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Memo to: Cindy Heil, ADEC

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Subject: Analysis of Fairbanks 2013-2015 Home Heating Surveys

Summary

In 2013, 2014, and 2015, Hays Research (under subcontract to Sierra Research) conducted three telephone-based surveys of roughly 700 households each in the Fairbanks area to determine and document trends in current practices in home heating. Similar Home Heating (HH) surveys were conducted in the winters of 2006, 2007, 2010, 2011, and 2012. The existing Fairbanks Moderate Area PM_{2.5} SIP emission inventory (EI) is largely based on device and fuel usage splits and practices from the earlier 2011 survey, which was the latest HH survey available at the time the EI was prepared. Results from these recent surveys were tabulated into annual estimates of wintertime heating energy use percentages by device/fuel. The key findings from these 2013–2015¹ HH surveys are summarized below.

1. Heating oil continues to be the principal fuel for home heating in Fairbanks. In 2011, it represented 72.6% of wintertime heating energy use. Heating oil use occurs mostly (91%) from central oil furnaces or boilers, with direct vent and portable heaters representing 7% and 2% of heating oil based energy use (as presented later in Table 4). From 2011 to 2015, total heating oil energy use was quite consistent—always within the 70%-74% range—and ended at 73.0% in 2015, a very modest increase from 2011 as reported in Table 4. The relative consistency in the year-to-year energy use fractions from heating oil was modulated by two competing effects for central oil devices (which represent over 90% of heating oil energy use). The increase in the fraction of households using central oil, which rose from 52.6% to 58.9% between 2011 and 2015, was offset by the reduction in the volume those households burned (declining 17% from 5.44 vs. 4.54 gallons/day) over the same period.
2. The wood-burning device sector is the second largest fuel source after home heating oil. It represents over 95% of space heating particulate matter emissions. Energy use for woodstoves/inserts has risen 24% from 2011 to 2015 (the composite of changes for cordwood and pellet devices reported later in Table 5),

¹ Where historical trends are presented, data from the 2006-2012 surveys are also included.

- while energy usage from fireplaces (without inserts) and outdoor wood boilers² (OWBs) has decreased by 18% and 45%, respectively, over the same time period (as shown in Table 5). This is significant because fireplaces and OWBs have the highest particulate emission rates and lowest heating efficiencies of commonly used wood burning devices in Fairbanks.
3. Wood device usage rose 11% between 2011 and 2015 (with the 22% share in 2011 increasing to 24.4% in 2015, as seen later in Table 4). As discussed in greater detail later, this may be related to the gradual rise in heating oil prices over the same period, where wood is a cheaper alternative fuel source.
 4. Although they represent small fractions of wintertime space heating energy use, natural gas and coal-based heating have trended in opposite directions since 2011 as shown later in Table 4. Natural gas use has declined from 2.8% of total energy use in 2011 to 0.6% in 2015, a decrease of over 77%. Conversely, energy use from coal-burning heating devices has risen over 34%, from 0.3% in 2011 to 0.5% in 2015. However, the sample sizes for these devices were small and the resulting energy use splits and trends may not be statistically representative.
 5. The gradual rise in residential wood and coal-based energy use shares, coupled with a leveling or modest reduction in heating oil use from 2011-2015, is consistent with the gradual rise in Fairbanks heating oil prices during same period. As oil prices approached levels over \$4 per gallon, last experienced in 2008, area residents continued to seek or “hedge” use of cheaper heating sources such as wood and coal.
 6. Even with annual surveys that encompass at least 700 separate households, sample size variation effects (i.e., the “luck of the draw”) tend to hinder development of clear, statistically significant trends for devices or fuel that represent small fractions of total home heating energy use. Therefore, greater uncertainty exists for “small proportional share” devices such as portable heaters, natural gas, coal heaters, and, within the wood-burning sectors for pellet stoves, fireplaces, and OWBs.
 7. Based on a careful review of detailed responses in each annual survey, the Fairbanks area may be exhibiting both survey weariness and wariness. In the three recent surveys, it appears that the number of anomalous or internally inconsistent survey responses has crept upward relative to the 2011 survey. Although corrections to anomalous fuel use or heating cost responses were performed when indicated by supporting evidence (other related survey responses), some data were discarded as simply invalid when they could not be thoughtfully interpreted. In addition, the 2015 survey exhibited a disturbing result: no respondents from the North Pole area (ZIP code 99705) indicated they operate an outdoor wood boiler. Based on the OWB device share found within North Pole respondents from the 2011-2014 surveys (2.7%), the likelihood of

² Also called outdoor hydronic heaters.

finding zero OWBs within the 149 North Pole households sampled in the 2015 survey is very small (less than 2%).

Methodology

Households were selected for the survey using a stratified random sample of telephone numbers that was designed to collect a representative number of respondents from the six Fairbanks area ZIP codes within the PM_{2.5} nonattainment area: 99701, 99703, 99705, 99709, 99712, and 99775. To help minimize sampling bias due to households that may not use landlines, cell phone numbers from the Fairbanks area were also randomly called, and responses from cell phone interviewees (for which address data were not generally available) were mapped to ZIP codes within the nonattainment area based on occupied household fractions developed from the 2010 U.S. Census. In all, 701 households were successfully surveyed in 2013, 700 in 2014, and 701 in 2015.

Table 1 provides an overview of the distributions of households by ZIP code from the 2010 U.S. Census (on which the survey targets by ZIP code were based); and, for comparison, the Hays survey sample, which nominally matched the 2010 Census household proportions. To provide the most accurate representation of the area-wide statistics, the survey results for each ZIP code were weighted using the 2010 Census data rather than simply adding the survey results across ZIP codes. (In most cases, this adjustment was on the order of 1% or less, relative to simply summing results.)

ZIP Code	Area	No. (%) of Occupied Households 2010 Census	No. (%) of Households Surveyed in 2013	No. (%) of Households Surveyed in 2014	No. (%) of Households Surveyed in 2015
99701	Downtown	7,805 (24.6%)	185 (23.3%)	190 (23.2%)	150 (22.5%)
99703	Wainwright/Birch Hill	1,474 (4.7%)	22 (4.4%)	7 (4.4%)	5 (4.3%)
99705	North Pole	7,576 (23.9%)	156 (22.6%)	170 (22.5%)	149 (21.9%)
99709	Airport	10,885 (34.3%)	234 (32.5%)	220 (32.3%)	238 (31.4%)
99712	Steese	3,809 (12.0%)	63 (11.4%)	72 (11.3%)	97 (11.0%)
99775	University	144 (0.5%)	3 (0.4%)	0 (0.4%)	2 (0.4%)
Cell Households		n/a	38 (5.4%)	41 (5.9%)	60 (8.6%)
TOTALS		31,693 (100%)	701 (100%)	700 (100%)	701 (100%)

n/a – not applicable. (Since cell household addresses were not known, they were assumed to be distributed in proportion to occupied households from the 2010 Census).

As in previous years, the surveys in 2013 to 2015 asked about the types of devices that provide space heating for each home, the estimated percentage of heat provided by each,

the amounts and cost of fuel used annually and in winter (October through March), and other related questions to help characterize the heating appliances and fuels used. The format, which was devised by Sierra in consultation with ADEC and Borough staff, was a structured series of up to 92 questions. Several additional questions were asked to learn about public awareness of energy logs and willingness to use natural gas. A copy of the full survey instrument from the most recent survey (2015) is provided in Attachment A.

Hays Research conducted the primary telephone surveys in 2013, 2014, and 2015, and provided the raw survey data to Sierra for review and analysis. Sierra first screened the data, reviewing answers for consistency and reasonableness. This review resulted in the identification of modest fractions (generally less than 10%) of inconsistent responses within each survey that were not caught by the internal logic Hays programmed into the phone surveying software. A common example of an inconsistent response was one where respondents indicated they did not have a wood heating device but then—when asked about other heating devices beyond those explicitly asked about (i.e., wood, central oil, direct vent heater, portable heater, coal heater, electricity, municipal heat)—would list a woodstove as the “other” device. These types of inconsistencies were corrected by adjusting the explicit device type responses when those devices were identified from descriptions of heating devices recorded in the “Other” miscellaneous device responses.

Limit/reasonableness checks were also applied to the annual and winter season (October through March) device-specific fuel usage responses to validate them and were developed in consultation with Borough staff.³ Examples of these limit checks included the following:

- ≤ 12 cords annually or 10 cords during winter for woodstoves, inserts, fireplaces;
- ≤ 20 cords annually or 16 cords during winter for outdoor wood boilers;
- $\leq 5,000$ gallons annually or 4,000 gallons during winter for oil devices (central oil, direct vent, portable heaters); and
- ≤ 20 tons annually or 16 tons during winter for coal heating devices.

When fuel usage responses exceeded these limits, the reported results were not simply invalidated and deleted—instead, all the data from each affected household were examined to assess whether the reported results were plausible, or if not, could be corrected by examining other responses from that household. Other responses reviewed in these cases included the dwelling size (ft²), the estimated device usage percentages, and annual fuel cost entries. In many instances, fuel use values exceeding the limits could be corrected based on information in these other fields.

For example, consider a household with only a central oil furnace (and no other heating device). If annual and winter oil usage (in gallons) responses were “6000” and “5000” and the annual oil cost (in dollars) response was also “6000,” the dwelling size was used to assess whether the annual energy use per unit dwelling size (e.g., BTU/ft²) was reasonable. Reasonable ranges of unit size energy use (i.e., per ft²) were based on 2014

³ Personal communication with Todd Thompson, Fairbanks North Star Borough Air Quality Office, June 25, 2015.

Alaska Housing Assessment⁴ estimates for the Borough developed by the Alaska Household Finance Corporation (AHFC). The average annual unit residential heating energy use in Fairbanks was 143,000 BTU/ft², although this could double for older, less energy efficient homes. If the dwelling size for the example above was 1,000 ft², this would yield a unit size annual energy use of 792,000 BTU/ft² (6000 gallons × 132,000 BTU/gallon), which is over five times the average reported by AHFC. In this instance, address data were used to double-check the entry for dwelling size using a location-based lookup from the property database maintained by the Borough's Assessor Department.⁵ If the dwelling size was corroborated from the property database in this example, the annual and winter usage entries of "6000" and "5000" were corrected based on the annual cost entry (of \$6,000). The average heating oil market price during the survey year (e.g., \$3.50 per gallon) was then used to back-calculate estimates of annual and winter usage of 1,714 gallons (6000/3.5) and 1,429 gallons (5000/3.5), respectively, yielding a more plausible annual unit size energy use of 226,000 BTU/ft². In a few of these types of instances, the reported dwelling size was not in agreement with the property database. That correction resulted in a more reasonable estimate of annual unit size energy use.

These types of adjustments were rare and were made only when corroborating information supporting the correction was available. If no corroborating data were available, then the flagged values were marked as invalid or missing and not used in calculating averages for the survey. Generally, fewer than 5% of the response records in each survey required this level of review and validation.

Summary of Survey Results

Heating Device Counts – Table 2 presents counts of the types of heating devices present in the surveyed homes for the 2013, 2014, and 2015 surveys by device and fuel type. Detailed wood-burning device breakouts are shown in the top portion of Table 2, and indentations in the "Heating Device Type" column reflect hierarchical breakouts. For example, there were four wood-burning device types tabulated: (1) Fireplaces (without insert); (2) Inserts; (3) Woodstoves; and (4) OWBs. And within the population of inserts and stoves, separate breakouts are also provided by certification status⁶ and wood type (cord wood or pellets). Oil, natural gas, coal and other heating devices are contained in the bottom portion of Table 2. For each of the three surveys, both the number and the percentage of surveyed households with each type of device are given. The percentages at the bottom of Table 2 exceed 100% because multiple heating devices are used in many residences. For example, in the 2014 survey a total of 1,227 devices were reported across the 700 surveyed households, resulting in a device-to-household percentage of 161% ($1,227 \div 700 = 1.61$ or 161%).

⁴ www.ahfc.us/efficiency/research-information-center/housing-assessment/

⁵ www.co.fairbanks.ak.us/Assessing/propsearch.aspx

⁶ The installation date of the device (before or after 1988) is a rough proxy for classifying a woodstove or insert as either uncertified or EPA-certified. Although some fraction of uncertified devices continued to be sold after 1988, it was not practical within these surveys to ask the respondent to identify and provide information from the certification label on their wood device.

Heating Device Type	No. of Households with Device				% of Households with Device			
	2013	2014	2015	Avg.	2013	2014	2015	Avg.
All Wood-Burning Devices	290	296	264	283	41.4%	42.3%	37.6%	40.4%
Fireplace (without insert)	20	19	18	19	2.9%	2.8%	2.5%	2.7%
Fireplace Insert (Insert)	13	20	20	18	1.8%	2.9%	2.8%	2.5%
Woodstove	251	240	215	235	35.8%	34.3%	30.7%	33.6%
All Inserts & Woodstoves	263	260	235	253	37.6%	37.2%	33.6%	36.1%
Stove/Insert, Uncertified (<1988)	40	44	27	37	5.7%	6.3%	3.9%	5.3%
Stove/Insert, Certified (≥1988)	196	196	193	195	28.0%	28.0%	27.6%	27.9%
Stove/Insert Using Cord Wood	212	218	199	210	30.3%	31.1%	28.3%	29.9%
Stove/Insert Using Pellets	33	32	31	32	4.7%	4.6%	4.4%	4.6%
Outdoor Wood Boiler (OWB)	6	13	11	10	0.8%	1.8%	1.6%	1.4%
Central Oil Furnace	583	529	544	552	83.1%	75.6%	77.6%	78.8%
Portable Heater	20	24	13	19	2.9%	3.4%	1.9%	2.7%
Direct Vent Heater	74	90	86	83	10.6%	12.9%	12.3%	11.9%
Natural Gas Heating	20	20	14	18	2.9%	2.9%	2.0%	2.6%
Coal Heat	15	21	4	13	2.2%	3.0%	0.6%	1.9%
District Heat	17	10	21	16	2.5%	1.5%	3.0%	2.3%
Electric	46	74	68	62	6.5%	10.5%	9.7%	8.9%
Other	36	62	62	53	5.1%	8.9%	8.8%	7.6%
All Heating Devices	1,102	1,127	1,076	1,101	157.2%	161.0%	153.4%	157.2%

Note: Total wood-burning devices are represented by the sum of fireplaces, inserts, woodstoves, and OWBs.

As shown in Table 2, central oil furnaces are the most common type of heating device, although the percentages of homes with these devices has drifted downward: from 83% in 2013 to under 78% in both 2014 and 2015. Interestingly, the percentage of homes with any type of wood heating device has also drifted downward slightly over the three surveys, from 42% in 2013 and 2014 to 38% in 2015, although these modest trends may result simply from year-to-year sample variations. This is likely to be the case for device types with smaller relative shares. For example, the variations in coal device percentages of 3.0%, 0.6%, and 1.9% over the three surveys is the result of small sample variations rather than actual usage changes.

Trends in Energy-Based Device Usage Fractions – As noted earlier, residential space heating emission estimates in the Moderate Area SIP are based on “energy equivalent” usage fractions calculated from the seasonal and annual fuel use estimates provided by respondents for each of the devices used in their home. Fuel usage estimates (or costs translated to fuel use based on estimated market prices) were then converted to energy use estimates (i.e., BTU) for each household based on the energy content of each type of fuel.

Table 3 lists the energy contents assumed for each fuel type used to convert survey-reported fuel usage to energy use (in BTUs). Wood density (to convert usage in cords to tons) was assumed to be 1.56 tons per cord.⁷

Fuel	Energy Content (per fuel unit)	Unit
Wood	13.5	mmBTU/ton
Fuel Oil	132,000	BTU/gal
Kerosene (Portable)	135,000	BTU/gal
Propane	91,700	BTU/gal
Natural Gas	1,015	BTU/ft ³
Electric	3,413	BTU/KWH
Coal	15.3	mmBTU/ton

BTU = British thermal unit

mmBTU = million BTU

KWH = Kilowatt-hour

To convert natural gas and district (municipal) heat data from the survey expressed as annual or seasonal costs (rather than fuel use), the following unit costs⁸ were assumed:

- Natural gas – \$2.34 per MCF (hundred cubic feet); and
- District heat – \$10.50 per mmBTU.⁹

Table 4 presents the resulting energy-based usage percentages for each of the annual surveys from 2011 through 2015. As with the earlier historical respondent-based splits, the 2011 survey data used in the Moderate Area SIP are highlighted and the two predominant fuel types—wood and heating oil—are shown in **bold**. As indicated in a footnote to Table 4, total heating oil usage is summed from Central Oil, Portable, and Direct Vent heaters which burn a combination of #1 and #2 heating oil and kerosene. Three-year averages from the 2013-2015 surveys are also shown, along with the relative change from 2011 to 2015. Again, percentages based on sample sizes of less than 30 households are footnoted within the table. (Unlike the respondent-based estimates, percentages were not available for electric heating; electricity usage was not part of the survey as it was impractical to ask respondents to split out the electricity usage into space heating vs. non-heating subsets.)

⁷ Developed from wood cord weights for Alaska southcentral/interior published by Alaska Department of Natural Resources, Division of Forestry,

<http://forestry.alaska.gov/Assets/uploads/DNRPublic/forestry/pdfs/wood/firewood.pdf>

⁸ Source: Fairbanks Natural Gas (www.fngas.com).

⁹ www.newsminer.com/power-and-energy-cost/image_6faf4854-7b2a-11e3-ae4e-001a4bcf6878.html.

District hot water cost of \$26.83 per mmBTU also reported. Residential customers were assumed to use steam heat.

Usage (%) by Fuel/Device	Survey Year					3-Year Avg. 2013-2015	% Change 2011-2015
	2011	2012	2013	2014	2015		
Wood	22.0%	25.8%	23.2%	23.9%	24.4%	23.8%	+10.6%
Total Heating Oil^b	72.6%	70.4%	74.3%	70.4%	73.0%	72.5%	+0.5%
Central Oil	66.3%	67.3%	70.9%	61.6%	70.0%	67.5%	+5.6%
Portable	1.1%	0.0% ^a	0.7% ^a	0.8% ^a	0.2% ^a	0.6%	-77.2% ^a
Direct Vent	5.2%	3.1%	2.7%	8.0%	2.7%	4.5%	-47.4% ^a
Natural Gas	2.8% ^a	2.5% ^a	1.0% ^a	2.6% ^a	0.6% ^a	1.4%	-77.5% ^a
Coal Heat	0.3% ^a	0.2% ^a	0.8% ^a	2.3% ^a	0.5% ^a	1.2%	+34.1% ^a
District Heat	2.3% ^a	1.2% ^a	0.8% ^a	0.8% ^a	1.6% ^a	1.0%	-30.3% ^a

^a Limited sample (< 30 households), may not be representative.

^b "Total Heating Oil" represents the sum of Central Oil, Portable and Direct Vent devices.

As seen in Table 4, both wood and central oil normalized energy uses have risen modestly from 2011 levels. Wood usage rose from 22.0% in 2011 to 24.4% in 2015, a relative increase of 10.6% ($24.4\% \div 22.0\%$). Similarly, the percentage of energy use from central oil also rose modestly from 66.3% in 2011 to 70.0% in 2015, a 5.6% increase. And grouping Direct Vent oil with central oil usage (both devices have similar emission factors) shows that heating oil (both No. 1 and No. 2) energy use has been essentially flat since 2011.

Meaningful trends in relative energy usage for the other fuel types is harder to discern due to small sample size effects for cells denoted in Table 4. For example, the reported reduction in natural gas usage from 2.8% in 2011 to 0.6% in 2015 is an artifact of small sample size variations; in reality, natural gas usage in Fairbanks during this period has remained essentially flat.

Table 5 summarizes the breakouts of energy use by wood-burning device type for each survey. Note that the winter season energy use percentages in Table 5 are normalized to all space heating devices, not just wood devices. For example, wood stoves and inserts burning cordwood used 16.9% of all space heating energy in 2011 (not 16.9% of wood heating energy). Again, the 2011 survey column is highlighted as a reminder that those splits were used in the Moderate Area SIP and footnoted entries reflect small sample sizes (<30 households) with greater uncertainty.

The key takeaway from Table 5 is that the 10.6% increase within the wood-burning sector from 2011 to 2015 is driven by higher use of wood stoves and fireplace inserts burning either cordwood or pellets, which offset the reductions in fireplace and outdoor wood boiler use shown in the rightmost column of Table 5 of 18.0% and 45.0%, respectively. Reductions in outdoor wood boiler usage are likely the result of efforts to remove or switch out the use of OWBs under the Borough's Wood Stove Change Out Program, but would require further analysis to confirm given the small sample sizes.

Usage (%) by Device	Survey Year					3-Year Avg. 2013-2015	% Change 2011-2015
	2011	2012	2013	2014	2015		
Stove/Insert, Cordwood	16.9%	21.9%	19.4%	21.1%	20.9%	20.4%	+23.3%
Stove/Insert, Pellets	0.7% ^a	0.6% ^a	1.7%	1.4% ^a	0.9% ^a	1.3%	+29.9%
Fireplace (no insert)	0.6% ^a	1.1% ^a	1.1% ^a	0.8% ^a	0.5% ^a	0.8%	-18.0% ^a
Outdoor Wood Boiler	3.8% ^a	2.2% ^a	1.0% ^a	0.6% ^a	2.1% ^a	1.2% ^a	-45.0% ^a
Total Wood	22.0%	25.8%	23.2%	23.9%	24.4%	23.8%	+10.6%

^a Limited sample (< 30 households), may not be representative.

Next, Table 6 shows trends in normalized energy use splits between uncertified and EPA certified (both non-catalytic and catalytic) woodstoves and inserts. These splits are rough approximations of the true split between uncertified and certified devices because they are based on a “proxy” question in the surveys asking if the devices were installed before or after 1988.¹⁰

Normalized Usage (%) by Device	Survey Year					3-Year Avg. 2013-2015	% Change 2011-2015
	2011	2012	2013	2014	2015		
Uncertified	23.6%	19.7%	16.7%	18.4%	13.8%	16.3%	-41.3%
Certified, Non-Catalytic	44.0%	51.7%	44.1%	44.1%	42.7%	43.7%	-2.8%
Certified, Catalytic	32.5%	28.5%	39.2%	37.5%	43.4%	40.1%	+33.7%

Note: Column totals sum to 100%, not 100.0% due to rounding and reported precision.

As seen in Table 6, the fraction of woodstove/insert energy use from uncertified devices has generally trended downward, from 23.6% in 2011 to 16.3% averaged over the 2013-2015 surveys. This descent results from replacement of woodstoves/inserts over time and the proxy question in the surveys tied to installation date. Nevertheless, it likely reflects the directional trend in the real (non-proxy) split between uncertified and certified stoves/inserts. This is significant because certified devices tend to emit less than half the PM emissions of their uncertified counterparts.

¹⁰ Not all indoor wood burning devices currently sold are EPA-certified. The 1988 New Source Performance Standards (NSPS) for residential wood heaters contains language that exempts certain wood-burning devices. Thus, the installation date of 1988 is a rough proxy for identifying a wood stove or insert as uncertified or EPA-certified to avoid the difficulty of having survey respondents attempt to find and identify a certification label affixed to the device.

Comparison of Heating Device Usage within the Nonattainment Area – The device and energy use breakdowns and trends shown earlier in this sub-section were presented as composite averages across the entire Fairbanks nonattainment area. Here, key survey summaries by individual ZIP code within the nonattainment area are provided.

First, Table 7 shows winter energy use percentages for key fuel groups (Wood, Oil,¹¹ and all other fuels) by individual ZIP code. (Only four of the six ZIP codes are shown because survey sample sizes for the Fort Wainwright and University ZIP codes were not sufficient to provide meaningful cross-comparisons.) Results from the 2011 survey are presented in the top portion of Table 6 (again for reference to the Moderate Area SIP inventory); results averaged across the 2013-2015 surveys are displayed in the bottom half.

Table 7				
Energy-Based Winter Season Device Usage Percentages by ZIP Code				
Usage (%) by Device	Fairbanks 99701	North Pole 99705	Airport 99709	Steese 99712
<i>2011 Survey</i>				
Wood	8.7%	29.6%	24.4%	23.3%
Oil	83.2%	69.5%	69.1%	74.7%
Other	8.1%	0.8%	6.5%	2.0%
TOTAL	100.0%	100.0%	100.0%	100.0%
<i>2013-2015 Survey Average</i>				
Wood	12.1%	28.3%	25.5%	30.3%
Oil	83.1%	68.4%	73.6%	67.4%
Other	4.9%	3.3%	0.9%	2.3%
TOTAL	100.0%	100.0%	100.0%	100.0%

Note: Column totals sum to 100%, not 100.0% due to rounding and reported precision.

As shown in Table 7 and observed across multiple surveys, the Fairbanks city (99701) and North Pole (99705) ZIP codes represent the extremes in wood vs. oil use across the nonattainment area; Fairbanks city has the lowest wood use while North Pole has had the highest (until being eclipsed by Steese over the recent three surveys). The key finding represented in Table 6 is the fact that wood use in North Pole may have reached a “saturation” level given the slight decline between the 2011 and averaged 2013-2015 surveys. Conversely, the greatest increases in wood energy use have occurred in the Fairbanks city and Steese areas, which exhibited lower wood use in 2011 than the other areas shown.

Table 8 provides breakdowns of wood energy use (relative to wood use, rather than all heating energy use) by wood device in each ZIP code, again providing comparisons between the 2011 and averaged 2013-2015 surveys.

¹¹ The Oil fuel group includes central oil, portable and direct vent heaters.

Table 8				
Energy-Based Winter Season Wood Device Usage Percentages by ZIP Code				
Normalized by Total Wood Energy Use				
Normalized Usage (%) by Wood Device	Fairbanks 99701	North Pole 99705	Airport 99709	Steese 99712
<i>2011 Survey</i>				
Stove/Insert, Cordwood	82.0%	67.7%	83.9%	92.4% ^a
Stove/Insert, Pellets	0.0%	4.8%	0.7%	5.4% ^a
Fireplace (no insert)	6.6%	2.8%	4.2%	0.0% ^a
Outdoor Wood Boiler	11.5%	24.7%	11.2%	2.1% ^a
TOTAL	100.0%	100.0%	100.0%	100.0%
<i>2013-2015 Survey Average</i>				
Stove/Insert, Cordwood	83.2%	87.4%	89.7%	78.3%
Stove/Insert, Pellets	9.9%	8.7%	3.2%	1.7%
Fireplace (no insert)	1.5%	1.8%	3.5%	10.0%
Outdoor Wood Boiler	5.4%	2.0%	3.6%	10.0%
TOTAL	100.0%	100.0%	100.0%	100.0%

Note: Column totals sum to 100%, not 100.0% due to rounding and reported precision.

^a Limited sample (< 30 households), may not be representative.

The most noteworthy element in Table 8 is the sharp drop in energy use of outdoor wood boilers (OWBs) in North Pole from the 2011 (24.7%) to the averaged 2013-2015 surveys (2.0%). As noted earlier in the Summary section, this is partially the result of finding no OWB households for North Pole in the 2015 survey, coupled with lower OWB counts in that ZIP code in 2013 and 2014 relative to that found in 2011. Given historical OWB shares in North Pole across all prior surveys, the probability of finding no OWB households in the 2015 survey is less than 2%. As noted earlier, this finding suggests that respondents in North Pole (and perhaps other portions of the nonattainment area) may be wary of an increased focus by the Borough and State on OWBs and not reporting them in recent surveys.

Trends in Average Fuel Usage and Costs per Device – After the initial section of the survey where respondents are asked to identify the types of heating devices present in their home, additional questions were asked about how much fuel was used in each device both annually and during the winter months (October through March) or their usage costs (for certain device types). Table 9 provides a tabular summary of ZIP code-weighted winter usage/cost averages compiled from each survey. It is noted that these are averages over only those households that use each device, rather than all households in the survey sample. (Tabulations shown later account for usage across all surveyed households.)

Table 9
Average Winter Season Fuel Usage/Cost by Device from 2006-2015 Home Heating Surveys
(ZIP-weighted)

Statistic	Survey Year							
	2006	2007	2010	2011	2012	2013	2014	2015
Stove/Insert Wood Use (cords)	3.14	2.84	3.51	3.17	3.68	3.46	3.74	3.40
Fireplace Wood Use (cords)	0.82 ^a	0.81 ^a	4.09 ^a	2.10 ^a	2.76 ^a	1.81 ^a	1.65 ^a	2.09 ^a
OWB Wood Use (cords)	n/a	n/a	6.00 ^a	16.29 ^a	12.01 ^a	6.34 ^a	3.16 ^a	6.02 ^a
Central Oil Use (gals)	1,172	1,027	819	972	874	918	875	818
Portable Heater Fuel Use (gals)	97.1 ^a	241.9 ^a	59.1 ^a	257.8 ^a	22.5 ^a	271.5 ^a	403.5 ^a	118.3 ^a
Direct Vent Heater Fuel Use (gals)	470	514	487	400	383	335	881	308
Coal Heater Coal Use (tons)	n/a	n/a	2.29 ^a	1.45 ^a	3.79 ^a	2.62 ^a	11.38 ^a	10.02 ^a
Natural Gas Heating Fuel Cost (\$)	\$1,414 ^a	\$1,287 ^a	\$1,346 ^a	\$1,548 ^a	\$1,622 ^a	\$2,150 ^a	\$2,419 ^a	\$1,837 ^a
District Heating Fuel Cost (\$)	\$70 ^a	n/a	\$1,452 ^a	\$2,067 ^a	\$1,112 ^a	\$1,108 ^a	\$2,065 ^a	\$2,400 ^a

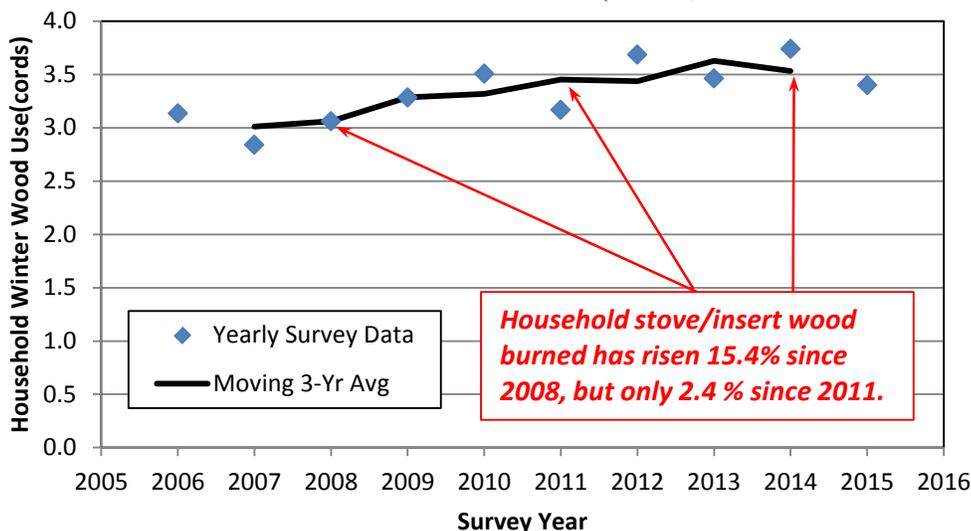
^a Limited sample (< 30 households), may not be representative.

For historical trend purposes, data from all home heating surveys (back to 2006) are shown. (The 2006, 2007, and 2010 surveys had smaller 300-household samples and did not explicitly include cell-only households.) Fuel usage data for woodstoves and central oil heaters are highlighted because they represent the most common heating devices in use during winter and contain statistically representative samples (see Table 8 footnote). Over the entire period of the surveys (2006-2015), wood usage per household equipped with stoves/inserts has generally risen over time, while central oil usage has dropped. Clear trends are less distinct for the other heating device types and fuels because of small sample size variation effects. (Natural gas and District/municipal heat usage is based on surveyed seasonal and annual costs since it is easier for respondents to provide costs rather than fuel usage estimates for these heating types.)

Figures 1 and 2 show the long-term trends for winter season (October through March) wood stove/insert and central oil device usage, respectively. In these figures, year-to-year variations are smoothed by the use of running three-year averages. As noted in Figure 1, winter-season wood usage in stoves/inserts per equipped household has risen by over 15% since 2008, from 3.0 cords to just over 3.5 cords (using three-year averages). However, this increase in wood usage has flattened in recent years, rising only 2.4% since 2011.

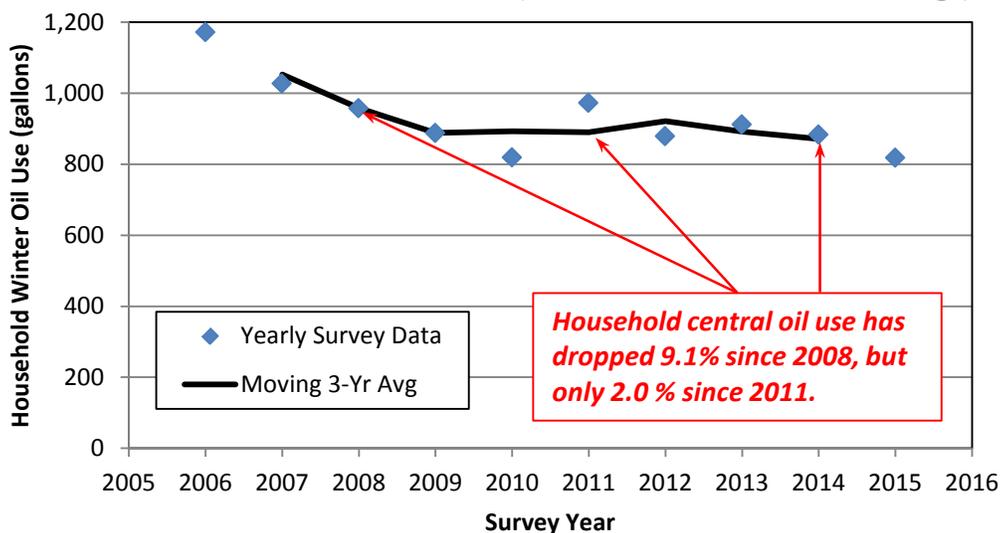
Conversely, winter season central oil usage in homes with central oil heaters has dropped over 9% since 2008, as shown in Figure 2 (using three-year averaging). But as with wood stove usage, this decrease has slowed in recent years, dropping only 2% since 2011.

Figure 1
Trend in Household Wood Stove/Insert Wood Use (Cords, Winter Season Average)



Note: Points for 2008 and 2009 are based on interpolation of 2007 and 2010 survey data.

Figure 2
Trend in Household Central Oil Use (Gallons, Winter Season Average)



Note: Points for 2008 and 2009 are based on interpolation of 2007 and 2010 survey data.

Trends in Respondent-Estimated Device Usage Percentages – Within the annual surveys, device usage fractions can be tabulated from responses in two different sections of the surveys: (1) respondent-estimated usage percentages; and (2) actual fuel usage (or heating cost) by device. The latter approach—calculation of relative energy use based on device-specific fuel usage provided by each household—is believed to be the more robust approach and, as explained earlier, is the approach used to distribute heating energy use by device/fuel within the SIP inventory. Since the fuel usage-based approach is the one

utilized in the SIP, only these results are presented in the body of this memorandum. However, Attachment B provides a more detailed discussion of the differences between the two approaches.

Effect of Fuel Oil Prices on Heating Device Choices

With key survey results and trends summarized above, a comparative analysis of historical heating oil prices and shifts in heating fuel use is presented in this sub-section.

Figure 3 shows plotted heating oil prices in Fairbanks and North Pole, as well as statewide from 2005-2015, roughly corresponding to the period over which all historical Fairbanks home heating surveys were conducted. To account for inflation, prices are presented in constant 2015 dollars. Alaska No. 2 data (available up to 2011) were obtained from the U.S. Energy Information Administration (EIA). Local heating oil price data for Fairbanks and North Pole were obtained via the Alaska Energy Data Gateway¹² reflecting the sources listed below Figure 3.

As shown in Figure 3, heating oil prices spiked dramatically in 2008, rising from \$3 per gallon to the \$5 per gallon range. Although prices dropped back to the \$3 per gallon range the following year, they began steadily increasing again, reaching sustained levels from 2011-2014 of just under \$6 per gallon for No. 1 oil in North Pole and roughly \$4 per gallon for No. 1 in Fairbanks. In 2014, No. 1 prices dropped back to the \$4 per gallon range in North Pole and the \$3 per gallon range in Fairbanks. The current price for No. 2 oil in Fairbanks (as of September 2015) stands at \$2.38 per gallon.

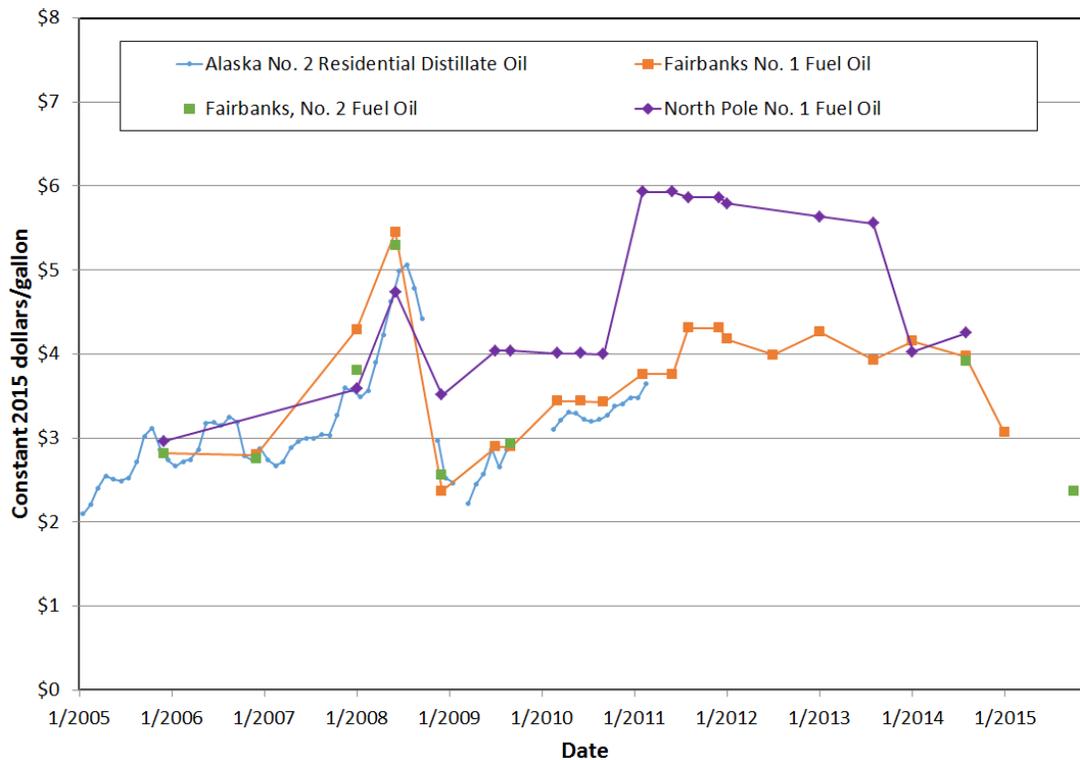
Given the cost of heating a home in the Fairbanks area during the winter season, these significant fluctuations in the price of heating oil (the dominant fuel used in home heating) generally explain the trends in fuel use seen in the historical home heating survey. Namely, the increases in wood use and commensurate decreases in heating oil use from 2006 to 2014 shown earlier in Figures 1 and 2 track with the rise in heating oil prices that began in 2008 and continued from 2011 to early 2014, as seen in Figure 3. Although heating oil prices dropped significantly in 2009 before rising again to the \$4-\$6 per gallon range in 2011, residents were likely reluctant to switch back to oil during this time, given the dramatic price spike in 2008.

Table 12 presents comparisons of costs per unit energy (\$/mmBTU) of several key fuels in Fairbanks and is based on the energy content values provided earlier in Table 6 and the prices shown in the “Assumed Fuel Price” column. As shown, fuel oil is roughly four times the cost of wood or coal per unit energy when priced at \$5 per gallon. And, based on the annual average space heating energy use per dwelling in the Fairbanks Borough estimated by AHFC¹³ (188 mmBTU), the choice of heating fuel can result in a difference of up to several thousand dollars in annual heating costs per household, which is significant.

¹² <https://akenergygateway.alaska.edu/>

¹³ “2014 Alaska Housing Assessment, Fairbanks North Star Borough,” Alaska Household Finance Corporation.

Figure 3
Historical Heating Oil Prices in Fairbanks, North Pole and Alaska (2005-2015)



Sources:

Fairbanks and North Pole No. 1: Alaska Household Finance Corporation/Division of Community and Regional Affairs Survey (AHFC/DCRA)

Fairbanks No. 2: AHFC/DCRA Survey, plus September 2015 data point from Sept. 12, 2015 Fairbanks Daily News Miner article

Alaska No. 2: U.S. Energy Information Administration

Fuel	Assumed Fuel Price	Cost per Unit Energy
Wood	\$200 per cord	\$9.50 per mmBTU
Fuel Oil, High Price	\$5.00 per gallon	\$37.88 per mmBTU
Fuel Oil, Low Price	\$2.50 per gallon	\$18.50 per mmBTU
Natural Gas	\$2.34 per 100 ft ³	\$23.05 per mmBTU
Coal	\$130 per ton	\$8.50 per mmBTU

The price of heating oil has been much more volatile than other available heating fuels over the last ten years. Thus, it follows that these heating oil price swings can trigger shifts to cheaper fuels, such as wood or coal, in spite of the convenience of oil relative to those fuels (i.e., cutting/splitting wood or regular fuel loading).

Since heating oil prices have dropped significantly within the last year and are now under \$2.50 per gallon, a key question whose answer cannot yet be seen in the home heating survey data through 2015 is whether wood (and coal use) will drop given the decreased price gap relative to oil. Such a decrease in wood and coal use is plausible, but is only likely to occur once Fairbanks residents are convinced that the heating oil price has stabilized at this lower level. It is important to remember that any price-based shifts in fuel use will be modulated by residents' need to have more than one heating fuel available to deal with supply interruptions in an arctic environment.

ATTACHMENT A

2015 Home Heating Survey

Hays Research Group LLC
Fairbanks Heating Survey
2015 FINAL FIELDDED VERSION

Phone # _____ Survey # _____
Interviewer Name _____
Date _____

(Location of Home)

Good evening, I am calling from Hays Research Group; we are conducting a brief survey on behalf of the Alaska Department of Environmental Conservation (ADEC) and the Fairbanks Northstar Borough (BURR-oh) regarding home space heating options. May I please speak to the person most knowledgeable about the heating devices in your home? (IF NOT AVAILABLE – When would be the best time to reach him/her? Set a callback and get a name.)

Q1) First I need to verify that you live in the boundaries of this survey. Can you tell me the zip code of your physical address?

1. 99701
2. 99702
3. 99703
4. 99705
5. 99709
6. 99712
7. 99714
8. 99725
9. 99760
10. 99775
11. Other (TERMINATE)

Please tell me which of the following devices provide space heat for your home?

Q2) A wood burning device?

1. Yes
2. No
3. DK/REF

Q3) A central Oil furnace?

1. Yes
2. No
3. DK/REF

Q4) Portable Fuel Oil/Kerosene heating device?

1. Yes
2. No
3. DK/REF

Q5) Toyo (TOY-oh), Monitor or other direct vent type heater?

1. Yes
2. No
3. DK/REF

Q6) Natural Gas Heat?

1. Yes
2. No
3. DK/REF

Q7) Coal Heat?

1. Yes
2. No
3. DK/REF

Q8) Municipal Heat or steam heat?

1. Yes
2. No
3. DK/REF

Q9) Other not listed?

(Specify) _____

Q10) And can you please tell me how many square feet are in your home, not including any garage space?

1. _____ sq. ft.
2. DK/REF

(AT LEAST ONE OF THE QUESTIONS BETWEEN Q2-Q9 MUST = 1 "YES", OTHERWISE TERMINATE)

(ASK Q11 IF Q2=1 "YES – WOOD BURNING DEVICE", OTHERWISE SKIP TO Q12)

Q11) Is your wood burning device a fireplace, a fireplace with insert, a wood burning stove or outdoor wood boiler? (note to interviewers, pellet stoves and masonry heaters are considered wood burning stoves)

1. Fireplace
2. Fireplace with insert
3. Wood burning stove
4. Outdoor Wood Boiler (note could called hydronic heater by some)
5. DK/REF

Q12)(Q12 answers must total 100%) What percentage of your heating is done by each of the following devices during the winter months, from October to March? (IF possible, read only heating options that they indicated they had in Q2-Q9)

1. Wood Burning Device (Q2)	%
2. Central Oil furnace (Q3)	%
3. Portable Fuel Oil/Kerosene (Q4)	%
4. Direct Vent type (Q5)	%
5. Natural Gas Heat (Q6)	%
6. Coal Heat (Q7)	%
7. Municipal Heat (Q8)	%
8. Other (Q9)	%

We'll now get into some usage details of each type of heating.

(Section 1: Wood burning stove/Fireplace insert)

(ASK Q13-Q16 IF Q11 = 2. "FIREPLACE WITH INSERT" OR 3. "WOOD BURNING STOVE", OTHERWISE SKIP TO Q17)

Q13) Was your wood burning stove or insert installed before or after 1988?

1. Before 1988
2. After 1988
3. DK/REF

Q14) How old is your wood burning stove or insert? (allow multiple responses)

1. Less than 1 year old
2. 1-5 years old
3. 5-10 years old
4. 10-15 years old
5. 15+ years old
6. DK/REF

Q15) Is your wood stove or insert catalytic or non –catalytic?

1. catalytic
2. non-catalytic
3. DK/REF

Q16) Do you have a pellet stove or a wood stove? (allow multiple responses)

1. Pellet stove
2. Wood stove
3. DK/REF

(ASK Q17-Q18 IF Q16=1. "PELLET STOVE" –OR- 2. "WOOD STOVE", OTHERWISE SKIP TO Q19)

Q17) What best describes your use of wood heat during the winter months, October to March?

1. Daytime only
2. Evening only
3. Daytime and evening
4. Weekend only
5. Evening and weekend only
6. Occasional use
7. Not currently using any device
8. Don't know (do not read)
9. Refused (do not read)

(ASK Q18 IF Q16 = 2. "WOOD STOVE", OTHERWISE SKIP TO Q19a)

Q18) Where do you get the wood for your heating? Do you buy it or cut your own? (allow multiple responses)

1. Buy wood
2. Cut your own
3. DK/REF

(ASK Q19a IF Q18 = 2. "CUT YOUR OWN", OTHERWISE SKIP TO Q20)

Q19a) When cutting wood do you get a permit?

1. Yes
2. No
3. DK/REF

Q19b) How do you store your wood?

1. Shed
2. Under a tarp
3. Uncovered pile
4. Other (open ended)
5. DK/REF

Q20) How many months do you season or dry your wood before burning it?

1. 1. _____ Months
DK/REF=9999

Q21) Do you know what the moisture content of your wood is, and if so, what is it?

1. 1. _____ Percent
DK/REF=9999

*(ASK Q22 IF Q21 = 1 (ANY KNOWN PERCENT OTHER THAN DK/REF) ,
OTHERWISE SKIP TO Q23)*

Q22) How do you know the moisture content? (read list)

1. Tested with moisture meter
2. Information provided by wood seller
3. Know its dry because they seasoned it
4. Other
5. DK/REF=9999

(ASK Q23-Q24 IF Q16 =2 "WOOD STOVE", OTHERWISE SKIP TO Q25)

Q23) In cords, how much wood do you burn in your wood burning stove or insert annually?

(Interviewer note: If the respondent asks, one cord of wood is four feet wide, four feet high, and eight feet long stacked)

1. 1. Wood in cords _____
DK/REF=9999

Q24) In cords, how much do you burn from October to March?

1. Wood in cords _____
DK/REF=9999

(ASK Q25-Q26 IF Q16 = 1. "PELLETS", OTHERWISE SKIP TO Q27)

Q25) How many pounds of pellets do you burn in your wood burning stove or insert annually?

1. pounds of pellets _____
DK/refused=9999

Q26) How many pounds of pellets do you burn from October to March?

1. pounds of pellets _____
DK/refused=9999

(ASK Q27 IF Q23 –OR- Q24 = DK/REF, OTHERWISE SKIP TO Q28)

Q27) How much do you spend per year on wood?

1. \$ _____
DK/refused=9999

(ASK Q28 IF Q25 –OR- Q26 = DK/REF, OTHERWISE SKIP TO Q29)

Q28) How much do you spend per year on pellets?

1. \$ _____
DK/refused=9999

(ASK Q29-Q30 IF Q16 = 1. "PELLETS", OTHERWISE SKIP TO Q31)

Q29) Is there a pellet source or brand that you prefer?

1. Yes
2. No
3. DK/REF

(ASK Q30 IF Q29 = 1. "YES", OTHERWISE SKIP TO Q31)

Q30) Why do you prefer that source?

(open ended)

(Section 2: Wood burning Fireplace)

(ASK Q31-Q32 IF Q11 = 1. "FIREPLACE", OTHERWISE SKIP TO Q39)

Q31) From this list, what best describes your use of wood heat during the winter months, from October to March?

1. Daytime only
2. Evening only
3. Daytime and evening or 24 hours a day
4. Weekend only
5. Evening and weekend only
6. Occasional use
7. Not currently using any device
8. Don't know (do not read)
9. Refused (do not read)

Q32) Where do you get the wood for your heating? (Allow multiple responses)

1. Buy wood
2. Cut your own
3. DK/REF

(IF Q32 = 2. "CUT YOUR OWN" ASK Q33, IF Q32 = 1. "BUY WOOD" OR "DK/REF" SKIP TO Q34)

Q33) When cutting wood do you get a permit?

1. Yes
2. No
3. DK/REF

Q34) How many months do you season or dry your wood before burning it?

1. Months _____
DK/refused=9999

Q35) Do you know what the moisture content of your wood is, and if so, what is it?

1. Percent _____
DK/refused=9999

Q36) In cords, how much wood do you burn in your fireplace annually?

1. _____ cords
DK/refused = 9999

Q37) In cords, how much do you burn in your fireplace from October to March?

1. _____ cords
DK/REF=9999

Q38) How much do you spend per year on wood for your fireplace?

1. \$ _____
DK/REF=9999

(Section 3: Outdoor Wood Boiler)

(ASK Q39-Q41 IF Q11 = 4. "OUTDOOR WOOD BOILER", OTHERWISE SKIP TO Q51)

Q39) Please specify the type of outdoor wood boiler you have (read list):

1. EPA qualified outdoor wood fired heater
2. Non EPA qualified outdoor wood fired heater
3. Outdoor pellet boiler
4. Other
5. DK/REF

Q40) What best describes your use of wood heat during the winter months, from October to March?

1. Daytime only
2. Evening only
3. Daytime and evening or 24 hours a day
4. Weekend only
5. Evening and weekend only
6. Occasional use
7. Continuous
8. Not currently using any device
9. Don't know (do not read)
10. Refused (do not read)

Q41) Where do you get the wood for your heating? (allow multiple responses)

1. Buy wood
2. Cut your own
3. Purchase Pellets
4. DK/REF

(ASK Q42-Q44 IF Q41=2 "CUT YOUR OWN", OTHERWISE SKIP TO Q45)

Q42) When cutting wood for your outdoor wood boiler do you get a permit?

1. Yes
2. No
3. DK/REF

Q43) How many months do you season or dry your wood before burning it in your outdoor wood boiler?

1. Months _____
DK/REF=9999

Q44) Do you know what the moisture content of your wood is, and if so, what is it?

1. Percent _____
DK/REF=9999

Q45) How much wood do you burn in your outdoor wood boiler annually? (record answer in either cords tons of pellets)

1. _____ cords
2. _____ tons of pellets
3. DK/REF=9999

Q46) How much do you burn in your outdoor wood boiler from October to March?

1. _____ cords
2. _____ pellets
REF=9999

(ASK Q47 IF Q41= 3 "PURCHASE PELLETS", OTHERWISE SKIP TO Q49)

Q47) Is there a pellet source that you prefer?

1. Yes
2. No
3. DK/REF

(ASK Q48 IF Q47="YES", OTHERWISE SKIP TO Q49)

Q48) Why do you prefer that source?

(open ended)

(ASK Q49 IF Q41 = 1. "BUY WOOD", OTHERWISE SKIP TO Q50)

Q49) How much do you spend per year on wood?

1. \$ _____
DK/REF=9999

Q50) What is the brand name of your outdoor wood boiler? (open ended)

(Section 4: Central Oil)

(ASK Q51-Q54 IF Q3 = 1. "YES", OTHERWISE SKIP TO Q55)

Q51) How large is your fuel oil tank, in gallons?

1. _____ Gallons
DK/REF=9999

Q52) In gallons, how much oil do you use annually?

1. _____ Gallons
DK/REF=9999

Q53) How many gallons do you use during the winter months from October to March?

1. _____ Gallons
DK/REF=9999

Q54) How much do you spend per year on fuel oil?

1. \$ _____
9999=No/DK/REF

(Section 5: Portable Fuel Oil/Kerosene Heating Device)

(ASK Q55-Q56 IF Q4 = 1. "YES", OTHERWISE SKIP TO Q57)

Q55) You mentioned using a Portable Fuel Oil or Kerosene Heating Device, does the device use Fuel Oil?

1. Yes
2. No
3. DK/REF

Q56) Does the device use Kerosene?

1. Yes
2. No
3. DK/REF

(IF Q55 –OR- Q56 = 1. “YES”, READ Q57-Q58, OTHERWISE SKIP TO Q59)

Q57) In gallons, how much oil/kerosene do you use annually?

1. _____gallons
DK/REF=9999

Q58) How many gallons do you use during the winter months from October to March?

1. _____gallons
DK/REF=9999

Q59) How much do you spend per year on oil/kerosene?

1. \$ _____
DK/REF=9999

(Section 5.1 For homes using Central Oil, and/or Portable Fuel Oil/Kerosene Heating Devices, and/or Other devices)

(ASK Q60 IF Q3=1 “YES” OR Q4=1 “YES” OR Q9=1 “YES”, OTHERWISE SKIP TO Q61)

Q60) From this list please tell me what best describes your use of fuel oil and kerosene burning devices during the winter months, from October to March?

1. Daytime only
2. Evening only
3. Daytime and evening or 24 hours a day
4. Weekend only
5. Evening and weekend only
6. Occasional use
7. Not currently using any device
8. Don't know (do not read)
9. Refused (do not read)

Section 6: Toyo, Monitor, or other Direct Vent Type of Heater if uses fuel oil and direct vent fuel consumption question

(ASK THIS SECTION IF Q5 = 1. “YES”, OTHERWISE SKIP TO Q65)

(IF Q3 = 1 –AND- Q5 = 1 SKIP TO Q63)

Q61) In gallons, how much oil do you use annually for your Toyo, Monitor or other direct vent type heater?

1. _____Gallons
9999=DK/refused

Q62) How many gallons do you use during the winter months from October through March for your Toyo, Monitor or other direct vent type heater?

1. _____ Gallons
9999=DK/REF

Q63) How much do you spend per year on oil?

1. \$ _____
9999=DK/REF

Q64) What best describes your use of direct vent heating device during the winter months, from October to May?

1. Daytime only
2. Evening only
3. Daytime and evening or 24 hours a day
4. Weekend only
5. Evening and weekend only
6. Occasional use
7. Not currently using any device
8. Don't know (do not read)
9. Refused (do not read)

Section 7: Natural Gas Heating Device

(IF Q6 = 1. "YES", ASK Q65-Q67, OTHERWISE SKIP TO Q68)

Q65) Do you have storage tanks on your property for natural gas or propane?

(accept multiple responses)

1. Yes Natural Gas
2. Yes Propane
3. No
4. DK/REF

(IF Q65 = 1. "YES NATURAL GAS" OR 2. "YES PROPANE" ASK Q66 & Q67, OTHERWISE SKIP TO Q68)

Q66) How much do you spend on natural gas annually?

1. \$ _____
DK/REF=9999

Q67) How much do you spend on natural gas during the winter months, from October to March?

1. \$ _____
DK/REF=9999

Section X: Coal Heating Device

(IF Q7 = 1 "YES", ASK Q68-Q71, OTHERWISE SKIP TO Q72)

Q68) Coal is about 30% moisture, do you store your coal to warm or dry it prior to use?

1. Yes
2. No
3. Don't Know / Refused

Q69) How much coal do you use annually?

1. 1. ___ tons
2. 2. ___ bags
3. DK/refused

Q70) How much did you pay for the coal, either by the bag or by the ton?

1. 1. ___ \$/bag
2. 2. ___ \$/ton
3. DK/refused

Q71) How much coal do you use during the winter from October through March?

1. ___ tons
2. ___ bags
3. DK/refused

Q72) Is your coal burned in an indoor stove or an outdoor boiler?

1. Indoor stove
2. Outdoor boiler
3. DK/refused

(Section F: Municipal Heat)

(IF Q8 = 1. "YES", ASK Q73-Q74, OTHERWISE SKIP TO Q75)

Q73) How much do you spend on municipal heat annually?

1. \$ _____
DK/refused =9999

Q74) How much do you spend on municipal heat during the winter months from October to March?

1. \$ _____
DK/REF=9999

Future Section (to be completed for every survey)

Q75) Do you live in a single family home, multi family home, apartment, or something else. (If single family or multi family home, ask “do you own or rent?”)

1. 1, Single family home that own and live in
2. Single family home that you rent
3. Multi family home that you own and live in
4. Multi family home that you rent
5. Apartment
6. DK/Refused

Q76) Do you burn #1 or #2 fuel oil in your home, if you burn both please provide the % split between them.

1. # 1 only
2. # 2 only
3. _% #1 and _% # 2
4. DK/refused

Q79) Are you aware of the Borough’s Coal and Wood Heater Change Out Program? (some people may know this as the woodstove change-out program, or the SFBA Solid Fuel Burning Appliance program)

1. 1, Yes
2. No
3. DK/Refused

(IF Q79=1. “YES”, ASK Q80-Q81, OTHERWISE SKIP TO Q82)

Q80) Have you participated in the Borough’s Coal and Wood Heater Change Out Program?

1. 1, Yes
2. No
3. DK/Refused

(IF Q80 = 1. “YES”, CONTINUE TO Q81, OTHERWISE SKIP TO Q82)

Q81) Was your experience with the Coal and Wood Heater Change Out Program positive or negative?

1. Positive
2. Negative
3. DK/refused

(IF Q18 = 1. "BUY WOOD", -OR- IF Q32 = 1. "BUY WOOD", OR IF Q41 = 1. "BUY WOOD" -> ASK Q84 , OTHERWISE SKIP TO Q85)

Q84) Is your purchased wood in logs, round, or split form?

1. Logs
2. Rounds
3. Split
4. Combination
5. DK/REF

(IF Q2 = 1. "YES" -> ASK Q85-Q86, OTHERWISE SKIP TO Q87)

Q85) Have you purchased and burned energy logs to heat your home? (Note to interviewers – energy logs are made of compressed wood with a very low moisture content)

1. Yes
2. No
3. DK/REF

Q86) Do you plan to try the new pellet logs manufactured in North Pole? (Note: Some participants may know this product as an energy log or a compressed wood log. A company named Superior Pellet located in North Pole recently started making and selling energy logs under the name "Superior Pellet Logs")

1. Yes
2. No
3. DK/REF

Q87) What is the best method for you to keep abreast of air quality announcements and information in the Borough? (read list, allow more than one answer)

1. TV
2. Radio
3. Newspaper
4. Internet

5. Other
6. DK/refused

*(THESE NEXT 3 QUESTIONS, Q88-Q90, SHOULD ONLY BE ASKED IF Q2=1.
"HAVE WOOD DEVICE", OTHERWISE SKIP TO Q91)*

Q88) Has Borough and State outreach, like the Split, Stack, Store, Save Campaign, or Burn Wise Alaska, caused you to think about reducing the amount of wood that you burn, or helped increase your knowledge on wood burning?

1. Yes
2. No
3. DK/REF

Q89) As a result the Borough and State outreach, do you season your wood for longer periods before burning?

1. Yes
2. No
3. DK/REF

Q90) As a result of the Borough and state outreach, do you request dry wood when you buy it?

1. Yes
2. No
3. DK/REF

Q91) I am going to read you a list of ways the borough could inform residents about air quality. Please tell me which ones you would find useful or valuable. (read list)?

1. 1, Place Electric Reader Boards (like bank signs with temperatures, etc.) in hotspot neighborhoods and provide information on air quality
2. Revise websites to provide more information on the location of hotspots and options for improving air quality
3. Revise websites to provide more information about vendors selling dry wood
4. Something else (Open ended)
5. DK/Refused

Q92) In case my supervisor wants to verify that I did indeed complete this survey, or in case we need to follow up with any clarifications, can I have just your first name?

(If respondent will not provide name, ask for initials)

Thank you, those are all of the questions I have this evening.

(IF THEY ASK FOR MORE INFORMATION → GIVE THE FOLLOWING INFORMATION)

If you have questions or comments about this survey, I can give you the contact information for Hays Research Group. Again, thank you for your time. (IF PROMPTED FOR INFO: contact information for Hays Research Group is heatsurvey@haysresearch.com (NOTE NO 'E' in HAYS), or (907) 223-2406).

ATTACHMENT B

Comparison of Methods Used to Calculate Device Usage Fractions from Home Heating Surveys

Comparison of Methods Used to Calculate Device Usage Fractions from Home Heating Surveys

Within the annual home heating surveys, two different sets of responses from each surveyed household are available to represent the breakdown of device usage within each household (and aggregated across all households): (1) fuel use based energy splits and (2) device usage estimates. This attachment explains these two methods in detail, beginning with descriptions of each method, followed by comparisons of results tabulated from each.

Fuel Use Based Energy Splits (Primary Method) – Within each household survey, the survey begins with the respondent identifying the types of devices and fuel they have in their home that are used for space heating. These include wood devices, central oil furnaces/boilers, portable/kerosene heaters, direct vent (Toyo or Monitor) heaters, natural gas, coal heaters, and municipal (steam) heat. Based on the responses to these initial device identification questions, the survey then branches into separate sections that ask a series of follow-up questions for each device present in the household. One of the follow-up questions asks for the amount of fuel used within the device (annually and for the winter season). (For certain fuels/heating sources such as natural gas or steam heat, respondents are asked to estimate their costs for the fuel, both annually and seasonally, since it is easier to estimate their costs rather than the amount of gas burned or steam used.)

For example, if a household has both a wood-burning device and a central oil furnace, the respondent identifies the type of wood device (or devices) used (i.e., stove, insert, fireplace, outdoor boiler). Then in separate sections of the survey, these respondents provide estimates of how much wood they burned and how much oil they used (both annually and during winter). To calculate heating energy usage fractions for each device within the household, the fuel usage responses must be translated to an energy use basis. This is done by multiplying the fuel usage by the energy content of each fuel. (Energy contents in BTUs assumed for each fuel were provided earlier in Table 3.)

For example, assume one such household reported winter season wood use of 2 cords and 1,000 gallons of heating oil. The energy usage fractions for wood and oil device use in the home are computed as follows (which also includes conversion of wood volume in cords to mass in tons):

$$\text{Wood Energy: } 2 \text{ cords} \times 1.56 \text{ tons/cord} \times 13.5 \text{ mmBTU}^{14}/\text{ton} = 42.1 \text{ mmBTU}$$

$$\text{Oil Energy: } 1,000 \text{ gallons} \times 132,000 \text{ BTU} = 132.0 \text{ mmBTU}$$

$$\text{Total Household Energy} = 42.1 \text{ mmBTU} + 132.0 \text{ mmBTU} = 174.1 \text{ mmBTU}$$

$$\text{Wood Energy Percentage} = 42.1 \text{ mmBTU} \div 174.1 \text{ mmBTU} = 24.2\%$$

$$\text{Oil Energy Percentage} = 132.0 \text{ mmBTU} \div 174.1 \text{ mmBTU} = 75.8\%$$

¹⁴ mmBTU = One million BTUs

Similarly to this example for a single household, energy use splits for all households within a ZIP code or the entire survey sample would be tabulated by converting fuel use to energy use for each device used in any household and then dividing energy use for each device type (summed across all households) by total energy use from all devices (summed across all households). For example, assume a hypothetical survey of three households with the following wood and oil usages and calculated energy usages (in mmBTU):

<u>Household</u>	<u>Wood Use</u>	<u>Oil Use</u>	<u>Energy Use (mmBTU)</u>			<u>Energy Use Pct.</u>	
	<u>(cords)</u>	<u>(gallons)</u>	<u>Wood</u>	<u>Oil</u>	<u>Total</u>	<u>Wood</u>	<u>Oil</u>
1	2	1,000	42.1	132.0	174.1	24.2%	75.8%
2	10	500	210.6	66.0	276.6	76.1%	23.9%
3	0	1,500	0.0	198.0	198.0	0.0%	100.0%
Totals	12	3,000	252.7	396.0	648.7	39.0%	61.0%

The summed wood and oil energy usage and calculated splits at the bottom reflect total energy use across these three example households. Note that the resulting wood energy percentage (39%) is obtained by dividing wood energy use by total energy use after summing over the three households. This is not the same as taking the average wood energy percentage across the three households:

$$(24.2\% + 76.1\% + 0.0\%) \div 3 = 33.4\%$$

The wood percentages are different (39.0% vs. 33.4%) because the amount of energy use is not the same in each household. This is an important distinction and helps to explain the weakness of the alternative method, which is presented below.

Device Usage Estimates (Alternative Method) – After respondents are asked to identify the types of heating devices in their home, they are asked to provide a percentage estimate of the heating usage (during winter) of each device. These percentage usage estimates are provided near the start of the survey and precede the device-specific questions that follow where actual fuel usage responses are provided. As a result, these device usage percentages are rough estimates of the amount of operation of the mix of devices within a household and more likely reflect the amount of time they are used rather than the actual heating energy fractions.

Using the earlier single household example which burned 2 cords of wood and 1,000 gallons of heating oil for a 24.2% vs. 75.8% wood vs. oil energy use split, the responses to the device usage question could have been 40% wood and 60% oil and reflected the homeowner’s best guess of the relative usage of each device. Only when actual fuel use data are provided later in the survey can the relative energy usage percentages for the household be more robustly computed.

In addition, when tabulating the device usage percentage responses across multiple households (e.g., to represent a ZIP code or survey-wide average), these percentages can only be averaged across a set of households and do not account for the fact that some

households are of different size (and thermal efficiency) and therefore have greater or lesser usage from household to household.

For example, consider two households: one heated entirely by wood, the other by oil. Since only one type of device is present in each home, the device usage estimates of 100% wood in the first home and 100% oil in the second are unambiguous. The average device usage percentages across the two homes would be 50% wood and 50% oil. Suppose the first household is a large 3,000 square foot home that is heated with two relatively less-efficient uncertified woodstoves burning a total of eight cords of wood, while the second is a smaller 1,000 square foot residence heated with a more efficient central oil furnace consuming 500 gallons of oil during winter. The actual wood and oil energy use totaled across both homes (using the wood and oil energy contents listed earlier) would be as follows:

$$\text{Wood Energy: } 8 \text{ cords} \times 1.56 \text{ tons/cord} \times 13.5 \text{ mmBTU/ton} = 168.5 \text{ mmBTU}$$

$$\text{Oil Energy: } 500 \text{ gallons} \times 132,000 \text{ BTU} = 64.0 \text{ mmBTU}$$

$$\text{Total Energy} = 168.5 \text{ mmBTU} + 64.0 \text{ mmBTU} = 234.5 \text{ mmBTU}$$

And the energy use percentages would be 71.9% wood ($168.5 \div 234.5$) and 28.1% oil ($64.0 \div 234.5$), which is not close to the 50/50 split based on device usage percentages.

Historical Usage Split Comparisons – These examples illustrate the strength of using fuel use based energy splits rather than the simpler device usage percentages provided earlier in the sequence of survey questions. To see how device usage percentages compare using each method based on actual results from the historical surveys rather than hypothetical examples, Tables B-1 and B-2 present tabulations of usage percentages across all surveys under each method. First, Table B-1 contains fuel-based energy use percentages (the method used in the SIP) tabulated from each survey, starting in 2011. (Fuel use based energy estimates were not developed from the 2006, 2007, and 2010 surveys. And since fuel use was not provided for electric or “other” devices, no energy usage splits could be computed for those device types.) Table B-2 shows usage percentages tabulated from respondent estimates of relative device usage (the simpler alternative method). In both tables, the two most common device/fuel types, Wood and Central Oil are shown in **bold**. Percentages in the 2011 Survey Year column are highlighted as a reference point; residential space heating emissions from Moderate Area SIP inventory were based on device usage splits from the 2011 survey.

In comparing Tables B-1 and B-2, the device usage percentages are different, especially for the primarily used central oil and wood devices. The more robust energy-based wood use percentages in Table B-1 are several percentage points higher than those in Table B-2 based on the simpler respondent usage estimates. (In Table B-2, respondent-based electricity splits were estimated from narrative descriptions of their device usage recorded in an ancillary survey data response file.) Even if Table B-2 were renormalized to remove the “Electric Heat” and “Other” device entries for which fuel use data (and energy based splits in Table B-1) were not available, there are still significant differences between the two approaches.

Table B-1								
Tabulated Fuel-Based Winter Energy Use Percentages from 2011-2015 Home Heating Surveys (ZIP-weighted)								
Usage (%) by Device	Survey Year							
	2006	2007	2010	2011	2012	2013	2014	2015
Wood	n/a	n/a	n/a	22.0%	25.8%	23.2%	23.9%	24.4%
Central Oil	n/a	n/a	n/a	66.3%	67.3%	70.9%	61.6%	70.0%
Portable	n/a	n/a	n/a	1.1%	0.0% ^a	0.7% ^a	0.8% ^a	0.2% ^a
Direct Vent	n/a	n/a	n/a	5.2%	3.1%	2.7%	8.0%	2.7%
Natural Gas	n/a	n/a	n/a	2.8% ^a	2.5% ^a	1.0% ^a	2.6% ^a	0.6% ^a
Coal Heat	n/a	n/a	n/a	0.3% ^a	0.2% ^a	0.8% ^a	2.3% ^a	0.5% ^a
District Heat	n/a	n/a	n/a	2.3% ^a	1.2% ^a	0.8% ^a	0.8% ^a	1.6% ^a
Electric Heat	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Other	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Note: Column totals sum to 100%, not 100.0% due to rounding and reported precision.

n/a – not available

^a Limited sample (< 30 households), may not be representative.

Table B-2								
Tabulated Respondent-Estimated Winter Heating Device Usage Percentages from 2006-2015 Home Heating Surveys (ZIP-weighted)								
Usage (%) by Device	Survey Year							
	2006	2007	2010	2011	2012	2013	2014	2015
Wood	10.8%	12.4%	18.2%	15.4%	19.1%	20.8%	22.4%	19.5%
Central Oil	68.6%	64.8%	67.2%	67.5%	68.2%	66.8%	60.2%	64.3%
Portable	0.7% ^a	0.5% ^a	0.1% ^a	0.8%	0.1% ^a	0.8% ^a	0.9% ^a	0.5% ^a
Direct Vent	8.1%	7.0%	8.0%	9.4%	6.9%	5.6%	7.4%	7.0%
Natural Gas	2.4% ^a	2.0% ^a	4.2% ^a	3.2%	3.0%	1.6% ^a	1.7% ^a	1.7% ^a
Coal Heat	n/a	n/a	0.5% ^a	0.6% ^a	0.4% ^a	1.1% ^a	1.5% ^a	0.2% ^a
District Heat	2.0% ^a	0.8% ^a	1.1% ^a	1.8% ^a	1.9% ^a	1.7% ^a	0.9% ^a	2.9% ^a
Electric Heat	n/a	n/a	n/a	0.0% ^a	0.1% ^a	0.7%	1.7%	1.2%
Other	7.5% ^a	12.5% ^a	0.8% ^a	1.4%	0.3% ^a	0.8%	3.2%	2.6%

Note: Column totals sum to 100%, not 100.0% due to rounding and reported precision.

n/a – not available

^a Limited sample (< 30 households), may not be representative.

Previous reports¹⁵ and memoranda¹⁶ summarizing results from the Fairbanks Home Heating surveys relied on the simpler, respondent device split estimates. For the Moderate Area SIP, and in all reporting going forward, usage splits will be based on the more rigorous fuel-based energy use percentages.

¹⁵ T. Carlson, et al., “2010 Fairbanks Home Heating Survey,” prepared for Alaska Department of Environmental Conservation, Report No. SR2010-06-01, June 21, 2010.

¹⁶ F. Di Genova, “Fairbanks 2012 Home Heating Survey (Draft),” memorandum to Cindy Heil, Alaska Department of Environmental Conservation, April, 10, 2012.