

Trends in the Use of Natural Gas in U.S. Households, 1987 to 2001

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ABSTRACT

Electric utility demand for natural gas soared over 80 percent between 1987 and 2001 while household natural gas demand was flat. Between 1978 and 1987 the proportion of total household energy demand accounted for by natural gas remained constant at 53 percent. Beginning in 1987, the share of natural gas in total household energy demand for U.S. households started to fall and was approximately 49 percent in 2001. During the same time period, natural gas demand per household also fell—82 thousand cubic feet per household in 1987 and only 70 thousand cubic feet per household in 2001.

This paper presents trends in natural gas demand for U.S. household and explores some of the factors underlying these trends, such as: price, weather, appliance standards, and building codes. The paper also discusses indirect demand, the need for additional natural gas to generate electricity as household electricity demand increases.

Most of the data used in this analysis will be from the Energy Information Administration's (EIA) household energy consumption surveys.

INTRODUCTION

For households, total natural gas demand is determined by direct and indirect factors. Directly, natural gas demand is mainly as a result of demand for natural gas space heating followed by water heating and appliances. In 2001, almost 70 percent of household natural gas demand was space heating demand. Direct demand is the usual focus of analysis.

Although more difficult to assign to particular sectors such as the household sector, indirect demand for natural gas is rapidly increasing as natural gas has become the fuel choice used to generate additional electricity. By assumption, since electricity demand is growing in U.S. households, natural gas demand is increasing as well.

The main focus of this paper is on the trends of direct demand. In the first analysis section, trends are presented for natural gas demand and location of the demand. Since space heating is the most important driver of household natural gas demand, the second part of this section concentrates on trends in space heating demand. The next section looks at factors that affected or may have affected natural gas demand between 1987 and 2001. These factors include natural gas prices, weather, appliance efficiency standards, and building codes.

The secondary focus of this paper is on the trends of indirect demand—the rise of household electricity demand and indirect effects on natural gas demand. In the first part of this next section, trends in natural gas use in electricity generation will be presented. Given that electricity growth may place increased pressures for natural gas electricity generation, trends in household electricity demand such as space heating, air conditioning, and appliances will be presented—ending with a brief summary of the paper.

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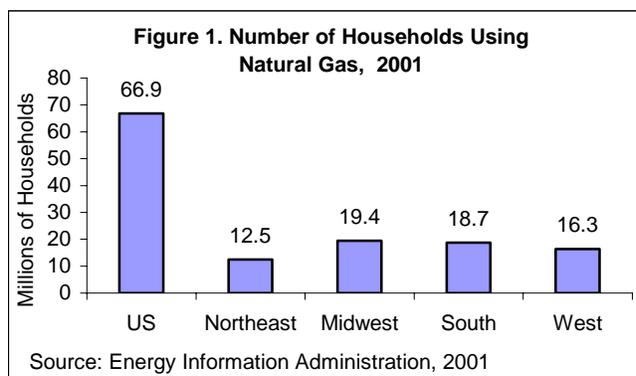
DATA USED

Most of the data used in this analysis will be from the Energy Information Administration's (EIA) household energy consumption surveys. EIA started fielding the Residential Energy Consumption Survey (RECS) in 1978 with the 2001 RECS being the latest in the series. For each survey, approximately 5,000 U.S. households participate in a personal interview consisting of household and housing unit questions. As part of the survey, householders give EIA permission to obtain their energy bills from their utilities. Since the RECS, as a series of surveys, presents "snapshots" of how energy is used, the RECS is ideal as a data source so as to reveal the underlying factors behind the trends in energy demand--and in this paper, household natural gas demand.

NATURAL GAS DEMAND TRENDS

Natural Gas Demand for All Uses

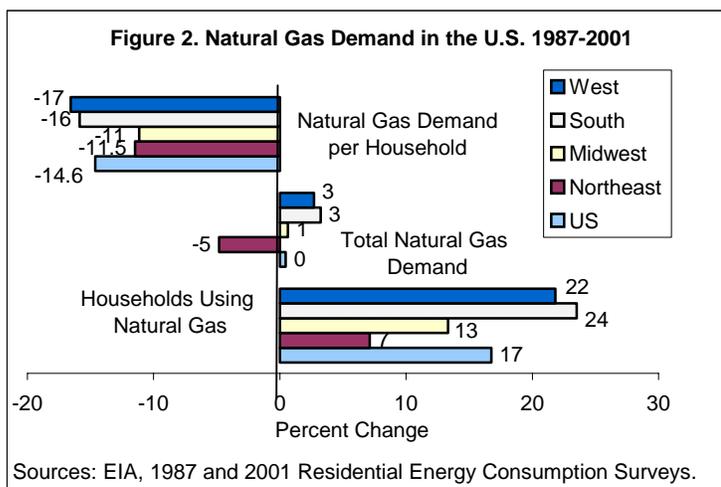
In 2001, 62 percent of U.S. households used 4.7 trillion cubic feet (Tcf) of natural gas—almost one half of the 9.86 quadrillion Btu of total site energy demand in the household sector.¹ Natural gas



demand in the household sector is more than one-half of U.S. industrial demand in 2001. Most of the natural gas is used in single-family homes--48.5 million out of a total of 66.9 million homes. Almost 38 percent of the U.S. natural gas demand was in the Midwest Census region in 19.4 million homes of all types. Following closely is the South with 18.7 million homes using gas (Figure 1). However, homes in the South accounted for only 23 percent of total U.S. household natural gas use--a reflection of newer homes in a warmer climate.

Between 1987 and 2001, the number of homes using natural gas increased by 17 percent. While in the Midwest, the number of homes using gas experienced a 13 percent increase, the South and West Census regions experienced 24 and 22 percent increases, respectively (Figure 2).

Although the number of homes using natural gas increased between 1987 and 2001, total U.S. household use of natural gas was flat--holding steady at approximately 4.7 Tcf. The mid-90s saw a modest increase in household natural gas use, which subsequently fell back to the 1987



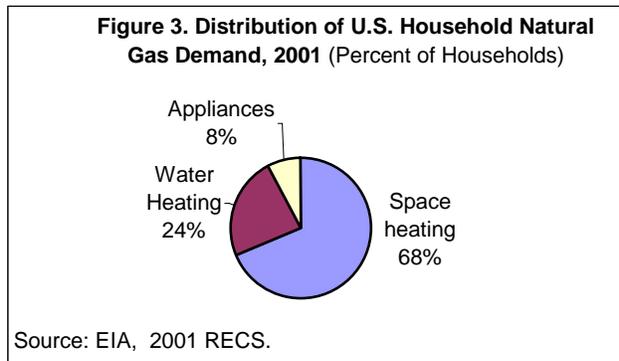
¹ Site energy does not include the losses in the generation and transmission of electricity.

levels in 2001. The South and West were exceptions, but even these regions experienced only small increases in natural gas demand.

While household natural gas demand in the U.S. was flat between 1987 and 2001, natural gas demand per household decreased by almost 15 percent--from 82 thousand cubic feet (Mcf) in 1987 to only 70 Mcf in 2001. Within the Census regions, per household demand decreases were the largest in the South and West between 1987 and 2001. The fall in per household demand wasn't a gradual decline between 1987 to 2001. Most of the decline took place between 1997 and 2001 when, as is shown later in this paper, natural gas prices increased rapidly.

Although demand was flat between 1987 and 2001, future demand could increase. Interesting to note is that in 2001, 77.7 million households said that natural gas was available in their area. Since approximately 67 million households actually used natural gas, almost 11 million households that are not using natural gas now, potentially could switch to natural gas.

Natural Gas Demand for Space Heating



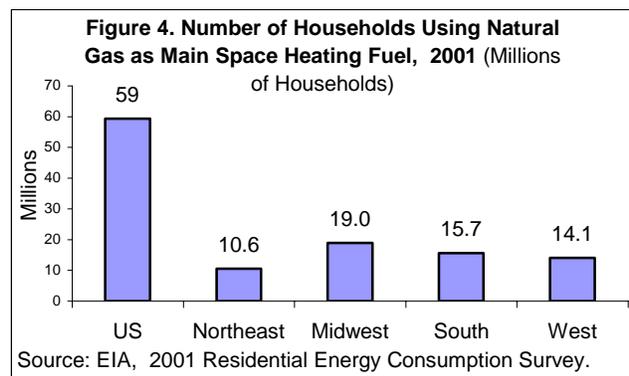
In 2001, 60.5 million out of 107 million total U.S. households used natural gas for space heating and 58 million used natural gas for water heating. Most households used gas as their main fuel for each of the end uses instead of as a secondary fuel. Almost 43 million households used natural gas for appliances. Natural gas appliances include ranges, ovens, clothes dryers, stovetop grills, hot tub and swimming pool heaters, outdoor lights, gas fireplaces, and outdoor grills.

Although natural gas has multiple uses in the home, most of household natural gas demand is for space heating--almost 70 percent of household demand for natural gas (Figure 3).

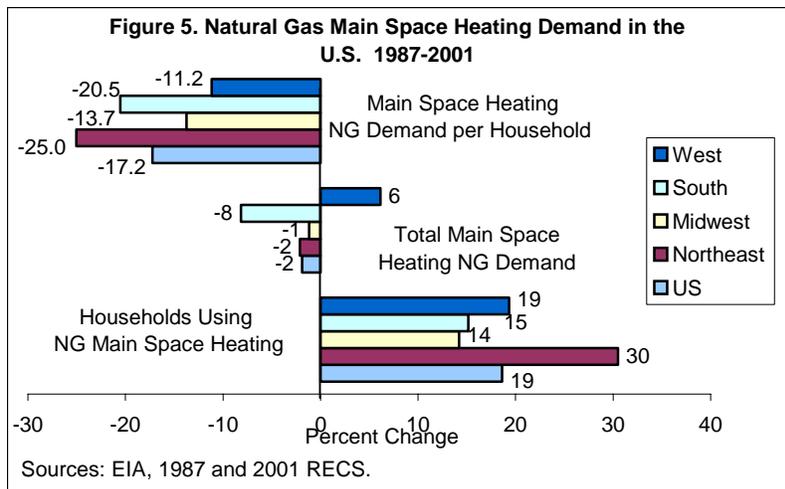
The space heating equipment used most is the central warm-air furnace. A few households use steam or hot-water systems, usually in homes built in 1949 or earlier. Also, a few older homes use floor, wall or pipeless furnaces or room heaters.

At the national level, almost 90 percent of households that use natural gas use the gas for at least space heating. The national percentage is heavily influenced by natural-gas space heating in the Midwest, where 98 percent of those who use natural gas use it for space heating. In all other regions less than 90 percent of natural gas households have gas space heating (Figures 1 and 4).

Since space heating dominates natural gas demand, Figures 2 and 5 are similar when comparing with a few distinct differences. In the Northeast, even though the number of homes using natural gas increased by 7 percent between 1987 and 2001, households using gas for space heating increased by 30 percent. During the same time period, the number of households using fuel oil for space heat dropped dramatically from 12.2 in 1987 to 8.1 in 2001—a 35 percent decrease. Most of households that use fuel oil are located in the Northeast.



Interesting to note is that at the U.S. level, although 18 percent more homes were using natural gas for space heating, per household demand dropped by 17 percent when comparing 1987 to 2001. Per household demand did drop for each of the other regions as well. In the next section, we will see the path of prices over the 1987 to 2001 time period—especially affecting the Northeast.



Although, in the South, the number of households using natural gas rose 24 percent between 1987 and 2001, the number of households using the gas for space heating was only 15 percent higher in 2001 than in 1987. Natural gas demand for space heating was 8 percent less in 2001 than in 1987. In the South, natural gas faces strong competition from electricity—especially since the heat pump started to penetrate the South as the space conditioning technology of choice and

electricity prices remained relatively low.

The next section discusses a few of the main factors that have affected household natural gas demand—especially space heating demand between 1987 and 2001. Factors include prices, weather, appliance efficiency standards and building codes.

FACTORS AFFECTING NATURAL GAS DEMAND

Many factors affect natural gas demand in the household sector including factors such as building shell and appliance efficiency standards. Household characteristics such as age of householder, income levels, cultural backgrounds, etc., also influence demand decisions. Factors outside of the home affect demand as well. Two of the most important factors in this category are price and weather. These will be discussed in the next section followed by discussions on appliance-efficiency standards and building codes.

Natural Gas Prices and Weather

Although it is difficult to measure accurately price and weather affects, use of indices will assist in showing the relationships between price, weather, and natural gas space heating demand. However, these comparisons are incomplete as interactions are present from other affects such as appliance and building shell standards, income, age of householder, etc.

Price increases affect demand to the extent substitutes are readily available. For example, if prices climb, householders may turn down thermostats and put on a sweaters. However, the extent of substitution depends on the size of the price increase, level of household income, and desired minimum or maximum service levels. Reactions to price reductions are limited since there are limited uses for natural gas and one dominant use, space heating. For example, a householder may react to lower prices by turning up the thermostat, but how much will be determined by the previous thermostat setting and level of comfort before the price decrease.

Since natural gas is used mainly for space heating, weather is a major factor on natural gas demand. Since space heating demand is the most important, this section looks at both the prices and weather with the corresponding changes on natural gas space heating demand (Table 1). Comparisons are

first made between only two survey years, 1987 and 1990, before mandatory furnace efficiency standards. The second comparison is between 1987 to 1997. Between these years, efficient furnaces started to penetrate the market as well as new building codes. The third comparison is again between two survey years, 1997 and 2001, where prices rose and weather in both years was similar.

Real natural gas prices were 8 percent lower in 1990 than 1987--\$7.87 to \$7.21 per 1000 cubic feet (Mcf).² As a measure of winter weather heating degree days (HDD) are used. There were 6 percent fewer heating-degree days per household in 1990 compared to 1987.³ As a possible response to the lower price, space heating demand was almost the same in 1990 than in 1987—even though it was milder. In the Midwest, the weather was about the same as in 1987. However prices dipped even lower—13 percent as space heating per household demand was only 2 percent more in 1990.

When comparing 1987 and 1997, even though there were 10 percent more HDD per household in 1997 than in 1987, space heating demand was rather flat while prices were 7 percent lower in 1997--\$7.87 per Mcf in 1987 to \$7.32 per Mcf in 1997. If price was the only factor, one would expect demand to go up—especially since it was colder. If weather was the only factor, then demand should have increased.

Table 1. Indices for Selected Energy and Economic Measures (1987 = 1)

United States	1990	1993	1997	2001
Space Heating Demand Per Household	0.97	1.06	1.00	0.83
Natural Gas Real Prices	0.92	1.32	0.93	1.24
Average HDD	0.94	1.13	1.10	0.99
Northeast				
Space Heating Demand Per Household	0.91	0.91	0.91	0.75
Natural Gas Real Prices	0.97	1.46	1.02	1.22
Average HDD	0.88	1.04	1.04	0.93
Midwest				
Space Heating Demand Per Household	1.02	1.09	1.09	0.86
Natural Gas Real Prices	0.87	1.43	0.89	1.19
Average HDD	1.00	1.16	1.16	1.01
South				
Space Heating Demand Per Household	0.87	1.09	0.93	0.80
Natural Gas Real Prices	0.91	1.16	0.97	1.32
Average HDD	0.84	1.07	1.00	0.93
West				
Space Heating Demand Per Household	1.06	1.10	0.97	0.89
Natural Gas Real Prices	0.91	1.10	0.88	1.29
Average HDD	1.02	1.14	1.08	1.09

Notes: Real prices are in 2000 Dollars; Heating-degree days are for households using Natural gas space heat only.

Sources: Bureau Of Economic Analysis - Table 1.1.9. Implicit Price Deflators; EIA, 1987, 1990, 1993, 1997, and 2001 RECS.

Regional comparisons show similar results. In the Northeast, space-heating demand was 9 percent less in 1997 while prices rose by 2 percent—although HDD per household were 4 percent higher. 1997 was a cold year in the Midwest. HDD per household were 16 percent higher than in 1987. Even though prices were 11 percent less in 1997, demand increased by only 9 percent. In the South, price reductions were almost half of the demand reductions while the weather was about the same in 1997 as it was in 1987. In the West, price reductions were 4 times as much as demand reductions (3 percent) although HDD per household were 8 percent higher in 1997 than in 1987. Clearly other factors are damping demand. One of these factors is energy-efficiency improvements in new home construction as a result of building codes and appliance efficiency standards and will be discussed in the next two sections.

Prices, for the most part, were lower in 1997 than in 1987. Between 1997 and 2001, price increased from \$7.32 per Mcf to \$9.78 per Mcf. Although there was a 34 percent price increase and HDD per household were 10 percent less, demand was only 18 percent less—65.2 Mcf per household in 1997 to 53.7 Mcf per household in 2001. Although the percent reduction in demand was greater than the reduction in HDD per households, it was

² All natural gas price indices are presented in real dollars (2000=1).

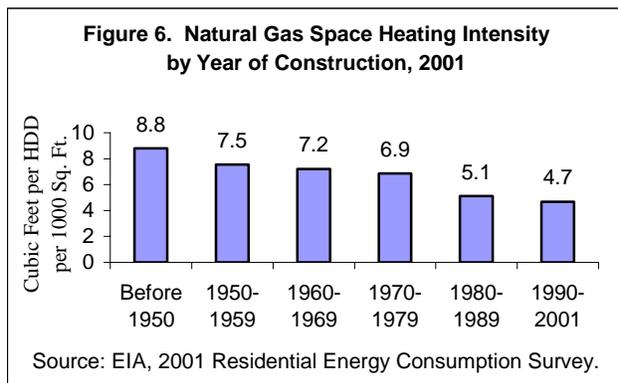
³ HDD is a measure of how cold a location was over a period of time, relative to a base temperature. In this paper it is the number of days temperature is below 65 degrees Fahrenheit in one year.

substantially less than the price increase. As mentioned earlier, there is a certain minimum level of demand below which substitutes may not be available or desirable. Regional comparisons show similar results where demand reductions between 1997 and 2001 show higher reductions than the mild weather in 2001 as compared to 1997 warranted, but still less than the price increases. With an exception of the West where the weather was similar, all regions faced milder winter weather in 2001 than in 1997. In all the regions, space heating demand percent reductions were greater than HDD per household percent reductions. However, in each of the regions, the percent demand was reduced was less than the percent prices were increased.

When comparing prices and weather over a period of time, 10 years in this paper, other factors play a role in affecting the level of demand such as energy-efficiency improvements. However, prices and weather play a large role in natural gas space heating demand. It was easier to see when a shorter period of time was used as in the last comparison. As prices fall, there doesn't seem to be as large of an effect as when prices rise. Price increases/reductions and weather seem to affect the level of demand up to a desired minimum/maximum service level for space heating.

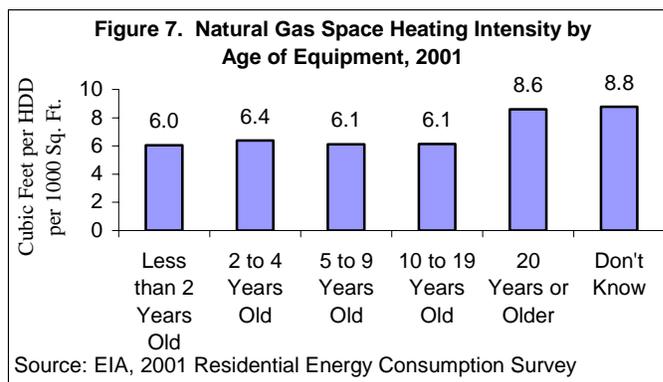
Appliance Efficiency Standards

In response to various energy efficiency standards, manufacturers have improved the energy efficiency of



household appliances beginning the 1970s, removing inefficient products from the market (ACEEE, 1995). The National Appliance Energy Conservation Act of 1987 set the minimum standards for several types of household appliances and equipment such as gas furnaces and water heaters. This followed the voluntary appliance efficiency targets of the Energy Policy and Conservation Act of 1975 and various State appliance-efficiency standards (EIA 1993). New gas furnaces are rated based on an Annual Fuel Utilization Efficiency (AFUE).⁴ The 1992 national appliance energy-

efficiency standard for all gas furnaces, as established by the U.S. Department of Energy, is 78 percent AFUE (IAMU).



Although it is difficult to measure the effects of appliance standards, using the results of a cross-sectional survey, using the RECS, we can develop natural gas space heating intensities and compare over the age of space heating equipment and year the housing unit was constructed. Natural gas space heating intensities are developed by computing natural gas demand for only space heating and adjusting for the effects of both the weather and size of home.⁵ In 1987, the natural gas space heating intensity was 10.0 cubic feet per HDD per thousand

⁴ AFUE is a measure of how well a furnace converts energy into usable heat. It is the proportion of the annual output of heat to the annual energy input to the furnace (U.S. DOE).

⁵ Space Heating Intensity = [Natural Gas Consumption ÷ {HDD x (Heated Square Feet ÷ 1000)}].

square feet of heated space (CF/HDDMSF). In 2001, the average household's natural gas space heating intensity was 6.9 (CF/HDDMSF).

The intensity of natural gas consumption for space heating has improved in new homes, constructed in 1990 through 2001 (Figure 6). The natural gas space heating intensity for homes constructed in 1990 through 2001 was 4.7 (CF/HDDMSF), compared with 8.8 (CF/HDDMSF) for homes built before 1950, and 6.9 (CF/HDDMSF) for homes constructed in the 1970s. That is, natural gas space heating intensity in new homes is 53 percent of the intensity for homes built before 1950 and 68 percent of the intensity for homes built in the 1970s. Among other things, this improvement seems to show that, as expected, new homes' furnaces are more efficient.

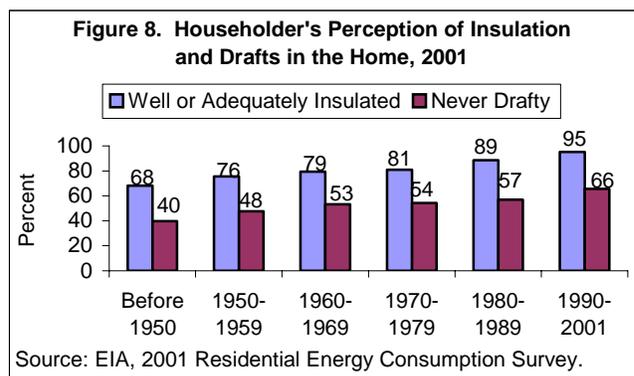
Table 2. Age of Space Heating Equipment by Year of Construction, 2001
(Million Households)

Age of Equipment	Before 1950	1950-1959	1960-1969	1970-1979	1980-1989	1990-2001	Total
Less than 2 Years	0.8	0.8	0.7	0.6	0.5	1.0	4.3
2 to 4 Years	1.8	1.2	0.8	0.9	0.5	2.0	7.2
5 to 9 Years	3.0	1.6	1.3	1.1	0.6	4.4	12.0
10 to 19 Years	3.1	1.7	1.3	0.8	4.6	1.0	12.5
20 Years or Older	5.9	2.9	3.2	3.5	0.6	0.0	16.0
Don't Know	3.1	0.9	1.1	1.0	0.7	0.2	7.0
All Households	17.7	9.2	8.5	7.8	7.3	8.5	59.1

Source: EIA, 2001 Residential Energy Consumption Survey.

The effect of appliance standards can also be measured by the age of main space heating equipment. Older homes have most of the heating equipment (Table 2). Regardless of the age of equipment, 73 percent of natural gas space heating equipment was located in housing units built before 1980.

For heating equipment less than 20 years, the average natural gas space heating intensity was lower than for those 20 years or older (Figure 7). The intensity was about 9 (CF/HDDMSF) for older equipment (20 years or older) and about 6 (CF/HDDMSF) for equipment less than 20 years old. The space heating intensity may have been higher if older homes' heating equipment had not been replaced. In the very old homes, built before 1950, 32 percent of space heating equipment was less than 10 years old, and about 18 percent of the space heating equipment was 10 to 19 years old. This indicates that the old gas space heating equipment for these homes were replaced by newer more efficient equipment. Furthermore, of the 12 percent of respondents who did not know the age of their space heating equipment; about 44 percent of these households were living in very old homes, those constructed before 1950. Most likely, a large proportion of householders did not know the age of their space heating equipment because they were very old systems.



Building Codes

Building codes are not new. Since 1905, several independent organizations were established as well as codes in local jurisdictions. However, it was only in 1994 that the International Code Council was established to promote the development of a single model building code in the United States (MAD CAD 2004). Today the U.S. Department of Energy works with national building code organizations as well as state

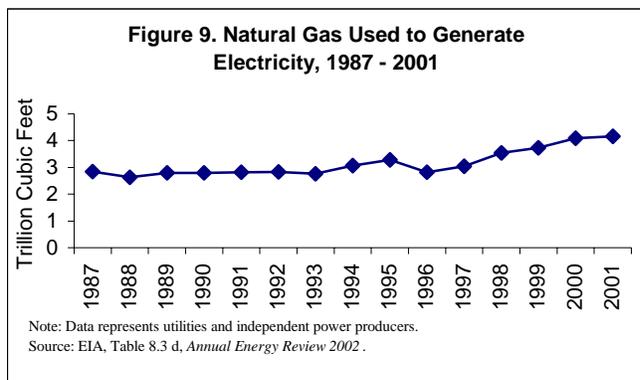
and local jurisdictions to improve building codes. Still, the local jurisdictions decide which code to select.

It is difficult to measure the effect of building codes on natural gas consumption. In the past EIA has tried to obtain information regarding the type of insulation in the home, and the r-value⁶ of the insulation. But, households do not know the technical details. Therefore, EIA has tried a different approach. EIA's latest RECS in 2001 asked householders to judge how well insulated and how drafty they perceive their homes to be in winter. In this paper householders' perceptions of insulation adequacy and drafts in the home is used to reflect the effect of building codes.

The data reveal that there was a statistically significant negative relationship between the age of the housing unit and the perceived adequacy of insulation: the newer the unit, the better the insulation was believed to be. Among houses built before 1950, about 68 percent were either "well insulated" or "adequately insulated," compared with 81 percent for houses built in the 1970s and about 95 percent for homes built in 1990 through 2001 (Figure 8). The proportion of households reporting "never" drafty homes increased from 40 percent for homes built before 1950 to 54 percent for units built in the 1970s to 66 percent for homes built in 1990 through 2001. Of course, these results could reflect wear and tear on a home overtime, as well.

INDIRECT DEMAND: ELECTRICITY

Between 2002 and 2025 EIA, projects household natural gas demand to increase by 0.9 percent per year. Natural gas demand for electricity generation is projected to grow even faster, 1.8 percent per year (EIA 2004b).

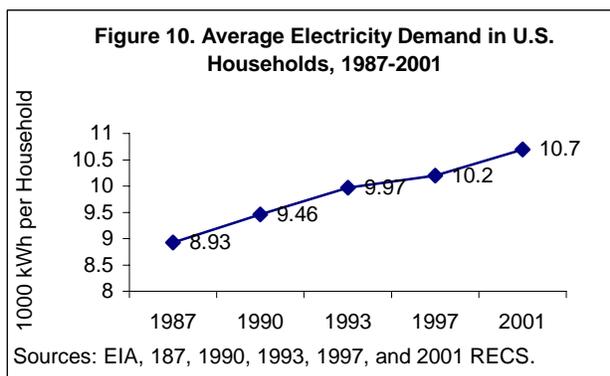


For environmental and cost reasons, in recent years natural gas has been the fuel of choice for the generation of most of the additional electricity (EIA 2004a). In each of the last several years, natural gas demand for electricity generation has increased (Figure 9).

Since most of the added electricity-generation capacity increases demand for natural gas, it can be assumed that some of the natural gas-fired electricity generation was for

households' demand for electricity—in other words, households' "indirect demand" for natural gas.

EIA projects electricity demand to increase by 1.4 percent per year in U.S. households. This will only be a continuation of the rapid growth in household electricity demand that has been taking place in the past several years. Between 1987 and 2001, electricity demand increased by 41 percent, 808 billion kWh in 1987 and 1,140 billion kWh in 2001. For the average household, demand increased from almost 9,000 kWh in 1987 to almost 11,000 kWh in 2001 (Figure10).



⁶ R-value is a measure of a material's resistance to heat flow (EIA, 2003).

During this time, the number of households using electricity as a main space heating fuel increased by 73 percent—reflective of the rapid growth of heat pump use, mainly in the South and the West. In 1987, 63 percent of homes had air conditioning. In 2001, not only did 76 percent of the homes have air conditioning, there was a change in the mix of air-conditioning equipment. There has been a decline in the number of homes using room air conditioners and an increase in the use of the central air conditioner. Homes using central air conditioners use more electricity for air conditioning. The big story is electricity demand for appliances including refrigerators. Appliances use the most electricity, 737 billion kWh in 2001. This was 65 percent of all the electricity demand in U.S. Households. In 2001 households used 42 percent more electricity for appliances than in 1987 in spite that many of the appliances are under appliance standards. As income grows so does the number of appliances in the home pushing up electricity demand and indirectly, natural gas demand

SUMMARY

Natural gas demand in U.S. households is almost half of that used in the industrial sector. Almost 40 percent of the demand is in the Midwest while many of the new homes using natural gas are located in the faster growing regions of the country, the South and the West. Space heating accounts for almost 70 percent of household natural gas demand.

Many factors affect natural gas demand. Several of the most important factors are prices, weather, appliances, and building codes.

In recent years, the household sector has been affecting demand for natural gas indirectly by the rapid increase in the demand for electricity. Most additional generation of electricity is undertaken using natural gas. In the future, if this “indirect” demand continues and expands as is forecasted, there will be implications in terms of supply and price increases that will affect those who directly use natural gas in the household sector and other sectors as well.

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