure 2-17.)

- Space heating's share of residential final energy use declined somewhat since 1973, but it still accounts for 65 to 75% of energy use except in Japan, where its share has remained under 40% in the last fifteen years. Japan's low share is due to its much warmer climate and less energy-intensive heating habits.
- Water heating has been steady in importance in all countries, with the U.K. and U.S. showing a larger share than the other countries.
- The share of cooking has dropped slightly in all countries. This is partly due to fewer meals being consumed at home, and partly due to increase in the market penetration of electric cooking.
- The share going to electric appliances has grown steadily in most of the countries. The level in the U.S. -- around 14% -- is higher than in Europe but less than in Japan, where the relatively low share of space heating inflates the shares of other end-uses.

Figure 2.17
Residential Energy Demand by End Use

3. Space Heating

Space heating has become less energy-intensive since 1973 in the U.S. and Europe. The change was greater in the U.S. due on one hand to the higher intensity existing in North America in 1973, and on the other to the fact that the structural intensity of heating increased in Europe. In 1984, the structural characteristics of the housing stock and the energy intensity in the US were more similar to those in Europe than was the case in 1973. Japan had and still has a very different heating structure and intensity.

The period since 1973 also saw considerable change in the fuel mix of space heating. The share of oil has declined in all countries, though it still accounts for over half of final energy consumption for space heating in Germany and Italy. The European countries, which were much more reliant upon oil in 1973 than the U.S., have experienced more substantial fuel substitution.

3.1. Overview

Final energy consumption for space heating declined in the 1973-84 period in most countries. (See Figure 3-1.) Overall for the six countries, consumption decreased by 10%. The decline relative to 1973 was largest in the U.S., though there was also substantial decrease in

Figure 3.1
Index of
Space Heating Demand

France.⁴ Most of the decline in consumption took place after 1977/78. This was even more pronounced in the European countries, where the growth due to increase in the comfort level (i.e. structural intensity of heating) was slowed but not stopped by the 1973 oil price shock. After continued growth in the seventies, Germany and Italy were back to the overall level of consumption observed in 1972-73. Japan and the U.K., the countries with the lowest indoor comfort level in 1973, had a general trend of increase in consumption.

⁴ Absolute figures are given in the Data Appendix.

Figure 3.2
Final Space Heating
Energy Use per Home

Final space heating energy use per home decreased in all countries.⁵ (See Figure 3-2.) The decline was greatest in the U.S. and France (33% between 1973 and 1984); and more modest elsewhere (16% in Italy, 10% in Germany, 7% in the U.K.). In Japan, the considerable drop from 1973 to 1980 (-23%) was partially reversed by 1984.

Normalized to exclude differences in climate, the level of demand in the U.S. is almost 30% higher than in any European country. This is partly due to the larger size of U.S. homes. The difference between the U.S. and Europe is less now than in 1973. A major reason for the larger percentage reduction in the U.S. is that there was more "fat" to trim in terms of both building efficiency and indoor temperature levels.

Energy consumption per home for heating in Japan is much lower than in Europe. This is mainly due to the frequent use of *point* heating instead of *space* heating in Japanese homes, resulting in much lower average internal temperature (14°C).

Changing Fuel Mix. The large increases in oil prices and developments with gas and electricity have led to major changes in the space heating fuel mix (See Figures 3-3-1 through 3-3-6). Here we present an overview of changes between 1972-73 and 1984; the causes of these changes are discussed later.

- In *France*, the contribution of gas doubled and that of electricity increased by a factor of five, to 24% and 10% respectively, while the shares of oil and solids decreased correspondingly.
- In *Germany*, the gas share grew from 9% to 27%. The use of solids and oil declined, but oil still accounted for 55% of consumption in 1983.
- *Italy* was most dependent on oil of the six countries in 1973. Between 1972 and 1980, however, the oil share declined from 85% to 64%. The share of gas increased strongly from 8% to 33%. Preliminary data for 1983 show a continuation of this trend. Electric heat was discouraged by the national utility and did not gain any market share.

⁵ We have normalized consumption for climate differences among countries by dividing the values by the number of average heating degree-days, base 18°C, for each country. In the Appendix we give the heating degree-day normals for each country.

Figure 3.3.1
FRANCE
Space Heating Energy Consumption
By Fuel

Figure 3.3.2
GERMANY
Space Heating Energy Consumption
By Fuel

Figure 3.3.3
ITALY
Space Heating Energy Consumption
By Fuel

Figure 3.3.4
JAPAN
Space Heating Energy Consumption
By Fuel

- In *Japan*, the oil share increased from 72% in 1973 to 87% in 1980, but declined thereafter to 79% in 1983.
- In the *U.K.*, gas rapidly became the dominant heating fuel, increasing from 26% in 1972 to 64% in 1984. Solid fuels experienced the most significant drop, from 45% to 22%, while oil's share fell from 17% to 7%. Electricity lost almost half of its market share to gas in the first half of the 1970s, and its contribution continued to decline until 1982.
- In the *U.S.*, the oil share declined from 38% to 22%. Part of this loss was taken up by wood, and some by gas (The low efficiency of burning wood inflates its share of final energy consumption). Gas continued to dominate heating, though electricity doubled its share.

Figure 3.3.5
UNITED KINGDOM
Space Heating Energy Consumption
By Fuel

Figure 3.3.6
UNITED STATES
Space Heating Energy Consumption
By Fuel

To summarize:

- The share of *oil* in space heating energy use has declined in all countries, though it remains dominant in France, Germany, Italy and Japan.
- The *gas* share has doubled in Germany, France, Italy, and the United Kingdom. It remained constant in the U.S. (where it already claimed more than 50% of space heating energy demand in 1973), as well as in Japan.
- The share of *solid fuels* has dropped in all countries except the U.S., where there was growth in the use of wood. Solids continue to be important in France and the U.K.
- *Electricity* has increased its share in France, Germany, and the United States. It declined in the U.K. and remained insignificant in Italy.
- The share of *district heating* is significant only in France and Germany, where it remained relatively constant.

Change in the mix of fuels used for space heating explains part of the decline in final energy consumption per home. More use of electricity for space heating contributed to the downward trend, as electricity is transformed into heat at close to 100% efficiency, while gas, oil, and solids lose 30 to 50% of their energy content at the furnace. The shift from solids to oil, electricity, and gas had a similar effect as the losses for oil and gas-burning systems are smaller than for solid fuels.

3.2. Fuel Choices

The changes in the fuel mix described above are in part the result of changes in fuel choice in existing and new homes. In all countries, other energy sources have been sought to replace or supplement oil-based space heating systems. In the early 1970s, the majority of the primary space heating systems in France, Germany, and Italy used oil. Coal heating was also still common. By the mid-1980s, oil had been partially replaced by natural gas or electric-based systems, and coal had become relatively unimportant.

This change has been a result of: (i) fuel switching in existing dwellings (replacement or conversion), and (ii) installation of non-oil systems in new dwellings. The degree of fuel switching from 1973 through 1984 depended primarily on the individual country's reliance on oil and the availability of alternative fuels. In new homes, fuel prices and equipment cost contributed in determining consumers' and builders' fuel choices, although national and local policies in limiting or providing incentives for the use of particular energy sources played a role. The lower cost of installation favors electricity over other fuels in new dwellings, particularly when the decision is taken by a developer and not by the person paying the heating bill. When the decision is left to the household, comparison of systems' life-cycle cost will favor the fuel with lower running costs, in most cases natural gas.

3.2.1. Evolution of the heating structure of the housing stock

The share of oil-based systems has declined since 1973 in every country (See Figure 3-4-1 through 3-4-4). The decline has been greatest in the U.S. and France. The use of coal, which was significant in the early 1970s in every country except the U.S., also was reduced considerably by the mid-1980s.

- In *France* (see Figure 3-4-1), the share of oil-heated homes declined from 52% in 1973 to 36% in 1985. Electricity experienced a substantial increase, primarily because electric heating in new homes was promoted by the government. The share of homes with gas heat grew from 15% to 26% in the same period, in large part because of conversions from solids. The share of coal-heated homes declined from 23% to 15%.

- In *Germany* (see Figure 3-4-2), the share of oil heat did not decline very much from the 1975-76 peak of 52%. This is partly because a high proportion of the oil heating systems are of fairly recent vintage (mid-to-late 1960s), and partly because conversions from oil to gas were not promoted. Still, gas heating has grown since 1975 to claim 26% of homes, in large part due to conversion from coal to gas. The share of coal-heated dwellings fell from 31% to 9% between 1972 and 1983.

- In *Italy*, as in Germany; the share of oil-heated dwellings did not decline until 1980. Gas systems increased mainly at the expense of coal- and LPG-fired systems, while conversions from oil to gas occurred in larger numbers after 1979, as the gas distribution system was expanded. Electric heating has been strongly discouraged, though it is still used in the warmer regions where lower heating requirements often do not justify the cost of gas connection and furnace installation.
- In *Japan*, space heating is provided by a combination of small systems. It is impossible to present one as the primary heating system, as a single home may rely on two or three different energy sources. Gas-fired room-heaters have diffused extensively in recent years, but over 90% of homes use at least one electric heating device, and kerosene is found in around 90 % of homes.

- In the *U.K.* (see Figure 3-4-3), only 6% of homes in 1972 relied on oil as a principal space heating fuel, and this share has declined slightly since then. Gas has grown to be the dominant heating fuel at the expense of coal and electricity. The share of gas-heating grew from 42% to 68% of homes, while the share of coal diminished from 30% to 15%, and electricity also declined from 21% to 13%.

In the U.S. (see Figure 3-4-4), gas heat has dominated the market since the late 1960s, and the percentage of homes with gas heating has remained fairly constant at around 56%. The share of oil-heating has declined from 32% to 20% of homes, while electric-heating grew from 11% to 19%. The share of homes using solids has increased, though many of the homes claiming wood as a primary heating fuel also retain oil-based systems.

3.2.2. Conversion and replacement

The large increase in oil prices led to a move away from oil heating in existing homes in all countries. When normal turnover was necessary, oil furnaces were often not replaced with systems using the same fuel. The incentive to shift away from oil also caused accelerated turnover of heating systems.

The main fuel gaining ground in existing homes has been gas. Electricity has seen much less market gain here, mostly because gas allows the opportunity to make use of the home's old heat distribution system. In the U.S., switching from oil to gas affected around 2 million homes (about 15% of the oil-heated stock) in the 1979-81 period, and switching to wood affected another 1 million homes. In Europe, where there was much movement from non-central to central heat, gas has been the preferred choice when available. Table 3-1 presents a qualitative assessment of the degree to which other fuels displaced oil in existing homes.

Table 3-1 Transition From Oil Heating in Existing Homes

	To Gas	To Electricity	To Wood
Country			
France	S	W	W
Germany	M	W	W
Japan	M	M	0
Italy	S	0	0
United Kingdom	S	0	?
United States	S	W	S
S = Strong M = Moderate W = Weak 0 = None			

3.2.3. Fuel choice in new dwellings

The percentage of homes in 1983 that were built after 1973 ranged from around 20% in the U.S., France, and Germany to only 12% in the U.K. (Data for Italy are not available, and data for Japan are not applicable since new homes do not have a single main heating system.)

The installation of oil heating systems in new dwellings has declined substantially since 1973, and natural gas and electric systems have become the predominant choice. (See Figure 3-5.)

- In France, the share of oil systems in new dwellings dropped abruptly from around 60% in 1974 to around 20% by 1978, and has fallen to zero by 1985. Electric systems were strongly promoted in accord with the government's nuclear energy program, and their share grew rapidly from only 4% of new homes in 1973 to 44% in 1982. The share of gas in new dwellings increased from 23% to 33%. District heating, which accounted for almost 10% of new installations up to 1979, has faded from the picture.
- In Germany, the installation of oil in new dwellings decreased considerably (from 58% to 31%), although it remained at the highest level among the six countries. Gas became the dominant choice, reaching 55% of new installations, while the share of electric systems remained constant at only about 6%.
- In the U.K., the already large share of new dwellings using gas in 1973 became greater, increasing from 52% to 77% between 1973 and 1984. The share of oil systems declined abruptly in 1979 to around 5%. The share of electric systems dropped from 22% in 1975 to 6% in 1980, but increased thereafter in part because of more home building away from the gas network.
- In the U.S., electricity was the most popular fuel in new homes already in 1973, and it increased its share slightly to nearly 60% by 1984. This was partly due to increase in the share of multi-family housing, which is more often heated by electricity. The share of gas remained in the 38-40% range, while oil practically disappeared from the market after 1979. The greater popularity of electricity in the U.S. compared to the other countries is partly due to the fact that a high percentage of new homes have been built in warm climates where electric heating is attractive.

3.2.4. Use of secondary heating fuels

The use of secondary heating fuels, mainly wood and electricity, has been significant in some countries. Around 20% of total electricity used for heating goes for secondary heating in Germany, and close to 12% in France. Secondary heating accounts for an even higher percentage of solids consumption: around 40% in France and the U.S.

Increase in use of secondary heating has contributed to the decline in intensity of the primary heating fuels. Use of wood in particular has contributed to the decline in oil intensity in the U.S. and in France. Around 18% of oil-heated single-family homes in the U.S. used a wood stove for secondary heating in 1982. For the average home, the wood stove reduced use of oil for heating by an estimated 45%.

3.3. Change in Space Heating Energy Use per Home

As Figure 3-2 showed, final energy consumption per home for space heating has declined in continental Europe and the U.S., but has been relatively stable in Japan and the U.K. Changes in average heating intensity are the result of changes in characteristics of the dwelling stock, heating equipment, and occupant behavior. In Europe, rising penetration of central heating systems and increase in the size of dwellings have pushed consumption upward. (We discuss these factors further below.) These factors have been less important in the U.S., where much of this structural "maturation" occurred in the 1960s.

Change in other factors have acted to reduce average heating consumption. These include improved thermal efficiency of buildings, improved efficiency of heating equipment, and lower indoor temperatures.

3.3.1. Factors affecting heating intensity

Dwelling Type. Single-family dwellings (SFD) use more energy per square meter for space heating than multi-family dwellings (MFD), since they have more outside surface area exposed to the elements and they also have more space to heat. Thus, a growing share of SFDs will act to increase space heating energy intensity. Among the six countries, there has been little overall increase in the share of SFDs in Europe, while in the U.S. the SFD share has declined slightly. (See Figure 3-6.)

Average Dwelling Size. Since 1973, the size of both SFD and MFD have increased in all countries, pushing upward the energy requirements for space heating. This change was more substantial in Europe than in the U.S. The much larger size of U.S. homes is one reason why heating intensity is higher in the U.S. (See Table 3-2).

Table 3-2 Average Dwelling Size in 1982/84 (m ²)			
Country	SFD	MFD	ALL
France	90	..	80
Germany	98	70	84
Italy	100	..	78
Japan	..	..	84
United Kingdom	..	..	85
United States	164	86	140
Notes: All data refer to net floor area.			

Figure 3.6
Share of Single Family Dwellings

Figure 3.7
Share of Heated Dwellings with Central Heating

Heating System Type. The growing penetration of central heating⁶ increased space heating energy demand considerably in Europe, and also had an effect in the U.S. (See Figure 3-7.) Dwellings with central heating systems use more energy than those with non-central systems since the entire living area is usually heated. The U.S. still has a higher share of central heating, but the European countries are now approaching the U.S. level. The greatest change was in the U.K., where the share of central heating increased from 43% in 1974 to around 65% in 1983. In France and Germany, the share of central heating increased from 50-55% to around 70% between 1973 and the early 1980s. In Italy, the saturation of central heating varies greatly between regions, going from less than 30% in warmer South to more than 80% in the North of the country. In Japan, central heating is present in only 5% of the homes, all located in the coldest Northern cities.

⁶ By central heating, we mean a heating system capable of heating the entire dwelling. In most cases, heat is distributed from a central furnace.

Figure 3.8.1
Share of Oil Heated Dwellings
with Central Heating

The penetration of central heating varies among fuels. In 1973, central heating saturation was higher in oil-heated dwellings than in dwellings using other heating fuels. (See Figures 3-8-1 through 3-8-3). By 1984, the central heating saturation in oil-heated homes was around 80% in France, Germany, the U.K., and the U.S. Penetration of central heating in gas-heated dwellings increased substantially in Europe, especially in the U.K. For electric-heated homes, the penetration of central heating increased almost 10-fold in France between 1973 and 1984, but non-central systems remained dominant in Germany.

Figure 3.8.2
Share of Gas Heated Dwellings
with Central Heating

Figure 3.8.3
Share of Electrically Heated Dwellings
with Central Heating

Figure 3-9 illustrates the increase in the "structural intensity" of heating that has occurred in France, Germany, and the U.S., and shows the differences in structure among the fuels. For gas and oil, the share of central heating and the share of SFD grew in France and Germany. For electricity, the share of centrally-heated SFD grew substantially in France.

Some fuels are more popular with SFDs than MFDs. Oil and solids tend to be more common in SFDs, while gas and electricity are more frequently found in apartments. France is an exception: electricity has been strongly promoted as a substitute for oil in SFDs that are not reached by the gas network. As a result, the electric-heating dwelling stock in France became more heavily composed of SFDs.

Figure 3.9
Dwelling Stock by Type of Dwelling
and Space Heating Equipment

Building and Equipment Efficiency. Higher energy costs motivated the retrofitting of old homes and the construction of new homes with higher thermal integrity.

Efficiency improvements in existing homes have probably been greatest in the U.S., but the level of retrofit activity in Europe has also been significant. In Japan, the level of retrofit activity appears to have been relatively low, even though most of the stock had virtually no insulation before 1973.

One reason why there was more retrofit activity in the U.S. is that retrofitting did not have to compete with structural upgrading in households' home improvement budgets. Preoccupation with bringing homes up to a minimum heating standard in the U.K. might explain why priority was placed on investments in central heating instead of increasing insulation and double glazing. Because indoor temperatures in Britain are lower than in the other European countries, retrofitting acted to enhance comfort levels more than to reduce energy use.

Indoor Temperature. In response to higher energy costs, people reduced their indoor temperatures, thereby decreasing their space heating requirements. In the U.S., the percentage of homes kept at 21°C (70°F) or higher during the day fell from around 85% in 1973 to around 46% in 1982. We do not have quantitative estimates of change for the other countries, but it has probably been less than in the U.S., largely because temperatures in Europe and Japan were already lower in 1973. This was especially the case in the U.K. and in Japan, where average temperatures were (and still are) quite low (around 16°C in the U.K. and around 14°C in Japan).

3.3.2. Heating intensity by fuel

Changes in average consumption varied among fuels, as structural changes and conservation activities had a different combined effect on the use for each fuel. **Figures 3-10 to 3-14** show the evolution of space heating intensity for the countries studied, given available data. Intensity for the fuels is not shown for Japan, where most homes use two or more fuels for heating.

- Oil intensity decreased in all countries. (See **Figure 3-10**.) The U.S. had the largest absolute decrease in oil intensity, but the intensity there was much higher than in the other countries in 1973 (mainly because the oil-heated stock includes many more single-family dwellings). Use of wood as a secondary heat source also contributed strongly to the reduction in oil intensity in the U.S. The decrease in France and Germany was only slightly smaller in percentage terms.

The effect of energy conservation activities is obscured by the structural changes (particular increases in central heating saturation). If we isolate the stock of centrally-heated single-family dwellings (See **Figure 3-11**), the decline was somewhat larger than for all homes.

Figure 3.10
Space Heating Energy Intensity: OIL

Figure 3.11
Space Heating Energy Intensity for Centrally Heated Single Family Dwellings: OIL

- Gas intensity over the total stock of gas-heated homes shows continuous decline only in the U.S. (See Figure 3-12.) In part this reflects the leakier state of U.S. homes in 1973. Gas intensity has remained relatively constant in the other countries, because the stock of gas-heated homes shifted there from being largely non-centrally-heated (room heaters) to mostly central heating. (See Figure 3-8-2). Looking only at centrally-heated SFDs, we see (for France) substantial decline in intensity. (See Figure 3-13.)

Figure 3.12
Space Heating Energy Intensity: GAS

Figure 3.13
Space Heating Energy Intensities for Centrally Heated Single Family Dwellings: Gas

Figure 3.14
Space Heating Energy Intensity: ELECTRICITY

- Electricity intensity declined somewhat in all countries except France. (See Figure 3-14.) The increase in France is due largely to the promotion of electric central heating. However, there was decline in intensity of almost 30% among centrally-heated SFDs. Intensity in Italy is low compared to the other countries because use of electricity for heating is limited to the warmer regions and to room heating devices.

A key feature for oil, gas, and electricity space heating intensities is that the difference between the U.S. and Europe is much less today than it was in 1973. This is not just a result of conservation in the U.S. The U.S. did "catch up" somewhat in terms of building efficiency. But it is also the case that the European countries moved toward the U.S. level of central heating and thereby increased the structural energy intensity of the residential sector.

3.4. Determinants of Space Heating Fuel Demand: Summary

Table 3-3 summarizes the factors discussed in this chapter and indicates the strength of their upward or downward effect on demand for oil, gas, and electricity for space heating. In general, structural factors have pushed upward on energy demand, while changes in efficiency and behavior have pushed downward. It is interesting to note that the effect of some factors is equally distributed among the fuels, while central heating is particularly important for gas and, in the case of France, for electricity.

This table leads us to the scenarios that will be developed in Appendix II. It is evident from this table and from the previous analysis that forecasts of future demand will have to respect the relative importance of these determinants as well as the peculiarities of each of the countries.

Table 3-3. Determinants of Space Heating Fuel Demand			
Factor	Oil	Effect on	
		Gas	Electricity
Conversions	----	+++	+
New Dwellings	0 (G.+, F.+)	++	+++
Secondary Fuels	---	-	+
SFD share	+	+	+
Central Htg.	+	+++	+ (F.++++)
Area	+	+	+
Intensity/Behavior of which:	----	---	-
- Equip. Efficiency	---	-	0
- Shell Efficiency	-	-	--
- Indoor Temperature	---	--	-

4. Water Heating and Cooking

Energy consumption per capita for water heating and cooking has not changed significantly since 1973, but there has been change in the types of equipment used as well as in household characteristics and habits. In some countries, there has been a modest reduction in final energy consumption per home for these uses. The mix of fuels used to meet water heating and cooking needs has also changed. Oil has mostly declined as a water heating fuel, while gas has risen somewhat in popularity. For cooking, there has been growth in the percentage of homes relying on electricity. Data on these end-uses is significantly more uncertain than for space heating. Information on energy intensity is particularly scarce since monitoring has been rare. In some cases it is difficult to isolate fuel demand for a particular end-use. For instance, hot water is likely to be produced by space heating furnaces as well as by washing machines, and small electric appliances are increasingly contributing to cooking energy demand.

Figure 4.1
Water Heating
Energy Consumption per Capita

Figure 4.2
Water Heating Energy Consumption
per Dwelling with Water Heating

4.1. Water Heating

Final energy consumption per capita for water heating has not changed greatly since 1973, except in Japan. (See Figure 4-1.) This was despite increase in the percentage of homes with water heating facilities, which was considerable in France and Italy. (See Table 4-1.)

Table 4-1 Percentage of Homes with Water Heating Equipment		
	1972/73	1983
France	63	99
Germany	84	100
Italy	55	95
Japan	90	100
United Kingdom	94	99
United States	96	100

Final energy consumption per home for water heating declined in the U.S. and the U.K., was more or less unchanged in France and Germany, and increased by around 50% in Japan. (See Figure 4-2.) The evolution of average consumption was shaped by several structural factors:

- Decline in the number of persons per home has pushed downward on use per home. Because much of a household's hot water goes for personal hygiene and washing dishes, there is a strong relationship between consumption and household size.
- Change in the type of equipment used for water heating has occurred. In Europe (especially France and Germany), there has been growth in the use of systems connected to the central space heating system and storage water heaters (displacing point-of-use heaters). In Japan, there has been increase in the number of storage water heaters. All of these push upward on consumption.
- Improvements in the efficiency of systems (including retrofit insulation of tanks) have contributed somewhat to lower energy consumption.

Water heating energy intensity is much higher in the U.S. than in Europe. Differences in water heating technology are a major reason. Most water heating in Europe (and Japan) does not rely on a single system, as is the case in the U.S. In Europe, most homes have small tank heaters and/or point-of-use heaters (although the share of water heating systems connected with the space heating system has been increasing). In Japan, most water heating is with point-of-use heaters. Clothes-washing and dish-washing machines in Europe generally heat their own water, and their consumption is included with appliances. In the case of Italy, part of water-heating needs are covered by hot water from *pasta* cooking, commonly used for soaking dishes. Climate considerations are also important in this country, where cold showers are common habit in the summer months.

4.1.1. Fuel choice

The market shares claimed by different fuels for water heating have changed through conversion of old systems and entry of new homes. (See Table 4-2.) In both the U.S. and Europe, many homes with central oil-based space-and-water heating systems have switched to electric systems so that the oil system can be turned off in the summer.

	Year	Oil	Gas	Electricity	Solids	Dist.Htg.
France	1973	40	31	24	2	3
	1985	30	37	31	1	2
Germany	1972	24	19	35	20	2
	1983	32	23	36	4	4
Italy	1978	16	16	55	14	..
Japan*	1973	82	<-	8	0	0
	1983	89	<-	11	0	0
United Kingdom	1976	4	35	41	20	0
	1984	4	55	29	12	0
United States	1978	13	55	32	<1	..
	1982	11	57	32	..	..

*** - Oil includes LPG and city gas.**

- In *France*, oil declined in popularity, while gas and electricity both increased.
- In *Germany*, the oil share increased as many homes connected their hot water supply to the main space heating system, although the trend began to reverse in 1982.
- In *Italy*, electricity is the dominant water heating fuel, but gas is growing in popularity as the gas network expands.
- In *Japan*, most homes have more than one water heating device. Electric storage heaters have become more common, but LPG and gas water heaters still dominate.
- In the *U.K.*, the share of gas grew rapidly substituting for solids and electricity. In addition to the change of fuels, many of the new water heating systems were connected to central heating. This shift slightly pushed upward average use per home.
- In the *U.S.*, the dominant share of gas increased somewhat at the expense of oil, along with the conversion of oil-fired heating systems.

4.2. Cooking

We estimate that final energy use per home for cooking has declined or remained constant except in the U.K. and Italy. (See Figure 4-3.) The decline in the number of persons per dwelling

pushes downward on cooking use per household. The introduction of individual electric appliances such as toaster-ovens, coffee-makers, and egg-cookers has also reduced cooking energy use. There is also evidence that people are eating fewer meals at home.

Electricity has increased its share of the cooking market since 1973 in most countries. (See Table 4-3.) It is the main cooking fuel in half or more of all homes in Germany, the U.K., and the U.S.

Table 4-3 Main Fuel Used for Cooking
(percentage of homes)

	Year	Oil ^a	Gas	Electricity	Solids
France	1973	44	29	23	3
	1985	34	30	34	2
Germany	1972	0	30	63	7
	1983	0	17	76	7
Italy	1978	50	29	16	n/a
Japan	1973	->	90	3	2
	1981	->	95	5	0
United Kingdom	1976	4	35	41	20
	1984	4	55	29	12
United States	1973	8	46	45	<1
	1982	6	40	54	0

(a) includes LPG.

5. Electric Appliances⁹

Average electricity consumption per home for electric appliances rose between 1973 and 1983 in all of the countries except the U.S., where it remained more or less stable. (See Figure 5-1.) The largest part of the increase occurred before 1979. Since then, growth in penetration of major appliances has slowed and efficiency improvement in new appliances has had a greater effect.

The main reason for the different trend in the U.S. is that the penetration of electric appliances was at a more advanced stage in the U.S. in 1973. Despite the "catching up" of Europe and Japan, average consumption is still higher in the U.S. by a factor of three or more. This is more a function of intensity (average use per unit) than of market penetration.

⁹ This end-use category includes "electric-specific" uses. That means uses that exclusively or almost exclusively use electricity. This includes food refrigeration and freezing, clotheswashing and drying, dishwashing, lighting, TV and video equipment, and the numerous other small home appliances. Because of the intrinsic dependence on or great advantage of electricity, fuel choice is not an issue in this subsector.

5.1. Growth in Appliance Saturation

Growth in the penetration of major appliances was higher in Europe and Japan than in the U.S. between 1970 and 1983 due to the reason mentioned above. (See Table 5-1.) This pushed up electricity use significantly in those countries. Penetration of refrigerators was already high (85-100%) in 1972, but many of them did not have a freezer compartment. The penetration of refrigerators with a freezer compartment was strong in Europe in the 1970s. Growth in penetration of separate freezers, which are major electricity users, has been considerable everywhere except in Japan and the U.S. In the U.S., penetration of freezers was already high in 1973 (and refrigerators have large freezer compartments).

Table 5-1 Market Penetration of Major Electric Appliances (% of homes)

	Refrigerator ^a		Freezer		Clotheswasher		Dryer		Dishwasher	
	1972/73	1983	1972/73	1983	1972/73	1983	1972/73	1983	1972/73	1983
France	87	100	8	34	65	87	0	1	5	21
Germany	89	100	25	52	71	86	2	10	6	23
Italy	87	97	1	14	62	80	0	2	6	11
Japan	100	100	0	0	96	98	0	9	0	1
United Kingdom	71	96	3	32	67	80	26	38	1	2
United States	99	100	34	37	70	70	38	45	25	36

(a) By 1983 some households had more than one refrigerator in most countries.

Penetration of clotheswashers also increased everywhere except in Japan and the U.S. Clothesdryers have not penetrated very much outside the U.S. except in the U.K.

Growth in penetration of dishwashers was an important factor for France and Germany. This was also an area of growth in the U.S., though these appliances in Europe are higher electricity users because they heat their water internally. There has been almost no penetration of dishwashers in Japan.

The market penetration of smaller appliances -- color TV, VCRs, and smaller devices -- has also increased, though this has not had a large effect on consumption.

Table 5-2 Estimated Annual Consumption of Major Electric Appliances (kWh)
(Average over Entire Stock)

	Refrigerator ^a		Freezer		Clotheswasher ^f		Dryer		Dishwasher ^f	
	1972/73	1983	1972/73	1983	1972/73	1983	1972/73	1983	1972/73	1983
France ^b	425	540	740	720	300	300	-	-	470	440
Germany	375	480	680	580	350	280	450	290	760	400
Italy	180	220	490 ^c	470	450	410 ^d	540 ^c	500	1000	1050
Japan	700	600	-	-	-	37 ^d	-	-	-	-
United Kingdom	300	300	975	780	200	200	300	300	500	500
United States ^e	1400	1290	1390	1220	90 ^d	85 ^d	1110	1080	250	250

(a) The 1983 values include a higher proportion of units with freezer compartments. (b) First year is 1975. (c) 1980. (d) Washers do not heat water. (e) First year is 1977.

Table 5-3 Reduction in Electricity Consumption of New Electric Appliances

	Refrigerator	Freezer	Washer	Dryer	Dishwasher	Oven	Cooling	Years
	(% reduction)							
Germany	24	-	15	-	27	14	-	78-84
Japan	60	-	-	-	-	-	32	73-84
United States	42	37	-	-	-	-	23/20 ^a	72-84

In Germany and the U.S., figures represent sales-weighted averages (expected annual consumption for different models of each kind of appliance, weighted by the actual appliances sold).

(a) The values refer to central and room air-conditioners respectively.

5.2. Energy Use per Home for Appliances

The average intensity of appliances is determined by the efficiency, size, and features of the appliances in use as well as by usage patterns. Though there are few measurements of average annual consumption of particular appliances, estimates indicate decline in some areas (See Table 5-2.)

The penetration of larger and frost-free refrigerators has pushed upward on average consumption in all of the countries. In Europe, the greater size and use of automatic defrost has had more effect than improved efficiency. In the U.S., refrigerators were already large in the early 1970s, and the considerable efficiency improvement in new appliances brought average consumption down. In Japan, average volume more than doubled, and the presence of freezer compartments became more widespread, but this was outweighed by substantial improvement in efficiency.

In some cases, there has been considerable decline in average intensity (e.g., dryers and dishwashers in Germany). This is because the stock of a particular appliance grew from a very low base in the early 1970s, and a high proportion of the stock existing in the 1980s was manufactured in the period when electricity efficiency was improving.

The main force pushing downward on intensity is the higher efficiency of new appliances. (See Table 5-3). Considerable improvement has occurred for refrigerators and freezers. Though there are only limited actual data, all European manufacturers report significant improvements in their appliances since 1975.

6. Conclusions

The historical period covered in the previous chapters was marked by substantial change in residential energy demand. The high rate of change was primarily due to the extreme increase in the price of oil and to the structural evolution that changed the kinds of energy-using equipment in homes. The latter was less important in the U.S. than elsewhere.

The increase in oil prices caused a movement away from oil-using equipment and reduction in use for homes retaining such equipment. In Europe, it also accelerated development of natural gas distribution, which enabled the rapid penetration of gas in the residential sector. Increases in gas and electricity prices and the general concern with energy led to improvements in the efficiency of use for these fuels as well.

The structural evolution of energy-using equipment, particularly growth in use of central heating and certain major electric appliances, pushed upward on energy demand. This force was significant in the 1970s because income growth allowed the residential sectors to move relatively quickly toward what we refer to as "maturation." By this we mean a high level of indoor comfort and ease of equipment use and widespread ownership of major electric appliances.

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Some of the data used in preparing this report come from government and electric utility statistical reports. Many of the sources used are unpublished reports provided directly by experts in energy industries, ministries, and universities in the countries we studied.

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Data Appendix

Table A-1 Overview of Residential Energy Demand in Selected OECD Countries

Table A-2 Final Energy Demand Fuel Shares

Table A-3 Final Energy Demand End-Use Shares

Table A-4 Space Heating Energy Demand

Table A-5 Space Heating Structure

Table A-6 Space Heating Intensities

Table A-7 Water Heating, Cooking, and Appliance Intensities

TABLE A-1 OVERVIEW OF RESIDENTIAL ENERGY DEMAND IN SELECTED OECD COUNTRIES (1)

COUNTRY/ YEAR	POPULATION (10E6)	HOUSEHOLDS (HH) (10E3)	FINAL ENERGY, PJ	FINAL ENERGY PER HH, GJ	PRIMARY ENERGY PER CAPITA, GJ	USEFUL PER CAPITA, GJ
FRANCE						
1973	52.1	17323	1553	89.6	34.5	19.7
1978	53.3	18655	1583	84.9	37.8	20.4
1980	53.7	19165	1485	77.5	36.9	19.3
1984	54.9	20378	1460	71.7	38.3	19.0
GERMANY						
1972	61.7	21027	1781	84.7	36.5	19.9
1978	61.3	22636	2067	91.3	44.8	23.9
1980	61.6	22958	1970	85.8	43.6	22.8
1983	61.4	23526	1919	81.6	43.8	22.6
ITALY						
1972	54.4	15490	947	61.2	21.2	11.9
1978	56.1	16800	1059	63.1	23.9	13.1
1980	56.4	17362	1029	59.2	23.8	12.8
1984	57.0	18369	1068	58.1	25.0	13.3
JAPAN						
1973	108.7	31900	985	30.9	13.7	6.6
1978	114.9	34900	1225	35.1	17.1	8.0
1980	116.8	35800	1204	33.6	16.8	7.8
1984	120.0	37800	1416	37.5	19.5	8.9
UNITED KINGDOM						
1972	55.8	17942	1567	87.3	41.1	19.3
1978	55.8	19669	1631	82.9	41.9	20.4
1980	56.0	20042	1661	82.9	42.3	20.8
1984	56.5	20660	1600	77.4	40.5	20.0
UNITED STATES						
1973	211.4	69351	11359	163.8	72.5	38.6
1978	222.1	77130	10871	140.9	69.7	35.7
1980	227.3	80776	10622	131.5	68.3	34.3
1983	234.3	83918	10326	123.0	65.9	32.5

NOTES: (1) All energy consumption is corrected for yearly climate variations.

TABLE A-2 FINAL ENERGY DEMAND FUEL SHARES (1)

COUNTRY/ YEAR	FUEL SHARES				
	OIL %	GAS %	SOLIDS %	ELECTRICITY %	DISTRICT HTG %
FRANCE					
1973	56.0	11.2	24.7	6.8	1.3
1978	49.5	16.7	19.8	11.5	2.4
1980	45.7	19.6	18.0	14.3	2.5
1984	38.0	23.3	17.1	19.0	2.5
GERMANY (2)					
1972	57.6	10.1	18.3	11.0	3.0
1978	57.6	17.5	7.7	14.0	3.2
1980	51.3	21.3	8.7	15.5	3.2
1983	46.9	25.0	7.4	17.1	3.6
ITALY					
1972	71.7	11.2	7.6	9.5	0.0
1978	62.3	22.0	4.0	11.7	0.0
1980	54.0	29.3	3.3	13.3	0.2
1984	47.0	35.0	3.1	14.5	0.3
JAPAN					
1973	47.3	22.8	7.5	22.4	0.0
1978	48.5	22.7	2.3	26.5	0.0
1980	47.0	23.9	1.6	27.6	0.0
1984	45.2	24.9	1.2	28.8	0.0
UNITED KINGDOM					
1972	10.8	31.2	37.7	20.3	0.0
1978	9.3	47.3	24.4	19.0	0.0
1980	6.9	53.5	21.0	18.7	0.0
1984	6.3	59.4	15.3	18.9	0.0
UNITED STATES					
1973	28.3	48.6	4.6	18.5	0.0
1978	24.2	47.1	6.4	22.4	0.0
1980	18.7	47.9	9.0	24.4	0.0
1983	17.2	46.2	10.3	26.2	0.0

NOTES: (1) Shares may not sum to 100% due to rounding.

(2) Unlike other countries LPG is included with natural gas use.

TABLE A-3 FINAL ENERGY DEMAND END-USE SHARES

COUNTRY/ YEAR	END-USE SHARES		COOKING %	APPLIANCES %
	SPACE HEATING %	WATER HEATING %		
FRANCE				
1973	81.5	10.0	4.6	3.9
1978	78.5	10.6	5.1	5.8
1980	76.8	10.8	5.4	7.0
1984	74.6	11.0	5.5	8.5
GERMANY				
1972	83.3	9.2	3.5	4.0
1978	78.8	11.2	2.8	5.4
1980	78.4	12.3	2.8	6.4
1983	77.9	12.0	2.5	7.4
ITALY				
1972	80.6	7.4	5.8	6.2
1978	74.6	9.8	7.3	8.3
1980	73.2	10.3	7.5	9.0
1984	71.6	10.4	7.3	10.8
JAPAN				
1973	38.5	30.0	15.4	16.0
1978	32.1	36.3	11.4	18.9
1980	27.1	39.9	11.8	20.8
1984	28.4	38.7	10.6	20.8
UNITED KINGDOM				
1972 (1)	62.6	26.3	-->	11.1
1978	65.3	16.9	9.0	8.8
1980	65.4	16.8	8.8	9.1
1984	65.1	18.3	6.0	10.3
UNITED STATES				
1973	68.9	14.4	3.6	12.8
1978	64.4	16.1	3.7	15.6
1980	63.4	...	...	...
1983	61.0	16.1	3.7	18.3

Notes: (1) The share of energy used for cooking is combined w/appliance use.

TABLE A-4 SPACE HEATING ENERGY DEMAND

COUNTRY/ YEAR	SPACE HEATING	FINAL ENERGY	OIL %	FUEL SHARES			DH %
	ENERGY, PJ	PER HH, GJ		GAS %	SOLIDS %	ELECTRICITY %	
FRANCE							
1973	1266	73.1	57.3	9.5	29.8	2.0	1.3
1978	1243	66.6	52.3	15.6	24.9	4.6	2.5
1980	1140	59.5	48.8	19.1	23.1	6.3	2.7
1984	1094	53.7	41.0	23.9	22.5	9.7	2.9
GERMANY							
1972	1483	70.5	65.9	9.1	18.5	3.1	3.4
1978	1630	72.0	66.1	18.4	7.4	4.6	3.4
1980	1545	67.3	59.2	23.0	9.4	4.9	3.5
1983	1495	63.5	55.2	26.8	8.5	5.4	4.0
ITALY							
1972	763	49.3	84.9	8.3	6.2	0.7	0.0
1978	791	47.1	74.0	22.5	3.0	0.4	0.1
1980	753	43.4	63.7	33.3	2.4	0.4	0.2
1984	764	41.6	...	...	...	...	...
JAPAN							
1973	379	11.9	72.3	8.4	14.3	5.0	0.0
1978	393	11.3	84.4	5.5	5.1	5.0	0.6
1980	326	9.1	86.8	5.8	4.0	3.4	0.0
1984	402	10.6	80.2	10.6	3.0	6.3	0.0
UNITED KINGDOM							
1972	981	54.7	16.7	26.1	45.1	12.1	0.0
1978	1065	54.1	11.1	50.2	31.8	6.9	0.0
1980	1086	54.2	8.3	57.9	27.2	6.6	0.0
1984	1041	50.4	7.2	64.4	22.4	6.0	0.0
UNITED STATES							
1973	7824	112.8	38.1	52.5	6.6	2.7	0.0
1978	6999	90.7	33.6	53.1	9.9	3.3	0.0
1980	6735	83.4	25.9	55.5	14.2	4.3	0.0
1983	6295	75.0	22.9	55.0	17.0	5.1	0.0

TABLE A-5 SPACE HEATING STRUCTURE

COUNTRY/ YEAR	HEATED DWELLINGS (10E3)	PRIMARY SPACE HEATING FUEL SYSTEM SHARES				SINGLE FAMILY		CENTRAL HEATING %	PERSONS PER DWELLING
		OIL %	GAS %	SOLIDS %	ELECTRICITY %	DH %	DWELLINGS %		
FRANCE									
1973	16119	52.1	14.6	22.7	8.5	2.0	46.5	55.4	3.0
1978	18519	48.0	18.1	19.3	11.9	2.7	51.2	61.7	2.9
1980	19050	45.1	20.8	17.7	14.0	2.5	52.3	64.8	2.8
1984	20378	38.4	25.3	14.8	19.0	2.5	55.1	69.1	2.7
GERMANY									
1972	21027	48.4	10.7	31.0	4.5	5.4	47.6	49.0	2.9
1978	22636	51.9	19.5	12.7	8.2	7.7	48.6	65.4	2.7
1980	22958	50.3	22.1	11.1	8.7	7.8	49.0	67.7	2.7
1983	23526	48.5	25.8	8.9	9.1	7.8	49.4	70.8	2.6
ITALY									
1972	14710	...	17.7	...	6.1	...	22.0	41.0	3.5
1978	16464	53.6	19.1	18.5	8.8	(1)	27.0	57.0	3.3
1980	17362	53.2	27.9	11.7	7.2	(1)	29.0	58.4	3.2
1984	18369	...	...	...	...	...	27.0	61.0	3.1
JAPAN (2)									
1973	...	...	...	...	...	...	65.0	2.0	3.4
1978	...	...	...	...	...	...	65.0	4.0	3.3
1980	...	...	...	...	...	...	65.0	4.0	3.3
1984	...	...	...	...	...	...	65.0	7.0	3.2
UNITED KINGDOM (3)									
1973	18154	6.2	42.2	30.3	21.2	0.0	81.4	42.6	3.1
1978	19689	6.2	56.3	21.1	16.4	0.0	82.7	51.8	2.8
1980	20042	5.3	62.0	16.9	15.8	0.0	83.4	58.2	2.8
1984	20660	4.7	68.4	14.6	12.4	0.0	83.9	65.1	2.7
UNITED STATES									
1973	68744	31.5	56.0	2.0	10.5	0.0	68.6	83.0	3.0
1978	76440	26.4	55.6	1.9	16.0	0.0	67.8	86.0	2.9
1980	80035	24.0	56.0	2.2	17.9	0.0	68.6	87.0	2.8
1983	83089	20.2	55.7	2.7	18.7	0.0	68.1	86.0	2.8

NOTES: (1) There exists a small percentage of homes that have district heating fuel systems but the data is unavailable and therefore not calculated into the total.

(2) Most homes use more than one system and more than one fuel.

(3) Single family dwelling data from 1975 and central heating data from 1974.

TABLE A-6 SPACE HEATING INTENSITIES

COUNTRY/ YEAR	HEATING DEGREE-DAY (DD) INDEX (18C)	HEATING PER DWELL.(1) PER DD,MJ	OIL PER DWELL., PER DD,MJ	GAS PER DWELL., PER DD,MJ	SOLIDS PER DWELL., PER DD,MJ	ELECTRICITY PER DWELL., PER DD,MJ
FRANCE	(245000=100)					
1973	104.00	32.1	35.3	20.9	42.1	7.6
1978	102.00	27.4	29.8	23.7	35.3	10.7
1980	97.30	24.4	26.4	22.4	32.0	11.1
1984	99.20	21.9	23.4	20.7	33.4	11.2
GERMANY	(311300=100)					
1972	104.20	22.7	30.9	19.3	13.5	15.8
1978	101.50	23.1	29.5	21.8	13.4	13.1
1980	102.95	21.6	25.4	22.5	18.3	12.1
1983	97.10	20.4	23.2	21.2	19.5	12.2
ITALY	(214000=100)					
1972	98.70	...	...	11.3	...	2.6
1978	100.50	22.5	31.0	26.5	2.8	0.9
1980 (2)	100.00	20.5	24.3	24.2	4.1	1.1
1984 (2)	100.00	19.4	...	...	...	...
JAPAN (3)	(197500=100)					
1973	98.00	6.0	...	...	...	...
1978	99.00	5.7	...	...	...	...
1980	101.00	4.6	...	...	...	...
1984	113.00	5.4	...	...	...	...
UNITED KINGDOM	(282400=100)					
1972	95.10	...	...	...	...	...
1978	98.96	19.2	34.1	17.1	28.9	8.0
1980	100.42	19.2	29.9	17.9	30.9	8.0
1984	98.82	17.8	27.5	16.8	27.4	8.7
UNITED STATES	(258500=100)					
1973	94.00	44.0	47.0	41.3	143.1	13.7
1978	107.00	35.4	39.7	33.8	182.5	8.9
1980	101.00	32.5	31.0	32.2	215.3	9.5
1984	97.00	29.3	29.4	28.9	92.0	9.6

NOTES: (1) Per heated dwelling.

(2) It is assumed that 1980 and 1984 were normal years, i.e. 100=214000.

(3) Energy consumption has been corrected for variations in heating seasons only.

TABLE A-7 WATER HEATING, COOKING AND APPLIANCE INTENSITIES

COUNTRY/ YEAR	WATER HEATING PER DWELLING(1) GJ	WATER HEATING PER CAPITA, GJ	COOKING USE PER DWELLING, GJ	COOKING USE PER CAPITA, GJ	APPLIANCE USE PER DWELLING, GJ	APPLIANCE US PER CAPITA, GJ
FRANCE						
1973	12.1	3.0	4.1	1.4	3.5	1.2
1978	10.8	3.2	4.4	1.5	4.9	1.7
1980	9.5	3.0	4.2	1.5	5.4	1.9
1984	8.7	2.8	3.8	1.4	5.8	2.2
GERMANY						
1972	7.8	2.7	3.0	1.0	3.4	1.2
1978	10.3	3.8	2.6	0.9	5.0	1.8
1980	10.6	3.9	2.4	0.9	5.5	2.0
1983	9.8	3.8	2.1	0.8	6.1	2.3
ITALY						
1972	8.2	1.9	3.6	1.0	3.8	1.1
1978	7.6	1.9	4.6	1.4	5.2	1.6
1980	...	1.9	4.5	1.4	5.3	1.6
1984 (2)	6.4	1.9	4.2	1.4	6.4	2.1
JAPAN						
1973	8.3	2.7	4.3	1.2	5.2	1.5
1978	...	3.9	4.0	1.2	6.6	2.0
1980	...	4.1	4.0	1.2	7.0	2.1
1984	14.5	4.6	4.0	1.2	7.8	2.5
UNITED KINGDOM						
1972	...	7.4	...	...	...	...
1978	14.2	4.9	7.5	2.6	7.3	2.6
1980	...	5.0	7.3	2.6	7.5	2.7
1984	14.3	6.7	4.6	1.7	8.0	2.9
UNITED STATES (3)						
1973	24.5	7.7	6.0	2.0	20.9	6.9
1978	23.1	7.9	5.2	1.8	21.9	7.6
1983	17.7	7.1	4.5	1.6	22.5	8.1

Notes: (1) Per dwelling equipped with a water heating device.

(2) 1983 water heating data.

(3) 1980 data unavailable.

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