INFORMATION BRIEF
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Residential Space Heating Fuels in Minnesota

Minnesotans spend about $2 billion annually to heat their residences. The heating fuels they use vary significantly in different regions of the state, reflecting availability, fuel and heating system costs, and other factors. This information brief presents count-by-county use of residential heating fuels based on survey data compiled by the U.S. Census Bureau. It also contains information on fuel price trends over time, residential conservation, federal fuel assistance, and Minnesota's Cold Weather Rule.

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Introduction

Approximately one-half of the 431 trillion Btus consumed by Minnesota homes in 2014 was used to heat those residences.[1] Minnesota's collective residential heating bill that year was about $1.9 billion.[2] Individual heating expenditures vary significantly throughout the state, depending on the size of the home, the type of fuel used, furnace efficiency, lifestyle, and weather. These differences, given a heating season that lasts six months or longer, can amount to thousands of dollars annually for a household.

Statewide Distribution of Residential Space Heating Fuels

Statewide data on fuels used for space heating in Minnesota is presented in Table 1. The left-hand columns compare the distribution of space heating fuels among occupied housing units in Minnesota and the United States in 2015. Minnesota differs from the national profile in several respects. A much larger proportion of Minnesota's housing units are heated with natural gas and propane, a result of the state's relative proximity to natural gas supplies in Texas, Oklahoma, and Kansas and its position as a large importer of Canadian natural gas. (Two-thirds of propane supplies are produced from the processing of natural gas.) Conversely, the share of units heated with electricity and fuel oil in the state are both less than half the national average.

Table 1
Distribution of Space Heating Fuels Among Occupied Residential Units
U.S. and Minnesota, 2005-2015

	2015			2005 to 2015	
Fuel	**U.S. (percent)**	**Minnesota (percent)**	**Minnesota (units)**	**Change in Minnesota Units**	**Percentage Change in Minnesota Fuel Share**
Natural Gas	48.2%	66.1%	1,420,349	59,416	(1.3%)
Electricity	38.2	17.1	366,326	96,008	3.7
Propane	4.7	10.5	225,549	10,529	(0.1)
Fuel Oil	5.1	2.0	41,930	(56,729)	(2.9)

[1] Nationally, space heating accounted for 41.5 percent of total energy consumption in homes in 2009, a figure that is likely to be several percentage points higher in Minnesota's colder climate. U.S. Energy Information Administration, *Today in Energy*, "Heating and cooling no longer majority of U.S. home energy use," March 7, 2013, www.eia.gov/todayinenergy/detail.php?id=10271. U.S. Energy Information Administration, State Energy Data System, Table C5, *Residential Sector Energy Consumption Estimates: 2014*, www.eia.gov/state/seds/sep_sum/html/pdf/sum_btu_res.pdf.

[2] U.S. Energy Information Administration, State Profiles and Energy Estimates, Table E-10 *Residential Sector Energy Expenditure Estimates, 2014*, www.eia.gov/state/seds/sep_sum/html/pdf/sum_ex_res.pdf. These expenditure estimates were multiplied by estimates of the proportion of residential energy used for space heating for each fuel type, based on U.S. Department of Energy, Buildings Energy Database, Table 2.1.5, *2010 Residential Energy End-Use Splits, by Fuel Type*, http://buildingsdatabook.eren.doe.gov/TableView.aspx?table=2.1.5.

	2015			2005 to 2015	
Fuel	**U.S. (percent)**	**Minnesota (percent)**	**Minnesota (units)**	**Change in Minnesota Units**	**Percentage Change in Minnesota Fuel Share**
Wood	2.0	2.4	51,735	10,890	0.4
Other	1.8	1.9	41,373	7,004	0.2
Total	**100.0%**	**100.0%**	**2,147,262**	**127,118**	**—**

Source: U.S. Census Bureau, American Community Survey one-year estimates.

The right-hand columns of the table show how these figures have changed in Minnesota since 2005. The shares of electricity, wood, and “other” fuels increased during the decade, at the expense of natural gas, fuel oil, and propane. More than 96,000 residential units that heat with electricity were added, an increase of more than 35 percent. The absolute number of housing units heating with fuel oil fell by almost 57,000, nearly 60 percent. In 2015, the number of units heated with wood (firewood or wood pellets), which increased by 10,500 homes over the decade, exceeded those heated with fuel oil.

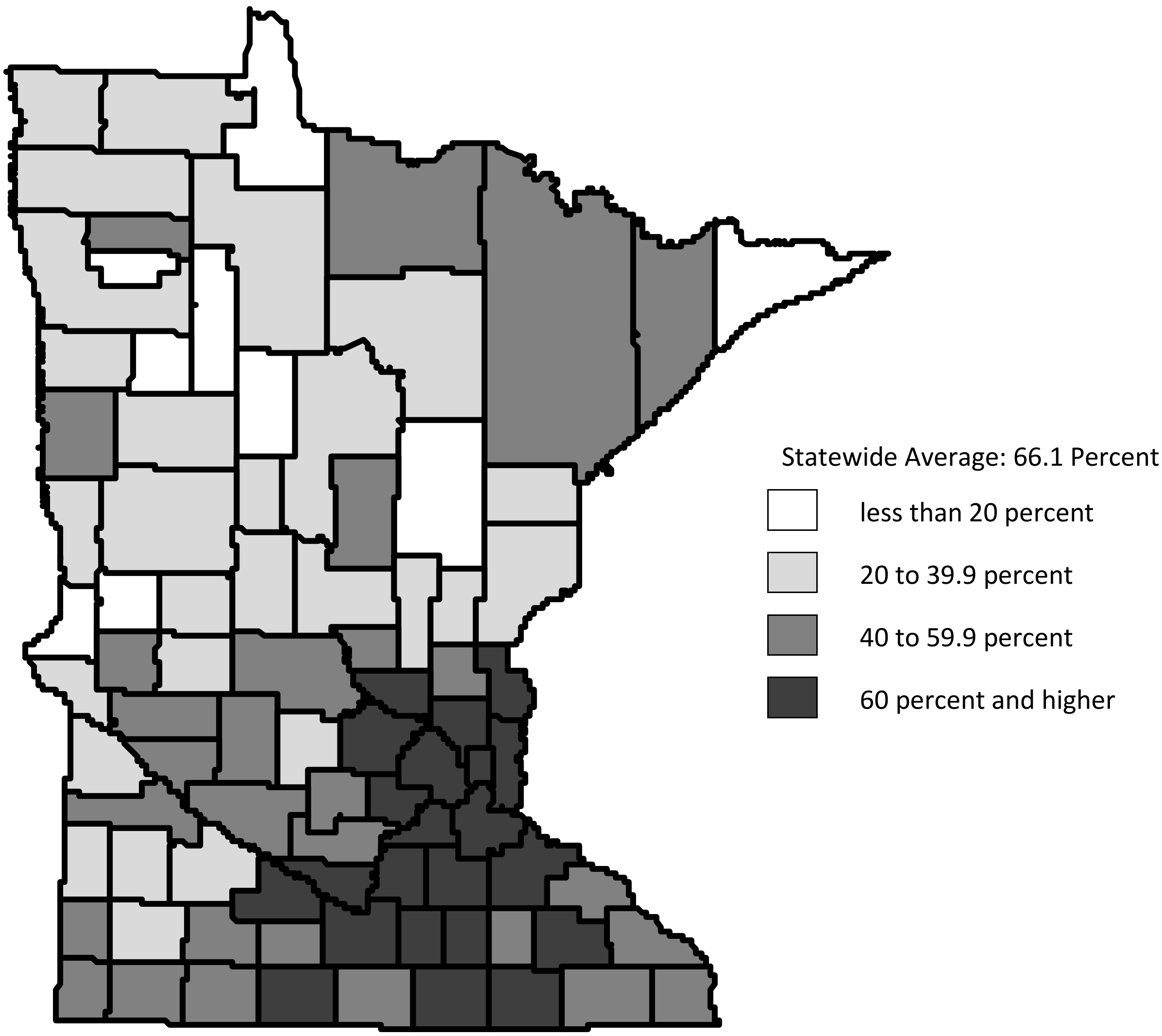
Distribution of Residential Space Heating Fuels by County

The statewide figures in Table 1 mask the considerable variations in the fuels used to heat Minnesota homes in different regions of the state. The following map (Figure 1) shows the use of natural gas for heating fuel by county, based on data obtained from the U.S. Census Bureau’s American Community Survey (ACS). The ACS combines samples from five consecutive years to produce estimates that are statistically reliable for small populations, such as those found in some of Minnesota’s smaller counties.[3] Counties whose proportion of homes heated with a given fuel fall within the ranges shown in the maps and are shaded identically. Lighter shadings indicate less use of that fuel, darker shadings indicate heavier use.

Figure 1 shows that the highest proportion of residences that are heated with natural gas—the darkest areas on the map, indicating that 60 percent or more of housing units heat with natural gas—are located in the Twin Cities metropolitan area and counties directly south. This is confirmed in the first column of Table 2 (on page 5), which lists the ten counties with the highest proportion of residences heated with natural gas. In the seven metropolitan counties, the proportion ranges from 77 percent to just under 85 percent. Most of the other counties in which natural gas is used in more than 40 percent of homes are located in the southern third of the state.

[3] The average number of Minnesota households surveyed during the 2010-2014 period reflected in these maps exceeded 68,000 annually. U.S. Census Bureau, American Community Survey, *Sample Size, Minnesota*, www.census.gov/acs/www/ methodology/sample-size-and-data-quality/sample-size/index.php.

Figure 1
Percentage of Housing Units Using Natural Gas as a Heating Fuel, 2010-2014



Source: U.S. Census Bureau, American Community Survey five-year estimates

Table 2
Minnesota Counties With the Highest Proportion of Residential Units Heated By a Specific Fuel, 2010-2014

Natural Gas		Electricity		Propane		Fuel Oil		Wood	
County	**% of Homes**	**County**	**% of Homes**	**County**	**% of Homes**	**County**	**% of Homes**	**County**	**% of Homes**
Scott	84.9	Clay	36.4	Traverse	48.6	Grant	19.4	Aitkin	17.7
Anoka	84.9	Lake of the Woods	36.1	Aitkin	46.6	Red Lake	18.6	Clearwater	16.6
Dakota	83.6	Red Lake	35.9	Grant	45.2	Traverse	17.6	Kanabec	16.4
Washington	83.4	Marshall	34.5	Murray	44.4	Murray	17.3	Cook	16.4
Hennepin	81.2	Norman	34.0	Cook	42.1	Mahnomen	16.0	Hubbard	16.2
Ramsey	78.9	Beltrami	32.5	Kanabec	40.8	Norman	15.8	Cass	16.0
Carver	77.1	Becker	31.9	Cass	39.0	Kittson	14.4	Morrison	15.6
Olmsted	74.3	Hubbard	31.9	Lincoln	35.8	Blue Earth	13.4	Todd	15.2
Sherburne	71.2	Mahnomen	30.7	Faribault	35.1	St. Louis	13.2	Wadena	14.1
Blue Earth	70.3	Grant	30.2	Mahnomen	33.9	Marshall	10.8	Pine	13.4

Source: U.S. Census Bureau, American Community Survey five-year estimates.

Since natural gas is the most economical home heating fuel at the end-user level (see Table 4 on page 13), the question arises: Why isn't it used more widely throughout the state?

The geographic distribution of natural gas service results from the interplay between economic and demographic factors. As is the case with electricity, natural gas is delivered by means of a physically connected capital-intensive system that can extend over hundreds of miles or more to bring energy to each individual customer location. Transporting natural gas from producing areas to a residential customer is expensive. Interstate pipelines cost from $1.9 million to $3.6 million per mile to construct, depending on the pipe's diameter; distribution pipelines, which bring gas from the interstate line to the customer's location, cost about $1.5 million per mile.[4]

The expansion of rural electricity was promoted by federal government programs initiated in the 1930s that were designed to reduce the costs and risks of borrowing by public agencies and rural cooperatives seeking to build that infrastructure. No similar assistance has been available in rural areas to expand or support expansion of natural gas service.

These high fixed costs have two important implications for the provision of natural gas service. First, the further a community is located from an interstate natural gas pipeline, the more expensive it is to construct a distribution pipeline to provide service there. Second, the smaller the population of the community seeking service (absent a large industrial customer), the fewer gas units over which there are to recover high fixed costs; this results in high, sometimes prohibitive, retail prices.

These principles underlie the distribution of natural gas service shown in Figure 1. Northern Natural Gas Company is the only domestic pipeline that serves Minnesota, transporting natural gas from Midwestern and Gulf states. Its pipelines are concentrated in the southern half of the state, where most of Minnesota's urban and suburban populations live, with extensions to Duluth and several communities on the north shore of Lake Superior, and to Iron Range cities. Four Canadian pipelines cross the state from northwest to southeast, serving adjacent communities, but most of the northwest quadrant of the state is unserved, as shown by the more lightly-shaded counties in that region in Figure 1. Here, the small size of many communities is the controlling factor. According to census data, Minnesota contains 2,021 cities and organized towns with a population below 1,000.[5]

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[4] IHS Economics, *The Economic Benefits of Natural Gas Pipeline Development on the Manufacturing Sector*, prepared for the National Association of Manufacturers, May 2016, pp. 26-27, www.nam/org/Data-and-Reports/Reports/Natural-Gas-Study/Energizing-Manufacturing-Full-Report/. These estimates are based on the following assumptions for transmission and distribution pipelines, respectively: length: 200 miles, 10 miles; capacity: 700 million cubic feet per day, 10 million cubic feet per day; pressure: 900 pounds per square inch gauge, 100 pounds per square inch gauge.

[5] Minnesota State Demographic Center, Data by Place, City and Township, http://mn.gov/admin/demography/data-by-place/.

A recent study by the Oregon Public Utilities Commission examining the expansion of natural gas service to unserved areas illustrates the importance of these principles. It found that while every city with a population of 10,000 or more has natural gas service, only one out of four cities with a population below 1,000 does. Almost all unserved cities with populations over 1,000 are located more than 10 miles from an interstate natural gas pipeline. No city under 1,000 located more than 15 miles from a pipeline has natural gas service, nor do half of those located closer.[6]

In Minnesota, natural gas service extensions are funded through a monthly bill surcharge paid by the new customers, which must be approved by the Minnesota Public Utilities Commission. In 2014, for example, the commission approved a $33.50 monthly surcharge to residents of Ely Lake for a period of 20 years to repay the cost of extending natural gas service to that community, a charge that amounts to more than $8,000 per customer over the period.[7, 8]

Other heating fuels dominate areas of the state where natural gas service is unavailable. Figure 2 shows the distribution of homes using electricity for space heating. The heaviest use occurs in counties in the northwestern quadrant of the state, ranging from 30 percent to 36 percent of all homes, as confirmed in Table 2 (on page 5). Electricity is used in 20 percent to 30 percent of homes in a group of counties located in the west central region. Electric heating is less widespread in the eastern half of the state.

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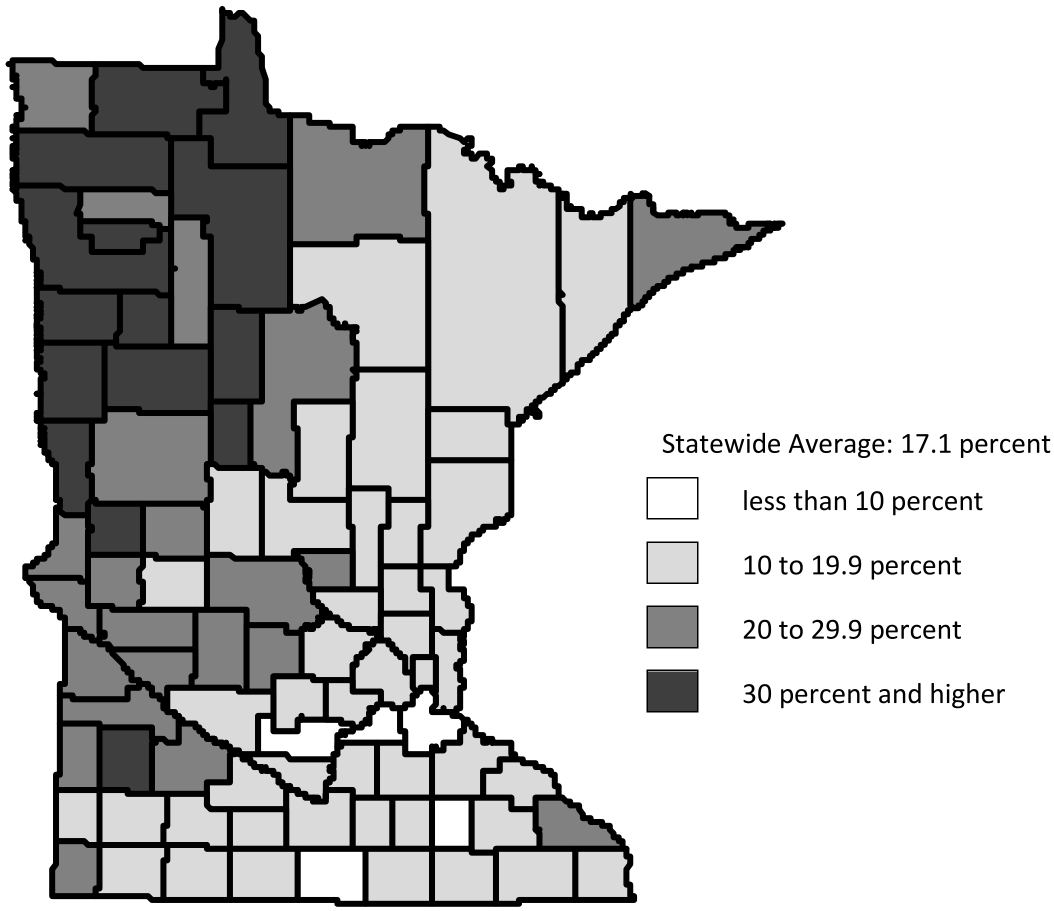
[6] Public Utility Commission of Oregon, Senate Bill 32 Work Group, *Study of Natural Gas Expansion to Unserved Areas*, September 15, 2016, pp. 7-8, www.puc.state.or.us/commission/09-15-2016%20SB32%20Report.pdf.

[7] Minnesota Public Utilities Commission, *Order Approving New Area Surcharge and Proposed Tariff Modification*, Docket No. G-011/M-14-524, September 5, 2014.

[8] In 2015, the Minnesota Legislature enacted a bill allowing up to one-third of the cost of natural gas extensions to be allocated to a utility's existing natural gas customers. Minn. Stat. § 216B.1638.

Figure 2
Percentage of Housing Units Using Electricity as a Heating Fuel, 2010-2014

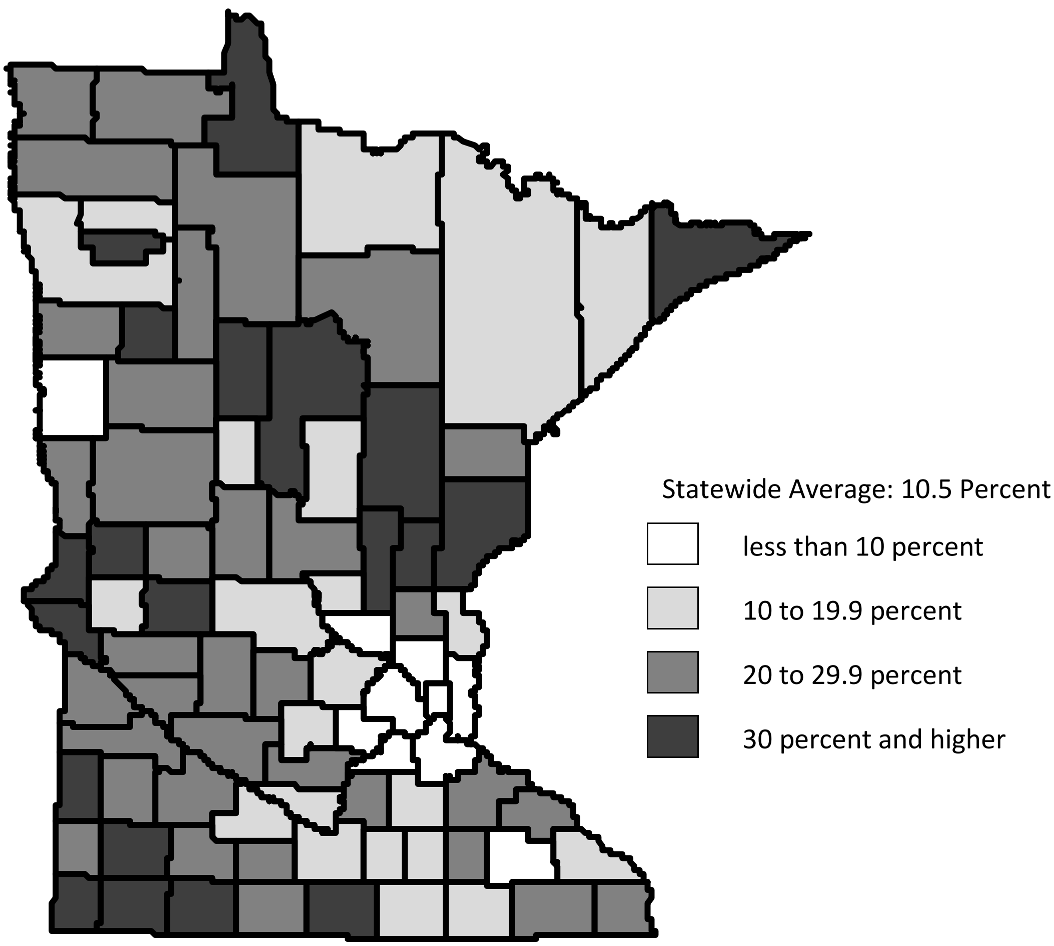


Source: U.S. Census Bureau, American Community Survey five-year estimates

Propane and fuel oil are delivered to customers by trucks that obtain these fuels from bulk storage stations supplied by pipelines or rail cars. The use of propane as a heating fuel is less geographically concentrated than are natural gas and electricity, as shown in Figure 3. High-use areas (30 percent and above) are found in all regions of the state except the metropolitan area and the southeast corner. Areas of moderate use (20 percent to 30 percent) include much of western Minnesota and the southeast.

Figure 3

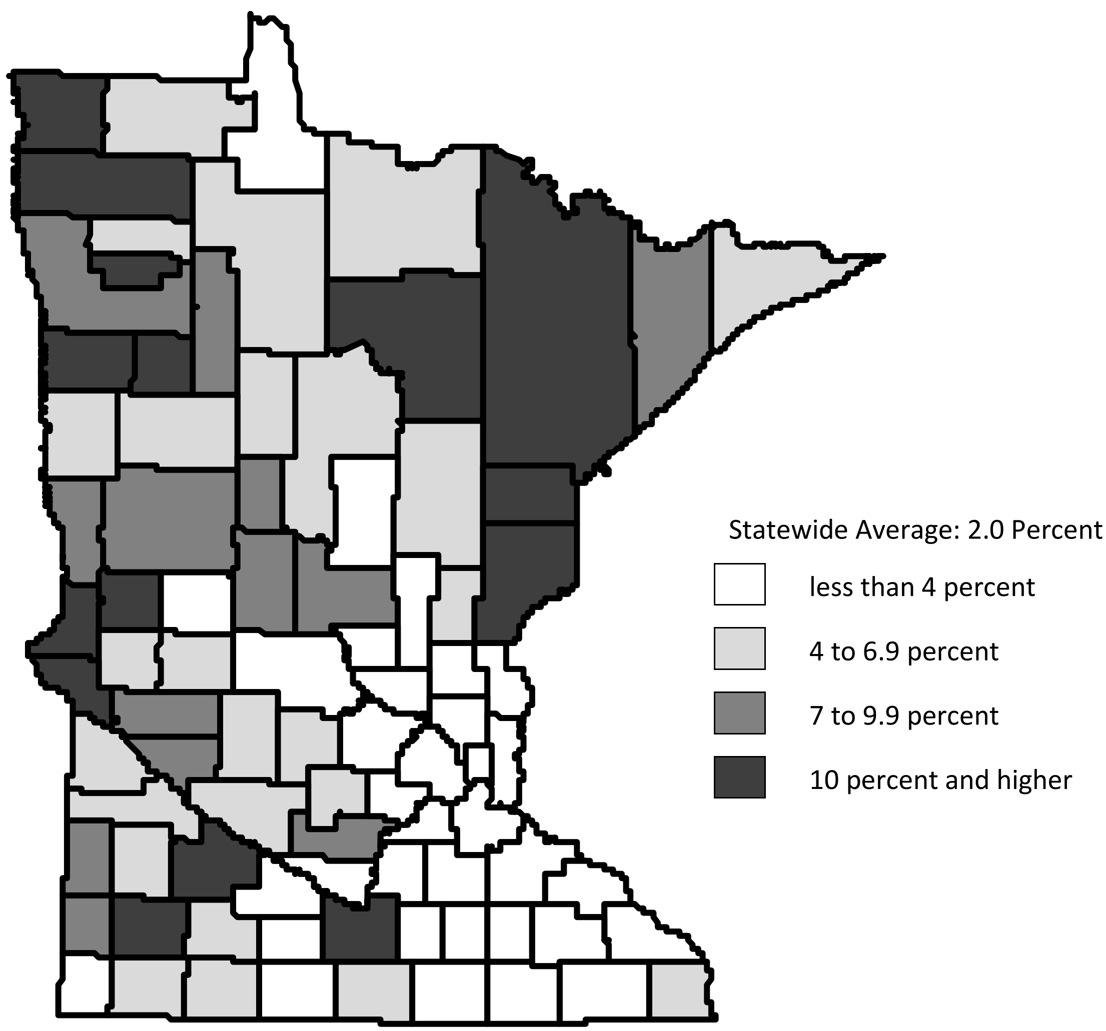
Percentage of Housing Units Using Propane as a Heating Fuel, 2010-2014



Source: U.S. Census Bureau, American Community Survey five-year estimates

Although the use of fuel oil for space heating has declined to just 2 percent of homes statewide, in some areas of the state it is used in 10 percent to 20 percent of homes, as shown in Figure 4. These include groups of counties in the northeast, northwest, west central, and south central/southwest portions of the state. Fuel oil is used least frequently in the southeastern quadrant of the state.

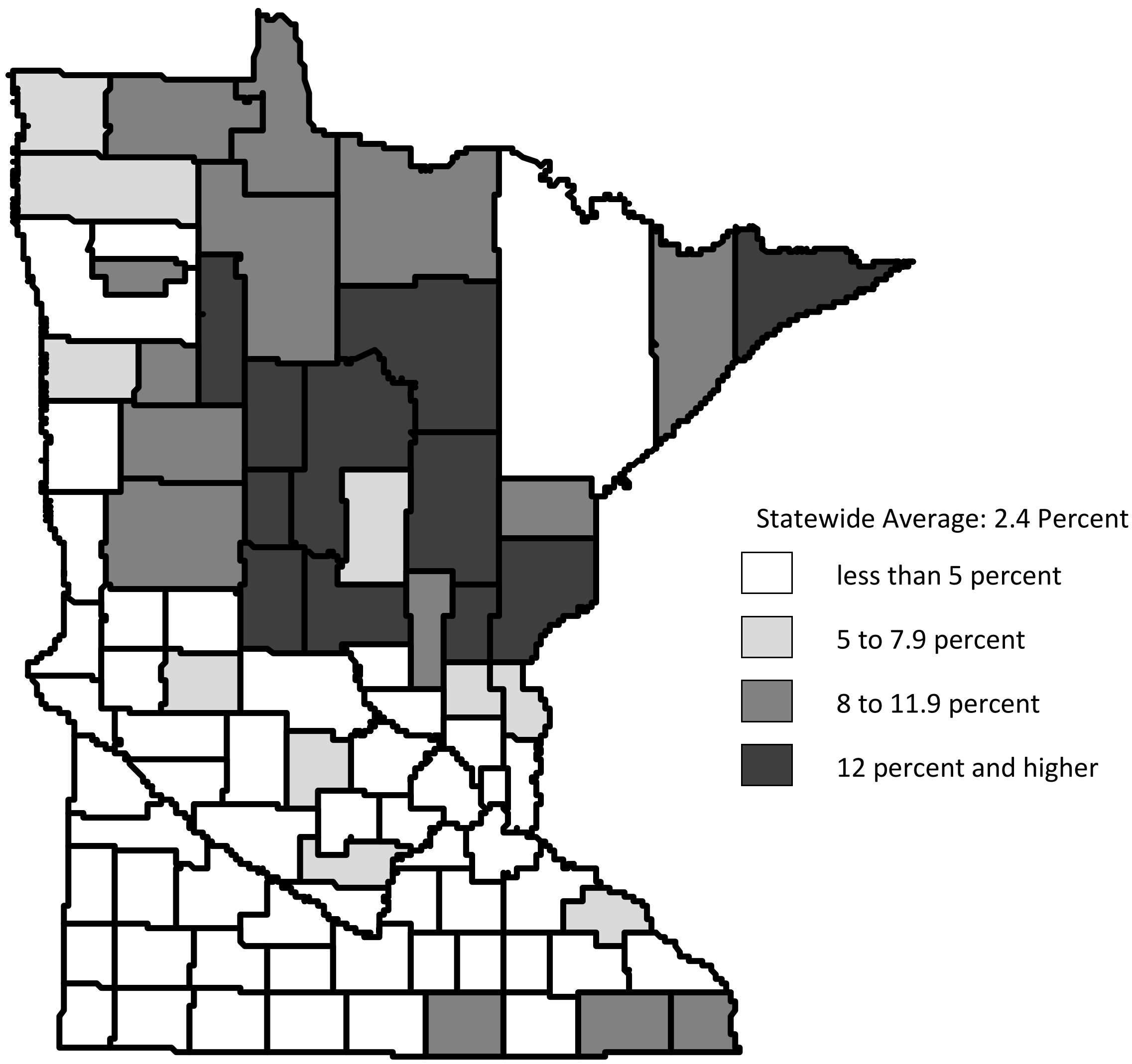
Figure 4
Percentage of Occupied Housing Units Using Fuel Oil as a Heating Fuel 2010-2014



Source: U.S. Census Bureau, American Community Survey five-year estimates

Heating with wood includes burning both firewood and manufactured wood pellets. As shown in Figure 5, wood is used most heavily in northern Minnesota. In 15 counties, wood is the primary heating fuel in more than 10 percent of the county's residences.

Figure 5
Percentage of Housing Units Using Wood as a Heating Fuel, 2010-2014



Source: U.S. Census Bureau, American Community Survey five-year estimates

Residential Space Heating Fuel Prices

One factor that influences a homeowner's choice of fuel for space heating is cost. Table 3 shows the average price for residential heating fuels over the past five heating seasons.[9] Both propane and fuel oil prices fluctuated significantly during this period, varying by almost 100 percent, while natural gas prices have been more stable.

Table 3
Average Heating Season Prices For Space Heating Fuels in Minnesota, 2011 to 2016

Heating Season*	Natural Gas ($/Mcf)	Propane ($/gal)	Fuel Oil ($/gal)
2011-2012	8.12	2.08	3.58
2012-2013	7.61	1.56	3.65
2013-2014	8.97	2.41	3.56
2014-2015	9.16	1.83	2.70
2015-2016	7.67	1.26	1.88
*October through March			

Sources: Natural gas: U.S. Energy Information Administration, *Minnesota Price of Natural Gas Delivered to Residential Consumers, 1989-2016*, http://www.eia.gov/dnav/ng/hist/n3010mn3m.htm.
Propane: U.S. Energy Information Administration, *Weekly Minnesota Propane Residential Prices, 1990-2016*, http://www.eia.gov/special/heatingfuels/#/us-mn=propane.week.
Fuel Oil: U.S. Energy Information Administration, *Weekly Minnesota No. 2 Heating Oil Residential Price, 1990-2016*, https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=W_EPD2F_PRS_SMN_DPG&f=W.

An accurate measure of relative fuel costs must go beyond a simple comparison of the commodity fuel prices in Table 3. Such an analysis lacks a crucial element: the amount of fuel that must be input into a heating system in order to produce a given amount of heat—in other words, the efficiency of the heating unit. Table 4 incorporates this important variable by presenting the cost of producing an output of one million Btus of heat via furnaces of different efficiencies using different fuels, based on the average fuel prices reported in Table 3, as well as a range of electricity prices.

[9] Electricity prices are not reported in Table 3 because no data source calculates an average price specifically for space heating customers. Some utilities offer lower rates for space heating than for other residential electricity consumption; others offer a lower rate if the customer participates in programs that allow the utility to reduce the customer's consumption during peak demand periods.

Table 4
Estimated Cost of Residential Heating per Million BTUs, by Fuel Source and Furnace Efficiency

Fuel	**Price per Unit**	**Furnace Efficiency/Price per Million BTU**		
Natural Gas	$8.31/Mcf	**80%**	**90%**	**95%**
		$10.39	$9.22	$8.76
Propane	$1.83/gal.	**65%**	**80%**	**90%**
		$31.28	$25.42	$22.59
Fuel Oil	$3.07/gal.	**60%**	**70%**	**85%**
		$36.56	$31.32	$25.80
Electricity		**Furnace Only**	**ASHP 2.0***	**ASHP 2.6***
	$0.06/kwh	$17.58	$8.79	$6.76
	$0.08/kwh	$23.44	$11.72	$9.02
	$0.10/kwh	$29.30	$14.65	$11.27
	$0.12/kwh	$35.16	$17.48	$13.53
* Electric furnace and air source heat pump, with a coefficient of performance as shown.				

Sources: Column 2: Average Statewide Annual Heating Season Price, 2011-2016, Table 3.
Columns 3 to 5: Duke Energy, Ohio: Estimating Costs with Changing Prices, www.duke-energy.com/ohio/savings/heating costs.asp.

As shown in the upper portion of Table 4, based on Minnesota's average heating season fuel prices over the past five years, natural gas is the lowest-cost option, followed by propane and fuel oil, which each cost about three times as much per unit of heat produced. As furnace efficiencies rise for each fuel, the effective cost declines, although the price ratios among the fuels are largely maintained. Of course, more efficient furnaces have a higher initial purchase cost, which is not reflected in the table; neither are furnace maintenance costs included.

The lower portion of Table 4 presents a similar analysis based on four different end-user electricity rates. Even at the low rate of six cents per kilowatt hour, an electric furnace is significantly more costly than natural gas; at 12 cents per kilowatt hour, it is more expensive than a low-efficiency (65 percent) propane furnace, and slightly less expensive than a low-efficiency fuel oil furnace.

The analog to a higher efficiency furnace with respect to electric heat is the addition of an air-source heat pump to the system. A heat pump, powered by electricity, uses a liquid refrigerant in its outdoor copper coils to extract heat from the outside air, evaporating the refrigerant into a gas. Indoor coils release the heat from the refrigerant as it condenses back into a liquid. The efficiency of this operation—the heat produced per unit of electric energy needed to operate the heat pump—is known as the unit's coefficient of performance. As shown in the table, heat pumps can reduce the cost of electric space heating by up to two-thirds.

Energy Conservation

The amount of energy used to heat homes has been declining as a proportion of total residential energy use for several decades. While the increase in electricity use for new appliances has increased the denominator of that ratio, technology has lowered the numerator by vastly improving the efficiency of space heating furnaces, by developing new building materials, and by employing advanced building designs that result in a tighter building envelope. These innovations reduce the amount of heat that must be produced in order to maintain a given temperature in a residence.

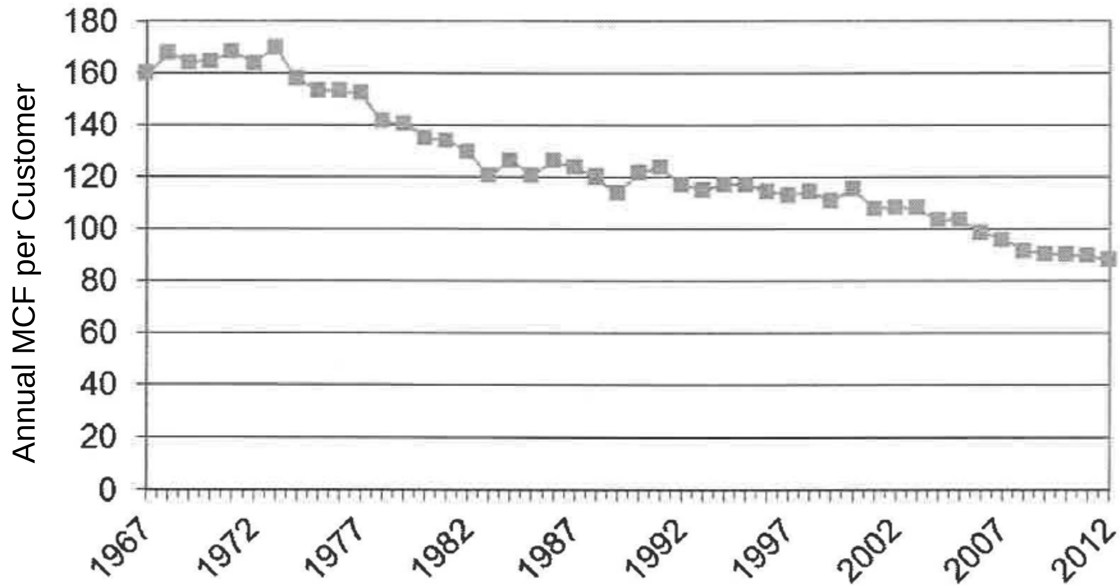
Residential building codes have played a key role in this trend. The International Energy Conservation Code (IECC) is revised every three years and has been regularly adopted in Minnesota. Residences constructed to conform to the 2015 IECC are estimated to use 45 percent less energy than homes in compliance with the building code in effect in 1975.[10]

One way to measure the extent of conservation of home heating fuels is to examine use per customer over time. Figure 6 shows the weather-normalized consumption of natural gas per residential customer in Minnesota between 1967 and 2012.[11] Use per customer began to decline in the early 1970s and has continued steadily, with only a few exceptions, reaching approximately half the level of its highest point in 1973.

[10] Carolyn Sarno Goldthwaite and Lauren Westmoreland, "Regional Construction Starts: Trends, Impacts and Energy Costs," 2016 American Council for an Energy Efficient Economy Summer Study on Energy Efficiency in Buildings, p. 5-3, www.aceee.org/files/proceedings/2016/data/papers/5_461.pdf.

[11] Seventy percent of the natural gas in U.S. homes that heat with that fuel is used for space heating, with the balance used for cooking and water heating. This figure is likely to be several percentage points higher in Minnesota's colder climate. U.S. Department of Energy, Buildings Energy Database, Table 2.1.5, *2010 Residential Energy End-Use Splits, by Fuel Type*, http://buildingsdatabook.even.doe.gov/docs/ xlspdf.2.1.5.pdf.

Figure 6
Weather-Normalized Natural Gas Use per Residential Customer in Minnesota, 1967-2012



Source: Minnesota Department of Energy, *The Minnesota Utility Data Book: A Reference Guide to Minnesota Electric and Natural Gas Utilities, 1965-2012,* p. 133, http://mn.gov/commerce-stat/pdfs/utility-data-book-2012.pdf.

Significant declines in energy consumption for space heating have occurred even though the size of homes in the Midwest has grown steadily, from 1,585 square feet in 1975 to 2,608 square feet in 2015, a 65 percent increase.[12]

Financial Assistance for Residential Space Heating

The federal Low-Income Home Energy Assistance Program (LIHEAP) provides financial assistance to households whose income is below 50 percent of the state median income (currently $47,194 for a family of four). Grants are paid directly to utilities and other energy suppliers, and averaged about $500 for each of the 156,068 successful applicants in 2014, when the state received $114.5 million in federal funds.[13]

[12] U.S. Census Bureau, Characteristics of New Housing, *Median and Average Square Feet of Floor Area in New Single-Family Houses Completed: Built for Sale*, p.10, www.census.gov/construction/chars/pdf/squarefeet.pdf.

[13] Minnesota Department of Commerce press release, "Minnesota consumers can seek winter protection under the Cold Weather Rule and apply for housing assistance," October 12, 2015, http://mn.gov/commerce/media/news/?id=17-70733.

In its 2016-2017 LIHEAP plan, the Minnesota Department of Commerce proposed the following allocation of federal funds: 58.5 percent to heating assistance; 19 percent to crisis assistance (imminent energy disconnection); 4.5 percent to weatherization assistance; 5 percent to services to reduce household energy consumption, including energy audits; 3 percent to be carried over into the following year; and 10 percent to administration.[14]

In 2014, the Minnesota Legislature appropriated $20 million to supplement LIHEAP funding, as a result of very cold conditions and a significant spike in the price of propane.[15]

Minnesota's Cold Weather Rule

State law provides protection from utility service disconnections during winter months for certain space heating customers using natural gas or electricity. Public utilities, cooperative electric associations, and municipal utilities are prohibited from disconnecting heating customers whose income is below 50 percent of the state median income between October 15 and April 15 of the following year, provided the customer has entered into and makes reasonably timely payments under a payment agreement with the utility that is based on the financial resources and circumstances of the household. A customer under a payment agreement to a public utility may pay no more than 10 percent of household income under such an agreement, unless the customer concurs. A public utility is also prohibited from disconnecting a customer of any income level if the customer makes timely payments under a payment agreement that reflects the customer's financial circumstances and is accepted by a utility. These protections against disconnections of heating service do not apply to those heating with propane, fuel oil, or wood.[16]

For more information about energy, visit the utility regulation area of our website, www.house.mn/hrd/.

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[14] Minnesota Department of Commerce, *Draft application for Federal Assistance SF 424*, http://mn.gov/commerce-stat/pdfs/draft-ffy2016-liheap-state-plan.pdf.

[15] Laws of Minnesota 2014, ch. 145, as amended by ch. 254, § 24.

[16] Minn. Stat. 2016, §§ 216B.096 and 216B.097.