Housing Trends as an Indicator of Future Housing Stock and Energy Use: 1990 and 2001 RECS Comparisons

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ABSTRACT

Characteristics of new homes, the presence and use of technology in these homes, as well as characteristics of the inhabitants can give an indication of the trends in future housing stock and the implications on present and future energy use.

It would be ideal to characterize new housing as defined by homes built in 1999 - 2001 and compare these homes to the rest of the U.S. housing stock. However, new homes represent only 2 percent of the housing stock in 2001 as measured by the Residential Energy Consumption Survey (RECS), the latest household energy survey fielded by the U.S. Energy Information Administration. It would be difficult to accurately compare the stock of new homes to any level of disaggregation since new homes sampled are limited--introducing large standard errors into the comparisons.

Instead, using the 1990, 1993, 1997, and 2001 RECS, this paper examines changes in the housing stock including new housing in an attempt to obtain indications of trends in future housing stock and energy use. Comparisons include those characteristics most closely related to energy use such as type of housing unit, geographical location, size of the housing unit, number and type of appliances as well as usage and household characteristics. Other factors are considered such as the price of energy, weather, and income growth.

Upon examination, if the trends in housing stock and energy use between 1990 and 2001 continue, more large housing units household will be build as well as a continued growth in the purchase of appliances for use within the homes. Additional population growth in the South Census Region and the corresponding use of central air conditioning will continue to push up demand—especially the demand for electricity.

Introduction

The *2004 Annual Energy Outlook* (AEO, 2004), a U.S. energy forecast by the Energy Information Administration (EIA), projects household energy use to increase by 25 percent between 2002 and 2025.[2] According to the 2004 AEO, the factors driving energy demand upward include electricity use, a continuing trend of larger homes, and housing growth in the South Census Region. Damping the upward trend, according to the forecast, is stock turnover of energy-efficient appliances as well as technology advances.

This paper examines time-related changes in the housing stock including new housing in an attempt to obtain indications of trends in future housing stock and energy use. Data used are from the 1990, 1993, 1997, and 2001 RECS. These surveys were chosen so as to incorporate the

[1] The opinions and conclusions expressed herein are solely that of the author and should not be construed as representing the opinions or policy of any agency of the United States Government.

[2] EIA's residential energy projections include the losses in generation and transmission of electricity. This paper will present the analysis using "site" energy-energy without the transmission and generation losses as the focus is on energy used within the housing unit.

influences of appliance standards resulting from the National Appliance Energy Conservation Act of 1987 (NAECA), and amendments of 1988 as well as the Energy Policy Act of 1992 (EPACT).

Using the AEO projections as a guide, comparisons are presented for energy use. Discussion includes total energy and major energy sources with particular attention to electricity. Aiding the comparisons are several selected indices including energy, weather, price, and income. Next is an examination of housing units and households including the growth of housing units by type and location along with a discussion of the implications for energy demand growth—especially looking at the trend in the South. A discussion of household size is included in this section. Next the use of heating fuel and cooling equipment is evaluated—showing changes in the mix of energy used for heating as well as growth and change in the mix of the air conditioning equipment. The remainder of the paper discusses the growth of electricity used by appliances as well as the trends in the numbers and usage patterns of selected appliances. Stock turnover is included as well—an important indicator of the penetration of energy-efficient appliances.

Data Used

At the present time the Energy Information Administration conducts the RECS every four years. The RECS is a national multistage probability sample survey where housing unit and household characteristics data are collected via personal interview with the householder. Householders are asked to sign authorization forms allowing their suppliers of energy to release billing information about their households. A mail survey is used to collect this information on energy consumption and expenditures from the energy suppliers. Using regressions for each of the major energy sources, the billing data is disaggregated into estimates for the end uses: space heat, air conditioning, water heating, and appliances. First conducted in 1978, the survey was conducted annually until 1982, followed by 1984, 1987, 1990, 1993, 1997, and 2001.

Energy Use, 1990 – 2001

In 2001, U.S. households used 7 percent more energy than they did in 1990—9.2 quadrillion BTUs (quads) in 1990 and 9.9 quads in 2001. Although energy use was higher in 2001 than in 1990, the comparison of energy use between 1990 and 1993 as well as 1997 shows a larger percent increase, a 9 and 11 percent growth, respectively (Table 1).

Table 1. Selected Energy and Economic Growth Indices

	1990	1993	1997	2001
Total Energy Demand	1.00	1.09	1.11	1.07
Natural Gas Demand	1.00	1.08	1.09	1.00
Electricity Demand	1.00	1.08	1.17	1.28
Energy Cost (Real Dollars Per Housing Unit)	1.00	1.00	.97	1.00
Average HDD	1.00	1.17	1.12	1.02
Average CDD	1.00	0.96	.92	1.02
Energy Cost (Real Dollars per MBtu)	1.00	0.95	.93	1.06
Electricity Cost (Real Dollars per MBtu)	1.00	0.96	.90	.92
Natural Gas Cost (Real Dollars per MBtu)	1.00	0.99	1.02	1.47
Disposable Personal Income	1.00	1.01	1.08	1.21

Note: Implicit Price Deflator (2000=100) is used to calculate real dollars.
Sources: Bureau of Economic Analysis, EIA, 1990, 1993, 1997, and 2001 Residential Energy Consumption Surveys.

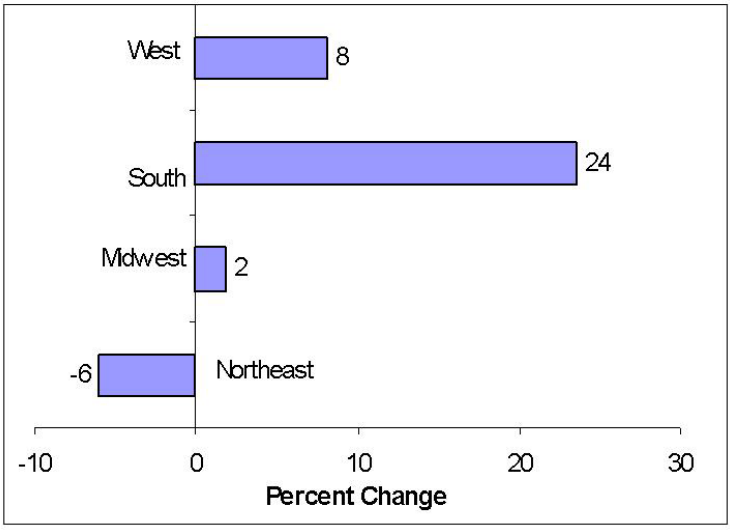
Since the energy sector is so complex, several factors explain

why total energy use did not continue growing at a fast pace in 2001. Three of the factors could be: weather, energy price, and income growth. Upon examination, the results presented in this section are mixed. Most likely other factors such as regional effects including the 24 percent energy growth in the South Census Region as well as the change in the energy mix—notably the 28 percent in electricity demand between 1990 and 2001 influenced the differences in the comparisons (Table 1 and Figure 1).

Weather

A comparison of the average heating-degree days (HDD) in 1990 (3,887 HDD) and for the RECS survey years 1993 (4,544 HDD) and 1997 (4,361 HDD) shows that the winters for these two years were harsh, pushing space-heating energy demand upward.[3] Although other regions of the U.S. face colder winters, percentage-wise, the South faced the harshest winters as compared to 1990 with average HDD of 2,252 compared to 2,878 HDD and 2,709 HDD, respectively for 1993 and 2001. However for 2001, average HDD for the U.S. were only 2 percent higher than in 1990 as the U.S. faced a milder winter. Again, an exception was in the South where average HDD were 11 percent higher than in 1990—pushing up mainly electric space heating.

Figure 1. Percent Change in Household Energy Demand, 1990-2001



Source: EIA, 2001 Residential Energy Consumption Survey.

In 2001, U.S. households experienced a summer cooler in comparison to 1990, with only a 2 percent difference in average cooling degree-days (CDD) between the two years. However, in the South, where most of the air-conditioning electricity is used, average CDD were 8 percent higher in 2001 than 1990—pushing energy use higher in 2001. For the RECS survey years 1993 and 1997, in each of the Census regions with the exception of the Northeast, summers were cooler and CDD were below that of 1990—pushing electricity use downward. Since 57 million housing units out of almost 107 million housing units in the U.S. use central air conditioning while almost all units use space heating, this examination may be showing that in addition to weather, other factors such as prices and income levels are exerting their influence on energy use as well.

Weather cannot be controlled, but its impact can be reduced through the use of energy-related technology. However, as the technology penetrates, even though the improvement may be energy efficient, such as new central air conditioners, the increase in the number of larger homes with the technology does push up total consumption. Also, as shown in Figure 2, the

[3] HDD and CDD are measures of how hot/cool a location was over a period of time, relative to a base temperature. RECS uses a base temperature of 65.

increase in saturation of appliances in households with greater income can result in household energy increases.

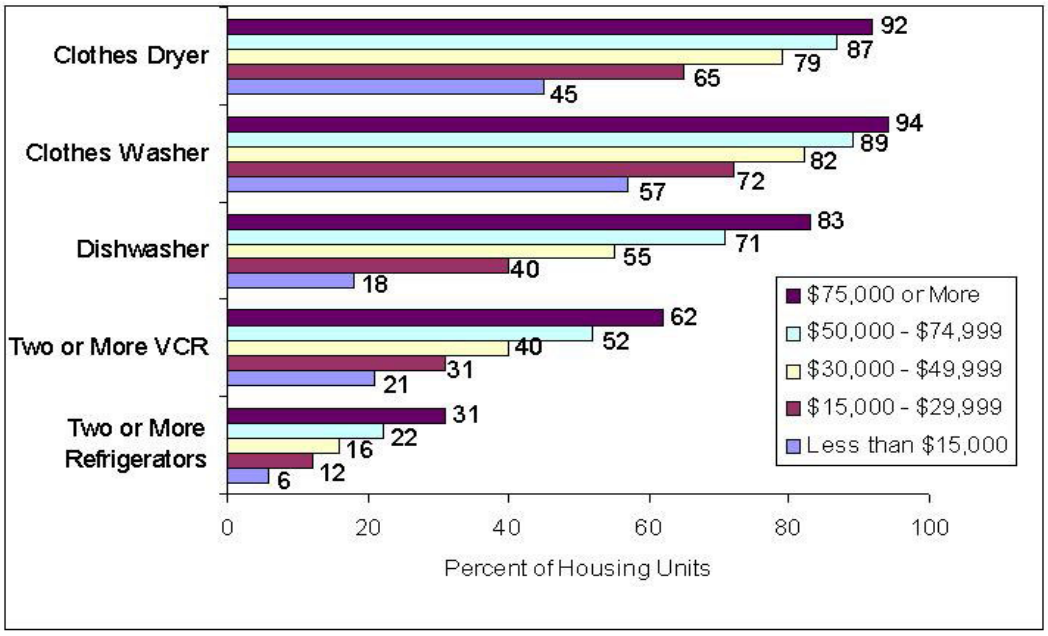
Energy Prices

In 2001, although the average household used 6 percent less total energy than in 1990, they spent, after adjusting for inflation, about the same in 1990 ($1,456) as they did in 2001 ($1,458)—implying price increases. Real prices per million Btu of total energy were higher in 2001 ($15.85) as compared to 1990 ($14.91)—6 percent higher. Interesting to note; while the demand for electricity was growing 28 percent, the inflation-adjusted price for electricity has been falling—down 8 percent in 2001, $27.11 per million Btu in 2001 and $28.12 per million Btu in 1990 (Table 1).

Prices do seem to matter as natural gas demand was higher in both 1993 and 1997 compared to 2001. The average real price of natural gas was flat in 1993 as compared to 1990. There was only a 2 percent difference in 1997 as compared to 1990 (Table 1). Real natural gas prices increased sharply by 43 percent between 1997 and 2001. In 2001, natural gas prices were 47 percent higher than 1990 --$6.96 per million Btu in 1990 and $10.20 per million Btu in 2001 (inflation adjusted).

Natural gas is used mainly for space-heating and water heating. With prices as high as they were in 2001, households may have substituted or reduced space heat. Substitutes or measures may have included more efficient furnaces, small electric heaters, more insulation, lower thermostat settings, and sweaters. Although electricity is used for space heating and substitutes are similar to those for natural gas, many of electricity's uses have no substitutes, especially the electricity used for appliances. If prices climb for electricity as regulated caps are removed, we may see demand for appliances fall—especially in the low-income households.

Figure 2. Percent of Housing Units Having the Selected Appliances by Income Levels, 2001



Source: Energy Information Administration, 2001 Residential Energy Consumption Survey.

Household Income

Although income growth is generally presumed to spur household energy demand, it also offers the means for households to buy more energy-efficient homes and appliances. The change in demand depends on numerous factors such as household age, education, behavior, cultural background, location, etc. As household income increases a young household may, for example, purchase an additional television, VCR, personal computer, and other electronic equipment, increasing demand. They also may purchase a replacement energy-efficient refrigerator, reducing demand. However, if they keep their old refrigerator, demand would increase. Although, as mentioned earlier, energy standards may have reduced per unit energy use, in total, energy use increases as additional appliances are added.

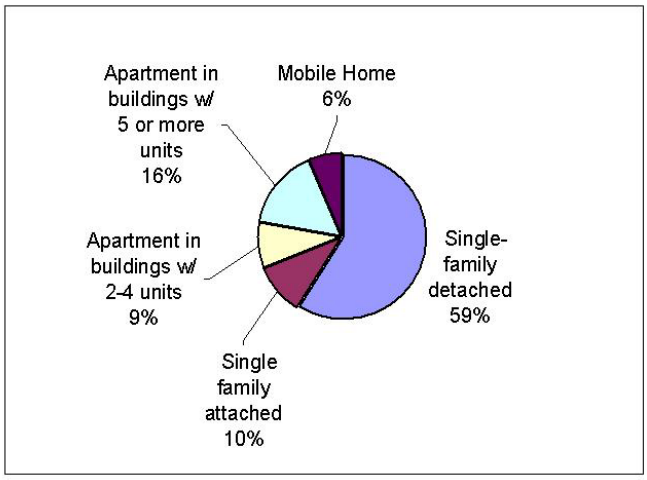
However, since personal income has been growing over time, it is worthwhile to examine the relationship of income and appliance ownership. In 2001, real disposable per capita income ($25,653) was 21 percent higher than in 1990 ($21,281). As income levels increase, so does the demand for appliances—pushing especially the demand for electricity upward. Figure 2 demonstrates this relationship clearly.

Housing Units and Households

Housing Unit Growth by Type

Most housing units in the U.S. are single family, attached and detached. Between 1990 and 2001, the share of single-family housing units has been fairly stable, staying around 68 to 69 percent. Within this category, single-family attached housing units have grown relatively rapidly, but still commands only a small share compared to single-family detached housing, 10 percent in 2001. The average household in the single-family attached unit used more energy in 2001 than in 1990, 86 MBtu in 1990 compared to 100 MBtu in 2001.

Figure 3. Distribution of Housing Unit Types, 2001



Source: EIA, 2001 RECS.

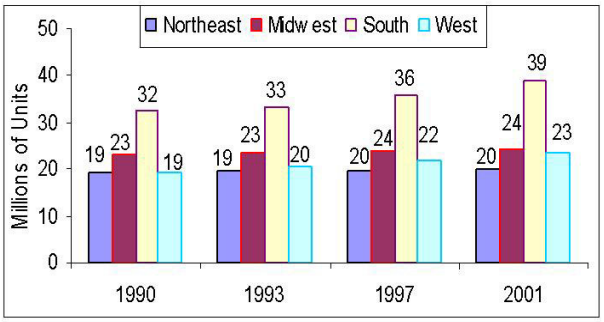
In 2001, 59 percent of all housing units were single-family detached (Figure 3). Although the average household in the single-family detached unit used less energy in 2001 than in 1990—113 million Btu in 1990 vs. 109 MBtu in 2001—the average single-family household used more than any other housing type. Two other housing-unit types, apartments in buildings with 2-4 units and apartment in buildings with 5 or more units, on average, used less energy in 2001 than in 1990. The housing units in apartments with 2-4 units, on average, used 17 percent less and housing units in apartments with 5 or more units, on average, used 18 percent less.

As single-family housing units continue to be the choice housing-type, upward pressures will continue to be placed on energy demand as single-family homes tend to use more energy than units in apartment buildings. This is especially true as household income grows and mortgage interest rates remain at low levels.

Housing Unit and Census Region

Between 1990 and 2001 the South Census Region experienced the highest growth—growing from 32 million households to 39 million households in 2001 (Figure 4). The South consists of three Census Divisions, South Atlantic, East South Central, and the West South Central. The South Atlantic and West South Central experienced the fastest growth in the number of housing units, 23 and 27 percent, respectively.[4] Growth in the South Census Region carries with it the growth in the utilization of heat pumps for both heating and cooling and thus increasing the demand for electricity.

Figure 4. Number of Households in U.S. Census Regions, 1990 to 2001



Sources: EIA, 1990, 1993, 1997, and 2001 Residential Energy Consumption Surveys.

Housing Unit Size

As disposable income increased between 1990 and 2001, so did the average size of housing units. The average total square footage of U.S. housing units in 1990 was 1,800 square feet and in 2001, the average size was 2,066 square feet—a 15 percent increase.[5] Between 1990, 1993, and 2001, the average single-family unit has increased in size from 2,242 square feet in 1990 to 2,337 and 2,553 square feet, respectively for 1993 and 2001. The housing unit of choice is not only the single-family unit, but also a larger unit. These larger units have more rooms, garages, and family rooms.[6]

As energy-savings have been introduced through building codes and energy-efficiency appliance standards, some of the gains are "taken back" when a homeowner chooses the larger single-family home. In 2001, the average household in a housing unit between 2,000 to 2,499 square feet used 93.1 MBtu whereas the average energy used was 106.8 MBtu in a unit between 2,500 and 2,999 square feet.

Household Size

Energy per person is increasing as housing units grow in size and household size falls. Over the last 25 years household size has been falling. The average household size was 2.83 in

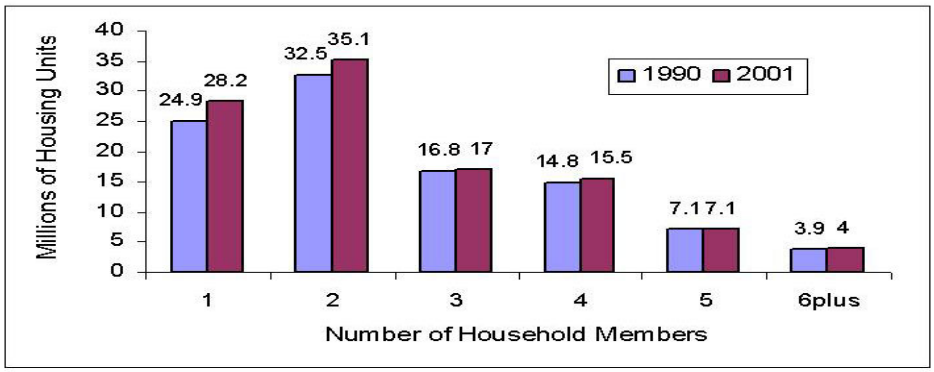
[4] South Atlantic includes MD, DE, DC, WVA, VA, NC, SC, GA, and FL. West South Central includes TX, OK, AR, and LA.

[5] It should be noted that these values are gross square footage as opposed to conditioned floor space which is usually less. For an in-depth discussion of the measurement issues, please see "Square Footage Measurements and Comparisons: Caveat Emptor" located at http://www.eia.doe.gov/emeu/rece/sqft-measure.html.

[6] In the 1997 RECS, the householders were asked the size of their units. The units were not measured.

1978. Over the focus of this paper, average household size was 2.61 in 1990 and 2.56 in 2001. Figure 5 shows that between 1990 and 2001, there has been an increase in the number of housing units with only 1 or 2 members. Figure 6 shows energy use for the average housing unit. There is only a 68 percent difference between the energy used in a four-member household verses a one member household—not four times as much.

Figure 5. Number of Households by Household Member Size, 1990 and 2001

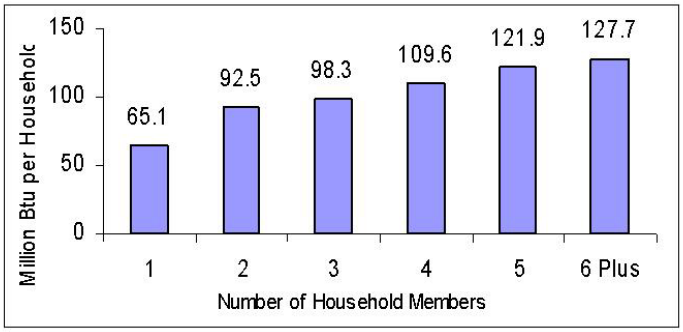


Sources: EIA, 1990 and 2001 Residential Energy Consumption Surveys.

Another way of looking at this is to take the per household energy use on the graph and divide by the number of household members for each grouping on the graph. The results are startling. Energy use per household member decreases dramatically as the number of household members increases. For a household with 1 member, per member energy use is the 65.1 MBtu as shown on the graph. This amount continues to decrease and if the per household energy use is divided by 6 members, per household member use is only 21.3 MBtu. Clearly showing that growth in the smaller households influence increased demand.

Clearly, if household size continues to drop, i.e., as the baby boomers become "empty nesters" and their children continue to purchase homes, smaller household size will place upward pressures on demand. Mitigating the decrease in household size, could be a change in the proportions of different race groups in total U.S. households. Different race groups have different birth rates. These differences have implications for future energy use (Battles and Moorhead, 2003). Between 1990 and 2001 all race groups show declining household size with the exception of households with Hispanic householders. The average household size of Hispanic households was 3.30 in 1990 and 3.29 in 2001. The average household size of Non-Hispanic household was 2.56 in 1990 and 2.48 in 2001. In 2001, Hispanic households used 70 MBtu per household and 21 MBtu per household member. Non-Hispanic households used 35 percent more energy per household (94.5 MBtu) and 45 percent more energy per household member (38 MBtu) than Hispanic households.

Figure 6. Energy Used in Average Households by Household Size, 2001



Source: EIA, 2001 Residential Energy Consumption Survey.

Heating and Cooling Equipment

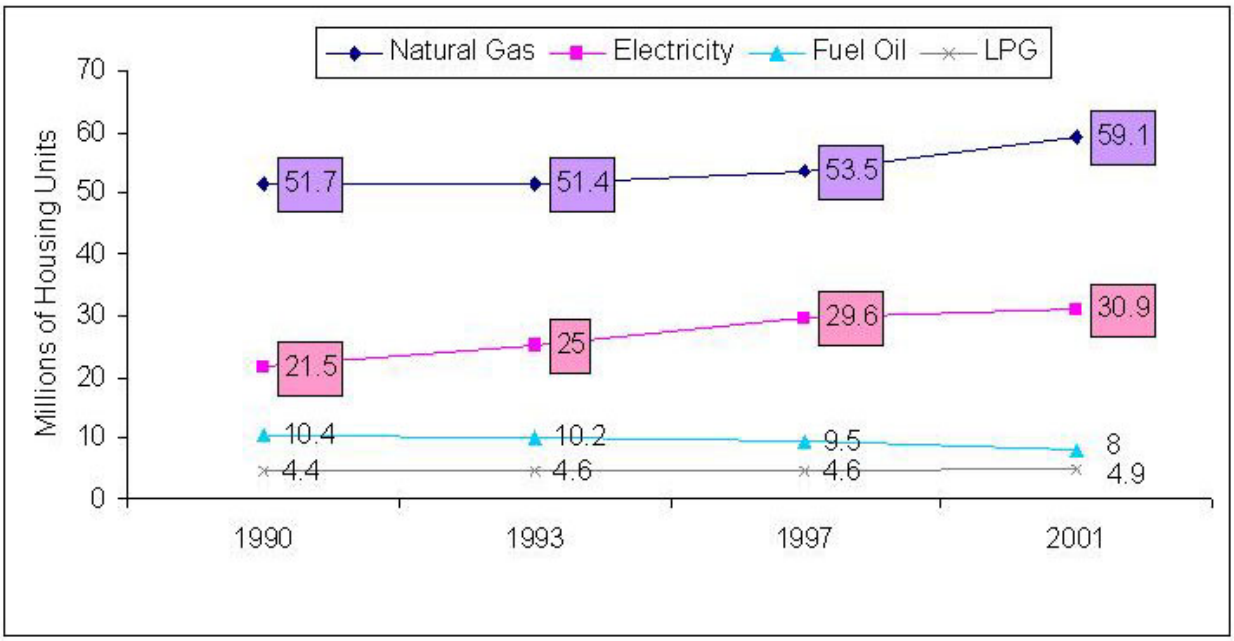
Space heating is the largest end use of energy in the household sector followed by appliances and water heating. Next comes refrigerators and then lastly is air conditioning. However, as we will see in the section on cooling equipment, air conditioning use is growing rapidly, especially as rapid development continues in the South and disposable income rises. Air conditioning used to be considered a "luxury," now it is considered essential and most new homes have central air conditioning. Of the 15.5 million homes built between 1990 and 2001, 81 percent of the homes have central air conditioning.

The two of the major fuels for space heating are natural gas and electricity. Fuel oil use--mainly in the Northeast for space heating--is declining.

Heating Equipment and Fuel.

For both natural gas and electricity, the heating equipment of choice remains the central warm-air furnace. In 2001, over 75 percent of the 58.9 million households using natural gas for their main space heating fuel had a central warm-air furnace. In contrast, 41 percent of 31.6 million households using electricity as their main space-heating fuel, used the central warm-air furnace and another 33 percent used heat pumps. In 1990, there were 6.4 million heat pumps in use—growing to 10.5 million in 2001—a large increase of 64 percent. The choice of the heat pump system may lead automatically to the greater electricity use for space cooling.

Figure 7. Number of Housing Units Using Main Space Heating Fuel, 1990-2001



Sources: EIA, 1990, 1993, 1997, and 2001 Residential Energy Consumption Surveys.

Natural gas is still used more for main space heating than any other energy source in the household sector. Between 1990 and 2001, the use of natural gas as the main space-heating fuel increased by 14 percent—with 52 million housing units in 1990 and 59 million housing units using natural gas for main space heating in 2001. The use of fuel oil as a main space-heating fuel

dropped by 23 percent, down from 10.4 million households in 1990 to 8 million households in 2001 (Figure 7).

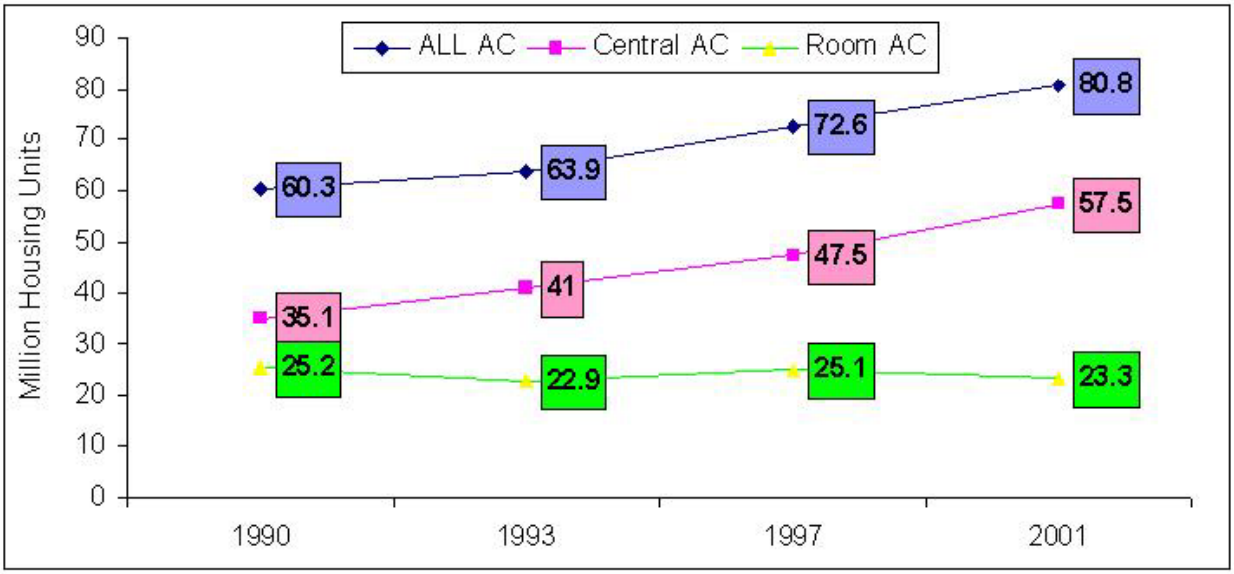
An important finding is the increase in the use of electricity for main space heat—driven by the development growth in the South. Between 1990 and 2001, the use of electricity for main space heat increased by 44 percent, going from almost 22 million households in 1990 to almost 31 households in 2001—again placing upward pressure on electricity demand.

Cooling Equipment

Prior to 1951, virtually no home had air conditioning. In 1951, the first room air conditioner was manufactured (Arsenault, 2001). Forty years later, in 1990, of the 94 million households, 60.3 million households had some type of air conditioning, a saturation of 64 percent for all types and 37 percent for central air conditioners (Figure 8). By 2001 seventy six percent of all housing units have some type of air conditioning—a 34 percent growth from 1990. The fundamental development is the saturation and growth of central air conditioning. Saturation of central air conditioning has gone from 37 percent in 1990 to 54 percent in 2001 for a growth of 64 percent. In the household sector, virtually all end-use energy for space cooling uses electricity – saturation for gas powered systems is almost nonexistent.

On average (with mobile homes as the exception) the household using central air conditioning uses roughly three times as much electricity for air conditioning as the household using electricity for room air conditioning.[7]

Figure 8. Number of Housing Units Using Air Conditioning, 1990-2001



Sources: EIA, 1990, 1993, 1997, 2001 Residential Energy Consumption Surveys.

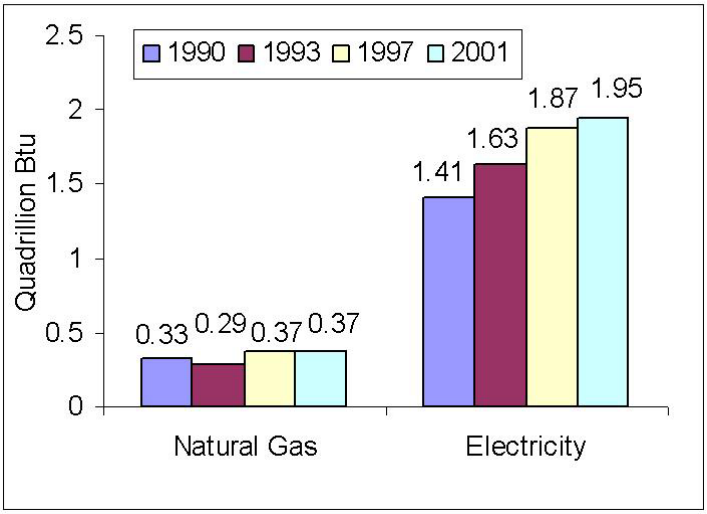
Energy-Efficient Equipment Stock Turnover

When a homeowner purchases a new heating system, cooling system or water heater, the replacement will usually be more energy efficient than the old equipment. However, each

[7] Electricity used for room air conditioning and central air conditioning varied by twice in mobile homes.

housing unit is different and so is the behavior of the occupants. These differences can "take back" the efficiency gains afforded through the energy efficiency. As an example, using weather-adjusted energy data, a comparison is made between two groups of housing units, those built before 1990 and those built in 1990 or later. While making comparisons over the two housing-unit groups for different age groupings of equipment, older households, on average, used more energy—even though each group (the older and the newer households) had equipment approximately the same age.[8] One explanation could be that there were different building codes and insulation requirements prior to 1990 than 1990 or after. Older homes using electricity-space heating also used more electricity than newer homes even though the equipment was in the same age.

Figure 9. Energy Used in U.S. Households for Appliances, 1990 to 2001



Sources: EIA, 1990, 1993, 1997, and 2001 Residential Energy Consumption Surveys.

When making the same type comparisons for natural gas water heating, newer homes used more natural gas than older homes for the same age of equipment brackets. These results hold for electric water heaters as well. In homes constructed in 1990 or later, 31 percent have large water heaters whereas 21 percent of homes constructed in 1949 or earlier have large water heaters. This is reflective of the facts that newer homes are larger, with larger water heaters, and have longer plumbing runs causing higher distribution losses to reach the point of use. Newer and larger homes also have more occupants. Thirty-seven percent of newer homes have more than three occupants as compared to 24 percent of the older homes.

If the comparisons are refrigerators, there doesn't seem to be a difference whether the refrigerator is in the newer or older housing unit for each refrigerator-age category.

Appliances

Appliance Energy Use

While natural gas used for appliances such as ovens, ranges, and clothes dryers has remained stable, the use of electricity has steadily climbed—increasing by 38 percent between 1990 and 2001 (Figure 9). This increase has taken place even though Federal mandatory energy-efficiency standards have been in effect since the early 1990's for many appliances including clothes washers, clothes dryers, dishwashers, central and room air conditioners, furnaces, heat pumps, refrigerators, and water heaters.

[8] An exception is the age group where the equipment is less than 2 years old. Older homes, on average, used less energy than the newer homes. This may be a data problem as the sample size is quite small for this group.

Number and Usage of Selected Appliances

For some appliances home size doesn't matter as only one appliance is typically employed. Examples include clothes washers, clothes dryers, and dishwashers. This is one reason why appliance energy use is not perfectly correlated with home size. In 2001, the average housing unit with less than 500 square feet used 13.2 MBtu for appliances, whereas the average housing unit with 4,000 square feet or more used 44.4 MBtu for appliances—not eight times as much. On the other hand, there are some appliances where the household has multiple units such as televisions, refrigerators, and computers.

As shown earlier, there is a strong correlation between income and appliance usage. However, as time goes by, appliances that once were affordable only by the higher income brackets saturates through all income groups as prices of those appliances fall. The clothes dryer, dishwasher, and personal computer are examples of luxury appliances that have gone mainstream. In 1990, only 14.8 million households had a personal computer. In 2001, there were 4 times as many households with computers, 60 million households (Table 2).
increased by almost 60 percent. Thirty-three percent more U.S. households have dishwashers. Interesting to note, the fraction of households with only 1 television set is now less than 28 percent. Seventy-two of all households have more than one television—14.7 million households have 4 or more televisions, more than tripling between 1990 and 2001. Adding to appliance demand are many new appliances that were not in households until recently such as business equipment including fax machines, scanners, copy machines, and entertainment equipment such as: VCR and DVD players, and large-screen television. Many of the new technology and old-technology appliances such as microwaves, have "instant on." Instant-on appliances use electricity even when the appliance is "off." Such miscellaneous appliance increases to "leaking

Table 2. Appliance Use in U.S. Households, 1990 and 2001
(Millions of Households)

Appliance	1990	2001	Percent Change 1990 to 2001	Appliance	1990	2001	Percent Change 1990 to 2001
Refrigerators	94	107	13.8	Personal Computer	14.8	60	305
1	79.4	88.7	11.7	Televisions	90.3	105.8	17
2 plus	14.4	18.1	25.7	1	43.2	29.3	-32
Microwave	74.1	92.1	24.3	2	30.6	38.4	26
Dishwasher	42.7	56.7	32.8	3	12.3	23.3	89
Clothes Washer	71.7	84.1	17.3	4 +	4.2	14.8	252
Clothes Dryer	49.5	78.8	59.0	Hot Tub Pump	3.3	4.4	33.3

Sources: EIA, 1990 and 2001 Residential Energy Consumption Surveys.

Table 2 shows examples of the growth of multiple appliances and also the growth of appliances that were once though of as luxury appliances such as dishwashers and computers. Between 1990 and 2001, the number of households with a clothes dryer, for example, has electricity" represents a fast growing segment of residential electricity demand. (Meier, 1994; Rainer et al., 1996).

As the number of housing units continues to grow, income growth spurs purchases of multiple appliances, and new technology creates new demand, pressures will be placed upward on energy demand—especially the demand for electricity.

Summary

Upon examination, trends in housing stock and energy use between 1990 and 2001 complement EIA's forecast of household energy of larger homes, growth in electricity-using appliances and electronic equipment, as well as continuing high population growth in the South Census Region.

Much of the heating and cooling equipment as well as many of the appliances are under mandatory standards. These standards help mitigate some of the potential demand increases.

While weather affects energy demand, analysis needs to account for other factors affecting demand such as prices. Prices of energy do have impact as illustrated recently for natural gas. Between 1997 and 2001, natural gas demand dipped as prices for natural gas increased. Income is another important driver of demand. As disposable income increased, so did housing unit sizes as well as purchases of new appliances, multiple appliances and appliances resulting from new technology advances—pushing up energy demand and especially electricity demand.

Standards are helping to mitigate energy demand increases, but the growth of unregulated appliances and "leaking" electricity more than offset that improvement. Also, the large growth in air conditioning energy use and associated electricity use may argue for greater concentration on improvements to buildings and technology that can help control this growth.

References

Arsenault, Raymond. 2001. "The History of Air Conditioning." University of South Florida, Tampa, Florida.

Battles, Stephanie J. and Vicki V. Moorhead. 2003. "Household Energy Consumption in the United States: Implications in the Growth of Minority Households." *Dialogue*, Volume 11, No. 2, United States Association for Energy Economics, p. 6-9, 28. Cleveland, Ohio.

Energy Information Administration. 2004. *Annual Energy Outlook with Projections to 2025*. Washington, D.C.: Energy Information Administration, Office of Analysis and Forecasting, http://www.eia.doe.gov/oiaf/aeo/demand/html.

Meier, A., L. Rainer, and S. Greenberg. 1992. "The Miscellaneous Electrical Energy Use in Homes. " *Energy – The International Journal*. 17(5): p. 509-518.

Rainer, L., A. Meier, and S. Greenberg. 1996. "You Can't Find These Leaks With a Blower Door," in ACEEE Summer Study on Energy Efficiency in Buildings, Asilomar, California. American Council for an Energy-Efficient Economy, Washington D.C.