Residential Energy Characterization Study of Illinois

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Executive Summary

This report presents the findings of an analysis of residential energy use in Illinois. The goal of the analysis has been to provide a basis for examining residential energy use on a geographically disaggregated basis using the most recent U.S. Census housing information and the detailed energy consumption findings of the 1997 Residential Energy Consumption Survey (RECS). The level of geographic disaggregation chosen for the study was the county, of which there are 102 in Illinois.

The primary fuels used by the residential sector are natural gas, fuel oil (distillate and kerosene), liquid petroleum gas (LPG), and electricity, which were consumed in the amounts 445 billion cubic feet, 982 thousand barrels, 6,514 thousand barrels, and 39,631 million kilowatt-hours (kWh) respectively in 1999. It is estimated that these quantities will grow to 458 billion cubic feet of natural gas, 1,012 thousand barrels of oil, 6,711 thousand barrels of LPG, and 41,013 million kWh in 2002. Stated in British Thermal Units (Btus), the units used throughout this report, these 2002 estimates are 468,782 billion Btus of natural gas consumed, 5,769 billion Btus of oil, 24,315 billion Btus of LPG, and 139,914 billion Btus of electricity. The county with the largest energy usage is Cook with 258,568 billion Btus of all major residential fuels. The county with the lowest energy usage is Pope with 213 billion Btus.

This report estimates the potential for energy conservation and energy efficiency in the residential sector. The potential is projected by considering the impact of 5 measures which could reasonably achieve substantial energy use reductions over a period of time sufficiently long to allow many of the major energy-consuming durable goods used in Illinois homes to be replaced as they wear out. For ease of presentation, we shall take this period of time as being 12 years. Thus we compare the estimated 2002 fuel use totals with estimates for 2002 that might follow if Illinois households benefitted from the impacts of the conservation and energy efficiency measures during the period of 1990 through 2002. It is projected that these measures would reduce energy consumption in Illinois to 413,721 billion Btus of natural gas, 4,728 billion Btus of oil, 23,851 billion Btus of LPG, and 117,619 billion Btus of electricity. This is an 11.7 percent decrease in natural gas consumption, an 18 percent decrease for oil, a 1.9 percent decrease for LPG, and a 15.9 percent decrease in electricity consumed.

The benefits to the residential sector of a prolonged period of aggressive conservation would include both lower expenditures on utility bills and improved environmental quality. This report estimates that households would have paid approximately $1.06 billion less in energy bills in 2002 had conservation and energy efficiency measures similar to those examined in this report been in place for the period 1990 through 2002. In addition, it is estimated that the state would have lowered 2002 environmental emissions by 18,743,000 metric tons of carbon dioxide, 299,252,000 pounds of sulfur dioxide, and 2,227,000 pounds of coarse particulate matter.

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1. INTRODUCTION*

1.1 The Importance of Energy Planning

Energy is an essential productive resource in the economy. Throughout the history of the U.S. the availability of energy has been a critical component of growth, and the pattern of overall economic growth on a national or regional level has been largely matched by the growth in energy consumption. Prior to the oil crisis of the 1970's, in fact, the ratio of energy to economic activity showed great stability at about 17 kBtu per dollar of GDP (U.S. DOE: 2000, p.1.42) and led to concerns that disruptions in the supply of energy resources would have a devastating long-term impact on the U.S. economy. In fact, the oil shock of the early 1970's did undermine the steady growth in the economy that had begun at the start of the 1960's and resulted in the 1970's and early 80's recording the first decline in per capita GDP since the Great Depression. However, to the surprise of many pessimists, the seeming direct link between energy use and economic activity was found not to be immutable, and the economy recovered in the 1980's while the energy intensity of the U.S. economy declined to about 12 kBtu per dollar of GDP.

More recently, the electricity crisis in California showed that conservation can play a very important role in reducing the effects of supply disruptions and price spikes. In the winter of 2000-2001, California launched one of the most ambitious crash programs to cut electricity use in history. Though the results are not yet entirely tallied or separated from confounding factors, it appears that the electric load was reduced at times by 10 percent, baseload electricity consumption dropped by as much as 4 percent, and California coasted through the summer of 2001 without a single blackout. By the summer of 2002 with the crisis behind them, Californians are maintaining some of the conservation habits that were developed during the crisis while also maintaining a high standard of living and high productivity.

Without minimizing the great accomplishments of the responses to the 1970's oil shock or the California electricity crisis, a troubling feature of both episodes is the disruptive nature of the hurried adoption of conservation programs. Since energy is not used by itself in production but is used in conjunction with energy-consuming equipment, the hurried adoption of conservation measures meant that prior investments made by businesses and individuals did not follow along otherwise carefully conceived business or personal plans. For instance, businesses may have fleets of electric powered cars before a crisis, only to find that after the crisis ethenol-fueled vehicles are allowed to operate without constraint and the use of electric vehicles is curtailed. Or an individual might purchase an existing home that uses natural gas for space heating and electricity for water heating before a crisis and discover that he is required at short notice to replace the water heater

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to a natural gas model. These short-term disruptions of plans lead to price spikes and inefficiencies.

An alternative to waiting for a crisis to force energy conservation on an economy is to recognize that most fuels are non-renewable and will be depleted in time. By taking steps to develop conservation and energy efficiency programs for adjusting to the inevitable, businesses and individuals are able to adjust over a longer period of time and include a recognition of conservation opportunities in their long-term planning. In particular, by organizing conservation and energy efficiency programs during non-crisis periods, businesses and individuals are able to adjust their stocks of equipment during normal replacement cycles rather than all at once. An energy policy that places great importance on assisting users of depletable energy sources to reduce their vulnerability to unforseen crises as well as to the long-term exhaustion of those resources will hold substantial benefit.

1.2 Energy and the Environment

Energy is interesting not only for its market's recent tendency toward crises or the fact that much of it is depletable, but also for the impact that it has on the environment. Environmental economists generally view the use of an energy resource as the source of unintended damage to people who are not involved in its purchase or sale. That is, when a motorist purchases gas for his car from an oil company, the market exchange does not include the costs that the burning of that gasoline has on neighbors both near and far. The fact that those neighbors also purchase and burn gasoline does not lessen the damage. Rather all react to the absence of the full cost of the burden that they place on the society when they generate harmful emissions into a common breathing space.

All energy sources create pollution at some point in their production and use cycle, but fossil fuels are particularly damaging to the environment in their emissions. One might view the damage as occurring on three levels and the benefits of lowering emissions as serving various areas. Most fossil fuels produce pollutants that remain local. Carbon monoxide, nitrogen oxides, coarse particulate matter, and volatile organic compounds are such pollutants and tend to damage areas near the location of their use. Reductions of such pollutants would be expected to improve the health of residents or workers near a power plant or in the community where the reductions occur. A community adopting strategies that reduce these local pollutants in a sense would be benefitting their own health. Some fossil fuels also contain pollutants that damage areas downwind from the place where the fuel is burnt. Sulfur dioxide and mercury emissions tend to travel long distances as they are caught in high altitude winds. The health costs created by these pollutants are borne largely by individuals that are not in the local communities or even the same region or country. A district choosing to reduce emissions in this group would not be creating any particular benefit for themselves, but would be generating a benefit to others that they would not necessary know. The third level of emissions from fossil fuels are global in their impact. These are common to the burning of any fossil fuel. They include carbon dioxide and the other greenhouse gases, like nitrous oxide and methane. Greenhouse gases spread quickly throughout the atmosphere and affect all locations. The benefits of reduced fossil fuel burning, therefore,

accrue to everyone and mix the selfish with the altruistic.

Though there has been great success in reducing emissions associated with the burning of fossil fuels, the chemical processes that are fundamental to the use of the fuels - such as the release of carbon and oxygen during combustion or the discharge of methane when coal is mined or natural gas is only partially burnt - would seem to assure environmental damage. As a result, the greatest opportunity for limiting damage in an economy dependent on fossil fuels would seem to be reducing to a minimum the quantity of fuel used.

1.3 Conservation and Energy Efficiency Opportunities

Energy Conservation, on the face of it, would seem to be a very straightforward and non-controversial concept. In general language, energy conservation is the amount by which energy consumption is reduced from the level that would have occurred otherwise, and the direct benefits of conservation are the financial savings from not consuming energy that is not needed to do the task at hand, like heating a house. In fact, however, energy conservation can be very controversial because it can involve people breaking patterns of behavior that have become comfortable and habitual. Also energy conservation can require the development of new markets and whole industries that previously did not exist in an area. In addition, when the financial savings are not great, the principal benefits of energy conservation are the improved environment which accrue to the community as a whole and not the individual purchasing and consuming the energy resource.

Of particular note are the difficulties associated with conservation and energy efficiency in creating new markets and industries. The development of a professional home energy rater industry may be typical. The home energy rater inspects and tests the home from the perspective of energy efficiency and identifies measures specific to the house that can reduce the cost of operation. The rater also can discover other problems with the home, such as moisture problems and comfort issues, that can be remedied. However, creating a market for home energy ratings in a community can involve a sort of chicken and egg difficulty. One needs satisfied clients to tell others about the value of home energy ratings in order to receive requests for ratings, but one also needs homeowners to request ratings before there is a sizeable number of satisfied clients. Many new markets for conservation services suffer from a “thin market syndrome”, in which too few consumers know about the service or the benefits to keep the market active. In contrast, a thick market is characterized by individual vendors serving the industry as a whole by producing informed consumers that tell their neighbors and sustain the market.

The thin market syndrome is not unique to the energy conservation industry. Most industries that have no huge economies of scale are subject to the problem. Since economies of scale enable a single producer to recapture his investment in information dissemination and market development, the consumer awareness problem of a thin market is simply another expenditure along the way to business growth. The costs and future profits remain within the same firm. For industries without economies to scale, the risks of market development in the early stages of an industry include a strong likelihood that any investment in consumer awareness by one firm will

slip away entirely to the benefit of others. This difficulty presents itself not only to the energy conservation industry, but also to businesses such as the high performance building market where one firm can expend a great deal of effort and money in creating consumer awareness and see his fellow contractors, who may not have built high performance buildings, reap higher revenues without the higher costs simply by being associated in consumers' minds.

1.4 Energy in the Residential Sector

In looking to create an awareness of conservation and energy efficiency opportunities, there is no better place to turn than the residential sector. Though the industrial sector may consume larger quantities of energy and generate more emissions, educating people about energy waste around the home can impact more individuals and communicate a message about conservation in a way that can be more readily understood. In fact, energy in the residential sector is used in much the same way as it is in the industrial sector. As in industry, homeowners and renters use energy in conjunction with equipment and investment items, and do not consume it separately or directly. Also as in industry, households purchase energy-using equipment and make investments in their residences based in part on the operating costs that they will face in the future. These operating costs will depend largely on the price of fuels or electricity. A consequence of educating homeowners and renters about conservation and energy efficiency opportunities around their homes can be a greater appreciation of the opportunities for reduced energy use in their workplaces.

The residential sector as a whole consumes approximately 20 percent of total primary energy consumption in the U.S. (U.S. DOE: 1999a, p. 1-1), or roughly 19.9 Quadrillion Btus of energy in 2000. By itself, this level of energy use is substantial. Energy use in the home depends on household demand for particular services that require energy, such as space conditioning, water heating, cooking, and lighting. It also depends on the manner in which energy is used to provide these services. Though the demand for energy is largely dependent on climate and the current stock of housing and household equipment, sizeable conservation potential exists in the choice of replacement equipment that people purchase and the renovation choices that individuals make.

The dependence on past housing choices - particularly the past choices associated with housing vintage and those associated with fuel used for space heating - provide an analyst with a means to estimate household energy use. This arises from the relatively stable energy intensity of different vintages of housing. Moreover, observing the fuel used for space heating is further informative to the analyst regarding per unit energy consumption. In this analysis, we will make use of this information in viewing the characteristics of energy consumption in Illinois.

1.5 Goals of the Analysis

The purpose of this analysis is to characterize the energy use of the residential sector in Illinois. Characterizing energy use must involve more than simply identifying the current quantities of fuels consumed. Because conservation and energy efficiency opportunities are a viable and in many cases cost-effective alternative to the current consumption patterns, it is

essential that characterizing residential energy use include the potential for conserving energy within the household sector. Also since energy use has impacts beyond that captured in the simple and direct exchange between the energy supplier and the energy consumer, one needs to examine the opportunities for reducing the environmental impact that is external to the market transaction. In order to capture these aspects of energy use in the residential sector, we will examine the quantities of energy consumed in physical terms as well as potential conservation and energy efficiency before we examine the market in financial terms and the environmental impacts.

To characterize residential energy use in Illinois, we shall estimate the overall rate of energy use on a disaggregated level. Reported data from the 2000 Census and the U.S. Department of Energy's Residential Energy Characterization Survey supports using the county as the level of detail for our study. We shall estimate energy use by major fuel type and end use.

Simply estimating current energy use does not, however, characterize the opportunities open to the residential sector. To understand Illinois homeowners and renters, one must also examine how they might alter their consumption patterns if conservation and energy efficiency measures were more easily available. In order to analyze the options of conservation and energy efficiency, we shall define and analyze a reasonable and achievable level of energy consumption that is compatible with five energy conservation measures.

From these two levels of consumption, we shall determine the utility expenditure reductions that would likely result from the conservation and energy efficiency measures. This estimated reduction in utility bills may be seen as the primary incentive for adopting conservation or energy efficiency measures. However, a larger benefit may be the environmental benefit of lower energy consumption. To that end, we shall compute the environmental consequences of the energy conservation and efficiency improvements. These environmental impacts will be defined for seven major pollutants.

2. CHARACTERIZING RESIDENTIAL ENERGY USE

2.1 Approach of the Analysis

In any analysis of energy use, one should recognize that energy is not used by itself. Energy is consumed in conjunction with capital and durable goods and other energy-using equipment. As a result, energy consumption in the short run tends to be inelastic with respect to price and maintains a relatively stable relationship with the quantity of energy-using stocks. A consequence of this inelasticity is that unexpected changes in relative fuel prices will not lead to a quick and full adjustment between the consumption of different fuels. The short run price inelasticity, however, also enables the analyst to estimate the quantity of energy consumed by looking at the stocks of energy-using goods and equipment held by consumers. For the residential sector this stock of energy using items is the stock of homes of different vintages and the stock of durable goods such as space heaters, air conditioners, and water heaters. In addition, it is seen that as the stock of homes and residential durable goods increases, the quantity of energy consumed increases.

The strong relationship between the housing stock and energy consumption can be and is modified over a long period of time as energy prices change and as technology improves. We argue here that energy consumption also will change as the cost of conservation changes.

An additional very important determinant of the energy used by the residential sector is the past choices of energy consumers. For instance, if a homeowner previously chose to heat his or her home with fuel oil, that homeowner will need to continue to purchase and consume oil after an increase in the price of heating oil until he or she can replace the furnace with one that uses natural gas, LPG, or some other fuel.

To characterize residential energy use, we shall approach our analysis in four steps. First, we shall develop a geographically disaggregated analysis of current energy use in the residential sector. This will be performed on the county level. The analysis will estimate the use of the four major residential fuels used on site by households: natural gas, fuel oil (distillate and kerosene), liquid petroleum gas (LPG), and electricity. Other fuels, such as wood and wind, will not be examined in this analysis. The four major fuels will be analyzed in terms of several end uses: space heat, water heat, cooking (which will included uses of natural gas, oil, and LPG for other kitchen and laundry purposes), refrigeration, air conditioning, and other electric end uses such as lighting and entertainment. (For purposes of the end use tables in later chapters, the electric end uses of refrigeration, air conditioning, lighting, and other miscellaneous uses will appear under the category “other”.) All estimates of energy use are made for the year 2002.

The second step in the approach is to estimate the impact on energy use that conservation or energy efficiency could have. We do this by specifying five energy measures. These measures

will be defined in detail in Chapter 4. Briefly the measures are: envelope and furnace measures that will reduce space heating, envelope and air conditioning efficiency or sizing measures that reduce electricity used for space cooling, electric water heater conversions in residences that have a natural gas connection or use LPG for space heating, replacements of incandescent light bulbs with compact fluorescent bulbs in high use areas, and replacement of high energy use refrigerators. We do not specify how these measures are implemented as programs. Throughout the U.S. conservation and energy efficiency programs have been designed and implemented in many different ways. Some states have organized and implemented measures as state supported programs, whereas in other regions the same measures have been offered through utilities or as private initiatives. Estimates of energy use are made for 2002 under the assumption that these conservation or energy efficiency measures had been fully implemented by Illinois households for a period of time sufficient to allow many of the major appliances, energy-consuming durable goods, and capital stock to be replaced or renovated as they wear out. Since many furnaces, water heaters, refrigerators, and other appliances are switched out in a 12 year period, we will find it convenient to think of this analytical period as 12 years.

The third step in our approach is to examine the impact that the conservation or energy efficiency measures will have on the utility bills households pay. Despite deregulation in Illinois, most households continue to be served by their local electric and gas utility. For this reason, we apply the rates of the local utilities to compute the financial impact of the measures. The rates used are those currently used by the Energy Wise Homes of Illinois program. The uniform rates are used for all counties within each of nine regions of the state.

The final step in the approach is to estimate the consequent reduction in emissions of pollutants from the conservation or energy efficiency measures. We develop estimates for seven different pollutants. These pollutants are: carbon dioxide, carbon monoxide, nitrous oxide, sulfur dioxide, mercury, coarse particulate matter (PM-10), and volatile organic compounds. The emission factors used in these estimates are taken from summaries of U.S. EPA reports.

2.2 Sources of Data

The major sources of information for this study came from the federal government. Energy intensity for homes of different vintages and building types or homes using different types of energy-using equipment were drawn from the Residential Energy Consumption Survey (RECS), a product of the U.S. Department of Energy's Energy Information Administration (EIA). County level information on the number of residential units of different vintages and building types along with the number of units heated with different space heating fuels came from the 2000 Census conducted by the U.S. Bureau of the Census. Also the emission factors for different fuels were taken from summaries of reports of the U.S. Environmental Protection Agency (EPA). Below we look at these data sources.

2.2.1 Residential Energy Consumption Survey

The RECS data presents information about household end-use consumption of energy (U.S. DOE: 1999b). The survey was conducted in 1997. It was the tenth household energy

consumption survey conducted by the federal government since 1978. The survey included 5,900 households from across the nation. The information collected for each household included the building type (single family detached, single family attached, small multifamily, large multifamily, mobile home, or other), the vintage or age of the structure, the types of heating and cooling equipment (including fuels used), the cooking fuel, and the presence of lights left on for more than 10 per day, as well as information on the quantities of fuels used, the number of heating and cooling degree days, and the region in which the building is located.

For the purposes of this study, we downloaded the micro-data files of the RECS to permit the use of individual survey records, the microdata. To comply with federal government restrictions on giving violating the privacy of survey subjects, the RECS does not identify the location of the subject with much specificity. For several states, such as New York and California, the state in which the subject resides is given. However, for survey subjects from Illinois, the regional descriptor specified "East North Central" as the census division. As a result, Illinois location information could not be distinguished from that of Ohio, Indiana, Michigan, and Wisconsin. Nevertheless, the housing stock and resident behavior characteristics in northern Illinois is similar to that in Wisconsin, Michigan, and northern Indiana; and the homes and residents of southern Illinois are not different from those of southern Indiana or southern Ohio. Moreover, the RECS data includes climate information in the form of heating and cooling degree days, which we used in the analysis.

The RECS data was used for two types of information. First and most important, the RECS was used to obtain energy intensity information. We extracted average energy intensity estimates for different building types of different vintages using different fuels. The end uses for which these energy intensities were estimated included space heating, water heating, cooking, air conditioning, refrigeration, and other miscellaneous electric uses. These estimates were compared to conditional demand estimates that were independently developed. For space heating and air conditioning energy intensity estimates, the information was developed on a per square foot per degree day basis so that differing climatic conditions around Illinois could be distinguished.

The second type of information that was taken from the RECS concerned the saturation of fuels used for water heating and cooking. The saturation rates were defined in terms of the choice of space heating fuel. This method of conditioning estimated saturation rates based on space heating fuel was necessary because the county level information available in the 2000 Census included only space heating fuel information for the different building types and building vintages.

2.2.2 Census Information

In 2000 the twenty-second decennial census of the U.S. population was conducted by the U.S. Bureau of the Census. As in recent censuses, extensive information was collected on the housing stock of the nation. These data have been tabulated from the 100 percent 2000 American Community Survey Questionnaire and are available on the Census Bureau's web site for each state, county, and census tract in the country (U.S. Census: 2002). Included in these data are: number of households, number of housing units of different types, number of housing units of

different vintages, and number of housing units using different space heating fuels.

The 2000 Census has not yet released the microdata information. The datasets containing the microdata will probably not be available until late 2003. Also not yet available is the 10 percent survey information which contains more in-depth questions of the Census subjects. Nevertheless, the currently available tables include adequate information on a county level for the purposes of this analysis. In fact, the approach taken in this project could be applied on a census tract level of disaggregation, but such a strategy would become unwieldy.

For the purposes of this analysis, we collected housing information from the 2000 Census on all 102 Illinois counties. The analytical results for the counties are organized in tables for nine different regions of Illinois for ease of presentation. These regions and the counties which compose the regions are shown in Table 2.1 below.

Table 2.1: Illinois Counties and Regions

Northeast	Northwest	East	Central	West	East Southeast	West Southwest	Southeast	Southwest
Boone	Bureau	Champaign	De Witt	Adams	Clark	Bond	Edwards	Alexander
Cook	Carroll	Ford	Logan	Brown	Clay	Calhoun	Franklin	Clinton
DeKalb	Henry	Iroquois	Macon	Fulton	Coles	Cass	Gallatin	Jackson
DuPage	Jo Daviess	Kankakee	Marshall	Hancock	Crawford	Christian	Hamilton	Johnson
Grundy	Lee	Livingston	Mason	Henderson	Cumberland	Greene	Hardin	Monroe
Kane	Mercer	Piatt	McLean	Knox	Douglas	Jersey	Jefferson	Perry
Kendall	Ogle	Vermilion	Menard	McDonough	Edgar	Macoupin	Massac	Pulaski
La Salle	Putnam		Peoria	Schuyler	Effingham	Madison	Pope	Randolph
Lake	Rock Island		Stark	Warren	Fayette	Montgomery	Saline	St. Clair
McHenry	Stephenson		Tazewell		Jasper	Morgan	Wabash	Union
Will	Whiteside		Woodford		Lawrence	Pike	Wayne	Washington
	Winnebago				Marion	Sangamon	White	Williamson
					Moultrie	Scott		
					Richland			
					Shelby			

The richness of the 2000 Census information is only partially captured in the current study. This is due to the fact that most information has not yet been released. As more information becomes available - particularly the economic information associated with the 10 percent sampling and the microdata - analysts will be presented with greater opportunities to examine Illinois households and their energy choices.

2.2.3 Emission Factors from the U.S. EPA

A third source of information from the federal government that was used in this project relates to emissions of pollutants associated with energy use. Emissions from the burning of fossil fuels have been extensively measured by the U.S. Environmental Protection Agency. Comprehensive emission factors from the EPA have been published on the web (EPA: 2001) and have been updated regularly (EPA: 2002). The emission factors estimated by the EPA have been summarized by analysts at the Leonardo Academy and presented in functional tables (Leonardo

Academy: 2002). The summary of the EPA information was part of a study that the Leonardo Academy conducted for the EPA and the State of Wisconsin. It also incorporated information on greenhouse gases that was developed by the U.S. Department of Energy (DOE: 2002).

In this study, we look at seven pollutants. These are: carbon dioxide, carbon monoxide, nitrogen oxides, sulfur dioxide, mercury, coarse particulate matter (PM-10), and volatile organic compounds. These are certainly not all of the harmful emissions associated with burning fossil fuels or consuming energy. We focus on these because they are harmful to human health and emitted in large quantities. Moreover, these pollutants can be seen as representative of emissions that have impact in different locations. Carbon monoxide, nitrogen oxides, coarse particulate matter, and volatile organic compounds impact local areas near the site of use of the fossil fuel. Sulfur dioxide and mercury pollute areas at great distances downwind of the location where the fuel is burnt. We also calculate the emissions of carbon dioxide to examine a global pollutant.

Table 2.2: Emission Factors

Pollutant	Natural Gas	Oil	LPG	Electricity in northern counties	Electricity in southern counties
CO_2	117.08	159.29	139.18	1.387	2.341
CO	0.024	0.03571	0.02021	0.000196	0.000329
NOx	0.15	0.129	0.149	0.004354	0.007358
SO_2	0.0006	1.014	0.00106	0.011932	0.020192
Mercury	0	0	0	3.77E-08	6.38E-08
PM 10	0.00186	0.00286	0.00426	0.000085	0.000143
VOC	0.00539	0.00397	0.00532	0.000028	0.000048

Source: Leonardo Academy, 2002

In Table 2.2, we present the emission factors used in this analysis. The units for the emission factors of natural gas are given in pounds per million Btus. Similarly the units in Table 2.2 for oil and LPG are given in pounds per million Btu. For electricity, the units of the emission factors is pounds per kilowatt-hour. Two sets of emission factors are given for electricity to distinguish between the service territory served by ComEd and the service territories in the central and southern portions of the state. We do this because ComEd makes much greater use of nuclear energy, whereas the utilities in the rest of Illinois supply electricity generated overwhelmingly by fossil fuels. For purposes of emission factors, the northern counties are the 23 included in the Northeast and Northwest regions defined in Table 2.1. The southern counties are those in all other regions of Illinois.

No pollution estimates are made in this analysis relating to the use of nuclear energy or alternative energy sources. This is not to suggest that electricity generated from nuclear energy is without harmful effects on the environment. The massive and very long-term damage that can be imposed on locations where spent nuclear fuel is permanently buried may be difficult to quantify but surely will be substantial, and the damage resulting from accidents is still the subject of engineering and medical research. However, for the purposes of this study we shall concentrate

on the emissions associated with fossil fuels. Moreover, as will be seen later in this report, the benefits of conservation and energy efficiency measures are very substantial even without adding the damage created by non-fossil energy sources.

2.3 Methods of Combining Information Sources

This project is one of the first to use information from the 2000 Census. Indeed, many of the tables that have been created by the Census Bureau have not even been published and only exist on the Internet. Of the four summary files with state level information that the Bureau will be producing, just two have been released. In the next nine to 15 months, more information will be released, including the 10 percent sampling data and the microdata files. Using the currently available information and the future releases will provide rich veins for analysts to mine. However, using this information for residential energy consumption analysis requires that the analyst combine the Census data with other sources of energy information.

This project has combined the results of the 2000 Census with energy intensity estimates from the RECS data. One could choose to join the Census findings with engineering estimates as an alternative approach. In fact, using engineering analysis can provide a great deal of insight into the way energy is used in the residential sector. We have chosen not to follow this path because engineering estimates of energy intensities can miss some of the great diversity that exists in the residential sector. For instance, one may choose a house as typical of the stock in a particular climate zone and develop careful energy intensity estimates based on the building's walls, equipment, and appliances, but miss the way homes that are not typical perform in the same climate zone. That is, the extremes within the distribution of the housing stock may not average out to what may be something typical.

This is not to suggest that the benefit of engineering judgement did not enter into this analysis. We carefully examined all energy intensity estimates that were developed from the microdata in the RECS to see how it conformed to the recognized judgements of engineers. In this way, we attempted to achieve the benefits of both survey results - that will include the extremes of the housing stock distributions - and engineering judgement.

One would expect that combining information from two sources like the 2000 Census and the RECS will be useful for other energy consumption estimation projects in the future. This approach may prove especially useful when the microdata is released by the Census Bureau and the U.S. Department of Energy releases its 2001 RECS.

2.4 Home Energy Ratings as Corroborating Evidence

In addition to combining information from two sources like the 2000 Census and the RECS, this project has made use of the results of over 70 home energy ratings performed around Illinois. Home energy rating systems (HERS) offer a different vantage point on energy use because they look at the component parts of homes and define estimates of the energy used for several very important end uses, particularly space heating and space cooling. Until the late Spring of this year, the ratings conducted in Illinois overwhelmingly provided only a view of the

new construction. Since the late Spring, the Adams Electric incentive program, with funding from Illinois' Bureau of Energy and Recycling, has developed a wealth of information on existing homes from ratings it has completed (Cavallo: 2002). This information was used for comparisons of the RECS estimates. In addition, we found the ratings information particularly useful in developing estimates of what can be reasonably expected from energy improvements of the building shells, furnaces, and air conditioners in homes of a variety of vintages.

3. CURRENT ENERGY USE

3.1 Analyzing Residential Energy Use

The first step in our estimation of residential energy use is to break up per capita household energy use into its major components, or end uses, for each fuel and building type. We then multiply the per capita end use estimate by the number of households in each building/fuel category. The per capita end use estimates can be thought of as energy intensities for the different equipment or appliances. For space heating and space cooling, we define the estimate energy intensities in terms of energy used per square foot and per degree-day so that we can allow for the greater heating requirements of the northern counties and the increased cooling needs of the southern portions of Illinois. Estimates summed over all end uses and building types are calibrated to a forecasted state fuel consumption total for 2002 and allocated back to each end use.

The energy intensities for space heating are given in Table 3.1. Space heating is the largest end use for the categories specified, and we use this table to show the separate building type categories. The building categories are largely self-explanatory with the exception of the two multifamily building types. Small multifamily are buildings with fewer than 10 units. Large multifamily have 10 or more units. All values in Table 3.1 were computed from the RECS for the East North Central census division. The estimates for electricity appear low relative to the others, but this is due to fact that electricity is represented in the amount consumed within the home and not at the generating site and that essentially 100 percent of the electricity consumed is converted into heat whereas for other fuels a sizeable percentage of the energy is lost up the chimney. There are very few households that use oil for space heating in the building type categories of single family attached, small or large multifamily, or mobile home. Also a negligible number of households used liquid petroleum gas to heat multifamily homes.

Table 3.1: Energy Intensities for Space Heating by Building Type and Fuel
(in Btus per square foot per heating degree-day)

Building Type	Natural Gas	Oil	LPG	Electricity
Single Family Detached	7.804	8.073	5.996	.874
Single Family Attached	8.811	n.s.	9.054	1.911
Small Multifamily	14.425	n.s.	n.s.	3.552
Large Multifamily	7.904	n.s.	n.s.	1.486
Mobile Home	16.178	n.s.	9.192	5.133

n.s. indicates the fuel/building category was not significantly represented in the population

The energy intensities for other end uses are given in the computer code in Appendix A and will not be shown here to avoid unnecessary length. The energy intensities, however, produced a very convincing result. We found that the overall estimated energy use for the two largest energy sources came very close to the state totals when summed over all end uses and building types. For natural gas, the energy consumption based developed from the energy intensity approach summed to 455,656,762 million Btus whereas our forecasted 2000 natural gas consumption for the residential sector was 459,550,000, less than one percent off. For electricity, the energy consumption estimated through energy intensities was 132,725,175 million Btus as compared to our 2000 residential electricity consumption forecast of 137,158,000, which is slightly more than 3 percent at variance.

3.2 Estimated Energy Use by County, End Use, and Fuel Type

The tables below show energy use in two ways. For each region of the state, we show the energy use by the fuel types natural gas, oil (distillate and kerosene), LPG, and electricity. Fuel consumption is shown in billions of Btus for each fuel. Electricity use is represented as that consumed within the residence, i.e., the on-site energy rather than the energy used at the generating source to produce the households' needs. We also show the energy consumed by end use. The end uses are space heating, water heating, cooking, and other electrical uses. Due to the construction of the RECS information, cooking includes all non-space and non-water heating uses of natural gas, oil, and LPG. For instance, the average energy intensities of cooking for natural gas will include natural gas used for clothes dryers, whereas the electricity energy intensity for cooking does not include such other end uses. For our purposes, however, this is only a matter of terminology and will not effect the results since no cooking conservation measure is specified. The "Other" category includes only electricity. It is the sum of three components: air conditioning, refrigeration, and all electricity uses other than space conditioning, water heating, cooking, and refrigeration. No separate building type break out is presented here. Differences in table totals are due to rounding.

Table 3.2: Energy Use for Northeast Counties by Fuel Type
(in billion Btus)

County	Natural Gas	Oil	LPG	Electricity
Boone	1,489	65	151	511
Cook	203,580	565	2,743	51,680
DeKalb	3,033	109	134	1,036
DuPage	36,882	68	385	9,604
Grundy	1,436	27	149	503
Kane	16,339	53	552	4,150
Kendall	2,110	57	174	633
La Salle	5,105	134	322	1,459
Lake	24,661	43	288	6,769
McHenry	11,371	83	223	2,938
Will	20,804	141	509	5,245
Total	326,810	1,345	5,630	84,528

Table 3.3: Energy Use for Northeast Counties by End Use
(in billion Btus)

County	Space Heat	Water Heat	Cooking	Other
Boone	1,406	330	81	398
Cook	157,459	45,920	11,184	44,005
DeKalb	2,686	680	166	780
DuPage	29,208	7,752	1,899	8,079
Grundy	1,308	330	81	397
Kane	13,396	3,287	834	3,578
Kendall	1,874	454	114	533
La Salle	4,444	1,057	270	1,250
Lake	19,524	5,174	1,303	5,760
McHenry	9,464	2,149	549	2,453
Will	16,933	4,067	1,044	4,655
Total	257,702	71,200	17,525	71,888

Table 3.4: Energy Use for Northwest Counties by Fuel Type
(in billion Btus)

County	Natural Gas	Oil	LPG	Electricity
Bureau	1,527	96	208	500
Carroll	615	70	181	263
Henry	2,260	71	341	690
Jo Daviess	730	143	220	391
Lee	1,293	80	147	485
Mercer	584	58	217	239
Ogle	1,841	138	266	691
Putnam	227	18	52	98
Rock Island	7,530	64	214	1,870
Stephenson	2,008	109	247	704
Whiteside	2,508	96	264	831
Winnebago	13,902	89	185	3,356
Total	35,025	1,032	2,542	10,118

Table 3.5: Energy Use for Northwest Counties by End Use
(in billion Btus)

County	Space Heat	Water Heat	Cooking	Other
Bureau	1,473	343	86	428
Carroll	714	159	38	217
Henry	2,141	501	125	595
Jo Daviess	908	204	49	323
Lee	1,239	302	75	389
Mercer	697	162	39	201
Ogle	1,859	431	106	540
Putnam	243	57	14	82
Rock Island	6,142	1,505	383	1,647
Stephenson	1,943	451	111	562
Whiteside	2,318	560	140	683
Winnebago	11,380	2,614	669	2,869
Total	31,057	7,289	1,835	8,536

Table 3.6: Energy Use for East Counties by Fuel Type
(in billion Btus)

County	Natural Gas	Oil	LPG	Electricity
Champaign	6,176	60	322	2,218
Ford	515	34	106	202
Iroquois	1,001	74	289	461
Kankakee	3,796	61	342	1,280
Livingston	1,333	53	214	503
Piatt	645	15	124	225
Vermilion	3,254	73	328	1,177
Total	16,720	370	1,725	6,066

Table 3.7: Energy Use for East Counties by End Use
(in billion Btus)

County	Space Heat	Water Heat	Cooking	Other
Champaign	5,058	1,581	379	1,758
Ford	516	137	34	171
Iroquois	1,085	291	70	380
Kankakee	3,272	913	227	1,067
Livingston	1,257	343	85	418
Piatt	614	163	40	193
Vermilion	2,864	793	197	977
Total	14,666	4,221	1,032	4,964

Table 3.8: Energy Use for Central Counties by Fuel Type
(in billion Btus)

County	Natural Gas	Oil	LPG	Electricity
De Witt	678	16	135	238
Logan	1,088	33	187	395
Macon	5,233	51	228	1,585
Marshall	447	37	133	207
Mason	528	38	216	237
McLean	5,949	109	324	1,786
Menard	434	16	146	177
Peoria	7,558	73	391	2,457
Stark	198	22	89	94
Tazewell	5,371	79	404	1,746
Woodford	1,235	53	271	456
Total	28,719	527	2,524	9,378

Table 3.9: Energy Use for Central Counties by End Use
(in billion Btus)

County	Space Heat	Water Heat	Cooking	Other
De Witt	660	166	41	200
Logan	1,047	266	65	325
Macon	4,357	1,120	282	1,338
Marshall	501	124	30	170
Mason	629	155	37	197
McLean	5,011	1,337	332	1,487
Menard	478	120	29	147
Peoria	6,348	1,698	419	2,012
Stark	250	61	14	78
Tazewell	4,667	1,197	299	1,438
Woodford	1,250	311	76	379
Total	25,198	6,555	1,624	7,771

Table 3.10: Energy Use for West Counties by Fuel Type
(in billion Btus)

County	Natural Gas	Oil	LPG	Electricity
Adams	2,525	72	241	961
Brown	161	17	44	85
Fulton	1,445	70	299	541
Hancock	558	57	178	326
Henderson	290	24	97	135
Knox	2,372	54	254	740
McDonough	988	41	210	438
Schuyler	182	35	66	120
Warren	679	46	143	257
Total	9,200	416	1,532	3,603

Table 3.11: Energy Use for West Counties by End Use
(in billion Btus)

County	Space Heat	Water Heat	Cooking	Other
Adams	2,236	623	155	785
Brown	179	48	12	70
Fulton	1,452	361	88	454
Hancock	644	179	42	254
Henderson	332	81	20	115
Knox	2,116	538	134	632
McDonough	975	284	68	350
Schuyler	232	63	15	93
Warren	695	172	42	216
Total	8,861	2,349	576	2,969

Table 3.12: Energy Use for East Southeast Counties by Fuel Type
(in billion Btus)

County	Natural Gas	Oil	LPG	Electricity
Clark	423	51	257	270
Clay	378	43	176	220
Coles	1,651	40	196	769
Crawford	659	27	177	296
Cumberland	217	30	213	172
Douglas	625	22	128	281
Edgar	608	37	160	296
Effingham	844	59	287	498
Fayette	525	60	262	310
Jasper	180	28	212	152
Lawrence	501	26	145	236
Marion	1,338	73	250	613
Moultrie	462	19	131	194
Richland	507	39	128	258
Shelby	587	47	335	351
Total	9,505	601	3,057	4,916

Table 3.13: Energy Use for East Southeast Counties by End Use
(in billion Btus)

County	Space Heat	Water Heat	Cooking	Other
Clark	573	167	38	223
Clay	468	137	32	181
Coles	1,473	468	113	603
Crawford	668	193	47	252
Cumberland	363	106	24	140
Douglas	605	179	44	229
Edgar	628	186	45	244
Effingham	939	292	68	389
Fayette	662	192	46	256
Jasper	331	96	21	124
Lawrence	521	152	37	199
Marion	1,295	384	95	500
Moultrie	472	135	33	166
Richland	527	155	37	212
Shelby	758	221	51	290
Total	10,283	3,063	731	4,008

Table 3.14: Energy Use for West Southwest Counties by Fuel Type
(in billion Btus)

County	Natural Gas	Oil	LPG	Electricity
Bond	386	54	168	238
Calhoun	65	21	135	94
Cass	470	23	83	199
Christian	1,318	32	205	500
Greene	479	34	145	214
Jersey	474	61	255	323
Macoupin	1,625	86	462	721
Madison	9,678	50	749	3,725
Montgomery	991	48	251	428
Morgan	1,202	32	195	504
Pike	538	51	132	277
Sangamon	7,354	52	496	2,756
Scott	163	11	76	85
Total	24,743	555	3,352	10,064

Table 3.15: Energy Use for West Southwest Counties by End Use
(in billion Btus)

County	Space Heat	Water Heat	Cooking	Other
Bond	489	137	32	188
Calhoun	178	49	10	77
Cass	456	126	31	163
Christian	1,214	337	83	420
Greene	517	140	34	181
Jersey	638	182	42	252
Macoupin	1,711	467	113	602
Madison	8,248	2,370	586	2,997
Montgomery	1,016	278	68	357
Morgan	1,120	326	79	408
Pike	575	158	38	228
Sangamon	6,167	1,817	447	2,226
Scott	198	54	13	70
Total	22,527	6,441	1,576	8,169

Table 3.16: Energy Use for Southeast Counties by Fuel Type
(in billion Btus)

County	Natural Gas	Oil	LPG	Electricity
Edwards	171	16	50	116
Franklin	968	59	167	680
Gallatin	175	9	56	107
Hamilton	185	21	104	139
Hardin	109	18	33	85
Jefferson	825	63	278	606
Massac	399	33	105	243
Pope	52	18	59	84
Saline	750	38	140	431
Wabash	278	45	112	197
Wayne	355	38	218	279
White	440	22	148	251
Total	4,707	380	1,470	3,218

Table 3.17: Energy Use for Southeast Counties by End Use
(in billion Btus)

County	Space Heat	Water Heat	Cooking	Other
Edwards	182	64	15	92
Franklin	931	344	82	517
Gallatin	181	63	15	86
Hamilton	236	81	19	114
Hardin	123	42	10	70
Jefferson	896	331	77	467
Massac	407	141	34	197
Pope	102	37	8	66
Saline	702	248	60	348
Wabash	329	115	27	160
Wayne	465	163	38	223
White	456	157	38	210
Total	5,010	1,786	423	2,550

Table 3.18: Energy Use for Southwest Counties by Fuel Type
(in billion Btus)

County	Natural Gas	Oil	LPG	Electricity
Alexander	212	11	104	150
Clinton	852	39	226	481
Jackson	1,145	51	204	935
Johnson	88	32	143	195
Monroe	488	46	283	395
Perry	528	39	127	336
Pulaski	130	19	84	121
Randolph	680	64	206	480
St. Clair	7,292	79	603	3,338
Union	339	46	156	287
Washington	294	35	140	240
Williamson	1,305	82	207	1,065
Total	13,353	543	2,483	8,023

Table 3.19: Energy Use for Southwest Counties by End Use
(in billion Btus)

County	Space Heat	Water Heat	Cooking	Other
Alexander	243	89	21	124
Clinton	842	295	71	389
Jackson	1,101	463	107	664
Johnson	214	83	18	142
Monroe	627	230	51	304
Perry	530	188	45	267
Pulaski	180	64	15	95
Randolph	732	262	62	374
St. Clair	5,901	2,143	527	2,743
Union	419	154	36	219
Washington	364	129	30	186
Williamson	1,276	497	116	770
Total	12,429	4,597	1,099	6,277

4. POTENTIAL FOR ENERGY IMPROVEMENT

4.1 Energy Improvement Analysis

Energy use is not independent of the economic and institutional context of households. Most important certainly is the economic context. A household's choice of energy use will be influenced by the prices it faces and the technologies available to it. If the price of electricity is extremely low relative to fossil fuels - as has often been the case in some western states where the federal government has subsidized the price of hydroelectric power - one should not be surprised to find people choosing to heat their homes with electricity. Also, as new technologies are introduced, households are open to more opportunities and choices. In addition, the institutional structures surrounding the energy marketplace can influence the ease with which households select technologies. For instance, if a state government or university provides households with reliable information about their energy options, the costs that households face becoming educated about new technologies can be shared and lowered.

Because energy use is dependent on other factors, it is necessary to look at what energy choices might reasonably be if those factors changed if we are to offer a robust characterization of energy use. The availability of conservation and energy efficiency options is particularly interesting in terms of characterizing residential energy use.

For the purposes of this study we examine how energy choices might be different if five conservation or energy efficiency measures were in widespread and ready availability to the residential customer. In examining this, however, we do not define how these measures are implemented or delivered as programs. If we look around the U.S., we see essentially similar measures made available in vastly different ways. Home energy rating programs, for instance, may be offered as state supported programs in some states while in other areas HERS can be delivered through utilities or as private initiatives.

Our analysis does assume that the measures have been available for a long period of time. Though it is not necessary to define this long period of time precisely, it is sufficiently long for households to replace their energy using equipment or renovate their homes as they wear out. In such as circumstance, it is generally true that most energy conserving or efficient equipment costs little or no more than other equipment. For example, adding more insulation to walls or attics is a very minor cost when work is being done on those walls or attics - particularly when contractors view the higher insulation levels as standard. Also when energy efficient refrigerators are demanded as standard in a community or state, the competition between retailers pushes the price down to the prices paid for refrigerators of current efficiency when conservation is not viewed as the norm. Though we do not need to define the period of time needed to replace equipment or renovate homes within a normal product cycle, we will find it convenient to think of this period as 12 years since within such a period of time many furnaces, water heaters, and refrigerators are

switch out.

The five measures that we will consider are: envelope and furnace measures that reduce space heating, envelope and air conditioner efficiency and sizing measures that lower space cooling needs, electric water heater conversions in homes that have a natural gas connection or use LPG for space heating, replacement of incandescent light bulbs with compact fluorescent bulbs in high use areas, and replacement of high energy use refrigerators. These measures were chosen in part because there is a information basis for reasonable estimates of the savings in the 2000 Census, the RECS, or the Illinois HERS data, but these measures were chosen also because these measures can delivers substantial energy savings with relatively minor costs if implement in tandem with normal residential replacement or renovation projects.

To estimate the impact of the space heat measure, we examined rating results from over 70 home energy ratings performed around Illinois under the Energy Wise Homes of Illinois program. The ratings results give a predicted amount of the energy consumed for different end uses based on envelope characteristics and the mechanical systems of the home. Also most raters indicate whether the subject house is new or existing and, if it is an existing home, the year of construction, or vintage. In addition, some energy raters - particularly those in the Adams Electric incentive program - rate homes without and then again with energy conserving measures. Generally the energy performance of older homes is inferior to that of homes built more recently, but these older homes can achieve greater efficiency improvements relative to their initial state with the same outlay. In particular, homes built before 1950 have ratings in the range of 45 to 65, while homes built after 1980 tend to have ratings over 70. We used the energy ratings and energy improvement findings of the Adams Electric program, which averaged over 20 ratings points (Cavallo: 2002), to develop estimates of the improvement potential for different vintages of homes. This ranged from a space heating improvement of 18 percent for homes built before 1940 to a 2.5 percent improvement for homes built after 1985 but before 1995. A straight line improvement curve was used for vintages between those points. The estimated improvement curve was then combined with the Census information on building vintages to define a county-wide percentage improvement factor for space heating to adjust the baseline estimate.

Like space heating, air conditioning efficiency is dependent on envelope factors such as insulation and air sealing. It is also related to the efficiency of the equipment and the appropriateness of the sizing. Air conditioners, for instance, can perform very poorly if they are oversized and cycle frequently. In our analysis of the opportunities for energy improvements in space cooling, we were able to use much of the same information and approach as was used with space heating. We examined the results of the Illinois HERS results and specified a sliding scale of energy improvements based on housing vintage. For air conditioning, we estimated a nearly 20 percent improvement for homes built before 1940 and essentially the same, 2.5 percent, improvement for homes built after 1985 and before 1995. Because this was so similar to the space heating improvement curve and to include a bias toward a conservative estimate, we chose to use the same improvement curve as in the space heat measure. The estimated improvement curve was again combined with vintage information from the Census and defined for each county.

The water heat measure that was specified can be controversial. To many engineers, it is offensive to use a high quality form of energy to do something as pedestrian as heat water. To environmentalists, the idea of using a dirty fuel like coal to generate electricity when a cleaner fuel like natural gas or LPG could do the job is repugnant. Separate from offending sensibilities, using electricity to heat water is considerably more expensive than using natural gas or LPG. Nevertheless, several states and the federal government have found extreme resistance from electric utilities when trying to organize programs that switch out electric water heaters for fossil fuel models. We have specified for our analysis a measure that is less severe than switching out all electric water heaters. Instead we have specified that electric water heaters in residences where natural gas or LPG is used for space heating be switched out for their fossil fuel counterpart. This was relatively easy to compute using the available Census information that gave county-level information on space heating by building type.

One of the most cost-effective and as yet underutilized energy efficiency measure is compact fluorescent bulbs. In Cavallo (2001), we have estimated that in most regions of the country utility rates make it economical to replace all incandescent lights that burn for more than 3 hours per day with compact fluorescent bulbs. The RECS microdata for the East North Central census division provided information on the percent of homes of different building types that had lights which burned for more than 10 hours per day. This information was used to reduce the "other" end use by the associated energy used throughout a year for each of the different building types.

The final measure relates to refrigeration. The RECS microdata for the Midwest provided estimates of the energy used for refrigeration. We looked at the distribution of this energy use for each building type and specified a rule that households using more than 1400 kilowatt-hours per year for refrigerator would replace their refrigerator sometime over the 12 year period with a model using 650 kilowatt-hours per year. To be sure, 650 kilowatt-hours is not an Energy Star compliant refrigerator for most sizes. However, this assumption conforms to the conservative nature of most of our measures.

4.2. Estimated Energy Improvement Opportunities by County, End Use, and Fuel Type

The tables below show the impact of the conservation and energy efficiency measures described above. There are four tables for each region. The first table for each region gives the 2002 residential energy use with the conservation and energy efficiency measures by fuel type in billions of Btus. The second table displays the change in energy use for each fuel from the baseline of Chapter 3. The third table breaks out 2002 energy use with the conservation measures by end use. The fourth table for each region also presents the change in energy use from the Chapter 3 baseline but in terms of end use. Differences in table totals are due to rounding.

We notice that negative numbers appear in the tables showing the changes in energy use from the baseline. A negative number indicates an increase in energy use by the corresponding fuel or end use. In the fuel type tables, increases in fuel use occurs for LPG. This is a consequence of households switching out electric water heaters for LPG water heaters. In such

cases, the households will have reductions in their electricity usage. We also see negative values - energy use increases - for water heating. This is due to the greater on-site energy usage (in Btus) of fossil fuel water heaters compared to electric water heaters. For all of the energy reduction tables broken out by end use, cooking has a zero change because we have not specified any conservation or energy efficiency measure for the cooking end use.

Table 4.1: Energy Use with Conservation for Northeast Counties by Fuel Type (in billion Btus)

County	Natural Gas	Oil	LPG	Electricity
Boone	1,322	54	146	431
Cook	176,347	455	2,574	43,320
DeKalb	2,667	90	128	880
DuPage	33,945	59	380	8,166
Grundy	1,287	23	146	424
Kane	14,466	44	528	3,494
Kendall	1,903	49	171	536
La Salle	4,401	107	305	1,219
Lake	22,462	37	284	5,726
McHenry	10,286	71	217	2,493
Will	18,774	121	496	4,420
Total	287,860	1,110	5,375	71,109

Table 4.2: Energy Reductions from Conservation for Northeast Counties by Fuel Type (in billion Btus)

County	Natural Gas	Oil	LPG	Electricity
Boone	167	11	5	79
Cook	27,233	109	170	8,360
DeKalb	366	19	6	155
DuPage	2,936	8	5	1,438
Grundy	150	4	3	79
Kane	1,874	9	24	655
Kendall	207	8	3	97
La Salle	705	27	17	240
Lake	2,199	6	4	1,043
McHenry	1,086	12	6	445
Will	2,030	21	13	825
Total	38,953	234	256	13,416

Table 4.3: Energy Use with Conservation for Northeast Counties by End Use
(in billion Btus)

County	Space Heat	Water Heat	Cooking	Other
Boone	1,162	365	81	345
Cook	125,651	48,225	11,184	37,636
DeKalb	2,198	728	166	674
DuPage	25,447	8,198	1,899	7,007
Grundy	1,088	367	81	344
Kane	11,074	3,523	834	3,101
Kendall	1,588	494	114	464
La Salle	3,514	1,165	270	1,083
Lake	16,674	5,534	1,303	4,997
McHenry	8,080	2,303	549	2,134
Will	14,347	4,373	1,044	4,046
Total	210,823	75,275	17,525	61,831

Table 4.4: Energy Reductions from Conservation for Northeast Counties by End Use
(in billion Btus)

County	Space Heat	Water Heat	Cooking	Other
Boone	245	-36	0	53
Cook	31,808	-2,305	0	6,369
DeKalb	488	-49	0	107
DuPage	3,760	-445	0	1,072
Grundy	220	-37	0	53
Kane	2,322	-237	0	477
Kendall	287	-40	0	69
La Salle	930	-108	0	168
Lake	2,850	-360	0	762
McHenry	1,384	-155	0	319
Will	2,586	-306	0	608
Total	46,880	-4,078	0	10,057

Table 4.5: Energy Use with Conservation for Northwest Counties by Fuel Type
(in billion Btus)

County	Natural Gas	Oil	LPG	Electricity
Bureau	1,296	75	193	419
Carroll	524	55	169	221
Henry	1,948	57	322	575
Jo Daviess	634	115	208	332
Lee	1,114	64	139	409
Mercer	503	46	205	199
Ogle	1,608	113	253	584
Putnam	201	15	51	82
Rock Island	6,553	52	203	1,562
Stephenson	1,733	87	233	592
Whiteside	2,175	78	250	699
Winnebago	12,225	74	176	2,827
Total	30,514	831	2,402	8,501

Table 4.6: Energy Reductions from Conservation for Northwest Counties by Fuel Type
(in billion Btus)

County	Natural Gas	Oil	LPG	Electricity
Bureau	231	21	14	81
Carroll	91	15	13	42
Henry	313	14	19	115
Jo Daviess	96	27	12	59
Lee	180	16	8	76
Mercer	81	12	12	41
Ogle	233	25	13	107
Putnam	26	3	2	16
Rock Island	977	12	10	308
Stephenson	274	21	14	112
Whiteside	333	19	13	132
Winnebago	1,677	15	9	529
Total	4,512	200	139	1,618

Table 4.7: Energy Use with Conservation for Northwest Counties by End Use
(in billion Btus)

County	Space Heat	Water Heat	Cooking	Other
Bureau	1,142	383	86	371
Carroll	558	183	38	189
Henry	1,696	563	125	516
Jo Daviess	727	232	49	280
Lee	980	334	75	337
Mercer	550	190	39	175
Ogle	1,505	480	106	468
Putnam	199	65	14	71
Rock Island	4,933	1,629	383	1,425
Stephenson	1,546	502	111	486
Whiteside	1,852	618	140	592
Winnebago	9,356	2,793	669	2,484
Total	25,044	7,972	1,835	7,394

Table 4.8: Energy Reductions from Conservation for Northwest Counties by End Use
(in billion Btus)

County	Space Heat	Water Heat	Cooking	Other
Bureau	331	-40	0	57
Carroll	156	-24	0	29
Henry	444	-62	0	79
Jo Daviess	181	-29	0	43
Lee	260	-32	0	52
Mercer	147	-28	0	27
Ogle	354	-48	0	72
Putnam	44	-8	0	11
Rock Island	1,209	-124	0	223
Stephenson	397	-50	0	76
Whiteside	466	-59	0	91
Winnebago	2,024	-179	0	384
Total	6,013	-683	0	1,144

Table 4.9: Energy Use with Conservation for East Counties by Fuel Type
(in billion Btus)

County	Natural Gas	Oil	LPG	Electricity
Champaign	5,634	52	323	1,875
Ford	444	27	101	169
Iroquois	872	60	278	385
Kankakee	3,373	50	336	1,071
Livingston	1,164	43	207	419
Piatt	570	13	121	187
Vermilion	2,858	59	319	984
Total	14,915	304	1,685	5,090

Table 4.10: Energy Reductions from Conservation for East Counties by Fuel Type
(in billion Btus)

County	Natural Gas	Oil	LPG	Electricity
Champaign	542	9	-1	343
Ford	71	7	5	33
Iroquois	128	15	10	76
Kankakee	424	11	6	209
Livingston	168	10	7	84
Piatt	75	3	3	38
Vermilion	395	14	9	193
Total	1,803	69	39	976

Table 4.11: Energy Use with Conservation for East Counties by End Use
(in billion Btus)

County	Space Heat	Water Heat	Cooking	Other
Champaign	4,275	1,713	379	1,516
Ford	404	155	34	148
Iroquois	860	336	70	329
Kankakee	2,669	1,011	227	923
Livingston	999	388	85	362
Piatt	498	185	40	168
Vermilion	2,294	884	197	845
Total	11,999	4,672	1,032	4,291

Table 4.12: Energy Reductions from Conservation for East Counties by End Use
(in billion Btus)

County	Space Heat	Water Heat	Cooking	Other
Champaign	783	-132	0	242
Ford	112	-18	0	23
Iroquois	225	-46	0	50
Kankakee	603	-98	0	144
Livingston	258	-45	0	56
Piatt	117	-23	0	25
Vermilion	570	-91	0	132
Total	2,668	-453	0	672

Table 4.13: Energy Use with Conservation for Central Counties by Fuel Type
(in billion Btus)

County	Natural Gas	Oil	LPG	Electricity
De Witt	592	13	130	197
Logan	950	27	180	330
Macon	4,603	42	220	1,331
Marshall	387	30	127	173
Mason	465	30	211	195
McLean	5,352	91	320	1,499
Menard	384	14	142	146
Peoria	6,614	59	374	2,074
Stark	169	17	84	78
Tazewell	4,764	66	392	1,474
Woodford	1,094	44	263	381
Total	25,374	433	2,443	7,878

Table 4.14: Energy Reductions from Conservation for Central Counties by Fuel Type
(in billion Btus)

County	Natural Gas	Oil	LPG	Electricity
De Witt	86	3	5	41
Logan	138	6	7	65
Macon	630	9	8	253
Marshall	60	7	6	33
Mason	63	7	5	42
McLean	596	17	4	286
Menard	51	3	4	31
Peoria	944	13	17	383
Stark	29	5	6	16
Tazewell	606	13	12	273
Woodford	141	9	8	75
Total	3,344	92	82	1,498

Table 4.15: Energy Use with Conservation for Central Counties by End Use
(in billion Btus)

County	Space Heat	Water Heat	Cooking	Other
De Witt	528	191	41	173
Logan	839	301	65	282
Macon	3,535	1,220	282	1,159
Marshall	398	143	30	147
Mason	506	188	37	171
McLean	4,186	1,460	332	1,285
Menard	388	142	29	128
Peoria	5,129	1,832	419	1,741
Stark	194	72	14	68
Tazewell	3,841	1,308	299	1,248
Woodford	1,023	355	76	329
Total	20,567	7,212	1,624	6,731

Table 4.16: Energy Reductions from Conservation for Central Counties by End Use
(in billion Btus)

County	Space Heat	Water Heat	Cooking	Other
De Witt	133	-24	0	27
Logan	208	-34	0	43
Macon	822	-100	0	179
Marshall	103	-19	0	22
Mason	124	-33	0	26
McLean	825	-123	0	202
Menard	90	-21	0	19
Peoria	1,219	-134	0	271
Stark	55	-11	0	10
Tazewell	826	-112	0	190
Woodford	227	-44	0	50
Total	4,632	-655	0	1,039

Table 4.17: Energy Use with Conservation for West Counties by Fuel Type
(in billion Btus)

County	Natural Gas	Oil	LPG	Electricity
Adams	2,203	58	233	805
Brown	141	14	43	71
Fulton	1,244	56	283	451
Hancock	486	45	172	274
Henderson	259	20	97	112
Knox	2,046	43	241	617
McDonough	876	34	205	366
Schuyler	160	28	65	101
Warren	587	37	136	215
Total	8,002	335	1,475	3,012

Table 4.18: Energy Reductions from Conservation for West Counties by Fuel Type
(in billion Btus)

County	Natural Gas	Oil	LPG	Electricity
Adams	322	14	8	156
Brown	20	3	1	14
Fulton	201	14	16	90
Hancock	72	11	6	52
Henderson	31	4	1	24
Knox	326	11	13	122
McDonough	112	8	4	72
Schuyler	21	7	1	19
Warren	92	9	7	42
Total	1,197	81	57	591

Table 4.19: Energy Use with Conservation for West Counties by End Use
(in billion Btus)

County	Space Heat	Water Heat	Cooking	Other
Adams	1,776	691	155	678
Brown	142	56	12	60
Fulton	1,142	411	88	394
Hancock	508	207	42	220
Henderson	269	98	20	100
Knox	1,672	596	134	546
McDonough	789	322	68	303
Schuyler	185	74	15	81
Warren	549	195	42	187
Total	7,032	2,650	576	2,569

Table 4.20: Energy Reductions from Conservation for West Counties by End Use
(in billion Btus)

County	Space Heat	Water Heat	Cooking	Other
Adams	460	-68	0	108
Brown	37	-8	0	9
Fulton	310	-50	0	61
Hancock	136	-28	0	34
Henderson	62	-18	0	15
Knox	445	-57	0	85
McDonough	186	-39	0	48
Schuyler	46	-11	0	13
Warren	145	-23	0	29
Total	1,827	-302	0	402

Table 4.21: Energy Use with Conservation for East Southeast Counties by Fuel Type
(in billion Btus)

County	Natural Gas	Oil	LPG	Electricity
Clark	378	42	258	223
Clay	341	36	177	183
Coles	1,477	33	195	648
Crawford	585	22	175	246
Cumberland	197	25	216	141
Douglas	556	18	127	235
Edgar	534	30	157	247
Effingham	771	50	291	420
Fayette	471	49	264	256
Jasper	164	23	215	124
Lawrence	445	21	145	195
Marion	1,212	61	254	511
Moultrie	408	15	129	160
Richland	456	32	128	216
Shelby	525	38	335	290
Total	8,520	495	3,066	4,095

Table 4.22: Energy Reductions from Conservation for East Southeast Counties by Fuel Type
(in billion Btus)

County	Natural Gas	Oil	LPG	Electricity
Clark	45	9	0	47
Clay	37	8	-2	38
Coles	175	7	1	121
Crawford	75	5	2	51
Cumberland	20	5	-3	31
Douglas	69	4	1	46
Edgar	74	7	3	49
Effingham	73	9	-4	78
Fayette	54	11	-2	54
Jasper	17	5	-3	28
Lawrence	56	5	1	41
Marion	127	12	-4	102
Moultrie	54	4	2	33
Richland	51	7	0	42
Shelby	62	8	1	62
Total	989	106	-7	823

Table 4.23: Energy Use with Conservation for East Southeast Counties by End Use
(in billion Btus)

County	Space Heat	Water Heat	Cooking	Other
Clark	464	205	38	193
Clay	383	165	32	156
Coles	1,200	520	113	520
Crawford	537	225	47	218
Cumberland	299	135	24	122
Douglas	489	205	44	198
Edgar	498	214	45	211
Effingham	789	339	68	337
Fayette	537	236	46	222
Jasper	273	124	21	107
Lawrence	416	180	37	172
Marion	1,064	446	95	433
Moultrie	379	157	33	144
Richland	432	179	37	184
Shelby	615	270	51	252
Total	8,375	3,600	731	3,469

Table 4.24: Energy Reductions from Conservation for East Southeast Counties by End Use
(in billion Btus)

County	Space Heat	Water Heat	Cooking	Other
Clark	110	-38	0	30
Clay	85	-28	0	24
Coles	273	-52	0	82
Crawford	131	-32	0	34
Cumberland	63	-29	0	19
Douglas	116	-26	0	31
Edgar	130	-29	0	33
Effingham	151	-47	0	51
Fayette	126	-43	0	35
Jasper	57	-28	0	16
Lawrence	105	-28	0	27
Marion	232	-62	0	68
Moultrie	93	-22	0	22
Richland	95	-24	0	28
Shelby	143	-49	0	39
Total	1,910	-537	0	539

Table 4.25: Energy Use with Conservation for West Southwest Counties by Fuel Type
(in billion Btus)

County	Natural Gas	Oil	LPG	Electricity
Bond	346	45	168	199
Calhoun	58	17	134	78
Cass	414	19	82	165
Christian	1,155	25	200	417
Greene	418	27	140	178
Jersey	428	51	256	271
Macoupin	1,433	69	453	597
Madison	8,619	41	735	3,144
Montgomery	869	39	245	355
Morgan	1,070	26	193	422
Pike	472	41	129	232
Sangamon	6,596	43	492	2,322
Scott	143	9	74	70
Total	22,021	452	3,301	8,450

Table 4.26: Energy Reductions from Conservation for West Southwest Counties by Fuel Type
(in billion Btus)

County	Natural Gas	Oil	LPG	Electricity
Bond	40	10	0	39
Calhoun	7	4	1	17
Cass	57	5	2	34
Christian	163	6	6	84
Greene	61	7	4	37
Jersey	46	10	-1	52
Macoupin	192	16	9	123
Madison	1,059	9	14	581
Montgomery	122	10	6	73
Morgan	132	6	2	82
Pike	66	10	3	45
Sangamon	758	9	4	434
Scott	21	2	2	15
Total	2,724	104	52	1,616

Table 4.27: Energy Use with Conservation for West Southwest Counties by End Use (in billion Btus)

County	Space Heat	Water Heat	Cooking	Other
Bond	399	165	32	162
Calhoun	144	65	10	67
Cass	362	145	31	141
Christian	967	382	83	364
Greene	409	164	34	156
Jersey	528	218	42	219
Macoupin	1,371	547	113	521
Madison	6,753	2,603	586	2,597
Montgomery	807	324	68	309
Morgan	910	369	79	353
Pike	456	183	38	197
Sangamon	5,088	1,992	447	1,924
Scott	156	66	13	61
Total	18,350	7,223	1,576	7,071

Table 4.28: Energy Reductions from Conservation for West Southwest Counties by End Use (in billion Btus)

County	Space Heat	Water Heat	Cooking	Other
Bond	90	-27	0	25
Calhoun	34	-16	0	10
Cass	94	-19	0	22
Christian	247	-45	0	57
Greene	109	-24	0	24
Jersey	110	-36	0	33
Macoupin	340	-81	0	81
Madison	1,495	-233	0	401
Montgomery	209	-46	0	48
Morgan	210	-42	0	55
Pike	119	-25	0	31
Sangamon	1,079	-175	0	302
Scott	42	-11	0	10
Total	4,178	-780	0	1,099

Table 4.29: Energy Use with Conservation for Southeast Counties by Fuel Type
(in billion Btus)

County	Natural Gas	Oil	LPG	Electricity
Edwards	156	13	51	98
Franklin	867	48	169	578
Gallatin	161	7	58	88
Hamilton	168	17	107	115
Hardin	100	15	35	72
Jefferson	760	53	291	510
Massac	366	27	109	203
Pope	48	15	62	71
Saline	683	31	145	362
Wabash	253	37	116	164
Wayne	326	32	229	230
White	400	18	152	208
Total	4,288	313	1,524	2,699

Table 4.30: Energy Reduction from Conservation for Southeast Counties by Fuel Type
(in billion Btus)

County	Natural Gas	Oil	LPG	Electricity
Edwards	15	3	-2	19
Franklin	100	11	-2	102
Gallatin	14	1	-3	18
Hamilton	17	4	-3	24
Hardin	9	3	-2	13
Jefferson	65	10	-13	96
Massac	33	5	-4	40
Pope	4	3	-3	13
Saline	67	7	-4	69
Wabash	24	8	-4	32
Wayne	28	6	-11	49
White	40	4	-4	43
Total	416	65	-55	518

Table 4.31: Energy Use with Conservation for Southeast Counties by End Use
(in billion Btus)

County	Space Heat	Water Heat	Cooking	Other
Edwards	148	75	15	79
Franklin	746	387	82	447
Gallatin	149	76	15	75
Hamilton	191	99	19	99
Hardin	101	50	10	60
Jefferson	742	390	77	404
Massac	335	166	34	170
Pope	84	46	8	57
Saline	573	285	60	301
Wabash	268	137	27	138
Wayne	381	204	38	193
White	371	187	38	182
Total	4,089	2,102	423	2,205

Table 4.32: Energy Reduction from Conservation for Southeast Counties by End Use
(in billion Btus)

County	Space Heat	Water Heat	Cooking	Other
Edwards	34	-11	0	12
Franklin	185	-43	0	70
Gallatin	32	-13	0	12
Hamilton	45	-19	0	15
Hardin	22	-8	0	9
Jefferson	154	-58	0	63
Massac	72	-24	0	26
Pope	18	-10	0	9
Saline	129	-37	0	47
Wabash	61	-22	0	22
Wayne	83	-41	0	30
White	85	-30	0	28
Total	920	-316	0	343

Table 4.33: Energy Use with Conservation for Southwest Counties by Fuel Type
(in billion Btus)

County	Natural Gas	Oil	LPG	Electricity
Alexander	195	9	108	125
Clinton	789	33	238	401
Jackson	1,072	43	218	798
Johnson	83	27	154	165
Monroe	447	39	291	333
Perry	483	32	132	283
Pulaski	120	16	87	101
Randolph	623	53	215	403
St. Clair	6,645	67	618	2,818
Union	312	38	163	242
Washington	266	29	143	202
Williamson	1,192	69	213	914
Total	12,227	455	2,580	6,785

Table 4.34: Energy Reduction from Conservation for Southwest Counties by Fuel Type
(in billion Btus)

County	Natural Gas	Oil	LPG	Electricity
Alexander	17	2	-4	26
Clinton	63	6	-12	80
Jackson	74	7	-15	137
Johnson	5	5	-11	30
Monroe	41	7	-8	63
Perry	45	7	-5	53
Pulaski	11	3	-4	20
Randolph	57	11	-9	77
St. Clair	647	13	-15	521
Union	27	8	-7	45
Washington	28	6	-3	38
Williamson	113	14	-6	152
Total	1,128	89	-99	1,242

Table 4.35: Energy Use with Conservation for Southwest Counties by End Use
(in billion Btus)

County	Space Heat	Water Heat	Cooking	Other
Alexander	200	109	21	107
Clinton	703	349	71	337
Jackson	929	524	107	572
Johnson	182	106	18	123
Monroe	522	273	51	264
Perry	436	218	45	231
Pulaski	148	79	15	82
Randolph	600	309	62	324
St. Clair	4,897	2,355	527	2,370
Union	347	184	36	189
Washington	295	153	30	161
Williamson	1,051	553	116	667
Total	10,310	5,212	1,099	5,427

Table 4.36: Energy Reduction from Conservation for Southwest Counties by End Use
(in billion Btus)

County	Space Heat	Water Heat	Cooking	Other
Alexander	43	-19	0	17
Clinton	139	-54	0	52
Jackson	172	-60	0	92
Johnson	33	-23	0	19
Monroe	105	-42	0	40
Perry	94	-30	0	36
Pulaski	32	-15	0	13
Randolph	132	-47	0	51
St. Clair	1,005	-212	0	373
Union	73	-29	0	30
Washington	69	-24	0	25
Williamson	224	-56	0	104
Total	2,121	-611	0	852

5. UTILITY BILL REDUCTIONS OF RESIDENTIAL ENERGY EFFICIENCY

5.1 Local Rate Approximations for Various Fuels

The primary benefit that a homeowner or renter would see from conservation or energy efficiency measures is a reduced annual energy bill. As reported earlier in this report, the savings that households would receive is estimated at approximately $1.06 billion. This estimate is based on utility rates for the different counties around the state. The energy rates used in this study are given in Table 5.1 below.

Table 5.1: Utility Rates for Four Fuel Types

Region	Natural Gas	Oil	LPG	Electricity
Northeast	0.623288	0.9	1.35	0.10606
Northwest	0.838050	0.9	1.35	0.10606
East	0.840025	0.9	1.35	0.10166
Central	0.768125	0.9	1.35	0.08222
West	0.768125	0.9	1.35	0.08222
East Southeast	0.840025	0.9	1.35	0.10166
West Southwest	0.840025	0.9	1.35	0.10166
Southeast	0.721925	0.9	1.35	0.10166
Southwest	0.840025	0.9	1.35	0.10166

The rates shown in Table 5.1 were computed specifically for this study. The rates are computed separately for each fuel. We began with the rates shown in the latest libraries distributed by the Illinois' Bureau of Energy and Recycling as part of its Energy Wise Homes of Illinois program. The rates for fuel oil and LPG were taken directly from these libraries and are given in dollars per gallon. For natural gas and electricity, we assumed a standard usage level and computed a typical bill for that usage level. In so doing, a service charge is included in the rates. The average monthly usage level for natural gas was assumed to be 80 therms with the rates specified in dollars per therm. The typical monthly usage level for electricity was taken to be 500 kilowatt-hours and the rates are shown as dollars per kilowatt-hour.

5.2 Estimated Impacts by County and Fuel Type

The tables below show the dollar savings associated with the fuel consumption reductions of the conservation and energy efficiency measures defined in Chapter 4. The reductions are in thousands of dollars and are broken out for each fuel. A total of the four fuels is given for each county. As in the tables of Chapter 4, negative numbers indicate increases. Increased expenditures only occur for LPG and are a consequence of households switching out electric water heaters for LPG water heaters. In such cases, the households will have a greater reduction in their annual electric bills than the increase in their annual LPG bills.

Table 5.2: Utility Bill Reduction from Conservation for Northeast Counties
(in thousands of dollars)

County	Natural Gas	Oil	LPG	Electricity	Total
Boone	$1,042	$71	$62	$2,470	$3,645
Cook	$169,741	$710	$2,348	$259,868	$432,667
DeKalb	$2,281	$124	$79	$4,832	$7,316
DuPage	$18,302	$55	$74	$44,687	$63,118
Grundy	$932	$29	$38	$2,464	$3,463
Kane	$11,678	$58	$334	$20,376	$32,446
Kendall	$1,290	$55	$48	$3,012	$4,405
La Salle	$4,393	$175	$239	$7,470	$12,277
Lake	$13,706	$39	$59	$32,422	$46,226
McHenry	$6,768	$76	$86	$13,821	$20,751
Will	$12,655	$135	$182	$25,633	$38,605
Total	$242,788	$1,527	$3,549	$417,055	$664,919

Table 5.3: Utility Bill Reduction from Conservation for Northwest Counties
(in thousands of dollars)

County	Natural Gas	Oil	LPG	Electricity	Total
Bureau	$1,938	$134	$200	$2,532	$4,804
Carroll	$763	$95	$174	$1,318	$2,350
Henry	$2,619	$92	$269	$3,579	$6,559
Jo Daviess	$805	$178	$171	$1,831	$2,985
Lee	$1,504	$104	$112	$2,362	$4,082
Mercer	$680	$77	$167	$1,262	$2,186
Ogle	$1,953	$165	$174	$3,314	$5,606
Putnam	$218	$20	$21	$482	$741
Rock Island	$8,189	$79	$145	$9,584	$17,997
Stephenson	$2,300	$139	$193	$3,478	$6,110
Whiteside	$2,795	$121	$186	$4,111	$7,213
Winnebago	$14,051	$99	$121	$16,430	$30,701
Total	$37,815	$1,303	$1,933	$50,283	$91,334

Table 5.4: Utility Bill Reduction from Conservation for East Counties
(in thousands of dollars)

County	Natural Gas	Oil	LPG	Electricity	Total
Champaign	$4,551	$58	-$15	$10,223	$14,817
Ford	$598	$46	$71	$990	$1,705
Iroquois	$1,079	$95	$142	$2,262	$3,578
Kankakee	$3,558	$70	$83	$6,218	$9,929
Livingston	$1,413	$68	$94	$2,490	$4,065
Piatt	$633	$18	$43	$1,135	$1,829
Vermilion	$3,320	$90	$120	$5,736	$9,266
Total	$15,152	$445	$538	$29,054	$45,189

Table 5.5: Utility Bill Reduction from Conservation for Central Counties
(in thousands of dollars)

County	Natural Gas	Oil	LPG	Electricity	Total
De Witt	$662	$20	$70	$980	$1,732
Logan	$1,061	$41	$103	$1,563	$2,768
Macon	$4,840	$60	$108	$6,104	$11,112
Marshall	$458	$48	$88	$804	$1,398
Mason	$483	$46	$75	$1,013	$1,617
McLean	$4,578	$111	$50	$6,904	$11,643
Menard	$388	$19	$55	$736	$1,198
Peoria	$7,251	$87	$231	$9,226	$16,795
Stark	$222	$30	$77	$382	$711
Tazewell	$4,659	$87	$161	$6,576	$11,483
Woodford	$1,083	$60	$106	$1,811	$3,060
Total	$25,685	$609	$1,124	$36,099	$63,517

Table 5.6: Utility Bill Reduction from Conservation for West Counties
(in thousands of dollars)

County	Natural Gas	Oil	LPG	Electricity	Total
Adams	$2,473	$92	$111	$3,751	$6,427
Brown	$155	$22	$16	$334	$527
Fulton	$1,541	$93	$219	$2,164	$4,017
Hancock	$556	$74	$86	$1,253	$1,969
Henderson	$240	$29	$11	$572	$852
Knox	$2,505	$71	$184	$2,945	$5,705
McDonough	$859	$49	$59	$1,727	$2,694
Schuyler	$164	$43	$15	$456	$678
Warren	$709	$60	$102	$1,015	$1,886
Total	$9,202	$533	$803	$14,217	$24,755

Table 5.7: Utility Bill Reduction from Conservation for East Southeast Counties
(in thousands of dollars)

County	Natural Gas	Oil	LPG	Electricity	Total
Clark	$375	$61	-$2	$1,410	$1,844
Clay	$312	$49	-$22	$1,122	$1,461
Coles	$1,468	$46	$8	$3,594	$5,116
Crawford	$626	$33	$27	$1,512	$2,198
Cumberland	$168	$32	-$44	$924	$1,080
Douglas	$580	$26	$18	$1,373	$1,997
Edgar	$623	$48	$47	$1,462	$2,180
Effingham	$611	$58	-$60	$2,324	$2,933
Fayette	$451	$71	-$26	$1,620	$2,116
Jasper	$139	$30	-$40	$830	$959
Lawrence	$473	$32	$12	$1,230	$1,747
Marion	$1,063	$81	-$56	$3,050	$4,138
Moultrie	$452	$23	$34	$996	$1,505
Richland	$432	$43	-$3	$1,242	$1,714
Shelby	$521	$55	$8	$1,840	$2,424
Total	$8,294	$688	-$99	$24,529	$33,412

Table 5.8: Utility Bill Reduction from Conservation for West Southwest Counties
(in thousands of dollars)

County	Natural Gas	Oil	LPG	Electricity	Total
Bond	$333	$62	-$3	$1,169	$1,561
Calhoun	$58	$25	$11	$500	$594
Cass	$477	$29	$22	$999	$1,527
Christian	$1,369	$40	$79	$2,502	$3,990
Greene	$513	$44	$61	$1,095	$1,713
Jersey	$385	$66	-$7	$1,552	$1,996
Macoupin	$1,609	$106	$127	$3,675	$5,517
Madison	$8,900	$56	$190	$17,314	$26,460
Montgomery	$1,029	$62	$89	$2,175	$3,355
Morgan	$1,113	$37	$33	$2,454	$3,637
Pike	$555	$66	$43	$1,344	$2,008
Sangamon	$6,371	$56	$57	$12,938	$19,422
Scott	$173	$15	$29	$446	$663
Total	$22,885	$664	$731	$48,163	$72,443

Table 5.9: Utility Bill Reduction from Conservation for Southeast Counties
(in thousands of dollars)

County	Natural Gas	Oil	LPG	Electricity	Total
Edwards	$110	$18	-$22	$551	$657
Franklin	$724	$72	-$27	$3,049	$3,818
Gallatin	$99	$10	-$38	$545	$616
Hamilton	$124	$25	-$44	$715	$820
Hardin	$64	$21	-$23	$402	$464
Jefferson	$471	$66	-$176	$2,862	$3,223
Massac	$238	$35	-$60	$1,177	$1,390
Pope	$28	$19	-$43	$395	$399
Saline	$486	$43	-$62	$2,061	$2,528
Wabash	$176	$51	-$56	$962	$1,133
Wayne	$203	$42	-$151	$1,457	$1,551
White	$292	$25	-$59	$1,291	$1,549
Total	$3,015	$427	-$761	$15,467	$18,148

Table 5.10: Utility Bill Reduction from Conservation for Southwest Counties
(in thousands of dollars)

County	Natural Gas	Oil	LPG	Electricity	Total
Alexander	$145	$12	-$57	$772	$872
Clinton	$529	$39	-$160	$2,394	$2,802
Jackson	$620	$48	-$205	$4,089	$4,552
Johnson	$41	$30	-$148	$889	$812
Monroe	$342	$47	-$108	$1,864	$2,145
Perry	$378	$43	-$63	$1,582	$1,940
Pulaski	$90	$21	-$50	$594	$655
Randolph	$480	$71	-$120	$2,290	$2,721
St. Clair	$5,436	$83	-$208	$15,517	$20,828
Union	$227	$49	-$95	$1,350	$1,531
Washington	$233	$41	-$44	$1,135	$1,365
Williamson	$949	$89	-$88	$4,514	$5,464
Total	$9,470	$573	-$1,346	$36,990	$45,687

6. ENVIRONMENTAL CONSEQUENCES OF CONSERVATION AND ENERGY EFFICIENCY IMPROVEMENTS

6.1 Environmental Analysis of Residential Energy Measures

Often energy conservation and energy efficiency measures are viewed in terms of their dollar savings. Indeed it is a strong argument for a measure when the dollar savings from an action is greater than that dollar cost. As many of the conservation and energy efficiency measures described here have little or no added cost when implemented in the normal course of equipment replacement, these actions are clear winners in dollar terms to the household.

However, the cost-effectiveness for the individual homeowners generally overlooks or gives no weight to the environmental benefits of a conservation measure. Certainly it may be impossible to define in dollar terms the benefit a homeowner receives from his or her child growing up with a lower likelihood of suffering from asthma as a consequence of fewer pounds of coarse particulate matter being emitted into the local atmosphere. It may be even more difficult to quantity the benefit of lower the acidity of lakes and streams hundreds of miles away and unlikely to be used by the person conserving the energy. Nonetheless, one must think there is a benefit. In the absence of a method to compute a dollar value for the reduction of emissions, we compute and present the estimated quantities of those reductions.

In section 2.2.3 of this report, we presented the emission factors that were used in this study. The emission factors (see Table 2.2) came from a summary of EPA and U.S. Department of Energy reports that the EPA commissioned from the Leonardo Academy (2002). The method of computation simply multiplied the energy savings separately for each fuel in each county to arrive at the emission reduction attributable to that county's energy conservation.

6.2 Estimated Environmental Consequences of Energy Improvements

The tables presented below show emission reductions resulting from the conservation and energy efficiency measures described in Chapter 4. The units for the pollutants are defined so as the limit the number of trailing zeroes or non-significant digits. Carbon dioxide is given in thousands of metric tons. Carbon monoxide, nitrogen oxides, sulfur dioxide, coarse particulate matter, and VOC are shown in thousands of pounds. Mercury is presented in the tables in terms of pounds. The tables show the total reduction of each pollutant from energy savings of the four fuels.

Table 6.1: Pollution Reductions from Conservation for Northeast Counties

County	CO_2	CO	NO_x	SO_2	Mercury	PM 10	VOC
Boone	56	19	344	878	3	7	3
Cook	6,276	2,159	37,409	91,343	288	701	362
DeKalb	111	37	677	1,715	5	13	6
DuPage	984	329	6,166	15,696	50	117	53
Grundy	54	18	339	869	3	6	3
Kane	479	163	2,896	7,162	23	55	27
Kendall	68	23	418	1,066	3	8	4
La Salle	179	61	1,069	2,650	8	20	10
Lake	718	240	4,484	11,388	36	85	39
McHenry	315	106	1,936	4,864	15	37	17
Will	585	198	3,592	9,020	28	68	32
Total	9,825	3,353	59,330	146,651	462	1,117	556

Units: Carbon dioxide is in thousands of metric tons; mercury is in pounds; and all other pollutants are in thousands of pounds.

Table 6.2: Pollution Reductions from Conservation for Northwest Counties

County	CO_2	CO	NO_x	SO_2	Mercury	PM 10	VOC
Bureau	62	21	364	910	3	7	3
Carroll	31	11	186	478	1	4	2
Henry	85	29	510	1,271	4	10	5
Jo Daviess	42	14	254	671	2	5	2
Lee	55	19	333	845	3	6	3
Mercer	29	10	177	455	1	3	2
Ogle	76	26	465	1,189	4	9	4
Putnam	11	4	66	172	1	1	1
Rock Island	231	79	1,377	3,377	11	26	13
Stephenson	81	28	491	1,243	4	9	5
Whiteside	96	33	581	1,462	5	11	5
Winnebago	395	136	2,359	5,784	18	44	23
Total	1,194	410	7,163	17,857	57	135	68

Units: Carbon dioxide is in thousands of metric tons; mercury is in pounds; and all other pollutants are in thousands of pounds.

Table 6.3: Pollution Reductions from Conservation for East Counties

County	CO_2	CO	NO_x	SO_2	Mercury	PM 10	VOC
Champaign	363	117	2,391	6,345	20	46	18
Ford	37	12	236	621	2	5	2
Iroquois	82	27	533	1,417	4	10	4
Kankakee	226	73	1,470	3,865	12	28	12
Livingston	91	30	590	1,554	5	11	5
Piatt	41	13	269	707	2	5	2
Vermilion	210	68	1,358	3,569	11	26	11
Total	1,050	340	6,847	18,078	56	131	54

Units: Carbon dioxide is in thousands of metric tons; mercury is in pounds; and all other pollutants are in thousands of pounds.

Table 6.4: Pollution Reductions from Conservation for Central Counties

County	CO_2	CO	NO_x	SO_2	Mercury	PM 10	VOC
De Witt	45	15	288	754	2	6	2
Logan	71	23	459	1,204	4	9	4
Macon	281	92	1,801	4,687	15	34	15
Marshall	37	12	235	624	2	5	2
Mason	45	15	294	784	2	6	2
McLean	311	101	2,020	5,307	17	39	16
Menard	33	11	214	567	2	4	2
Peoria	424	139	2,722	7,083	22	52	22
Stark	18	6	113	298	1	2	1
Tazewell	299	97	1,931	5,053	16	37	15
Woodford	82	26	529	1,397	4	10	4
Total	1,646	537	10,606	27,758	87	204	85

Units: Carbon dioxide is in thousands of metric tons; mercury is in pounds; and all other pollutants are in thousands of pounds.

Table 6.5: Pollution Reductions from Conservation for West Counties

County	CO_2	CO	NO_x	SO_2	Mercury	PM 10	VOC
Adams	170	55	1,099	2,889	9	21	9
Brown	15	5	97	259	1	2	1
Fulton	100	33	639	1,673	5	12	5
Hancock	56	18	363	972	3	7	3
Henderson	25	8	165	443	1	3	1
Knox	138	45	875	2,268	7	17	7
McDonough	76	25	501	1,331	4	10	4
Schuyler	20	6	132	356	1	3	1
Warren	47	15	300	787	2	6	2
Total	647	210	4,171	10,978	33	81	33

Units: Carbon dioxide is in thousands of metric tons; mercury is in pounds; and all other pollutants are in thousands of pounds.

Table 6.6: Pollution Reductions from Conservation for East Southeast Counties

County	CO_2	CO	NO_x	SO_2	Mercury	PM 10	VOC
Clark	49	16	326	884	3	6	2
Clay	39	12	260	703	2	5	2
Coles	127	41	839	2,235	7	16	6
Crawford	54	17	354	942	3	7	3
Cumberland	31	10	212	578	2	4	1
Douglas	49	16	321	855	3	6	2
Edgar	52	17	343	913	3	7	3
Effingham	80	25	536	1,450	5	10	4
Fayette	56	18	375	1,015	3	7	3
Jasper	28	9	190	519	2	4	1
Lawrence	44	14	287	768	2	6	2
Marion	107	34	709	1,903	6	14	5
Moultrie	36	12	234	621	2	4	2
Richland	44	14	289	777	2	6	2
Shelby	64	20	426	1,149	4	8	3
Total	860	275	5,701	15,312	49	110	41

Units: Carbon dioxide is in thousands of metric tons; mercury is in pounds; and all other pollutants are in thousands of pounds.

Table 6.7: Pollution Reductions from Conservation for West Southwest Counties

County	CO_2	CO	NO_x	SO_2	Mercury	PM 10	VOC
Bond	41	13	271	734	2	5	2
Calhoun	17	5	114	314	1	2	1
Cass	36	12	235	624	2	5	2
Christian	91	30	591	1,557	5	11	5
Greene	40	13	258	685	2	5	2
Jersey	54	17	359	972	3	7	3
Macoupin	132	42	862	2,294	7	17	7
Madison	622	201	4,072	10,739	34	78	31
Montgomery	79	25	512	1,358	4	10	4
Morgan	88	28	575	1,527	5	11	4
Pike	48	16	315	843	3	6	2
Sangamon	463	149	3,037	8,027	25	58	23
Scott	16	5	104	279	1	2	1
Total	1,727	556	11,305	29,953	94	217	87

Units: Carbon dioxide is in thousands of metric tons; mercury is in pounds; and all other pollutants are in thousands of pounds.

Table 6.8: Pollution Reductions from Conservation for Southeast Counties

County	CO_2	CO	NO_x	SO_2	Mercury	PM 10	VOC
Edwards	19	6	127	345	1	2	1
Franklin	105	34	705	1,901	6	14	5
Gallatin	18	6	125	339	1	2	1
Hamilton	24	8	164	447	1	3	1
Hardin	14	4	92	252	1	2	1
Jefferson	97	31	656	1,784	6	13	5
Massac	40	13	271	735	2	5	2
Pope	13	4	90	248	1	2	1
Saline	71	23	476	1,284	4	9	3
Wabash	33	10	221	604	2	4	2
Wayne	49	15	332	910	3	6	2
White	44	14	297	804	3	6	2
Total	527	168	3,556	9,653	31	68	26

Units: Carbon dioxide is in thousands of metric tons; mercury is in pounds; and all other pollutants are in thousands of pounds.

Table 6.9: Pollution Reductions from Conservation for Southwest Counties

County	CO_2	CO	NO_x	SO_2	Mercury	PM 10	VOC
Alexander	26	8	177	480	2	3	1
Clinton	81	26	549	1,490	5	11	4
Jackson	137	43	933	2,542	8	18	6
Johnson	29	9	201	556	2	4	1
Monroe	63	20	427	1,162	4	8	3
Perry	54	17	364	987	3	7	3
Pulaski	20	6	136	371	1	3	1
Randolph	78	25	526	1,430	4	10	4
St. Clair	540	172	3,601	9,629	30	69	26
Union	46	14	309	844	3	6	2
Washington	39	12	261	710	2	5	2
Williamson	154	49	1,037	2,811	9	20	7
Total	1,267	401	8,521	23,012	73	164	60

Units: Carbon dioxide is in thousands of metric tons; mercury is in pounds; and all other pollutants are in thousands of pounds.

7. CONCLUSIONS

In this report, we have presented findings from an analysis of residential energy use in Illinois. The analysis has made use of the latest information from the 2000 U.S. Census and the most recent Residential Energy Consumption Survey of the U.S. Department of Energy. Our approach enabled estimates to be made on the geographically disaggregated basis of the 102 counties of Illinois. The analysis also developed estimates of the local opportunities for conservation and energy efficiency measures within the residential sector along with the associated utility bill savings and environmental benefits.

This project has shown that it is possible to create a geographically disaggregated analysis of residential energy consumption by combining the information available in two sources. The 2000 Census provides rich detail on the housing stock on a county level. Information on a census tract level could have been used, but that approach would have become unwieldy. The microdata information presented in the RECS offered a basis for computing average energy intensities for Midwestern households living in buildings of different vintages and different building types. Energy intensities were developed for various end uses. As more information from the 2000 Census becomes available, particularly the economic information associated with the 10 percent sampling and the microdata files, this approach of using combined information sources will likely prove even more fruitful.

The project has found that conservation and energy efficiency opportunities in the residential sector are very substantial. In the analysis, we have specified and estimated five measures. The measures include envelope and furnace improvements that reduce space heating requirements, envelope and air conditioning efficiency or sizing improvements that reduce the electricity needed for space cooling, electricity water heater conversions in residences that have natural gas connections or use LPG for space heating, replacement of incandescent light bulbs with compact fluorescent bulbs in high use areas, and replacement of high energy use refrigerators. The results of these measures lowered residential natural gas consumption by 11.7 percent, home oil use by 18 percent, household LPG use by 1.9 percent, and residential electricity consumption by 15.9 percent.

Associated with the conservation and energy efficiency opportunities, the residential sector will save approximately $1.06 billion in utility bills. Sixty-three percent of the savings comes from electricity bill reductions, and savings for natural gas customers represents thirty-five percent of the lower spending. Most of this savings would be associated with lowering energy use, but some would be due to shifting residential energy consumption from relatively high cost electricity to natural gas and LPG for heating water.

In addition to the benefit to residential customers from utility bill reductions, the

conservation and energy efficiency measures significantly reduce emissions of harmful pollutants. We looked at emissions only from burning fossil fuels, and no estimates were made for reductions in spent nuclear fuel or the by-products of alternative energy sources. Nevertheless, we found that over 6 million pounds of carbon monoxide, over 117 million pounds of NOx, nearly 2.23 million pounds of coarse particulate matter, and more than 1 million pounds of VOC would not be released into the local areas. In addition, with such conservation and energy efficiency efforts, Illinois would not emit nearly 300 million pounds of sulfur dioxide and 942 pounds of mercury into the atmosphere to damage the lakes and forests of eastern states and Canada. Finally, energy measures like those examined here would lower fossil fuel emissions of the major greenhouse gas carbon dioxide by over 18.7 million metric tons.

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Appendix A

Computer Code to Estimate Energy Use in 2002 by County, Fuel Type, and Housing Type

```
open(INFILE1, "il1.csv") ;
open(INFILE2, "il2.csv") ;
open(MAINOUT, ">initial.csv") ;
# ----------------------------------------------------------------
# Read in county identifiers and weather
  $a = <INFILE1> ;
  chomp $a ;
  @a = split(/,/, $a) ;
  @id[0] = @a[0] ; @cnty[0] = @a[1] ; @id2[0] = @a[2] ; @reg[0] = @a[3] ;
  @cdh[0] = @a[4] ; @hdd[0] = @a[5] ;
 $j = 1 ;
 while (eof(INFILE1) !=1) {
  $a = <INFILE1> ;
  chomp $a ;
  @a = split(/,/, $a) ;
  @id[$j] = @a[0] ; @cnty[$j] = @a[1] ; @id2[$j] = @a[2] ; @reg[$j] = @a[3] ;
  @cdh[$j] = @a[4] ; @hdd[$j] = @a[5] ;
 $j++ ;
   }
# ----------------------------------------------------------------
# Read in Census information: cnty id, cnty, no. of housing units, no. of occupied housing
#  units, no. of single family detached units, no. of single family attached units, no. of
#  multifamily units in bldgs w/ 2 apts, no. of multifamily units in bldgs w/ 3 or 4 apts,
#  no. of units in bldgs w/ 5 to 9 apts, no. of units in bldgs w/ 10 to 19 units, no. of
#  units in bldgs w/ 20 to 49 apts, no. of units in bldgs w/ 50 or more apts, no. of
#  mobile homes, no. of units in other types of structures, no. of units
#  using utility gas for space heat, no. of units using lpg or bottled gas for sh, no. of
#  units using electricity for sh, no. of units using oil or its derivatives for sh, no. of
#  units using coal or coke for sh, no. of units using wood for sh, no. of units using
#  solar energy for sh, no. of units using any other fuel for sh, and no. of units using
#  no fuel for sh
  $a = <INFILE2> ;
  chomp $a ;
  @a = split(/,/, $a) ;
  @id3[0] = @a[0] ; @hunits[0] = @a[2] ; @occ[0] = @a[3] ; @sfd[0] = @a[4] ;
  @sfa[0] = @a[5] ; @mfs[0] = "mf 2 to 9" ; @mfl[0] = "mf 10 & up" ;
  @mh[0] = "mh" ; @ng[0] = @a[14] ; @oil[0] = "oil" ; @lpg[0] = "lpg" ; @elec[0] = @a[16] ;
 $j = 1 ;
 while (eof(INFILE2) !=1) {
 $a = <INFILE2> ;
  chomp $a ;
  @a = split(/,/, $a) ;
  @id3[$j] = @a[0] ; @hunits[$j] = @a[2] ; @occ[$j] = @a[3] ; @sfd[$j] = @a[4] ;
  @sfa[$j] = @a[5] ; @mfs[$j] = @a[6]+@a[7]+@a[8] ; @mfl[$j] = @a[9]+@a[10]+@a[11] ;
  @mh[$j] = @a[12]+@a[13] ; @ng[$j] = @a[14] ; @oil[$j] = @a[17]+@a[18]+@a[19]+@a[21] ;
```

```
  @lpg[$j] = @a[15]+@a[22] ; @elec[$j] = @a[16]+@a[20] ;
 $j++ ;
   }
# ----------------------------------------------------------------
# Create names for housing type/space heat types
  @sfdng[0]='sfdng' ; @sfang[0]='sfang' ; @mfsng[0]='mfsng' ; @mflng[0]='mflng' ; @mhng[0]='mhng' ;
  @sfdoil[0]='sfdoil' ; @sfaoil[0]='sfaoil' ; @mfsoil[0]='mfsoil' ; @mfloil[0]='mfloil' ; @mhoil[0]='mhoil' ;
  @sfdlpg[0]='sfdlpg' ; @sfalpg[0]='sfalpg' ; @mfslpg[0]='mfslpg' ; @mfllpg[0]='mfllpg' ; @mhlpg[0]='mhlpg' ;
  @sfdelec[0]='sfdelec' ; @sfaelec[0]='sfaelec' ; @mfselec[0]='mfselec' ; @mflelec[0]='mflelec' ;
@mhelec[0]='mhelec' ;
# ----------------------------------------------------------------
# Loop through all counties
   for($j = 1 ; $j < @id ; $j++) {
## Test that counties of both files lined up correctly
    if(@id[$j] ne @id3[$j]) {
      print "Error", " ", @id[$j], "    ", @id3[$j], "\n" ;
        }
## ----------------------------------------------------------------
# Estimate no. of units using different major fuels by housing type
#  The estimate is made by multiplying the no. of units in each county using the different
#  fuels by the ratio of number of units in housing type category in the county by
#  the total number of housing units in that county
    @sfang[$j] = int(.5 + @ng[$j]*@sfa[$j]/@hunits[$j]) ;
    @mfsng[$j] = int(.5 + @ng[$j]*@mfs[$j]/@hunits[$j]) ;
    @mflng[$j] = int(.5 + @ng[$j]*@mfl[$j]/@hunits[$j]) ;
    @mhng[$j] = int(.5 + @ng[$j]*@mh[$j]/@hunits[$j]) ;
    @sfdng[$j] = @ng[$j] - @sfang[$j] - @mfsng[$j] - @mflng[$j] - @mhng[$j] ;
    @sfaoil[$j] = int(.5 + @oil[$j]*@sfa[$j]/@hunits[$j]) ;
    @mfsoil[$j] = int(.5 + @oil[$j]*@mfs[$j]/@hunits[$j]) ;
    @mfloil[$j] = int(.5 + @oil[$j]*@mfl[$j]/@hunits[$j]) ;
    @mhoil[$j] = int(.5 + @oil[$j]*@mh[$j]/@hunits[$j]) ;
    @sfdoil[$j] = @oil[$j] - @sfaoil[$j] - @mfsoil[$j] - @mfloil[$j] - @mhoil[$j] ;
    @sfalpg[$j] = int(.5 + @lpg[$j]*@sfa[$j]/@hunits[$j]) ;
    @mfslpg[$j] = int(.5 + @lpg[$j]*@mfs[$j]/@hunits[$j]) ;
    @mfllpg[$j] = int(.5 + @lpg[$j]*@mfl[$j]/@hunits[$j]) ;
    @mhlpg[$j] = int(.5 + @lpg[$j]*@mh[$j]/@hunits[$j]) ;
    @sfdlpg[$j] = @lpg[$j] - @sfalpg[$j] - @mfslpg[$j] - @mfllpg[$j] - @mhlpg[$j] ;
    @sfaelec[$j] = int(.5 + @elec[$j]*@sfa[$j]/@hunits[$j]) ;
    @mfselec[$j] = int(.5 + @elec[$j]*@mfs[$j]/@hunits[$j]) ;
    @mflelec[$j] = int(.5 + @elec[$j]*@mfl[$j]/@hunits[$j]) ;
    @mhelec[$j] = int(.5 + @elec[$j]*@mh[$j]/@hunits[$j]) ;
    @sfdelec[$j] = @elec[$j] - @sfaelec[$j] - @mfselec[$j] - @mflelec[$j] - @mhelec[$j] ;
  }
# ----------------------------------------------------------------
# Print out the no. of units in each housing type/sh fuel type category
 $oldhandle = select MAINOUT ;
 for($j = 0 ; $j < @id ; $j++) {
  print @id[$j], ',' , @cnty[$j], ',', @reg[$j], ',' ;
  print @sfdng[$j], ',', @sfang[$j], ',', @mfsng[$j], ',', @mflng[$j], ',', @mhng[$j], ',' ;
  print @sfdoil[$j], ',', @sfaoil[$j], ',', @mfsoil[$j], ',', @mfloil[$j], ',', @mhoil[$j], ',' ;
  print @sfdlpg[$j], ',', @sfalpg[$j], ',', @mfslpg[$j], ',', @mfllpg[$j], ',', @mhlpg[$j], ',' ;
```

```
  print @sfdelec[$j], ',', @sfaelec[$j], ',', @mfselec[$j], ',', @mflelec[$j], ',', @mhelec[$j],  "\n" ;
   }
# ----------------------------------------------------------------
# Create names for the energy consumed for each sh housing type/ fuel type category
    @sfdshng[0] = 'sfdshng' ; @sfashng[0] = 'sfashng' ; @mfsshng[0] = 'mfsshng' ;
    @mflshng[0] = 'mflshng' ; @mhshng[0] = 'mhshng' ;
    @sfdshoil[0] = 'sfdshoil' ; @sfashoil[0] = 'sfashoil' ; @mfsshoil[0] = 'mfsshoil' ;
    @mflshoil[0] = 'mflshoil' ; @mhshoil[0] = 'mhshoil' ;
    @sfdshlpg[0] = 'sfdshlpg' ; @sfashlpg[0] = 'sfashlpg' ; @mfsshlpg[0] = 'mfsshlpg' ;
    @mflshlpg[0] = 'mflshlpg' ; @mhshlpg[0] = 'mhshlpg' ;
    @sfdshelec[0] = 'sfdshelec' ; @sfashelec[0] = 'sfashelec' ; @mfsshelec[0] = 'mfsshelec' ;
    @mflshelec[0] = 'mflshelec' ; @mhshelec[0] = 'mhshelec' ;
# ----------------------------------------------------------------
# Estimate million btus for space heating by fuel and housing type
#  The estimate is based on the average (weighted) btus per hdd per square feet for each
#  fuel and housing type in RECS multiplied by the no. of units in that group, the hdd, and
#  the average square feet of that housing type.  Some groups are zeroed out for
#  suspiciously small groups.
 for($j = 1 ; $j < @id ; $j++) {
    @sfdshng[$j] = 7.804 * @sfdng[$j] * @hdd[$j] * 2306/1000000. ;
    @sfashng[$j] = 8.811 * @sfang[$j] * @hdd[$j] * 1599/1000000. ;
    @mfsshng[$j] = 14.425 * @mfsng[$j] * @hdd[$j] * 1010/1000000. ;
    @mflshng[$j] = 7.904 * @mflng[$j] * @hdd[$j] * 808/1000000. ;
    @mhshng[$j] = 16.178 * @mhng[$j] * @hdd[$j] * 849/1000000. ;
    @sfdshoil[$j] = 8.073 * @sfdoil[$j] * @hdd[$j] * 2306/1000000. ;
    @sfashoil[$j] = 0. ;
    @mfsshoil[$j] = 0. ;
    @mflshoil[$j] = 0. ;
    @mhshoil[$j] = 0. ;
    @sfdshlpg[$j] = 5.996 * @sfdlpg[$j] * @hdd[$j] * 2306/1000000. ;
    @sfashlpg[$j] = 9.054 * @sfalpg[$j] * @hdd[$j] * 1599/1000000. ;
    @mfsshlpg[$j] = 0. ;
    @mflshlpg[$j] = 0. ;
    @mhshlpg[$j] = 9.192 * @mhlpg[$j] * @hdd[$j] * 849/1000000. ;
    @sfdshelec[$j] = .874 * @sfdelec[$j] * @hdd[$j] * 2306/1000000. ;
    @sfashelec[$j] = 1.911 * @sfaelec[$j] * @hdd[$j] * 1599/1000000. ;
    @mfsshelec[$j] = 3.552 * @mfselec[$j] * @hdd[$j] * 1010/1000000. ;
    @mflshelec[$j] = 1.486 * @mflelec[$j] * @hdd[$j] * 808/1000000. ;
    @mhshelec[$j] = 5.133 * @mhelec[$j] * @hdd[$j] * 849/1000000. ;
  }
# ----------------------------------------------------------------
# Print out the space heat energy estimates for each county by housing type & fuel type
 for($j = 0 ; $j < @id ; $j++) {
  print @id[$j], ',' , @cnty[$j], ',', @reg[$j], ',' ;
  print @sfdshng[$j], ',', @sfashng[$j], ',', @mfsshng[$j], ',', @mflshng[$j], ',', @mhshng[$j], "," ;
  print @sfdshoil[$j], ',', @sfashoil[$j], ',', @mfsshoil[$j], ',', @mflshoil[$j], ',', @mhshoil[$j], "," ;
  print @sfdshlpg[$j], ',', @sfashlpg[$j], ',', @mfsshlpg[$j], ',', @mflshlpg[$j], ',', @mhshlpg[$j], "," ;
  print @sfdshelec[$j], ',', @sfashelec[$j], ',', @mfsshelec[$j], ',', @mflshelec[$j], ',', @mhshelec[$j], "\n" ;
   }
# ----------------------------------------------------------------
# Create names for the energy consumed for wh by housing type & fuel type category
```

```
   @sfdwhng[0] = 'sfdwhng' ; @sfawhng[0] = 'sfawhng' ; @mfswhng[0] = 'mfswhng' ;
   @mflwhng[0] = 'mflwhng' ; @mhwhng[0] = 'mhwhng' ;
   @sfdwhoil[0] = 'sfdwhoil' ; @sfawhoil[0] = 'sfawhoil' ; @mfswhoil[0] = 'mfswhoil' ;
   @mflwhoil[0] = 'mflwhoil' ; @mhwhoil[0] = 'mhwhoil' ;
   @sfdwhlpg[0] = 'sfdwhlpg' ; @sfawhlpg[0] = 'sfawhlpg' ; @mfswhlpg[0] = 'mfswhlpg' ;
   @mflwhlpg[0] = 'mflwhlpg' ; @mhwhlpg[0] = 'mhwhlpg' ;
   @sfdwhelec[0] = 'sfdwhelec' ; @sfawhelec[0] = 'sfawhelec' ; @mfswhelec[0] = 'mfswhelec' ;
   @mflwhelec[0] = 'mflwhelec' ; @mhwhelec[0] = 'mhwhelec' ;
# ----------------------------------------------------------------
# Estimate the million btus used for water heating by fuel and housing type
#  The estimate is made in two passes
 for($j = 1 ; $j < @id ; $j++) {
## In the first pass we estimate the number of units use the different fuels based on RECS
   @sfdwhng[$j] = @sfdng[$j]*352/401 ;  # 352 of the 401 sfd that sh w/ ng have ng for wh
   @sfawhng[$j] = @sfang[$j]*47/51 + @sfaoil[$j]*1/2 + @sfaelec[$j]*2/4 ;  # 47 of the 51 sfa that sh w/ ng & 1 of the 2 sfa that sh w/ oil & 2 of the 4 sfa that sh w/ elec have ng for wh
   @mfswhng[$j] = @mfsng[$j]*41/43 + @mfslpg[$j] ;  # 41 of the 43 mfs that sh w/ ng & all of the mfs that sh w/ lpg have ng for wh
   @mflwhng[$j] = @mflng[$j] + @mfllpg[$j] + @mflelec[$j]*4/36 ;  # all of the mfl that sh w/ ng or lpg & 4 of the 36 mfl that sh w/ elec have ng for wh
   @mhwhng[$j] = @mhng[$j]*16/27 + @mhelec[$j]*1/7 ;  # 16 of the 27 mh that sh w/ ng & 1 of the 7 mh that sh w/ elec have ng for wh
   @sfdwhoil[$j] = @sfdoil[$j]*4/29 ;  # 4 of the 29 sfd that sh w/ oil have oil for wh
   @sfawhoil[$j] = 0. ;
   @mfswhoil[$j] = 0. ;
   @mflwhoil[$j] = 0. ;
   @mhwhoil[$j] = 0. ;
   @sfdwhlpg[$j] = @sfdlpg[$j]*26/43 ;  # 26 of the 43 sfd that sh w/ lpg have lpg for wh
   @sfawhlpg[$j] = @sfalpg[$j] ;  # all sfa that use lpg for sh also use lpg for wh
   @mfswhlpg[$j] = 0. ;
   @mflwhlpg[$j] = 0. ;
   @mhwhlpg[$j] = @mhlpg[$j]*2/8 ;  # 2 of the 8 mh that sh w/ lpg have lpg for wh
   @sfdwhelec[$j] = @sfdng[$j]*49/401 + @sfdoil[$j]*25/29 + @sfdlpg[$j]*17/43 + @sfdelec[$j] ;
   @sfawhelec[$j] = @sfang[$j]*4/51 + @sfaoil[$j]*1/2 + @sfaelec[$j]*2/4 ;
   @mfswhelec[$j] = @mfsng[$j]*2/43 + @mfsoil[$j] + @mfselec[$j] ;
   @mflwhelec[$j] = @mfloil[$j] + @mflelec[$j]*32/36 ;
   @mhwhelec[$j] = @mhng[$j]*11/27 + @mhoil[$j] + @mhlpg[$j]*6/8 + @mhelec[$j]*6/7 ;
## ----------------------------------------------------------------
## In the second pass we estimate the energy usage in million btus for wh by the different fuels and housing types
   @sfdwhng[$j] = @sfdwhng[$j]*.76*365*.1 ;
   @sfawhng[$j] = @sfawhng[$j]*.709*365*.1 ;
   @mfswhng[$j] = @mfswhng[$j]*.697*365*.1 ;
   @mflwhng[$j] = @mflwhng[$j]*.619*365*.1 ;
   @mhwhng[$j] = @mhwhng[$j]*.853*365*.1 ;
   @sfdwhoil[$j] = @sfdwhoil[$j]*.75*365*.1 ;
   @sfdwhlpg[$j] = @sfdwhlpg[$j]*.81*365*.1 ;
   @sfawhlpg[$j] = @sfawhlpg[$j]*.81*365*.1 ;
   @mhwhlpg[$j] = @mhwhlpg[$j]*.81*365*.1 ;
   @sfdwhelec[$j] = @sfdwhelec[$j]*.31*365*.1 ;
   @sfawhelec[$j] = @sfawhelec[$j]*.209*365*.1 ;
   @mfswhelec[$j] = @mfswhelec[$j]*.178*365*.1 ;
```

```
    @mflwhelec[$j] = @mflwhelec[$j]*.16*365*.1 ;
    @mhwhelec[$j] = @mhwhelec[$j]*.269*365*.1 ;
## ----------------------------------------------------------------
  }
# ----------------------------------------------------------------
# Print out the energy used for water heating in each county by housing type & fuel type
 for($j = 0 ; $j < @id ; $j++) {
  print @id[$j], ',' , @cnty[$j], ',', @reg[$j], ',' ;
  print @sfdwhng[$j], ',', @sfawhng[$j], ',', @mfswhng[$j], ',', @mflwhng[$j], ',', @mhwhng[$j], "," ;
  print @sfdwhoil[$j], ',', @sfawhoil[$j], ',', @mfswhoil[$j], ',', @mflwhoil[$j], ',', @mhwhoil[$j], "," ;
  print @sfdwhlpg[$j], ',', @sfawhlpg[$j], ',', @mfswhlpg[$j], ',', @mflwhlpg[$j], ',', @mhwhlpg[$j], "," ;
  print @sfdwhelec[$j], ',', @sfawhelec[$j], ',', @mfswhelec[$j], ',', @mflwhelec[$j], ',', @mhwhelec[$j], "\n" ;
   }
# ----------------------------------------------------------------
# Create names for the energy consumed for cooking by housing type & fuel used
    @sfdckng[0] =   'sfdckng' ;   @sfackng[0] =   'sfackng' ;   @mfsckng[0] =   'mfsckng' ;
    @mflckng[0] =   'mflckng' ;    @mhckng[0] =    'mhckng' ;
    @sfdckoil[0] =  'sfdckoil' ;  @sfackoil[0] =  'sfackoil' ;  @mfsckoil[0] =  'mfsckoil' ;
    @mflckoil[0] =  'mflckoil' ;   @mhckoil[0] =   'mhckoil' ;
    @sfdcklpg[0] =  'sfdcklpg' ;  @sfacklpg[0] =  'sfacklpg' ;  @mfscklpg[0] =  'mfscklpg' ;
    @mflcklpg[0] =  'mflcklpg' ;   @mhcklpg[0] =   'mhcklpg' ;
    @sfdckelec[0] = 'sfdckelec' ; @sfackelec[0] = 'sfackelec' ; @mfsckelec[0] =  'mfsckelec' ;
    @mflckelec[0] = 'mflckelec' ;  @mhckelec[0] =  'mhckelec' ;
# ----------------------------------------------------------------
# Estimate the million btus used for cooking by fuel and housing type
#  The estimate is made in two passes
 for($j = 1 ; $j < @id ; $j++) {
## In the first pass we estimate the number of units use the different fuels based on RECS
    @sfdckng[$j] = @sfdng[$j]*230/401 + @sfdoil[$j]*1/32 + @sfdelec[$j]*1/33 ;
    @sfackng[$j] = @sfang[$j]*32/51 ;
    @mfsckng[$j] = @mfsng[$j]*27/43 ;
    @mflckng[$j] = @mflng[$j]*31/59 + @mfloil[$j] + @mfllpg[$j] + @mflelec[$j]*2/36 ;
     @mhckng[$j] = @mhng[$j]*21/27 + @mhelec[$j]*1/7 ;
    @sfdckoil[$j] = @sfdoil[$j]*3/32 ;
    @sfackoil[$j] = 0. ;
    @mfsckoil[$j] = 0. ;
    @mflckoil[$j] = 0. ;
     @mhckoil[$j] = 0. ;
    @sfdcklpg[$j] = @sfdoil[$j]*4/32 + @sfdlpg[$j]*18/43 ;
    @sfacklpg[$j] = @sfalpg[$j]*2/4 ;
    @mfscklpg[$j] = 0. ;
    @mflcklpg[$j] = 0. ;
     @mhcklpg[$j] = @mhlpg[$j]*4/8 ;
    @sfdckelec[$j] = @sfdng[$j]*171/401 + @sfdoil[$j]*24/32 + @sfdlpg[$j]*25/43 + @sfdelec[$j]*32/33 ;
    @sfackelec[$j] = @sfang[$j]*19/51 + @sfaoil[$j] + @sfalpg[$j]*2/4 + @sfaelec[$j] ;
    @mfsckelec[$j] = @mfsng[$j]*16/43 + @mfsoil[$j]+ @mfslpg[$j]+ @mfselec[$j] ;
    @mflckelec[$j] = @mflng[$j]*28/59 + @mflelec[$j]*34/36 ;
    @mhckelec[$j] = @mhng[$j]*6/27 + @mhoil[$j] + @mhlpg[$j]*4/8 + @mhelec[$j]*6/7 ;
## ----------------------------------------------------------------
## In the second pass we estimate the energy usage in million btus for ck by the different fuels and housing types
    @sfdckng[$j] =   @sfdckng[$j]*10766./1000 ;
```

```
   @sfackng[$j] =   @sfackng[$j]*9595./1000 ;
   @mfsckng[$j] =   @mfsckng[$j]*9894./1000 ;
   @mflckng[$j] =   @mflckng[$j]*6698./1000 ;
    @mhckng[$j] =    @mhckng[$j]*7023./1000 ;
   @sfdckoil[$j] =  @sfdckoil[$j]*10766./1000 ;
   @sfdcklpg[$j] =  @sfdcklpg[$j]*6977./1000 ;
   @sfacklpg[$j] =  @sfacklpg[$j]*6977./1000 ;
    @mhcklpg[$j] =   @mhcklpg[$j]*6977./1000 ;
   @sfdckelec[$j] = @sfdckelec[$j]*1653./1000 ;
   @sfackelec[$j] = @sfackelec[$j]*1120./1000 ;
   @mfsckelec[$j] = @mfsckelec[$j]*1058./1000 ;
   @mflckelec[$j] = @mflckelec[$j]*931./1000 ;
    @mhckelec[$j] =  @mhckelec[$j]*1829./1000 ;
## ------------------------------------------------------------------
  }
# ------------------------------------------------------------------
# Print out the energy used for cooking in each county by housing type & fuel type
 for($j = 0 ; $j < @id ; $j++) {
  print @id[$j], ',' , @cnty[$j], ',', @reg[$j], ',' ;
  print @sfdckng[$j], ',', @sfackng[$j], ',', @mfsckng[$j], ',', @mflckng[$j], ',', @mhckng[$j], "," ;
  print @sfdckoil[$j], ',', @sfackoil[$j], ',', @mfsckoil[$j], ',', @mflckoil[$j], ',', @mhckoil[$j], "," ;
  print @sfdcklpg[$j], ',', @sfacklpg[$j], ',', @mfscklpg[$j], ',', @mflcklpg[$j], ',', @mhcklpg[$j], "," ;
  print @sfdckelec[$j], ',', @sfackelec[$j], ',', @mfsckelec[$j], ',', @mflckelec[$j], ',', @mhckelec[$j], "\n" ;
   }
# ------------------------------------------------------------------
# Create names for elec. energy consumed for each housing type for lighting, AC, & refrigeration
  @sfdlight[0] = 'sfdlights' ; @sfdac[0] = 'sfdac' ; @sfdref[0] = 'sfdref' ;
  @sfalight[0] = 'sfalights' ; @sfaac[0] = 'sfaac' ; @sfaref[0] = 'sfaref' ;
  @mfslight[0] = 'mfslights' ; @mfsac[0] = 'mfsac' ; @mfsref[0] = 'mfsref' ;
  @mfllight[0] = 'mfllights' ; @mflac[0] = 'mflac' ; @mflref[0] = 'mflref' ;
  @mhlight[0] = 'mhlights' ; @mhac[0] = 'mhac' ; @mhref[0] = 'mhref' ;
# ------------------------------------------------------------------
# Estimate the million btus of elec. used for lighting, AC, and refrigeration by housing type
for($j = 1 ; $j < @id ; $j++) {
 @sfdlight[$j] = @sfd[$j] * 22264/1000. ;
 @sfalight[$j] = @sfa[$j] * 14782/1000. ;
 @mfslight[$j] = @mfs[$j] * 11049/1000. ;
 @mfllight[$j] = @mfl[$j] * 7895/1000. ;
 @mhlight[$j] = @mh[$j] * 15380/1000. ;
 @sfdac[$j] = @sfd[$j] * 4.095*@cdh[$j]/(1000*24.) ;
 @sfaac[$j] = @sfa[$j] * 2.190*@cdh[$j]/(1000*24.) ;
 @mfsac[$j] = @mfs[$j] * 1.521*@cdh[$j]/(1000*24.) ;
 @mflac[$j] = @mfl[$j] * 1.312*@cdh[$j]/(1000*24.) ;
 @mhac[$j] = @mh[$j] * 3.581*@cdh[$j]/(1000*24.) ;
 @sfdref[$j] = @sfd[$j] * 4649/1000. ;
 @sfaref[$j] = @sfa[$j] * 3257/1000. ;
 @mfsref[$j] = @mfs[$j] * 3406/1000. ;
 @mflref[$j] = @mfl[$j] * 2738/1000. ;
 @mhref[$j] =  @mh[$j] * 3747/1000. ;
  }
# ------------------------------------------------------------------
```

```
# Print out the lighting, AC, and refrigeration elec. energy use for each county by housing type
 for($j = 0 ; $j < @id ; $j++) {
  print @id[$j], ',' , @cnty[$j], ',', @reg[$j], ',' ;
  print @sfdlight[$j], ',', @sfalight[$j], ',', @mfslight[$j], ',', @mfllight[$j], ',', @mhlight[$j], "," ;
  print @sfdac[$j], ',', @sfdac[$j], ',', @mfsac[$j], ',', @mflac[$j], ',', @mhac[$j], "," ;
  print @sfdref[$j], ',', @sfaref[$j], ',', @mfsref[$j], ',', @mflref[$j], ',', @mhref[$j], "\n" ;
   }
# ------------------------------------------------------------------
close (INFILE1) ;
close (INFILE2) ;
open(FINAL,">est2002.csv") ;
$oldhandle = select FINAL ;
close (MAINOUT) ;
# ------------------------------------------------------------------
# Sum over fuels
  $totng = 0 ; $totoil = 0 ; $totlpg = 0 ; $totelec = 0 ;
  @tng[0] = 'ng' ; @toil[0] = 'oil' ; @tlpg[0] = 'lpg' ; @telec[0] = 'elec' ;
for($j = 1 ; $j < @id ; $j++) {
  @tng[$j] =
@sfdshng[$j]+@sfashng[$j]+@mfsshng[$j]+@mflshng[$j]+@mhshng[$j]+@sfdwhng[$j]+@sfawhng[$j]+@mfs
whng[$j]+@mflwhng[$j]+@mhwhng[$j]+@sfdckng[$j]+@sfackng[$j]+@mfsckng[$j]+@mflckng[$j]+@mhckng
[$j] ;
  @toil[$j] =
@sfdshoil[$j]+@sfashoil[$j]+@mfsshoil[$j]+@mflshoil[$j]+@mhshoil[$j]+@sfdwhoil[$j]+@sfawhoil[$j]+@mfs
whoil[$j]+@mflwhoil[$j]+@mhwhoil[$j]+@sfdckoil[$j]+@sfackoil[$j]+@mfsckoil[$j]+@mflckoil[$j]+@mhckoil
[$j] ;
  @tlpg[$j] =
@sfdshlpg[$j]+@sfashlpg[$j]+@mfsshlpg[$j]+@mflshlpg[$j]+@mhshlpg[$j]+@sfdwhlpg[$j]+@sfawhlpg[$j]+@
mfswhlpg[$j]+@mflwhlpg[$j]+@mhwhlpg[$j]+@sfdcklpg[$j]+@sfacklpg[$j]+@mfscklpg[$j]+@mflcklpg[$j]+@
mhcklpg[$j] ;
  @telec[$j] =
@sfdshelec[$j]+@sfashelec[$j]+@mfsshelec[$j]+@mflshelec[$j]+@mhshelec[$j]+@sfdwhelec[$j]+@sfawhelec[$j
]+@mfswhelec[$j]+@mflwhelec[$j]+@mhwhelec[$j]+@sfdckelec[$j]+@sfackelec[$j]+@mfsckelec[$j]+@mflckel
ec[$j]+@mhckelec[$j]+@sfdlight[$j]+@sfalight[$j]+@mfslight[$j]+@mfllight[$j]+@mhlight[$j]+@sfdac[$j]+@
sfaac[$j]+@mfsac[$j]+@mflac[$j]+@mhac[$j]+@sfdref[$j]+@sfaref[$j]+@mfsref[$j]+@mflref[$j]+@mhref[$j] ;
  $totng += @tng[$j] ;  $totoil += @toil[$j] ;  $totlpg += @tlpg[$j] ;  $totelec += @telec[$j] ;
  }
# ------------------------------------------------------------------
# Print out sums over fuels
for($j = 0 ; $j < @id ; $j++) {
  print @id[$j], ',', @cnty[$j], ',', @tng[$j], ',', @toil[$j], ',', @tlpg[$j], ',', @telec[$j], "\n" ;
  }
  print 'Total ,', 'Illinois ,', $totng, ',', $totoil, ',', $totlpg, ',', $totelec, "\n" ;
# ------------------------------------------------------------------
# Adjust with ratios to 2002 Totals
  $ngratio = 455000000*1.030301/$totng ;
  $oilratio = 5600000*1.030301/$totoil ;
  $lpgratio = 23600000*1.030301/$totlpg ;
  $elecratio = 135800000*1.030301/$totelec ;
  $totng = 0 ; $totoil = 0 ; $totlpg = 0 ; $totelec = 0 ;
  $totsh = 0 ; $totwh = 0 ; $totck = 0 ; $totothr = 0 ;
```

```
  @tsh[0] = 'sh' ; @twh[0] = 'wh' ; @tck[0] = 'ck' ; @tothr[0] = 'othr' ;
for($j = 1 ; $j < @id ; $j++) {
  @tngsh[$j] = (@sfdshng[$j]+@sfashng[$j]+@mfsshng[$j]+@mflshng[$j]+@mhshng[$j])*$ngratio ;
  @toilsh[$j] = (@sfdshoil[$j]+@sfashoil[$j]+@mfsshoil[$j]+@mflshoil[$j]+@mhshoil[$j])*$oilratio ;
  @tlpgsh[$j] = (@sfdshlpg[$j]+@sfashlpg[$j]+@mfsshlpg[$j]+@mflshlpg[$j]+@mhshlpg[$j])*$lpgratio ;
  @telecsh[$j] = (@sfdshelec[$j]+@sfashelec[$j]+@mfsshelec[$j]+@mflshelec[$j]+@mhshelec[$j])*$elecratio ;
  @tngwh[$j] = (@sfdwhng[$j]+@sfawhng[$j]+@mfswhng[$j]+@mflwhng[$j]+@mhwhng[$j])*$ngratio ;
  @toilwh[$j] = (@sfdwhoil[$j]+@sfawhoil[$j]+@mfswhoil[$j]+@mflwhoil[$j]+@mhwhoil[$j])*$oilratio ;
  @tlpgwh[$j] = (@sfdwhlpg[$j]+@sfawhlpg[$j]+@mfswhlpg[$j]+@mflwhlpg[$j]+@mhwhlpg[$j])*$lpgratio ;
  @telecwh[$j] =
(@sfdwhelec[$j]+@sfawhelec[$j]+@mfswhelec[$j]+@mflwhelec[$j]+@mhwhelec[$j])*$elecratio ;
  @tngck[$j] = (@sfdckng[$j]+@sfackng[$j]+@mfsckng[$j]+@mflckng[$j]+@mhckng[$j])*$ngratio ;
  @toilck[$j] = (@sfdckoil[$j]+@sfackoil[$j]+@mfsckoil[$j]+@mflckoil[$j]+@mhckoil[$j])*$oilratio ;
  @tlpgck[$j] = (@sfdcklpg[$j]+@sfacklpg[$j]+@mfscklpg[$j]+@mflcklpg[$j]+@mhcklpg[$j])*$lpgratio ;
  @telecck[$j] = (@sfdckelec[$j]+@sfackelec[$j]+@mfsckelec[$j]+@mflckelec[$j]+@mhckelec[$j])*$elecratio ;
  @tothr[$j] =
(@sfdlight[$j]+@sfalight[$j]+@mfslight[$j]+@mfllight[$j]+@mhlight[$j]+@sfdac[$j]+@sfaac[$j]+@mfsac[$j]+
@mflac[$j]+@mhac[$j]+@sfdref[$j]+@sfaref[$j]+@mfsref[$j]+@mflref[$j]+@mhref[$j])*$elecratio ;
  @tng[$j] = @tngsh[$j] + @tngwh[$j] + @tngck[$j] ;
  @toil[$j] = @toilsh[$j] + @toilwh[$j] + @toilck[$j] ;
  @tlpg[$j] = @tlpgsh[$j] + @tlpgwh[$j] + @tlpgck[$j] ;
  @telec[$j] = @telecsh[$j] + @telecwh[$j] + @telecck[$j] + @tothr[$j] ;
  @tsh[$j] = @tngsh[$j] + @toilsh[$j] + @tlpgsh[$j] + @telecsh[$j] ;
  @twh[$j] = @tngwh[$j] + @toilwh[$j] + @tlpgwh[$j] + @telecwh[$j] ;
  @tck[$j] = @tngck[$j] + @toilck[$j] + @tlpgck[$j] + @telecck[$j] ;
  $totng += @tng[$j] ;  $totoil += @toil[$j] ;  $totlpg += @tlpg[$j] ;  $totelec += @telec[$j] ;
  $totsh += @tsh[$j] ;  $totwh += @twh[$j] ;  $totck += @tck[$j] ;  $totothr += @tothr[$j] ;
  }
# ----------------------------------------------------------------
# Print out final sums over fuels
for($j = 0 ; $j < @id ; $j++) {
  print @id[$j], ',', @cnty[$j], ',', @reg[$j], ',', @tng[$j], ',', @toil[$j], ',', @tlpg[$j], ',', @telec[$j], ',' ;
  print @tsh[$j], ',', @twh[$j], ',', @tck[$j], ',', @tothr[$j], "\n" ;
  }
  print 'Total ,', 'Illinois ,', ' ,', $totng, ',', $totoil, ',', $totlpg, ',', $totelec, ',' ;
  print $totsh, ',', $totwh, ',', $totck, ',', $totothr,  "\n" ;
# ----------------------------------------------------------------
close (FINAL) ;
```

Appendix B

Computer Code to Estimate Energy Use in 2002 by County, Fuel Type, and Housing Type using Conservation and Energy Efficiency Measures

```
open(INFILE1, "il1.csv") ;
open(INFILE2, "il2.csv") ;
open(INFILE3, "improvmt.csv") ;
open(MAINOUT, ">initialc.csv") ;
# ---------------------------------------------------------------
# Read in county identifiers and weather
  $a = <INFILE1> ;
  chomp $a ;
  @a = split(/,/, $a) ;
  @id[0] = @a[0] ; @cnty[0] = @a[1] ; @id2[0] = @a[2] ; @reg[0] = @a[3] ;
  @cdh[0] = @a[4] ; @hdd[0] = @a[5] ;
 $j = 1 ;
 while (eof(INFILE1) !=1) {
  $a = <INFILE1> ;
  chomp $a ;
  @a = split(/,/, $a) ;
  @id[$j] = @a[0] ; @cnty[$j] = @a[1] ; @id2[$j] = @a[2] ; @reg[$j] = @a[3] ;
  @cdh[$j] = @a[4] ; @hdd[$j] = @a[5] ;
 $j++ ;
   }
# ---------------------------------------------------------------
# Read in Census information: cnty id, cnty, no. of housing units, no. of occupied housing
#  units, no. of single family detached units, no. of single family attached units, no. of
#  multifamily units in bldgs w/ 2 apts, no. of multifamily units in bldgs w/ 3 or 4 apts,
#  no. of units in bldgs w/ 5 to 9 apts, no. of units in bldgs w/ 10 to 19 units, no. of
#  units in bldgs w/ 20 to 49 apts, no. of units in bldgs w/ 50 or more apts, no. of
#  mobile homes, no. of units in other types of structures, no. of units
#  using utility gas for space heat, no. of units using lpg or bottled gas for sh, no. of
#  units using electricity for sh, no. of units using oil or its derivatives for sh, no. of
#  units using coal or coke for sh, no. of units using wood for sh, no. of units using
#  solar energy for sh, no. of units using any other fuel for sh, and no. of units using
#  no fuel for sh
  $a = <INFILE2> ;
  chomp $a ;
  @a = split(/,/, $a) ;
  @id3[0] = @a[0] ; @hunits[0] = @a[2] ; @occ[0] = @a[3] ; @sfd[0] = @a[4] ;
  @sfa[0] = @a[5] ; @mfs[0] = "mf 2 to 9" ; @mfl[0] = "mf 10 & up" ;
  @mh[0] = "mh" ; @ng[0] = @a[14] ; @oil[0] = "oil" ; @lpg[0] = "lpg" ; @elec[0] = @a[16] ;
 $j = 1 ;
 while (eof(INFILE2) !=1) {
 $a = <INFILE2> ;
  chomp $a ;
  @a = split(/,/, $a) ;
  @id3[$j] = @a[0] ; @hunits[$j] = @a[2] ; @occ[$j] = @a[3] ; @sfd[$j] = @a[4] ;
```

```
  @sfa[$j] = @a[5] ; @mfs[$j] = @a[6]+@a[7]+@a[8] ; @mfl[$j] = @a[9]+@a[10]+@a[11] ;
  @mh[$j] = @a[12]+@a[13] ; @ng[$j] = @a[14] ; @oil[$j] = @a[17]+@a[18]+@a[19]+@a[21] ;
  @lpg[$j] = @a[15]+@a[22] ; @elec[$j] = @a[16]+@a[20] ;
 $j++ ;
   }
# ----------------------------------------------------------------
# Create names for housing type/space heat types
  @sfdng[0]='sfdng' ; @sfang[0]='sfang' ; @mfsng[0]='mfsng' ; @mflng[0]='mflng' ; @mhng[0]='mhng' ;
  @sfdoil[0]='sfdoil' ; @sfaoil[0]='sfaoil' ; @mfsoil[0]='mfsoil' ; @mfloil[0]='mfloil' ; @mhoil[0]='mhoil' ;
  @sfdlpg[0]='sfdlpg' ; @sfalpg[0]='sfalpg' ; @mfslpg[0]='mfslpg' ; @mfllpg[0]='mfllpg' ; @mhlpg[0]='mhlpg' ;
  @sfdelec[0]='sfdelec' ; @sfaelec[0]='sfaelec' ; @mfselec[0]='mfselec' ; @mflelec[0]='mflelec' ;
@mhelec[0]='mhelec' ;
# ----------------------------------------------------------------
# Loop through all counties
   for($j = 1 ; $j < @id ; $j++) {
## Test that counties of both files lined up correctly
    if(@id[$j] ne @id3[$j]) {
      print "Error", " ", @id[$j], "   ", @id3[$j], "\n" ;
        }
## ----------------------------------------------------------------
# Estimate no. of units using different major fuels by housing type
#  The estimate is made by multiplying the no. of units in each county using the different
#  fuels by the ratio of number of units in housing type category in the county by
#  the total number of housing units in that county
    @sfang[$j] = int(.5 + @ng[$j]*@sfa[$j]/@hunits[$j]) ;
    @mfsng[$j] = int(.5 + @ng[$j]*@mfs[$j]/@hunits[$j]) ;
    @mflng[$j] = int(.5 + @ng[$j]*@mfl[$j]/@hunits[$j]) ;
    @mhng[$j] = int(.5 + @ng[$j]*@mh[$j]/@hunits[$j]) ;
    @sfdng[$j] = @ng[$j] - @sfang[$j] - @mfsng[$j] - @mflng[$j] - @mhng[$j] ;
    @sfaoil[$j] = int(.5 + @oil[$j]*@sfa[$j]/@hunits[$j]) ;
    @mfsoil[$j] = int(.5 + @oil[$j]*@mfs[$j]/@hunits[$j]) ;
    @mfloil[$j] = int(.5 + @oil[$j]*@mfl[$j]/@hunits[$j]) ;
    @mhoil[$j] = int(.5 + @oil[$j]*@mh[$j]/@hunits[$j]) ;
    @sfdoil[$j] = @oil[$j] - @sfaoil[$j] - @mfsoil[$j] - @mfloil[$j] - @mhoil[$j] ;
    @sfalpg[$j] = int(.5 + @lpg[$j]*@sfa[$j]/@hunits[$j]) ;
    @mfslpg[$j] = int(.5 + @lpg[$j]*@mfs[$j]/@hunits[$j]) ;
    @mfllpg[$j] = int(.5 + @lpg[$j]*@mfl[$j]/@hunits[$j]) ;
    @mhlpg[$j] = int(.5 + @lpg[$j]*@mh[$j]/@hunits[$j]) ;
    @sfdlpg[$j] = @lpg[$j] - @sfalpg[$j] - @mfslpg[$j] - @mfllpg[$j] - @mhlpg[$j] ;
    @sfaelec[$j] = int(.5 + @elec[$j]*@sfa[$j]/@hunits[$j]) ;
    @mfselec[$j] = int(.5 + @elec[$j]*@mfs[$j]/@hunits[$j]) ;
    @mflelec[$j] = int(.5 + @elec[$j]*@mfl[$j]/@hunits[$j]) ;
    @mhelec[$j] = int(.5 + @elec[$j]*@mh[$j]/@hunits[$j]) ;
    @sfdelec[$j] = @elec[$j] - @sfaelec[$j] - @mfselec[$j] - @mflelec[$j] - @mhelec[$j] ;
  }
# ----------------------------------------------------------------
# Print out the no. of units in each housing type/sh fuel type category
 $oldhandle = select MAINOUT ;
 for($j = 0 ; $j < @id ; $j++) {
  print @id[$j], ',' , @cnty[$j], ',', @reg[$j], ',' ;
  print @sfdng[$j], ',', @sfang[$j], ',', @mfsng[$j], ',', @mflng[$j], ',', @mhng[$j], ',' ;
```

```
  print @sfdoil[$j], ',', @sfaoil[$j], ',', @mfsoil[$j], ',', @mfloil[$j], ',', @mhoil[$j], ',' ;
  print @sfdlpg[$j], ',', @sfalpg[$j], ',', @mfslpg[$j], ',', @mfllpg[$j], ',', @mhlpg[$j], ',' ;
  print @sfdelec[$j], ',', @sfaelec[$j], ',', @mfselec[$j], ',', @mflelec[$j], ',', @mhelec[$j],  "\n" ;
   }
# ------------------------------------------------------------------
# Enter the envelope improvement coefficients for each county
 $a = <INFILE3> ;
  chomp $a ;
  @a = split(/,/, $a) ;
  @id5[0] = @a[0] ; @improvement[0] = @a[2] ;
 $j = 1 ;
 while (eof(INFILE3) !=1) {
 $a = <INFILE3> ;
  chomp $a ;
  @a = split(/,/, $a) ;
  @id5[$j] = @a[0] ; @improvement[$j] = @a[2] ;
 $j++ ;
   }
   for($j = 1 ; $j < @id ; $j++) {
    if(@id[$j] ne @id5[$j]) {
      print "Error", " ", @id[$j], "    ", @id5[$j], "\n" ;
        }
    }
# ------------------------------------------------------------------
# Create names for the energy consumed for each sh housing type/ fuel type category
    @sfdshng[0] = 'sfdshng' ; @sfashng[0] = 'sfashng' ; @mfsshng[0] = 'mfsshng' ;
    @mflshng[0] = 'mflshng' ; @mhshng[0] = 'mhshng' ;
    @sfdshoil[0] = 'sfdshoil' ; @sfashoil[0] = 'sfashoil' ; @mfsshoil[0] = 'mfsshoil' ;
    @mflshoil[0] = 'mflshoil' ; @mhshoil[0] = 'mhshoil' ;
    @sfdshlpg[0] = 'sfdshlpg' ; @sfashlpg[0] = 'sfashlpg' ; @mfsshlpg[0] = 'mfsshlpg' ;
    @mflshlpg[0] = 'mflshlpg' ; @mhshlpg[0] = 'mhshlpg' ;
    @sfdshelec[0] = 'sfdshelec' ; @sfashelec[0] = 'sfashelec' ; @mfsshelec[0] = 'mfsshelec' ;
    @mflshelec[0] = 'mflshelec' ; @mhshelec[0] = 'mhshelec' ;
# ------------------------------------------------------------------
# Estimate million btus for space heating by fuel and housing type
#  The estimate is based on the average (weighted) btus per hdd per square feet for each
#  fuel and housing type in RECS multiplied by the no. of units in that group, the hdd, and
#  the average square feet of that housing type.  Some groups are zeroed out for
#  suspiciously small groups.
 for($j = 1 ; $j < @id ; $j++) {
    @sfdshng[$j] = @improvement[$j]*7.804 * @sfdng[$j] * @hdd[$j] * 2306/1000000. ;
    @sfashng[$j] = @improvement[$j]*8.811 * @sfang[$j] * @hdd[$j] * 1599/1000000. ;
    @mfsshng[$j] = @improvement[$j]*14.425 * @mfsng[$j] * @hdd[$j] * 1010/1000000. ;
    @mflshng[$j] = @improvement[$j]*7.904 * @mflng[$j] * @hdd[$j] * 808/1000000. ;
    @mhshng[$j] = @improvement[$j]*16.178 * @mhng[$j] * @hdd[$j] * 849/1000000. ;
    @sfdshoil[$j] = @improvement[$j]*8.073 * @sfdoil[$j] * @hdd[$j] * 2306/1000000. ;
    @sfashoil[$j] = 0. ;
    @mfsshoil[$j] = 0. ;
    @mflshoil[$j] = 0. ;
    @mhshoil[$j] = 0. ;
    @sfdshlpg[$j] = @improvement[$j]*5.996 * @sfdlpg[$j] * @hdd[$j] * 2306/1000000. ;
```

```
    @sfashlpg[$j] = @improvement[$j]*9.054 * @sfalpg[$j] * @hdd[$j] * 1599/1000000. ;
    @mfsshlpg[$j] = 0. ;
    @mflshlpg[$j] = 0. ;
    @mhshlpg[$j] = @improvement[$j]*9.192 * @mhlpg[$j] * @hdd[$j] * 849/1000000. ;
    @sfdshelec[$j] = @improvement[$j]*.874 * @sfdelec[$j] * @hdd[$j] * 2306/1000000. ;
    @sfashelec[$j] = @improvement[$j]*1.911 * @sfaelec[$j] * @hdd[$j] * 1599/1000000. ;
    @mfsshelec[$j] = @improvement[$j]*3.552 * @mfselec[$j] * @hdd[$j] * 1010/1000000. ;
    @mflshelec[$j] = @improvement[$j]*1.486 * @mflelec[$j] * @hdd[$j] * 808/1000000. ;
    @mhshelec[$j] = @improvement[$j]*5.133 * @mhelec[$j] * @hdd[$j] * 849/1000000. ;
  }
# ----------------------------------------------------------------
# Print out the space heat energy estimates for each county by housing type & fuel type
 for($j = 0 ; $j < @id ; $j++) {
  print @id[$j], ',' , @cnty[$j], ',', @reg[$j], ',' ;
  print @sfdshng[$j], ',', @sfashng[$j], ',', @mfsshng[$j], ',', @mflshng[$j], ',', @mhshng[$j], "," ;
  print @sfdshoil[$j], ',', @sfashoil[$j], ',', @mfsshoil[$j], ',', @mflshoil[$j], ',', @mhshoil[$j], "," ;
  print @sfdshlpg[$j], ',', @sfashlpg[$j], ',', @mfsshlpg[$j], ',', @mflshlpg[$j], ',', @mhshlpg[$j], "," ;
  print @sfdshelec[$j], ',', @sfashelec[$j], ',', @mfsshelec[$j], ',', @mflshelec[$j], ',', @mhshelec[$j], "\n" ;
   }
# ----------------------------------------------------------------
# Create names for the energy consumed for wh by housing type & fuel type category
    @sfdwhng[0] = 'sfdwhng' ; @sfawhng[0] = 'sfawhng' ; @mfswhng[0] = 'mfswhng' ;
    @mflwhng[0] = 'mflwhng' ; @mhwhng[0] = 'mhwhng' ;
    @sfdwhoil[0] = 'sfdwhoil' ; @sfawhoil[0] = 'sfawhoil' ; @mfswhoil[0] = 'mfswhoil' ;
    @mflwhoil[0] = 'mflwhoil' ; @mhwhoil[0] = 'mhwhoil' ;
    @sfdwhlpg[0] = 'sfdwhlpg' ; @sfawhlpg[0] = 'sfawhlpg' ; @mfswhlpg[0] = 'mfswhlpg' ;
    @mflwhlpg[0] = 'mflwhlpg' ; @mhwhlpg[0] = 'mhwhlpg' ;
    @sfdwhelec[0] = 'sfdwhelec' ; @sfawhelec[0] = 'sfawhelec' ; @mfswhelec[0] = 'mfswhelec' ;
    @mflwhelec[0] = 'mflwhelec' ; @mhwhelec[0] = 'mhwhelec' ;
# ----------------------------------------------------------------
# Estimate the million btus used for water heating by fuel and housing type
#  The estimate is made in two passes
 for($j = 1 ; $j < @id ; $j++) {
## In the first pass we estimate the number of units use the different fuels based on RECS
    @sfdwhng[$j] = @sfdng[$j] ; # All elec wh in ng or lpg sh homes are switched to ng or lpg
    @sfawhng[$j] = @sfang[$j] + @sfaoil[$j]*1/2 + @sfaelec[$j]*2/4 ;
    @mfswhng[$j] = @mfsng[$j] + @mfslpg[$j] ;
    @mflwhng[$j] = @mflng[$j] + @mfllpg[$j] + @mflelec[$j]*4/36 ;
    @mhwhng[$j] = @mhng[$j] + @mhelec[$j]*1/7 ;
    @sfdwhoil[$j] = @sfdoil[$j]*4/29 ;
    @sfawhoil[$j] = 0. ;
    @mfswhoil[$j] = 0. ;
    @mflwhoil[$j] = 0. ;
    @mhwhoil[$j] = 0. ;
    @sfdwhlpg[$j] = @sfdlpg[$j] ;
    @sfawhlpg[$j] = @sfalpg[$j] ;
    @mfswhlpg[$j] = 0. ;
    @mflwhlpg[$j] = 0. ;
    @mhwhlpg[$j] = @mhlpg[$j] ;
    @sfdwhelec[$j] = @sfdoil[$j]*25/29 + @sfdelec[$j] ;
    @sfawhelec[$j] = @sfaoil[$j]*1/2 + @sfaelec[$j]*2/4 ;
```

```
   @mfswhelec[$j] = @mfsoil[$j] + @mfselec[$j] ;
   @mflwhelec[$j] = @mfloil[$j] + @mflelec[$j]*32/36 ;
   @mhwhelec[$j] = @mhoil[$j]  + @mhelec[$j]*6/7 ;
## ----------------------------------------------------------------
## In the second pass we estimate the energy usage in million btus for wh by the different fuels and housing types
   @sfdwhng[$j] = @sfdwhng[$j]*.76*365*.1 ;
   @sfawhng[$j] = @sfawhng[$j]*.709*365*.1 ;
   @mfswhng[$j] = @mfswhng[$j]*.697*365*.1 ;
   @mflwhng[$j] = @mflwhng[$j]*.619*365*.1 ;
   @mhwhng[$j] = @mhwhng[$j]*.853*365*.1 ;
   @sfdwhoil[$j] = @sfdwhoil[$j]*.75*365*.1 ;
   @sfdwhlpg[$j] = @sfdwhlpg[$j]*.81*365*.1 ;
   @sfawhlpg[$j] = @sfawhlpg[$j]*.81*365*.1 ;
   @mhwhlpg[$j] = @mhwhlpg[$j]*.81*365*.1 ;
   @sfdwhelec[$j] = @sfdwhelec[$j]*.31*365*.1 ;
   @sfawhelec[$j] = @sfawhelec[$j]*.209*365*.1 ;
   @mfswhelec[$j] = @mfswhelec[$j]*.178*365*.1 ;
   @mflwhelec[$j] = @mflwhelec[$j]*.16*365*.1 ;
   @mhwhelec[$j] = @mhwhelec[$j]*.269*365*.1 ;
## ----------------------------------------------------------------
  }
# ----------------------------------------------------------------
# Print out the energy used for water heating in each county by housing type & fuel type
 for($j = 0 ; $j < @id ; $j++) {
  print @id[$j], ',' , @cnty[$j], ',', @reg[$j], ',' ;
  print @sfdwhng[$j], ',', @sfawhng[$j], ',', @mfswhng[$j], ',', @mflwhng[$j], ',', @mhwhng[$j], "," ;
  print @sfdwhoil[$j], ',', @sfawhoil[$j], ',', @mfswhoil[$j], ',', @mflwhoil[$j], ',', @mhwhoil[$j], "," ;
  print @sfdwhlpg[$j], ',', @sfawhlpg[$j], ',', @mfswhlpg[$j], ',', @mflwhlpg[$j], ',', @mhwhlpg[$j], "," ;
  print @sfdwhelec[$j], ',', @sfawhelec[$j], ',', @mfswhelec[$j], ',', @mflwhelec[$j], ',', @mhwhelec[$j], "\n" ;
   }
# ----------------------------------------------------------------
# Create names for the energy consumed for cooking by housing type & fuel used
   @sfdckng[0] =   'sfdckng' ;   @sfackng[0] =   'sfackng' ;   @mfsckng[0] =   'mfsckng' ;
   @mflckng[0] =   'mflckng' ;    @mhckng[0] =    'mhckng' ;
   @sfdckoil[0] =  'sfdckoil' ;  @sfackoil[0] =  'sfackoil' ;  @mfsckoil[0] =  'mfsckoil' ;
   @mflckoil[0] =  'mflckoil' ;   @mhckoil[0] =   'mhckoil' ;
   @sfdcklpg[0] =  'sfdcklpg' ;  @sfacklpg[0] =  'sfacklpg' ;  @mfscklpg[0] =  'mfscklpg' ;
   @mflcklpg[0] =  'mflcklpg' ;   @mhcklpg[0] =   'mhcklpg' ;
   @sfdckelec[0] = 'sfdckelec' ; @sfackelec[0] = 'sfackelec' ; @mfsckelec[0] =  'mfsckelec' ;
   @mflckelec[0] = 'mflckelec' ;  @mhckelec[0] =  'mhckelec' ;
# ----------------------------------------------------------------
# Estimate the million btus used for cooking by fuel and housing type
#  The estimate is made in two passes
 for($j = 1 ; $j < @id ; $j++) {
## In the first pass we estimate the number of units use the different fuels based on RECS
   @sfdckng[$j] = @sfdng[$j]*230/401 + @sfdoil[$j]*1/32 + @sfdelec[$j]*1/33 ;
   @sfackng[$j] = @sfang[$j]*32/51 ;
   @mfsckng[$j] = @mfsng[$j]*27/43 ;
   @mflckng[$j] = @mflng[$j]*31/59 + @mfloil[$j] + @mfllpg[$j] + @mflelec[$j]*2/36 ;
    @mhckng[$j] = @mhng[$j]*21/27 + @mhelec[$j]*1/7 ;
   @sfdckoil[$j] = @sfdoil[$j]*3/32 ;
```

```
   @sfackoil[$j] = 0. ;
   @mfsckoil[$j] = 0. ;
   @mflckoil[$j] = 0. ;
    @mhckoil[$j] = 0. ;
   @sfdcklpg[$j] = @sfdoil[$j]*4/32 + @sfdlpg[$j]*18/43 ;
   @sfacklpg[$j] = @sfalpg[$j]*2/4 ;
   @mfscklpg[$j] = 0. ;
   @mflcklpg[$j] = 0. ;
    @mhcklpg[$j] = @mhlpg[$j]*4/8 ;
   @sfdckelec[$j] = @sfdng[$j]*171/401 + @sfdoil[$j]*24/32 + @sfdlpg[$j]*25/43 + @sfdelec[$j]*32/33 ;
   @sfackelec[$j] = @sfang[$j]*19/51 + @sfaoil[$j] + @sfalpg[$j]*2/4 + @sfaelec[$j] ;
   @mfsckelec[$j] = @mfsng[$j]*16/43 + @mfsoil[$j]+ @mfslpg[$j]+ @mfselec[$j] ;
   @mflckelec[$j] = @mflng[$j]*28/59 + @mflelec[$j]*34/36 ;
   @mhckelec[$j] = @mhng[$j]*6/27 + @mhoil[$j] + @mhlpg[$j]*4/8 + @mhelec[$j]*6/7 ;
## ------------------------------------------------------------------
## In the second pass we estimate the energy usage in million btus for ck by the different fuels and housing types
   @sfdckng[$j] =   @sfdckng[$j]*10766./1000 ;
   @sfackng[$j] =   @sfackng[$j]*9595./1000 ;
   @mfsckng[$j] =   @mfsckng[$j]*9894./1000 ;
   @mflckng[$j] =   @mflckng[$j]*6698./1000 ;
    @mhckng[$j] =    @mhckng[$j]*7023./1000 ;
   @sfdckoil[$j] =  @sfdckoil[$j]*10766./1000 ;
   @sfdcklpg[$j] =  @sfdcklpg[$j]*6977./1000 ;
   @sfacklpg[$j] =  @sfacklpg[$j]*6977./1000 ;
    @mhcklpg[$j] =   @mhcklpg[$j]*6977./1000 ;
   @sfdckelec[$j] = @sfdckelec[$j]*1653./1000 ;
   @sfackelec[$j] = @sfackelec[$j]*1120./1000 ;
   @mfsckelec[$j] = @mfsckelec[$j]*1058./1000 ;
   @mflckelec[$j] = @mflckelec[$j]*931./1000 ;
    @mhckelec[$j] =  @mhckelec[$j]*1829./1000 ;
## ------------------------------------------------------------------
  }
# ------------------------------------------------------------------
# Print out the energy used for cooking in each county by housing type & fuel type
 for($j = 0 ; $j < @id ; $j++) {
  print @id[$j], ',' , @cnty[$j], ',', @reg[$j], ',' ;
  print @sfdckng[$j], ',', @sfackng[$j], ',', @mfsckng[$j], ',', @mflckng[$j], ',', @mhckng[$j], "," ;
  print @sfdckoil[$j], ',', @sfackoil[$j], ',', @mfsckoil[$j], ',', @mflckoil[$j], ',', @mhckoil[$j], "," ;
  print @sfdcklpg[$j], ',', @sfacklpg[$j], ',', @mfscklpg[$j], ',', @mflcklpg[$j], ',', @mhcklpg[$j], "," ;
  print @sfdckelec[$j], ',', @sfackelec[$j], ',', @mfsckelec[$j], ',', @mflckelec[$j], ',', @mhckelec[$j], "\n" ;
   }
# ------------------------------------------------------------------
# Create names for elec. energy consumed for each housing type for lighting, AC, & refrigeration
  @sfdlight[0] = 'sfdlights' ; @sfdac[0] = 'sfdac' ; @sfdref[0] = 'sfdref' ;
  @sfalight[0] = 'sfalights' ; @sfaac[0] = 'sfaac' ; @sfaref[0] = 'sfaref' ;
  @mfslight[0] = 'mfslights' ; @mfsac[0] = 'mfsac' ; @mfsref[0] = 'mfsref' ;
  @mfllight[0] = 'mfllights' ; @mflac[0] = 'mflac' ; @mflref[0] = 'mflref' ;
  @mhlight[0] = 'mhlights' ; @mhac[0] = 'mhac' ; @mhref[0] = 'mhref' ;
# ------------------------------------------------------------------
# Estimate the million btus of elec. used for lighting, AC, and refrigeration by housing type
for($j = 1 ; $j < @id ; $j++) {
```

```
 @sfdlight[$j] = @sfd[$j] * (22264-1.077*1121)/1000. ;
 @sfalight[$j] = @sfa[$j] * (14782-.934*1121)/1000. ;
 @mfslight[$j] = @mfs[$j] * (11049-.719*1121)/1000. ;
 @mfllight[$j] = @mfl[$j] * (7895-.882*1121)/1000. ;
 @mhlight[$j] = @mh[$j] * (15380-1.024*1121)/1000. ;
 @sfdac[$j] = @improvement[$j]*@sfd[$j] * 4.095*@cdh[$j]/(1000*24.) ;
 @sfaac[$j] = @improvement[$j]*@sfa[$j] * 2.190*@cdh[$j]/(1000*24.) ;
 @mfsac[$j] = @improvement[$j]*@mfs[$j] * 1.521*@cdh[$j]/(1000*24.) ;
 @mflac[$j] = @improvement[$j]*@mfl[$j] * 1.312*@cdh[$j]/(1000*24.) ;
 @mhac[$j] = @improvement[$j]*@mh[$j] * 3.581*@cdh[$j]/(1000*24.) ;
 @sfdref[$j] = @sfd[$j] * 2500/1000. ;
 @sfaref[$j] = @sfa[$j] * 1837/1000. ;
 @mfsref[$j] = @mfs[$j] * 1807/1000. ;
 @mflref[$j] = @mfl[$j] * 1890/1000. ;
 @mhref[$j] =  @mh[$j] * 1914/1000. ;
  }
# ------------------------------------------------------------------
# Print out the lighting, AC, and refrigeration elec. energy use for each county by housing type
 for($j = 0 ; $j < @id ; $j++) {
  print @id[$j], ',' , @cnty[$j], ',', @reg[$j], ',' ;
  print @sfdlight[$j], ',', @sfalight[$j], ',', @mfslight[$j], ',', @mfllight[$j], ',', @mhlight[$j], "," ;
  print @sfdac[$j], ',', @sfdac[$j], ',', @mfsac[$j], ',', @mflac[$j], ',', @mhac[$j], "," ;
  print @sfdref[$j], ',', @sfaref[$j], ',', @mfsref[$j], ',', @mflref[$j], ',', @mhref[$j], "\n" ;
   }
# ------------------------------------------------------------------
close (INFILE1) ;
close (INFILE2) ;
close (INFILE3) ;
open(FINAL,">est2002c.csv") ;
$oldhandle = select FINAL ;
close (MAINOUT) ;
# ------------------------------------------------------------------
# Sum over fuels
  $totng = 0 ; $totoil = 0 ; $totlpg = 0 ; $totelec = 0 ;
  @tng[0] = 'ng' ; @toil[0] = 'oil' ; @tlpg[0] = 'lpg' ; @telec[0] = 'elec' ;
for($j = 1 ; $j < @id ; $j++) {
  @tng[$j] =
@sfdshng[$j]+@sfashng[$j]+@mfsshng[$j]+@mflshng[$j]+@mhshng[$j]+@sfdwhng[$j]+@sfawhng[$j]+@mfs
whng[$j]+@mflwhng[$j]+@mhwhng[$j]+@sfdckng[$j]+@sfackng[$j]+@mfsckng[$j]+@mflckng[$j]+@mhckng
[$j] ;
  @toil[$j] =
@sfdshoil[$j]+@sfashoil[$j]+@mfsshoil[$j]+@mflshoil[$j]+@mhshoil[$j]+@sfdwhoil[$j]+@sfawhoil[$j]+@mfs
whoil[$j]+@mflwhoil[$j]+@mhwhoil[$j]+@sfdckoil[$j]+@sfackoil[$j]+@mfsckoil[$j]+@mflckoil[$j]+@mhckoil
[$j] ;
  @tlpg[$j] =
@sfdshlpg[$j]+@sfashlpg[$j]+@mfsshlpg[$j]+@mflshlpg[$j]+@mhshlpg[$j]+@sfdwhlpg[$j]+@sfawhlpg[$j]+@
mfswhlpg[$j]+@mflwhlpg[$j]+@mhwhlpg[$j]+@sfdcklpg[$j]+@sfacklpg[$j]+@mfscklpg[$j]+@mflcklpg[$j]+@
mhcklpg[$j] ;
  @telec[$j] =
@sfdshelec[$j]+@sfashelec[$j]+@mfsshelec[$j]+@mflshelec[$j]+@mhshelec[$j]+@sfdwhelec[$j]+@sfawhelec[$j
]+@mfswhelec[$j]+@mflwhelec[$j]+@mhwhelec[$j]+@sfdckelec[$j]+@sfackelec[$j]+@mfsckelec[$j]+@mflckel
```

```
ec[$j]+@mhckelec[$j]+@sfdlight[$j]+@sfalight[$j]+@mfslight[$j]+@mfllight[$j]+@mhlight[$j]+@sfdac[$j]+@
sfaac[$j]+@mfsac[$j]+@mflac[$j]+@mhac[$j]+@sfdref[$j]+@sfaref[$j]+@mfsref[$j]+@mflref[$j]+@mhref[$j] ;
  $totng += @tng[$j] ;  $totoil += @toil[$j] ;  $totlpg += @tlpg[$j] ;  $totelec += @telec[$j] ;
  }
# ----------------------------------------------------------------
# Print out sums over fuels
for($j = 0 ; $j < @id ; $j++) {
  print @id[$j], ',', @cnty[$j], ',', @tng[$j], ',', @toil[$j], ',', @tlpg[$j], ',', @telec[$j], "\n" ;
  }
  print 'Total ,', 'Illinois ,', $totng, ',', $totoil, ',', $totlpg, ',', $totelec, "\n" ;
# ----------------------------------------------------------------
# Adjust with same ratios for 2002 Totals as in non-conservation program
  $ngratio = 455000000*1.030301/455656762 ;
  $oilratio = 5600000*1.030301/9176593 ;
  $lpgratio = 23600000*1.030301/15934500 ;
  $elecratio = 135800000*1.030301/132725175 ;
  $totng = 0 ; $totoil = 0 ; $totlpg = 0 ; $totelec = 0 ;
  $totsh = 0 ; $totwh = 0 ; $totck = 0 ; $totothr = 0 ;
  @tsh[0] = 'sh' ; @twh[0] = 'wh' ; @tck[0] = 'ck' ; @tothr[0] = 'othr' ;
for($j = 1 ; $j < @id ; $j++) {
  @tngsh[$j] = (@sfdshng[$j]+@sfashng[$j]+@mfsshng[$j]+@mflshng[$j]+@mhshng[$j])*$ngratio ;
  @toilsh[$j] = (@sfdshoil[$j]+@sfashoil[$j]+@mfsshoil[$j]+@mflshoil[$j]+@mhshoil[$j])*$oilratio ;
  @tlpgsh[$j] = (@sfdshlpg[$j]+@sfashlpg[$j]+@mfsshlpg[$j]+@mflshlpg[$j]+@mhshlpg[$j])*$lpgratio ;
  @telecsh[$j] = (@sfdshelec[$j]+@sfashelec[$j]+@mfsshelec[$j]+@mflshelec[$j]+@mhshelec[$j])*$elecratio ;
  @tngwh[$j] = (@sfdwhng[$j]+@sfawhng[$j]+@mfswhng[$j]+@mflwhng[$j]+@mhwhng[$j])*$ngratio ;
  @toilwh[$j] = (@sfdwhoil[$j]+@sfawhoil[$j]+@mfswhoil[$j]+@mflwhoil[$j]+@mhwhoil[$j])*$oilratio ;
  @tlpgwh[$j] = (@sfdwhlpg[$j]+@sfawhlpg[$j]+@mfswhlpg[$j]+@mflwhlpg[$j]+@mhwhlpg[$j])*$lpgratio ;
  @telecwh[$j] =
(@sfdwhelec[$j]+@sfawhelec[$j]+@mfswhelec[$j]+@mflwhelec[$j]+@mhwhelec[$j])*$elecratio ;
  @tngck[$j] = (@sfdckng[$j]+@sfackng[$j]+@mfsckng[$j]+@mflckng[$j]+@mhckng[$j])*$ngratio ;
  @toilck[$j] = (@sfdckoil[$j]+@sfackoil[$j]+@mfsckoil[$j]+@mflckoil[$j]+@mhckoil[$j])*$oilratio ;
  @tlpgck[$j] = (@sfdcklpg[$j]+@sfacklpg[$j]+@mfscklpg[$j]+@mflcklpg[$j]+@mhcklpg[$j])*$lpgratio ;
  @telecck[$j] = (@sfdckelec[$j]+@sfackelec[$j]+@mfsckelec[$j]+@mflckelec[$j]+@mhckelec[$j])*$elecratio ;
  @tothr[$j] =
(@sfdlight[$j]+@sfalight[$j]+@mfslight[$j]+@mfllight[$j]+@mhlight[$j]+@sfdac[$j]+@sfaac[$j]+@mfsac[$j]+
@mflac[$j]+@mhac[$j]+@sfdref[$j]+@sfaref[$j]+@mfsref[$j]+@mflref[$j]+@mhref[$j])*$elecratio ;
  @tng[$j] = @tngsh[$j] + @tngwh[$j] + @tngck[$j] ;
  @toil[$j] = @toilsh[$j] + @toilwh[$j] + @toilck[$j] ;
  @tlpg[$j] = @tlpgsh[$j] + @tlpgwh[$j] + @tlpgck[$j] ;
  @telec[$j] = @telecsh[$j] + @telecwh[$j] + @telecck[$j] + @tothr[$j] ;
  @tsh[$j] = @tngsh[$j] + @toilsh[$j] + @tlpgsh[$j] + @telecsh[$j] ;
  @twh[$j] = @tngwh[$j] + @toilwh[$j] + @tlpgwh[$j] + @telecwh[$j] ;
  @tck[$j] = @tngck[$j] + @toilck[$j] + @tlpgck[$j] + @telecck[$j] ;
  $totng += @tng[$j] ;  $totoil += @toil[$j] ;  $totlpg += @tlpg[$j] ;  $totelec += @telec[$j] ;
  $totsh += @tsh[$j] ;  $totwh += @twh[$j] ;  $totck += @tck[$j] ;  $totothr += @tothr[$j] ;
  }
# ----------------------------------------------------------------
# Print out final sums over fuels
for($j = 0 ; $j < @id ; $j++) {
  print @id[$j], ',', @cnty[$j], ',', @reg[$j], ',', @tng[$j], ',', @toil[$j], ',', @tlpg[$j], ',', @telec[$j], ',' ;
  print @tsh[$j], ',', @twh[$j], ',', @tck[$j], ',', @tothr[$j], "\n" ;
```

```
  }
  print 'Total ,', 'Illinois ,', ' ,', $totng, ',', $totoil, ',', $totlpg, ',', $totelec, ',' ;
  print $totsh, ',', $totwh, ',',  $totck, ',', $tototh r,  "\n" ;
# ------------------------------------------------------------------------
close (FINAL) ;
```