Alaska Department of Environmental Conservation

Amendments to:
State Air Quality Control Plan

Vol. III: Appendix III.D.5.07

{Appendix to Volume II. Analysis of Problems, Control Actions; Section III. Area-wide Pollutant Control Program; D. Particulate Matter; 5. Fairbanks North Star Borough PM2.5 Control Plan}

Public Review Draft

November 14, 2014

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Appendix III.D.5.07

Reasonably Available Control Measures (RACT).

Addressing the precursor gases for Fairbanks PM2.5 State Implementation Plan.

Individual Emission Unit RACM Determinations.

Evaluation of Reasonably Available Control technologies (RACT) to Support the Development of the Fairbanks PM2.5 State Implementation Plan.

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Reasonably Available Control Measure (RACM) Analysis

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5.7. APPENDIX

5.7.1. BACKGROUND

In November 2009, Fairbanks was designated as a Moderate nonattainment area for the 2006 24-hour $PM_{2.5}$ National Ambient Air Quality standard.[1] The design value[2] is 44.7 µg/cubic meter.[3] The difference between this value and the ambient standard is 9.7 µg/cubic meter, which means that 98th percentile concentrations (the form of the standard) need to be reduced by 22% to demonstrate attainment.

The purpose of this document is to describe the process of identification and selection of Reasonably Available Control Measures (RACM) for the $PM_{2.5}$ Attainment Plan for the Fairbanks North Star Borough (FNSB, or Fairbanks) in Alaska.

5.7.1.1. Requirements for RACM Analysis

CAA section 172(c)(1) describes the general attainment plan requirement for reasonably available control measures (RACM). Attainment plan submissions must "provide for the implementation of all reasonably available control measures as expeditiously as practicable (including such reductions in emissions from existing sources in the area as may be obtained through the adoption, at a minimum, of reasonably available control technology) and shall provide for attainment" of the NAAQS.

Section 189 (a)(1)(C) requires that RACM measures in Moderate nonattainment areas be implemented no later than four years after designation.

Guidance on the steps to be followed in making RACM determinations for $PM_{2.5}$ were specified in the final Clean Air Fine Particulate Implementation Rule issued in 2007.[4] Additional guidance was provided in a subsequent EPA guidance document.[5] The rule was based on based on CAA Part D, Subpart 1. A court decision[6] in January 2013 remanded the $PM_{2.5}$ rule back to EPA to be re-promulgated to be consistent with Subpart 4. EPA withdrew the Subpart 1-based guidance document and new Subpart 4 based guidance has not been issued.

[1] 74 FR 58688, November 13, 2009.
[2] The design value is a statistic that describes the air quality status of a given location, for purposes of comparison with the relevant NAAQS. The goal of the attainment plan is to bring the design value to a level at or below the standard.
[3] EPA, *$PM_{2.5}$ Detailed information;* available at http://www.epa.gov/airtrends/values.html (accessed September 8, 2014)
[4] 72 FR 20586, April 25, 2007
[5] Stephen Page, *Implementation Guidance for the 2006 24-Hour Fine Particulate (PM2.5) National Ambient Air Quality Standards,* March 2, 2012
[6] Natural Resources Defense Council (NRDC) v. EPA, No. 08-1250 (D.C. Cir., Jan. 4, 2013)

The steps in the RACM analysis followed in this report were developed based on a review of CAA provisions. In addition, this analysis incorporates the requirement in subpart 4[7] that RACM must be implemented within four years after designation. The RACM analysis steps are outlined below.

5.7.1.2. Process for Identification and Evaluation of Control Measures

Listed below are the steps that were followed in evaluating control measures.

- Step 1: Identify source categories with non-trivial emissions of $PM_{2.5}$ or its precursors.

- Step 2: **For each source category, source, or activity from Step 1**, develop a list of technologically feasible emission control technologies and/or measures

- Step 3: **For each technologically feasible control measure,** evaluate emission reductions and costs, identify and exclude economically infeasible measures.

- Step 4: Determine whether control measure can be implemented within four years of designation.

- Step 5: Identify Reasonably Available Control Measures.

5.7.2. Step 1: Identify Sources of $PM_{2.5}$ and Precursors in Fairbanks

The first step in the RACM identification and evaluation process is to identify candidate control measures. In this step, all source categories with non-trivial emissions of $PM_{2.5}$ or its precursors are identified. A list of control measures potentially applicable to each source category is then developed for consideration as RACM.

"Primary" particulates (i.e., directly emitted $PM_{2.5}$) are emitted directly into the air as a solid or liquid particle (e.g., elemental carbon from diesel engines or fire activities, or condensable organic particles from gasoline engines). "Secondary" particulates (e.g., sulfate and nitrate) form in the atmosphere as a result of various chemical reactions. The main precursor gases associated with secondary fine particle formation are SO_2, NOX, volatile organic compounds (VOC), and ammonia.

Evaluation of monitoring data indicates that directly emitted $PM_{2.5}$ is the principle contributor to exceedances of the $PM_{2.5}$ NAAQS in Fairbanks. Figure 5.7-1 shows that directly emitted $PM_{2.5}$ comprises 63.2% of the measured concentration. Sulfates comprise 29.1%, nitrates comprise 7.6%, and secondary organic aerosols (SOAs) comprise 0%.

[7] Clean Air Act Section 189(a)(1)(C)

The most current estimate of directly emitted $PM_{2.5}$ and precursor emissions in the nonattainment area is the 2015 emission inventory shown in Table 5.7-1. It shows the average daily emissions across the two episodes (Jan-Feb, 2008 and Nov 2008) selected to represent conditions associated with exceedances of the 24-hour ambient $PM_{2.5}$ standard in Fairbanks.

Pollutant emissions from a source category were used as a proxy for its contribution to the ambient $PM_{2.5}$ concentration[8] (e.g., a source category's contribution to the fraction of ambient $PM_{2.5}$ attributed to directly emitted $PM_{2.5}$ was assumed to be the same as its emissions, expressed as a percentage of the total regional $PM_{2.5}$ inventory). Table 5.7-2 shows the contributions of each source category to ambient concentrations on the average episode day using this simplified technique.

Source category contributions to ambient concentrations were also estimated using photochemical modeling, and the results are compared with the results using the simplified estimate described above in Table 5.7-3. The modeling indicates that the contribution of wood combustion to ambient concentrations is greater than would be estimated from emissions alone. Presumably, this is because wood smoke is emitted close to the ground, below the mixed layer and dispersed throughout the Borough. Similarly, the contribution of pollutants from the combustion of gasoline is greater than share of emissions would suggest. Point sources, on the other hand, typically have tall stacks that release emissions well above the inversion layer; as a result, their contribution to ambient pollutant concentrations is relatively low.

Point sources are subject to Reasonably Available Control Technology (RACT) requirements, which is a specialized subset of RACM. Point sources are evaluated for RACT in a different part of this report.

[8] This is a simplified approach, used only to identify and eliminate source categories and/or control measures with insignificant contributions to ambient $PM_{2.5}$ concentrations. The contribution of each RACM control measure to attainment is subsequently quantified using photochemical modeling.

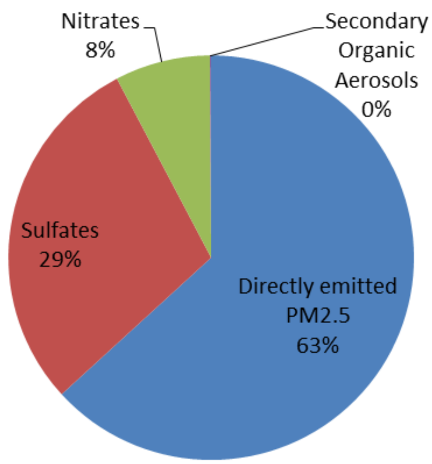

Figure 5.7-1. Constituents of Ambient $PM_{2.5}$ on High Concentration Days

Notes:
- Data are from the SANDWICH calculation spreadsheet that contains data over all winters from 2006- 2010 for the 98% days. They have been post processed through the SANDWICH method.
- Sulfates include primary and secondary sulfate + ammonium + particle bound water.
- Nitrates include primary + secondary nitrate + ammonium + particle bound water.
- Secondary organic aerosols were estimated from CMAQ.

Table 5.7-1. Average Daily Emissions by Source Category in 2015 for Episodes Selected for Fairbanks $PM_{2.5}$ Attainment Modeling

Source Category	Emissions (Tons per day)				
	Direct $PM_{2.5}$	SOx	NOx	VOC	NH_3
Point Sources					
Point Sources–all	1.59	22.97	27.39	1.15	0.00
Area Sources					
Space Heating–Wood	2.72	0.09	0.00	0.00	0.00
Central Oil–Residential	0.04	2.94	0.00	0.00	0.00
Central Oil–Commercial	0.02	1.14	0.00	0.00	0.00
Other Heating	0.05	0.12	0.00	0.00	0.00
Airport	0.01	0.08	0.76	0.26	0.00
Other Area Sources	0.06	0.00	0.00	0.60	0.00
Mobile Sources					
On-Road Vehicles (gasoline)	0.00	0.00	0.00	0.00	0.00
On-Road Vehicles (Diesel)	0.00	0.00	0.00	0.00	0.00
Non-Road Vehicles	0.01	0.01	0.30	0.15	0.00

Table 5.7-2. Estimated Source Category Contribution to Ambient $PM_{2.5}$ Concentration[a] (2015 Average Episode Day)

	$PM_{2.5}$			SOx			NOx			VOC			TOTAL
Source Category	%	Weighting[b] 63%	% of Ambient	%	Weighting[b] 29%	% of Ambient	%	Weighting[b] 8%	% of Ambient	%	Weighting[b] 0%	% of Ambient	% of Ambient[a]
Point Sources													
Point Sources–All	31%	63%	20%	84%	29%	24%	87%	8%	7%	19%	0%	0%	51%
Area Sources													
Space Heating–Wood	54%	63%	34%	0%	29%	0%	0%	8%	0%	0%	0%	0%	34%
Central Oil–Residential	1%	63%	1%	11%	29%	3%	0%	8%	0%	0%	0%	0%	4%
Central Oil–Commercial	0%	63%	0%	4%	29%	1%	0%	8%	0%	0%	0%	0%	1%
Other Heating	1%	63%	1%	0%	29%	0%	0%	8%	0%	0%	0%	0%	1%
Airport	0%	63%	0%	0%	29%	0%	2%	8%	0%	4%	0%	0%	0%
Other Area Sources	1%	63%	1%	0%	29%	0%	0%	8%	0%	10%	0%	0%	1%
Mobile Sources													
On-Road Vehicles (gasoline)	10%	63%	6%	0%	29%	0%	5%	8%	0%	60%	0%	0%	7%
On-Road Vehicles (Diesel)	1%	63%	1%	0%	29%	0%	5%	8%	0%	4%	0%	0%	1%
Non-Road Vehicles	0%	63%	0%	0%	29%	0%	1%	8%	0%	7%	0%	0%	0%
TOTAL													100%

Notes:
[a] No modeling involved. Estimated contributions of source categories to ambient concentrations were calculated by assuming that contribution to ambient PM subspecies ($PM_{2.5}$, nitrate, sulfate, VOC aerosol) concentration is proportional to emissions.
[b] Weighting factor for each PM subspecies ($PM_{2.5}$, nitrate, sulfate, VOC aerosol) is its measured fraction of the ambient $PM_{2.5}$ concentration across 2006 – 2010 winter period.

Table 5.7-3. Comparison of Estimated Source Category Contribution to Ambient $PM_{2.5}$ Concentration with Modeling Results (Projections to 2015)

Source Category	% of Ambient $PM_{2.5}$	
	Estimated[a]	Modeled
Point Sources		
Point Sources–All	51%	6%
Area Sources		
Space Heating–Wood	34%	66%
Central Oil–Residential	4%	3%
Central Oil–Commercial	1%	1%
Other Heating	1%	0%
Airport	0%	1%
Other Area Sources	1%	3%
Mobile Sources		
On-Road Vehicles (gasoline)	7%	18%
On-Road Vehicles (Diesel)	1%	2%
Non-Road Vehicles	0%	2%
TOTAL	100%	102%

Notes:
a. Estimated contributions of source categories to ambient concentrations were calculated by assuming that contribution to ambient PM subspecies ($PM_{2.5}$, nitrate, sulfate, VOC aerosol) concentration is proportional to emissions. The contribution of each subspecies is its measured fraction of the ambient $PM_{2.5}$ concentration on the episode day.

Based on the information in Table 5.7-2 and Table 5.7-3, the following source categories were evaluated for RACM.[9]

- Wood burning
  - Outdoor Wood-burning boilers (hydronic heater)
  - Wood Stoves
  - Fireplaces
  - Burn barrels
  - Open burning

- Residential Fuel Oil Combustion

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[9] A number of control measures were not considered because emissions from this category of sources are *de minimis* in Fairbanks (either the number of such sources was too small to consider, or the seasonality of emissions means that reductions would not contribute to attainment). A list of such sources and control measures is provided in Appendix A.

- Transportation
  - Automobiles
  - Heavy-duty Vehicle

5.7.3. Step 2: For Each Source Category, Identify Technologically Feasible Emission Control Technologies and/or Measures

An initial list was compiled that included all of the categories/measures identified by EPA in various guidance documents as likely candidates for RACM. To this list were added control measures that were suggested by public comments during Alaska's SIP development process. Some control measures on EPA's list (e.g., control of emissions from commercial charbroiling/cooking operations)[10] were eliminated because emissions from the source category make an insignificant contribution to PM concentrations in Fairbanks.

Additionally, $PM_{2.5}$ SIPs from other jurisdictions were reviewed for lists of control measures. Of the 35 areas originally designated to be nonattainment for the 2006 federal $PM_{2.5}$ standard, 23 also either had been or currently are an ozone nonattainment area; 6 of the remaining 12 have acquired a Clean Area Determination for $PM_{2.5}$, and therefore have not prepared a RACM analysis. The RACM analyses for each of the remaining six SIPs were reviewed for candidate control measures.

Controls applicable to stationary sources (large industrial facilities) were also eliminated because such facilities are subject to RACT review, and are addressed elsewhere in the SIP.

Table 5.7-4 lists the candidate control measures that were evaluated as potential RACM.

Table 5.7-4. Candidate Control Measures Considered for RACM

Source Category	Control Measure	Sources of Candidate Control Measure(s)[a]
Dry Wood Measures	Education and Outreach	1, 2, 4
	Regional kiln	7
	Ban on green wood sales	1

[10] The estimated $PM_{2.5}$ emission rate from conveyorized charbroilers in FNSB is about 0.0069 tons per day during the winter season. If all of these sources were controlled, the reduction (at an assumed 80%) would equal about 11 pounds per day.

Source Category	Control Measure	Sources of Candidate Control Measure(s)[a]
Hydronic Heaters	Education and Outreach	1, 2, 4
	Voluntary curtailment on air quality advisory days	1, 2
	Mandatory curtailment on air quality advisory days	1, 3, 5, 6
	All new units must be certified	7
	All units must be certified	7
	Ban new installations	5, 6
	Remove at time of home sale	3
	Subsidize heater change outs	2
	Ban use	7
Wood Stoves	Education and Outreach	1, 2, 3, 4
	Voluntary curtailment on air quality advisory days	1, 2
	Mandatory curtailment on air quality advisory days	1, 3, 5, 6
	All new units must be certified	2, 3, 4, 5, 6
	All new units must meet more stringent standards	7
	All units must be certified	3
	Replace uncertified stoves at time of home sale	3, 4
	Replace uncertified stoves in rental units	3
	Require alternate heat source in rental units	3
	Require alternate heat source in new construction	7
	Ban new installations	7
	Subsidize stove change outs	3, 4
	Ban use	3
	Use stove change outs to generate NSR offsets	3

Source Category	Control Measure	Sources of Candidate Control Measure(s)[a]
Fireplaces/Fireplace Inserts	Education and Outreach	1, 2, 3, 4
	Voluntary curtailment on air quality advisory days	1, 2, 5
	Mandatory curtailment on air quality advisory days	1
	Subsidize fireplace insert change outs	2
Open Burning	Reinstate open burning ban	1, 2, 3
Burn Barrel	Prohibit use of burn barrels (seasonal or year-round)	7
Residential Fuel Oil Combustion	Provide economic incentives to switch to low-sulfur fuel	7
	Increase coverage of District heating systems	3
Energy Efficiency Measures	Subsidize heating upgrades and weatherization	1, 3, 4, 5
Transportation	Improved public transit	1
	HOV lanes	1
	Traffic flow improvement programs	1
	Create non-motorized traffic zones	1
	Restrict truck idling	1
	Reduce cold start emissions	1
	Employer-sponsored flexible work schedules	1
	Retrofit diesel fleet (school buses, transit fleets)	1, 3
	Onroad vehicle I&M program	1
	Heavy-duty vehicle I&M program	1
	State LEV Program	1, 3

a. Control Measure Sources:
1 – EPA guidance
2 – FNSB programs and proposals
3 – Klamath Falls, Oregon SIP
4 – Oakridge, Oregon SIP
5 – Provo, Utah SIP
6 – Logan, Utah SIP
7 – Other

The identified control measures for area sources fall into four broad categories:

- Education and outreach;
- Voluntary curtailment;
- Mandatory curtailment; and
- Device upgrade and/or replacement.

Each control measure listed in Table 5.7-4 was evaluated for technological feasibility. Listed below are the criteria used. These criteria were developed based on a review of CAA provisions, past RACT and RACM guidance issued by EPA, the1992 general preamble for the implementation of Title of the 1990 CAA amendments and the addendum to the preamble..[11]

1. A measure is technologically infeasible if it is “absurd, unenforceable, or impractical.”

2. A measure is technologically infeasible if it would cause severe socioeconomic impacts.

3. A measure is technologically infeasible if, considering the availability of mitigating adverse impacts of that control on other pollution media, the control would not, in the State’s reasoned judgment, provide a net benefit to public health and the environment.

4. A measure may be determined to be technologically infeasible upon consideration of other relevant factors:

    a. The capability of effective implementation and enforcement of the measure; and

    b. Local circumstances, such as the condition and extent of needed infrastructure, population size, or workforce type and habits, which may prohibit certain potential control measures from being implementable.

The capability of effective implementation and enforcement are relevant considerations in the RACM analysis, even though public “unpopularity” is not. The General Preamble[12] states:

> *… the SIP submittal to EPA should contain a reasoned justification for partial or full rejection of any available control measures, including those considered or presented during the state’s public hearing process, that explains, with appropriate documentation, why each rejected control measure is infeasible or otherwise unreasonable.*

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[11]Federal Register, Vol. 57, No. 74, April 16, 1992.

[12] Page 13541 of the April 16, 1992 Preamble

5.7.3.1. Background Information

Education and Outreach Programs and Voluntary Curtailment

Education and outreach programs are necessary for successful implementation of curtailment programs. It is necessary that the target audience be aware of the reasons for, and means of implementing, curtailment of the specific behavior. Education and outreach should precede the implementation phase so that individuals may prepare for curtailment events. Education and outreach should continue through the program, to reinforce the message and to reach individuals who may have missed the previous outreach efforts.

Education and outreach efforts and voluntary curtailment programs may help increase community support for mandatory programs. Education and outreach increases the number of people who are aware of the air pollution problem, and explains the contribution that individuals can make to reduce the problem. Voluntary curtailment programs can help individuals understand the level of effort and cost needed to reduce the problem. Voluntary curtailment programs decrease opposition to mandatory programs by reducing the number of people who must change their behavior, and by demonstrating the feasibility of curtailment.

The State of Alaska and the FNSB have significant experience in educational programs that help citizens reduce their emissions. Public outreach is an important component of the Fairbanks air quality program with respect to improving residents' use of solid-fuel heating devices, thereby reducing $PM_{2.5}$ emissions. Public outreach efforts focus on measures residents can take to protect themselves and to reduce $PM_{2.5}$ emissions from activities like wood and coal burning. For example, the Borough and DEC have developed and implemented an extensive outreach effort to encourage residents to employ "best burning" practices when using wood heating devices. The Borough has also developed and implemented a program to support and encourage voluntary efforts to encourage residents who can to shift away from wood burning on advisory days and use their primary fuel oil heating systems instead.

Emission reductions from voluntary curtailment are potentially significant. However, because the reductions are not enforceable, EPA policy limits the amount of credit that may be taken for planning purposes to 6% of the total reductions needed for attainment.[13]

Mandatory Curtailment Programs

Mandatory curtailment programs that affect home heating are currently not feasible in Fairbanks North Star Borough because the community has, on several occasions, indicated that it would not accept such a program. The community has indicated this by approving, and renewing, a referendum that prohibits the Borough from imposing or

[13] http://www.epa.gov/ttn/caaa/t1/memoranda/evm_ievm_g.pdf

enforcing any limits on fuels used to heat homes.[14] While this initiative failed in the most recent election in October 2014, it has not been feasible to implement a local mandatory curtailment program.

Under Alaskan laws, voter-approved ordinances cannot be amended by local officials for two years. In 2012, more than two years after the 2009 initiative passed, the Borough proposed "moderate" regulations affecting home heaters. In response, the proponents of the 2009 proposition circulated a new proposition, renewing and strengthening the previous measure. On October 2, 2012, the voters of the Fairbanks North Star Borough approved Proposition 3, the Home Heating Initiative:

> *The borough shall not, in any way, regulate, prohibit, curtail, nor issue fines or fees associated with, the sale, distribution, or operation of heating appliances or any type of combustible fuel.*
>
> *'Heating Appliances' is defined as, but not limited to: oil furnaces, gas furnaces, wood stoves, coal stoves, wood-fired hydronic heaters, wood-fired furnaces, coal-fired hydronic heaters, coal-fired furnaces, masonry heaters, pellet stoves, cook stoves, and fireplaces.*

Continuation of the four-year voter ban against Fairbanks North Star Borough regulation of air pollution from home heaters and fuels failed on October 14, 2014 when Proposition 2, the Home Heating Initiative, was defeated. The ban will be lifted when the vote is certified by the Borough Assembly. Since this information became available after the preparation of this document, there is insufficient time to prepare revisions and meet the schedule for delivering the SIP to EPA by the end of 2014. Moreover, the Borough has not had time to make decisions about any additional control measures to be implemented in the wake of the vote.

The Borough assembly interpreted the above language to require a repeal of its ban on open burning. This resulted in the DEC implementing its existing statewide open burning regulations within the nonattainment area.

This October, Fairbanks voters considered another initiative renewing the ban on local adoption of restrictions on combustion sources. And, although the initiative failed (giving the Borough the authority to establish local regulations for home heating devices) community opposition to limits on options for home heating is also grounded in the economics of home heating in the far north. Fairbanks experiences extremely and persistently cold temperatures during the winter, and the cold temperatures coincide with strong inversions that result in high 24-hour $PM_{2.5}$ concentrations.

While fuel oil is the dominant source of home heating in Fairbanks, with roughly two thirds of the market, many homes are equipped to burn multiple fuels to ensure that a

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[14] FNSB Code 8.21.025 "The borough shall not, in any way, regulate, prohibit, curtail, nor issue fines or fees associated with, the sale, distribution, or operation of heating appliances or any type of combustible fuel."

backup is available in the event of a supply disruption in an arctic environment. The cost of fuel has risen from a low point of $2.25/gallon in Nov. 2006, to a high of $4.12 in January 2013. Current prices are roughly $4/gallon. The increase in fuel oil prices has stimulated a shift towards increase use of wood and coal as a way to conserve home heating expenses. Any perceived constraint on limiting the use of lower priced fuels is a significant concern in the community.

To illustrate the magnitude of home heating expenses in Fairbanks, information on the cost of living associated with energy use was assembled for PM nonattainment communities and northern tier (cold climate, high energy cost) communities located in states with wood burning controls. The Council for Community and Economic Research (C2ER) publishes a Cost of Living Index for 279 urban areas.[15] A total of 57 indices are provided for grocery items, housing, utilities, transportation, health care and miscellaneous goods and services. The utility categories include those described below.

- *Total Home Energy Cost* – monthly cost, at current rates, for average monthly consumption of all types over the previous 12 months for a 2,400 sq. ft. living area new house on an 8,000 sq. ft. lot (i.e., four bedrooms and two baths)
- *Electricity* – the average monthly cost for all electric homes
- *Other Home Energy* – average monthly cost, at current rates for natural gas, fuel oil, coal and any other forms of energy except electricity
- *Telephone* – not relevant to this discussion

It is important to note that these indices do not represent the average energy cost of all homes in each community and they do not include the cost of all fuels (e.g., wood is not included in the cost estimates). The collection of this level of detail across 279 communities on a quarterly basis is impractical. Instead, the indices provide a consistent metric to contrast utility- based energy costs of same size homes in each of the surveyed communities. The concept is that while smaller and larger homes may have different fuel use and fuel mixes, the relative cost observed in the indexes should provide a representative estimate of the cost of utility based fuels used in homes. Thus, the absolute value of the energy costs expressed in the index are less important the relative cost among participating communities.

A summary of the *Other Home Energy* and *Total Home Energy* indices for the second quarter of 2014 is presented below in Table 5.7-5 for 24 urban areas. The table also shows the percentage of each listed community's index relative to Fairbanks. It shows that Fairbanks had the highest energy costs of any of the listed urban areas. The C2ER data also show that Fairbanks has the highest home energy costs in the U.S. Juneau,

[15] Council for Community and Economic Research (C2ER),*Cost of Living Index, Comparative Data for 279 Urban Area, Second Quarter 2014, August 2014*

Alaska had home energy costs closest to those of Fairbanks at roughly 50% (i.e., one half). Outside of Alaska and Hawaii[16], the community with the highest energy costs

Table 5.7-5. Comparison of the Cost of Living Indices for *Other Home Energy and Total Home Energy* for Communities with Home Heating Particulate Control Measures

[16] Hilo and Honolulu, Hawaii have the second and third highest *Total Home Energy* cost in the U.S. (96.0% and 81.3%, respectively). While the State of Hawaii has outdoor burning restrictions, neither Hilo nor Honolulu community has wood burning restrictions and they have no PM nonattainment designations, so their values were not included in the Fairbanks comparisons.

Urban Area & State	Other Energy		Total Energy	
	Index	% Relative to Fairbanks	Index	% Relative to Fairbanks
Fairbanks, AK	426.93	100.0%	566.36	100.00%
Juneau, AK	223.11	52.3%	309.99	54.7%
Anchorage, AK	79.57	18.6%	162.30	28.7%
Phoenix, AZ	-	-	184.66	32.6%
Fresno, CA	79.30	18.6%	223.83	39.5%
Los Angeles, CA	70.71	16.6%	184.89	32.6%
Sacramento, CA	38.28	9.0%	215.80	38.1%
Denver, CO	69.21	16.2%	165.84	29.3%
Stamford, CT	129.19	30.3%	247.60	43.7%
Boise, ID	58.52	13.7%	148.85	26.3%
Boston, MA	122.55	28.7%	229.83	40.6%
Portland, ME	53.35	12.5%	136.28	24.1%
Detroit, MI	67.25	15.8%	183.32	32.4%
St. Paul, MN	71.76	16.8%	149.01	26.3%
Bozeman, MT	90.47	21.2%	154.02	27.2%
Manchester, NH	97.64	22.9%	205.55	36.3%
Newark, NJ	78.11	18.3%	206.39	36.4%
Buffalo, NY	70.01	16.4%	160.36	28.3%
Ithaca, NY	80.40	18.8%	179.24	31.6%
Manhattan, NY	148.24	34.7%	277.18	48.9%
Portland, OR	74.95	17.6%	158.73	28.0%
Burlington-Chittenden, VT	133.58	31.3%	234.60	41.4%
Salt Lake City, UT	76.03	17.8%	146.75	25.9%
Seattle, WA	-	-	173.47	30.6%
Tacoma, WA	79.94	18.7%	135.66	24.0%

(both categories) is Manhattan, NY, with 34.7% of the *Other Home Energy* index and 48.0% of the *Total Home Energy* index. Stamford, CT is second with 30.3% of the *Other Home Energy* index and 43.7.0% of the *Total Home Energy* index. Burlington-Chittenden, VT is third with 31.3% of the *Other Home Energy* index and 41.4.0% of the *Total Home Energy* index. Boston, MA is in fourth place, with 40.6% of the *Total Home Energy* index and 28.7% of the *Other Home Energy* costs.

Four communities (Fresno, Sacramento, Manchester, and Newark) had *Total Home Energy* indices falling between 33% and 40%. The rest of the listed communities had had energy costs that are one third or less than those incurred in Fairbanks. This information demonstrates that home heating expenses are two to three times higher in Fairbanks than any other community with wood burning controls. The magnitude of this expense directly influences the public's willingness to comply with controls that increase the cost of home heating. The cost data also demonstrate the limited economic impact of wood burning controls in the other PM nonattainment areas, which influences public willingness to bear the cost of those controls.

Finally, in addition to the economic issues described above, some residences that are equipped with alternative sources of heat may find those sources inadequate on some of the coldest days of the year. In these cases, supplemental heating with a wood-fired device may be necessary when the fuel oil-fired heater does not provide enough heat.

For this reason, control measures that require the use of an alternative fuel source to wood have a much greater cost to the consumer in Fairbanks (a factor of two or three) than to consumers in other parts of the United States. The magnitude of this expense directly influences the public's willingness and ability to comply with controls that further increase the cost of home heating. A ban on use of woodstoves during high pollution days in Fairbanks has a dramatically different effect than such a ban in Sacramento.

As demonstrated by the Home Heating Initiative described above, the community resistance in Fairbanks to measures that would increase home heating costs has been carried over to other measures affecting the fuel supply, such as prohibitions on the use of wet wood.
While the initiative failed in October 2014, it will take some time to establish locally effective controls. For the reasons outlined above, such a program would still face resistance by many in the community, which remains opposed to limits on residential fuel use. Because of this opposition, candidate control measures that fall within the scope of the referendum's ban have been determined to be not practically enforceable at this time.

5.7.3.2. Dry Wood Programs

The Cold Climate Housing Research Center estimated in 2009 that residential wood burning accounted for slightly over 560 tons of $PM_{2.5}$ emissions per year in the FNSB.[17] As shown in Table 5.7-2, emissions from wood combustion are responsible for 2.99 tons per day of direct $PM_{2.5}$ emissions on episode days. Based on photochemical modeling, wood combustion is responsible for 66% of the ambient $PM_{2.5}$ concentration on episode days.

Dry wood programs reduce emissions from all categories of wood burning equipment by reducing the moisture content of the wood fuel mix. Reducing wood fuel moisture content reduces emissions of $PM_{2.5}$ and its precursors by (1) improving combustion, burning more cleanly and reducing emissions on a per pound of fuel basis; and (2) by burning more efficiently. Less moisture means less water needs to be evaporated, and

[17] Cold Climate Housing Research Center, *Reducing PM2.5 Emissions from Residential Heating Sources in the Fairbanks North Star Borough*, February 23, 2009. p. 14.

therefore more heat is available as useful heat. Because less fuel is required to provide the same amount of useful heat, emissions of all combustion pollutants is reduced. A secondary effect is that less energy is required to transport fuel, resulting in a modest reduction in onroad emissions.

Fuel wood can be dried actively in kilns. It can also be dried by letting cut wood season before being burned. Freshly cut “wet” wood may contain as much as 40% to 60% moisture, depending on the type of wood.[18] Wood that has been allowed sufficient time to dry (usually six months or more, for split wood that is air-dried) typically contains 20% moisture or less.[19] According to a 2008 report by the Northeast States for Coordinated Air Use Management (NESCAUM), for every 10 percentage point increase in the moisture content of wood, the $PM_{2.5}$ emissions increase by 65% to 167%.[20] Part of this increase is due to the increased amount of wood fuel needed to evaporate the extra water, but a larger part of this increase is due to poor combustion conditions that lead to reduced heat transfer efficiency and to more particulates in the smoke.

If only wet wood is burned, the total wood volume used for an entire winter may be as much as 100% more than if seasoned wood were used.[21]

Education and Outreach

The State of Alaska and the FNSB have significant experience in educational programs that help citizens reduce their emissions.[22] The agencies publish a brochure, *Split Stack Store and Save!*, that encourages the use of only dry wood, explains methods for ensuring that wood is dry (seasoning after cutting,), and explains some of the benefits (less wood needed, cleaner burning). EPA publishes a similar brochure, *Wet Wood is a Waste*, as part of its Burn Wise program. Burn Wise materials are also available from the FNSB and Alaska DEC. Because it involves voluntary efforts on the part of the public, and is implemented as a state program, community resistance to the FNSB and Alaska DEC’s outreach programs has been minimal.

A more comprehensive program that encourages the use of only dry wood, explains the methods for ensuring that wood is dry (seasoning after cutting, use of inexpensive moisture meters), and explains the benefits (less wood is needed, wood is lighter/easier to carry, less creosote is formed) has been developed and is in the process of being implemented.

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[18] EPA, *Subpart AAA—Standards of Performance for New Residential Wood Heaters, Revised Draft Review Document,* December 30, 2009, p. 35

[19] EPA, *Subpart AAA—Standards of Performance for New Residential Wood Heaters, Revised Draft Review Document,* December 30, 2009, p. 35

[20] NESCAUM, *Source Characterization of Outdoor Wood Furnaces,* September 9, 2008, p. 4-1

[21] Bureau of land Management, *Wood Heat as a Comparison* http://www.blm.gov/ca/st/en/fo/alturas/woodheatcomparison.html (“Wet wood alone can reduce the efficiency of a wood stove by an additional 50%.”)

[22] As discussed in the introduction to this Section.

Overall effectiveness of voluntary measures as an emission reduction measure depends upon the extent of implementation, as well as the actual steps taken by the public. Education and outreach measures can reduce opposition to future efforts to implement mandatory measures.

This control measure is technologically feasible.

<u>Increased availability—regional kiln</u>

Of the wood burned in FNSB, 26.2 % is purchased from firewood dealers (the rest is harvested by the user).[23] Less than 20% of the wood sold in FNSB is dry wood; the rest is sold green, or self-cut, and contains a considerable amount of moisture.[24]

As discussed above, wet wood does not burn as efficiently as dry wood. One of the barriers to use of dry wood is availability. Construction of a regional kiln is one way to increase the availability of dry wood. A regional kiln would allow wet firewood to be dried quickly. Depending on the source of heat[25] for drying, substantial reductions in PM emissions could be achieved. The source of drying heat would also affect the cost of the process, and therefore the premium charged for kiln-dried wood.

This measure would reach only a portion of the wood supply. More than 75% of the wood burned in residential heaters is self-cut or comes from unlicensed wood suppliers; this wood could not be processed in a regional kiln.

As discussed above, dry wood provides several advantages for the consumer: it burns hotter and cleaner, each log weighs less, and less fuel is needed for the same amount of heat. Depending upon the cost of drying heat, the premium for dry wood may be less than the consumer's savings due to the reduced need for fuel.[26] Economic incentives from government agencies may therefore be necessary to kickstart construction of a regional kiln.

There is no evidence that the current demand for sales of dry firewood is sufficiently high to require construction of a regional kiln.[27] As discussed below, adoption of a ban on the

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[23] 2013 Tag survey.

[24] Most wood sold in the area comes from trees that have been cut down, but not sectioned and split until purchased by the consumer. As a result, the wood is still wet when sold.

[25] Sources of heat could include kiln-dried firewood produced in the facility, fuel oil or LNG, or low pressure steam or recovered heat from an industrial process.

[26] The current premium for dry vs. wet wood is $50 per cord ($375 per cord vs. $325 per cord). The moisture content of kiln-dried firewood must be similar to that of air-dried firewood in order for certified stoves to work properly.

[27] At least one firewood vendor is constructing a kiln, based either on current demand or anticipation of demand. If this venture is successful, other vendors may choose to do the

sale of green wood would increase demand, possibly justifying construction of a kiln; however, such a ban has not been feasible in FNSB. Furthermore, regional emissions from kiln-dried firewood are much higher than from air-dried firewood, because of the fuel needed to operate the kiln.

This measure is not technologically feasible.

Ban on green wood sales

A ban on the sale of green wood would require wood vendors to have access to facilities to dry wood. This would be either a kiln (such as a regional kiln described in the previous section) or sufficient storage space to store and dry all of the fuel wood to be sold in the following year. The amount of dry wood storage needed for one year of wood fuel sales in FNSB is 42,300 cords.[28]

This measure would reach only a portion of the wood supply. As discussed in the previous section, more than 70% of the wood burned in residential heaters is self-cut or comes from unlicensed wood suppliers; this would not be affected by a ban on sale of green wood.

As discussed above, the referendum prohibiting the Borough's regulation of home heating and fuels has prevented the Borough from implementing this program. Any such program would have to be implemented by the State, in the face of opposition from the local community.

This measure is not technologically feasible.

5.7.3.3. Residential Wood Burning: Outdoor Wood-burning Boilers (hydronic heaters)

A hydronic heater (also called an outdoor wood heater or outdoor wood boiler) burns wood to heat liquid flowing through pipes in the combustion chamber. The hot liquid is then piped to provide heat and hot water to occupied buildings. The number of units in FNSB has been estimated[29] at about 480: 380 are uncertified, and 100 are Phase 2 Qualified units (see below).

same. A much larger unmet demand for dry wood would be needed to justify a regional kiln, however.

[28] A 2011 home heating survey (Sierra Research, June 10, 2011) indicated average wood fuel use of 3.57 cords/year per installation for stoves and inserts, and 1.80 cords/year for fireplaces. The SIP inventory for 2015 projects a total of 11,510 stoves, inserts, and hydronic heaters, and 660 fireplaces. Total estimated annual wood fuel consumption = 3.57 * 11,510 + 1.80 * 660 = 42,300 cords

[29] Sierra Research, projected 2015 (attainment year) inventory based on 2011 home heating survey

Emissions from wood boilers are currently not regulated at the national level, but EPA has initiated a voluntary program for manufacturers of hydronic heaters.[30] The program encourages manufacturers to produce and sell cleaner, more efficient devices. Hydronic heaters that are "Phase 2 Qualified" under the EPA program must meet an emissions limit of 0.32 lbs per million BTU output.[31] This represents a reduction of about 90% compared to unqualified units.

Direct $PM_{2.5}$ emissions from hydronic heaters are estimated to be 350 tons per year.[32]

Education and Outreach

The State of Alaska and the FNSB have significant experience in educational programs that help citizens reduce their emissions.[33] The agencies publish a brochure, *Split Stack Store and Save!*, that encourages the use of only dry wood, explains methods for ensuring that wood is dry (seasoning after cutting,), and explains some of the benefits (less wood needed, cleaner burning). EPA publishes a similar brochure, *Wet Wood is a Waste,* as part of its Burn Wise program. Burn Wise materials are also available from the FNSB and Alaska DEC. In order to maximize the effectiveness of this control measure, additional materials that target hydronic heaters should be developed, containing the information currently available on the EPA website.[34]

Because it involves voluntary efforts on the part of the public, and is implemented as a state program, community resistance to the FNSB and Alaska DEC outreach programs has been minimal.

Overall effectiveness of voluntary measures as an emission reduction measure depends upon the extent of implementation, as well as the actual steps taken by the public. Education and outreach measures can reduce opposition to future efforts to implement mandatory measures.

This control measure is technologically feasible.

Voluntary curtailment on air quality advisory days

Under a voluntary curtailment program, owners of wood burning devices are asked to voluntarily reduce or avoid operation of the devices on days when air quality is poor. Such a program relies on agency efforts to predict poor air quality days, agency efforts to make the public aware of predictions, agency efforts to educate the public about reducing emissions, and public cooperation with requests to minimize emissions.

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[30] EPA, *EPA's Phase 2 Voluntary Partnership Program: Hydronic Heaters*
[31] Ibid.
[32] Cold Climate Housing Research Center, *Reducing $PM_{2.5}$ Emissions from Residential Heating Sources in the Fairbanks North Star Borough*, February 23, 2009. p. 14.
[33] As discussed in the introduction to this Section.
[34] http://www.epa.gov/burnwise/woodboilers.html.

The FNSB Air Quality Division provides daily air quality information on its website and by telephone. Alaska DEC also provides air quality advisories when circumstances call for them. FNSB has developed a voluntary burn cessation program that includes direct notification of participants when an advisory is called. Advisories are called when $PM_{2.5}$ concentrations above 35 micrograms per cubic meter are predicted.

Under this control measure, the agencies will develop and distribute additional educational materials. They will increase efforts to publicize the program, beginning with links on the existing Air Quality Index webpages to the FNSB's existing AQ Advisory program webpages.

In February, 2014, the FNSB adopted an ordinance[35] to create a voluntary burn cessation program with the following elements:

- Provide incentives (sign-up bonus, yard sign, or other form of public acknowledgment) to households that agree to voluntarily avoid use of wood-burning appliances during air quality advisories.

- Establish methods, such as automated phone calls, to notify participants when an advisory is called.

- Allow the Borough to contract with an agency to promote the program.

This control measure is technologically feasible.

<u>Mandatory curtailment on air quality advisory days</u>

Mandatory curtailment on air quality advisory days would prohibit use of some hydronic heaters on days of poor air quality. This prohibition could be implemented to affect all hydronic heaters, or only those that do not meet EPA qualification standards. An exemption from the ban for units that are the sole source of a residence's space heating would be included in either case. Approximately 4% of households in Fairbanks use wood as the sole source of heat.

State law currently prohibits the operation of wood-fired heating devices on episode days:

> *18 AAC 50.075 (b) A person may not operate a wood-fired heating device in an area for which the department has declared an air quality episode under 18 AAC 50.245.*

The criteria for declaring an air quality episode do not currently include $PM_{2.5}$ concentrations. Alaska DEC has proposed[36] to revise the criteria for declaring an air

[35] http://co.fairbanks.ak.us/meetings/ordinances/2014/2014-11.pdf
[36] Alaska DEC, *Proposed Regulation changes Pertaining to: Open Burning, Wood-fired Heating Device Visible Emission Standards, Solid Fuel-Fired Heating Device Fuels,*

quality episode to include $PM_{2.5}$, but at a concentration well above the federal standard. At the same time, Alaska DEC proposed a revision to Section 50.075 to give the agency discretion about declaring an episode. The revision would benefit public health by reducing $PM_{2.5}$ concentrations on the worst episode days. Advisories are called when $PM_{2.5}$ concentrations above 35 micrograms per cubic meter are predicted.

As discussed above, the Borough has not been able to implement this measure because of the referendum prohibiting the Borough's regulation of home heating and fuels. Any such measure would have to be implemented by the State, in the face of opposition from the local community and would not be practically enforceable.

This measure is not technologically feasible.

<u>All new units must be certified</u>

Alaska DEC has already proposed a more stringent standard. See next section.

This control measure is technologically feasible.

<u>All new units must meet a more stringent state standard of 2.5 gram/hour</u>

EPA has initiated a voluntary program for manufacturers of hydronic heaters. EPA's primary intent is to first encourage manufacturers to produce cleaner hydronic heater models. EPA also wants those who buy a hydronic heater to buy the cleanest models available, which are those that qualify for the EPA voluntary program. EPA maintains a list of qualifying models, of which there are many.

Many local agencies have developed ordinances that ban unqualified hydronic heaters and establish minimum distances to neighbors and minimum stack heights. EPA has provided technical and financial support for the NESCAUM to develop a model rule that state and local agencies can use to regulate hydronic heater emissions.

Alaska DEC has proposed[37] to adopt a new regulation, 18 AAC 50.077(b)(1), that would require that all new hydronic heaters meet an emission limit of 2.5 gm/hr. While this measure cannot be implemented by the Borough because of the referendum prohibiting the Borough's regulation of home heating and fuels, the State could implement the measure. Since it would only affect the supply of wood stoves offered for sale and not impact homeowner fuel choice decisions, enforceability limitations and concerns would not apply.

Wood Fired Heating Device Standards, & Fine Particulate Matter (PM-2.5) Air Episode and Advisories, Public Review Draft, September 19, 2013.

[37] Alaska DEC, *Proposed Regulation changes Pertaining to: Open Burning, Wood-fired Heating Device Visible Emission Standards, Solid Fuel-Fired Heating Device Fuels, Wood Fired Heating Device Standards, & Fine Particulate Matter (PM-2.5) Air Episode and Advisories, Public Review Draft*, September 19, 2013.

This measure is technologically feasible.

All units must be certified, requiring retrofits/replacement of existing units

Adoption of a performance standard for all hydronic heaters would require replacement or retrofit of existing heaters that do not meet the standard (e.g., qualified under the EPA program described above).

As discussed above, this measure cannot be implemented by the Borough because of the referendum prohibiting the Borough's regulation of home heating and fuels. Any such measure would have to be implemented by the State, in the face of opposition from the local community and would not be practically enforceable.

This control measure is not technologically feasible.

Ban on new installations

A ban on new installations would not reduce emissions from hydronic heaters in the near term, but would ultimately reduce emissions as hydronic heaters were retired. However, this approach could have the negative effect of prolonging the use of existing, dirty units because replacing them with newer, much cleaner units would not be allowed. As a result, this measure would not result in quantifiable reductions in the four years after designation.

As discussed above, this measure cannot be implemented by the Borough because of the referendum prohibiting the Borough's regulation of home heating and fuels. Any such measure would have to be implemented by the State, in the face of opposition from the local community and would not be practically enforceable. Since the measure has been recently defeated in October 2014. This information became available after the preparation of this document, there is insufficient time to prepare revisions and meet the schedule for delivering the SIP to EPA by the end of 2014. Moreover, the Borough has not had time to make decisions about any additional control measures to be implemented in the wake of the vote.

This control measure is not technologically feasible.

Remove at time of home sale

A requirement to replace hydronic heaters at the time of home sale would not reduce emissions from hydronic heaters in the near term, but would ultimately reduce emissions as hydronic heaters were retired when residential property changed hands. As a result, this measure would not result in quantifiable reductions in the four years after designation. The cost of the measure would be borne by the seller, because the home's sale price would be diminished by the value of the heater that must be removed.

As discussed above, this measure cannot be implemented by the Borough because of the referendum prohibiting the Borough's regulation of home heating and fuels. Any such measure would have to be implemented by the State, in the face of opposition from the local community would not be practically enforceable.

This control measure is not technologically feasible.

Subsidize heater change outs

FNSB has a solid fuel burning appliance (SFBA) change out program. Qualifying residents can be reimbursed for replacing, removing, or repairing solid fuel burning devices (wood and coal-stoves, wood and coal-fired furnaces, hydronic heaters, fireplace inserts, etc.). FNSB offers reimbursement of 100% of the cost (up to $10,000) of a new qualifying hydronic heater. There is also a bounty program for dismantling an old device without replacement.

This control measure is technologically feasible.

Ban use

A ban on the use of hydronic heaters would require those with access to alternate heat sources to use them. Unless an exemption were offered, those with no alternate heat source would be required to install one. As discussed above, on very cold days some residences with alternate heat sources find those sources to be inadequate, and need to supplement with heat from wood combustion. An enforcement mechanism is required to implement this measure. Such a mechanism does not currently exist.

As discussed above, this measure cannot be implemented by the Borough because of the referendum prohibiting the Borough's regulation of home heating and fuels. Any such measure would have to be implemented by the State, in the face of opposition from the local community would not be practically enforceable.

This control measure is not technologically feasible.

5.7.3.4. Residential Wood Burning: Wood Stoves

The number of units in FNSB has been estimated[38] at about 11,000: 3,645 (33%) are uncertified; 3,811 (35%) are EPA-certified non-catalytic units; 2,497 (23%) are EPA-certified catalytic units; and 412 (4%) are pellet stoves

Direct $PM_{2.5}$ emissions from wood stoves are estimated to be 214 tons per year.[39]

[38] Sierra Research, projected 2015 (attainment year) inventory based on 2011 home heating survey

[39] Cold Climate Housing Research Center, *Reducing PM2.5 Emissions from Residential Heating Sources in the Fairbanks North Star Borough*, February 23, 2009. p. 14.

Education and Outreach

The State of Alaska and the FNSB have significant experience in educational programs that help citizens reduce their emissions.[40] The FNSB and State of Alaska have programs focused on woodstoves. Program materials include brochures on woodstoves, catalytic woodstoves, and non-catalytic woodstoves; *Split Stack Store and Save!*, that encourages the use of only dry wood, explains methods for ensuring that wood is dry (seasoning after cutting,), and explains some of the benefits (less wood needed, cleaner burning). EPA publishes a similar brochure, *Wet Wood is a Waste,* as part of its Burn Wise program. Burn Wise materials are also available from the FNSB and Alaska DEC. Because it involves voluntary efforts on the part of the public, and is implemented as a state program, community resistance to the FNSB and Alaska DEC outreach programs has been minimal.

Overall effectiveness of voluntary measures as an emission reduction measure depends upon the extent of implementation, as well as the actual steps taken by the public. Education and outreach measures can reduce opposition to future efforts to implement mandatory measures.

This control measure is technologically feasible.

Voluntary curtailment on air quality advisory days

Under a voluntary curtailment program, owners of wood burning devices are asked to voluntarily reduce or avoid operation of the devices on days when air quality is poor. Such a program relies on agency efforts to predict poor air quality days, agency efforts to make the public aware of predictions, agency efforts to educate the public about reducing emissions, and public cooperation with requests to minimize emissions.

The FNSB Air Quality Division provides daily air quality information on its website and by telephone. Alaska DEC also provides air quality advisories when circumstances call for them.

In February, 2014, the FNSB adopted an ordinance[41] to create a voluntary burn cessation program with the following elements:

- Provide incentives (sign-up bonus, yard sign, or other form of public acknowledgment) to households to agree to voluntarily avoid use of wood-burning appliances during air quality advisories.
- Establish methods, such as automated phone calls, to notify participants when an advisory is called
- Allow the Borough to contract with an agency to promote the program.

[40] As discussed in the introduction to this Section.
[41] http://co.fairbanks.ak.us/meetings/ordinances/2014/2014-11.pdf

This measure is technologically feasible.

Mandatory curtailment on air quality advisory days

Mandatory curtailment on air quality advisory days would prohibit use of some woodstoves. This prohibition could be implemented to affect all woodstoves, or only those that do not meet EPA certification standards. An exemption from the ban for units that are the sole source of a residence's space heating would be included in either case.

State law currently prohibits the operation of wood-fired heating devices on episode days:

> *18 AAC 50.075 (b) A person may not operate a wood-fired heating device in an area for which the department has declared an air quality episode under 18 AAC 50.245.*

The criteria for declaring an air quality episode do not currently include $PM_{2.5}$ concentrations. Alaska DEC has proposed[42] to revise the criteria for declaring an air quality episode to include $PM_{2.5}$, but at a concentration well above the federal standard. At the same time, Alaska DEC proposed a revision to Section 50.075 to give the agency discretion about declaring an episode. The revision would benefit public health by reducing $PM_{2.5}$ concentrations on the worst episode days.

As discussed above, this measure cannot be implemented by the Borough because of the referendum prohibiting the Borough's regulation of home heating and fuels. Any such program would have to be implemented by the State, in the face of opposition from the local community would not be practically enforceable. Since the measure has been recently defeated in October 2014. This information became available after the preparation of this document, there is insufficient time to prepare revisions and meet the schedule for delivering the SIP to EPA by the end of 2014. Moreover, the Borough has not had time to make decisions about any additional control measures to be implemented in the wake of the vote.

This control measure is not technologically feasible.

All new units must be certified

Alaska DEC has proposed a more stringent measure. Please see next section.
This control measure is technologically feasible.

Only stoves meeting more stringent state standards (2.5 gram/hr) may be sold

[42] Alaska DEC, *Proposed Regulation changes Pertaining to: Open Burning, Wood-fired Heating Device Visible Emission Standards, Solid Fuel-Fired Heating Device Fuels, Wood Fired Heating Device Standards, & Fine Particulate Matter (PM-2.5) Air Episode and Advisories, Public Review Draft*, September 19, 2013.

Alaska DEC has proposed[43] to adopt a new regulation, 18 AAC 50.077(b)(2), that would require that all new woodstoves meet an emission limit of 2.5 gm/hr and be certified by EPA. The short-term effectiveness of this measure is low, as the turnover of wood stoves built before 1992 is very slow; however, the measure would stop the projected growth in the number of uncertified wood stoves (~1.3% per year).[44] Changeover to newer units could be accelerated with a wood stove change-out program.

This control measure is technologically feasible.

Replace uncertified stoves at time of home sale

A requirement to replace uncertified stoves at the time of home sale would not reduce emissions from wood stoves in the near term, but would ultimately reduce emissions as wood stoves were retired when residential property changed hands. As a result, this measure would not result in quantifiable reductions in the four years after designation. The cost of the measure would be borne by the seller, because the home's sale price would be diminished by the value of the stove that must be removed.

As discussed above, this measure cannot be implemented by the Borough because of the referendum prohibiting the Borough's regulation of home heating and fuels. Any such measure would have to be implemented by the State, in the face of opposition from the local community would not be practically enforceable. Since the measure has been recently defeated in October 2014. This information became available after the preparation of this document, there is insufficient time to prepare revisions and meet the schedule for delivering the SIP to EPA by the end of 2014. Moreover, the Borough has not had time to make decisions about any additional control measures to be implemented in the wake of the vote.

This control measure is not technologically feasible.

Replace uncertified stoves in rental units

A requirement to replace uncertified stoves in rental units would result in emission reductions upon replacement. The cost of the measure would be borne by the landlords, and presumably passed on to the renter.

As discussed above, this measure cannot be implemented by the Borough because of the referendum prohibiting the Borough's regulation of home heating and fuels. Any such measure would have to be implemented by the State, in the face of opposition from the

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[43] Alaska DEC, *Proposed Regulation changes Pertaining to: Open Burning, Wood-fired Heating Device Visible Emission Standards, Solid Fuel-Fired Heating Device Fuels, Wood Fired Heating Device Standards, & Fine Particulate Matter (PM-2.5) Air Episode and Advisories, Public Review Draft*, September 19, 2013.

[44] Sierra Research, projected 2015 (attainment year) inventory based on 2011 home heating survey

local community would not be practically enforceable. Since the measure has been recently defeated in October 2014. This information became available after the preparation of this document, there is insufficient time to prepare revisions and meet the schedule for delivering the SIP to EPA by the end of 2014. Moreover, the Borough has not had time to make decisions about any additional control measures to be implemented in the wake of the vote.

This control measure is not technologically feasible.

Require alternate heat source in rental units

Emission reductions occur to the extent that the renter uses the alternate heat source during air pollution advisories. The availability of an alternate heat source allows the renter to participate in curtailment programs. It is not clear what fraction of the rental housing stock is physically able to install an alternate heat source. The cost of the measure would be borne by the landlords, and presumably passed on to the renter.

As discussed above, this measure cannot be implemented by the Borough because of the referendum prohibiting the Borough's regulation of home heating and fuels. Any such measure would have to be implemented by the State, in the face of opposition from the local community would not be practically enforceable. Since the measure has been recently defeated in October 2014. This information became available after the preparation of this document, there is insufficient time to prepare revisions and meet the schedule for delivering the SIP to EPA by the end of 2014. Moreover, the Borough has not had time to make decisions about any additional control measures to be implemented in the wake of the vote.

This control measure is not technologically feasible.

Require alternate heat source in new construction

A requirement to include alternate heat sources in new construction would not reduce emission; it would, however, potentially reduce the magnitude of new emissions associated with population growth. Emission minimization occurs to the extent that the resident uses the alternate heat source during air pollution advisories. The availability of an alternate heat source allows the resident to participate in curtailment programs. This measure would not result in quantifiable reductions in the four years after designation.

As discussed above, this measure cannot be implemented by the Borough because of the referendum prohibiting the Borough's regulation of home heating and fuels. Any such measure would have to be implemented by the State, in the face of opposition from the local community would not be practically enforceable.

This control measure is not technologically feasible.

Ban on new installations

A ban on new installations would not reduce emissions from wood stoves in the near term, but would ultimately reduce emissions as wood stoves were retired; however, this approach could have the negative effect of prolonging the use of existing, dirty units because replacing them with newer, much cleaner units would not be allowed. This measure would not result in quantifiable reductions in the four years after designation.

The short-term effectiveness of this measure is low, as the turnover of wood stoves built before 1992 is very slow. Changeover to newer units could be accelerated with a wood stove change-out program.

As discussed above, this measure cannot be implemented by the Borough because of the referendum prohibiting the Borough's regulation of home heating and fuels. Any such measure would have to be implemented by the State, in the face of opposition from the local community would not be practically enforceable. Since the measure has been recently defeated in October 2014. This information became available after the preparation of this document, there is insufficient time to prepare revisions and meet the schedule for delivering the SIP to EPA by the end of 2014. Moreover, the Borough has not had time to make decisions about any additional control measures to be implemented in the wake of the vote.

This control measure is not technologically feasible.

Subsidize woodstove change outs

FNSB has a SFBA change out program. Qualifying residents can be reimbursed for replacing, removing, or repairing solid fuel burning devices (wood and coal-stoves, wood and coal-fired furnaces, hydronic heaters, fireplace inserts, etc.). FNSB offers reimbursement of 100% of the cost (up to $4,000) of a new certified wood stove. There is also a bounty program for dismantling an old device without replacement.

This control measure is technologically feasible.

Ban on all use

A ban on the use of woodstoves would require those with access to alternate heat sources to use them. Unless an exemption were offered, those with no alternate heat source would be required to install one. As discussed above, on very cold days some residences with alternate heat sources find those sources to be inadequate, and need to supplement with heat from wood combustion.

An enforcement mechanism is required to implement this measure. The mechanism would need to be much larger than needed to enforce a ban on hydronic heaters, due to the larger number of stoves and the fact that stoves are less conspicuous. Such a mechanism does not currently exist.

This control measure is not technologically feasible.

Incentive program: use stove change outs to generate New Source Review (NSR) offsets

Incentive programs provide cash incentives to equipment owners to retire or replace old, dirty equipment. Proposals for incentive programs focus on the source of funds, the amount of subsidy per transaction, and the amount of funds available.

This measure would allow applicants for new major industrial sources to obtain emission offsets by funding stove change outs. Emissions from woodstoves would be reduced, and some fraction of the reduction would be made available to offset emissions from the new industrial source.

Based upon discussions with Alaska DEC permitting staff, the likelihood of an industrial project in FNSB triggering PM offset requirements is small. Because no projects have been proposed that might find this option useful, no reductions will occur in the four years following designation.

This measure is not technologically feasible.

5.7.3.5. Residential Wood Burning: Fireplaces

The number of units in FNSB has been estimated[45] at about 1,275; 610 (48%) do not have inserts; 234 (18%) have uncertified inserts; 245 (19%) are EPA-certified non-catalytic units; 160 (13%) are EPA-certified catalytic units; and 24 (2%) are pellet-burning inserts.

Education and Outreach

The State of Alaska and the FNSB have significant experience in educational programs that help citizens reduce their emissions.[46] The agencies publish a brochure, *Split Stack Store and Save!*, that encourages the use of only dry wood, explains methods for ensuring that wood is dry (seasoning after cutting,), and explains some of the benefits (less wood needed, cleaner burning). EPA publishes a similar brochure, *Wet Wood is a Waste,* as part of its Burn Wise program. Burn Wise materials are also available from the FNSB and Alaska DEC. Because it involves voluntary efforts on the part of the public, and is implemented as a State program, community resistance to the FNSB and Alaska DEC outreach programs has been minimal.

Overall effectiveness of voluntary measures as an emission reduction measure depends upon the extent of implementation, as well as the actual steps taken by the public.

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[45] Sierra Research, projected 2015 (attainment year) inventory based on 2011 home heating survey

[46] As discussed in the introduction to this Section.

Education and outreach measures can reduce opposition to future efforts to implement mandatory measures.

This control measure is technologically feasible.

Voluntary curtailment on air quality advisory days

Under a voluntary curtailment program, owners of wood burning devices are asked to voluntarily reduce or avoid operation of the devices on days when air quality is poor. Such a program relies on agency efforts to predict poor air quality days, agency efforts to make the public aware of predictions, agency efforts to educate the public about reducing emissions, and public cooperation with requests to minimize emissions.

The FNSB Air Quality Division provides daily air quality information on its website and by telephone. Alaska DEC also provides air quality advisories when circumstances call for them.

In February 2014, the FNSB adopted an ordinance[47] to create a voluntary burn cessation program with the following elements:

- Provide incentives (sign-up bonus, yard sign, or other form of public acknowledgment) to households that agree to voluntarily avoid use of wood-burning appliances during air quality advisories.

- Establish methods, such as automated phone calls, to notify participants when an advisory is called.

- Allow the Borough to contract with an agency to promote the program.

This program is technologically feasible.

Mandatory curtailment on air quality advisory days

Mandatory curtailment on air quality advisory days would prohibit use of some fireplaces. This prohibition could be implemented to affect all fireplaces, or only those that do not meet EPA certification standards (e.g., certified inserts; chimney abatement systems). An exemption from the ban for units that are the sole source of a residence's space heating would be included in either case.

State law currently prohibits the operation of wood-fired heating devices on episode days:

> *18 AAC 50.075 (b) A person may not operate a wood-fired heating device in an area for which the department has declared an air quality episode under 18 AAC 50.245.*

[47] http://co.fairbanks.ak.us/meetings/ordinances/2014/2014-11.pdf

The criteria for declaring an air quality episode do not currently include $PM_{2.5}$ concentrations. Alaska DEC has proposed[48] to revise the criteria for declaring an air quality episode to include $PM_{2.5}$, but at a concentration well above the federal standard. At the same time, Alaska DEC proposed a revision to Section 50.075 to give the agency discretion about declaring an episode. The revision would benefit public health by reducing $PM_{2.5}$ concentrations on the worst episode days. However, because the proposed threshold for calling an advisory is well above the federal standard, this revision will not result in emission reductions on many violation days, and therefore will not contribute to attainment in FNSB.

This control measure is not technologically feasible.

Subsidize fireplace insert change outs

FNSB has an SFBA change out program. Qualifying residents can be reimbursed for replacing, removing, or repairing solid fuel burning devices (wood and coal-stoves, wood and coal-fired furnaces, hydronic heaters, fireplace inserts, etc.). FNSB offers reimbursement of 100% of the cost (up to $4,000) of a new certified fireplace insert. There is also a bounty program for dismantling an old device without replacement.

This control measure is technologically feasible.

5.7.3.6. Residential Wood Burning: Burn Barrels, Open Burning

Reinstate seasonal open burning ban

Open burning is currently banned between November 1 and March 31 in Wood Smoke Control Areas (18 AAC 50.065(f)). FNSB is not currently a Wood Smoke Control Area. Alaska DEC has proposed adding $PM_{2.5}$ non-attainment areas to the areas covered by this regulation as a proactive measure to prevent additional smoke during winter months.[49]

Alaska DEC's regulation 18 AAC 50.065(e) prohibits open burning during an air quality advisory. Advisories are called when $PM_{2.5}$ concentrations above 35 micrograms per cubic meter are predicted.

Since the 1970s, the Fairbanks North Star Borough had an ordinance to restrict wintertime open burning. In 2013, the Borough Assembly repealed that ordinance in

[48] Alaska DEC, *Proposed Regulation changes Pertaining to: Open Burning, Wood-fired Heating Device Visible Emission Standards, Solid Fuel-Fired Heating Device Fuels, Wood Fired Heating Device Standards, & Fine Particulate Matter (PM-2.5) Air Episode and Advisories, Public Review Draft*, September 19, 2013.
[49] Alaska DEC, *Proposed Regulation changes Pertaining to: Open Burning, Wood-fired Heating Device Visible Emission Standards, Solid Fuel-Fired Heating Device Fuels, Wood Fired Heating Device Standards, & Fine Particulate Matter (PM-2.5) Air Episode and Advisories, Public Review Draft*, September 19, 2013.

response to a voter initiative that restricted the Borough's authority to regulate fuel burning.

Although the voters of FNSB have clearly indicated opposition to local regulations affecting home heating, there is no indication of similar widespread opposition to the FNSB's historical open burning control program.

The cost of such a program is the increased administrative cost of enforcing the ban. Most of this cost can be recovered through fines imposed on violators.

This control measure is technologically feasible.

Burn barrel prohibition

Although the voters of FNSB have clearly indicated opposition to local regulations affecting home heating, there is no indication of similar widespread opposition to the FNSB's historical open burning control program. Burn barrels are used by some residents to dispose of combustible waste, not to provide useful heat.

Many states and localities ban the use of burn barrels, mostly because these devices are prone to creating a nuisance. If used only to burn clean, dry wood, they can be operated in a smokeless, odor-free manner. Combustion of almost any other materials will result in both smoke and odors.

Burn barrels are covered by the State's open burning regulation, which bans open burning between November 1 and March 31 in Wood Smoke Control Areas (18 AAC 50.065(f)). FNSB is not currently a Wood Smoke Control Area. Alaska DEC has proposed adding $PM_{2.5}$ nonattainment areas to the areas covered by this regulation as a proactive measure to prevent additional smoke during winter months.[50]

Alaska DEC's regulation 18 AAC 50.065(e) also prohibits open burning during an air quality advisory. Advisories are called when $PM_{2.5}$ concentrations above 35 micrograms per cubic meter are predicted.

This control measure is technologically feasible.

5.7.3.7. Residential Fuel Oil

The number of units in FNSB has been estimated at about 27,000.[51] Direct $PM_{2.5}$ emissions from fuel oil combustion in residential heaters are estimated to be 42 tons per

[50] Alaska DEC, *Proposed Regulation changes Pertaining to: Open Burning, Wood-fired Heating Device Visible Emission Standards, Solid Fuel-Fired Heating Device Fuels, Wood Fired Heating Device Standards, & Fine Particulate Matter (PM-2.5) Air Episode and Advisories, Public Review Draft*, September 19, 2013.
[51] Sierra Research, projected 2015 (attainment year) inventory based on 2011 home heating survey

year.[52] Additionally, fuel oil combustion contributes to secondary particulate formation because virtually all (99%) of the sulfur in fuel oil is oxidized to SO_2 when combusted, and a portion of the SO_2 reacts to form sulfate aerosols, a form of $PM_{2.5}$. SOx emissions from fuel oil combustion are estimated to be about 770 tons per year,[53] equivalent to 130 tons per year of direct $PM_{2.5}$ emissions.

Economic incentives to switch to low sulfur fuel

The most effective strategy for reducing SO_2 emissions from residential oil use is lowering the sulfur content of heating oil. Currently in the U.S. (and in the FNSB), heating oil for residential use has an average sulfur content of about 0.20–0.25% (about 2,500 ppm). Switching to low sulfur content fuel (500 ppm) could eliminate 75–80% of the SO_2 emissions generated by residential oil heating systems, as well as 80% of direct $PM_{2.5}$ emissions.

The American Society for Testing and Materials (ASTM), an international voluntary standards development organization, has approved a Low-Sulfur No. 2 Heating Oil specification. Also, the Oilheat Manufacturers Association has been promoting low-sulfur heating oil, both to improve air quality and to reduce equipment maintenance costs. Low-sulfur heating oil reduces the level of residue build-up on the surfaces of boilers and furnaces, improving equipment performance and reducing maintenance costs.

The control measure would consist of providing an economic incentive (in the form of a cash rebate[54]) to consumers to purchase low-sulfur fuel oil instead of their current supply. Because participation in the program would be voluntary, it would not conflict with the fuel regulation ban in the Home Heating Initiative.

This control measure is technologically feasible.

5.7.3.8. District Heating System

Many residential, commercial, and institutional buildings within the FNSB are connected to district heating systems that supply low pressure steam or hot water for space heating and domestic hot water use. Use of the district heating systems allows for the widespread use of energy produced by a central steam generating unit that is well controlled. These systems essentially eliminate the need for the operation of individual fuel combustion units by the facilities connected to them.

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[52] Cold Climate Housing Research Center, *Reducing PM2.5 Emissions from Residential Heating Sources in the Fairbanks North Star Borough*, February 23, 2009. p. 15.

[53] Cold Climate Housing Research Center, *Reducing PM2.5 Emissions from Residential Heating Sources in the Fairbanks North Star Borough*, February 23, 2009. p. 15. SOx emissions are calculated by dividing the reported sulfate formation (232 TPY) by the assumed conversion rate (30%).

[54] Because Alaska has no state income or sales tax, a tax credit or exemption would not work as a mechanism for implementing this program. A property tax offset is another possible mechanism, but would not be available to renters.

Even considering transmission losses, a well maintained and operated central unit can be much more efficient that individual combustion units, especially those that burn wood, coal, or oil. Pollutants from a central unit are emitted at a much higher elevation, and as a result are more dispersed.

Increased usage/coverage of district heating systems

Individual combustion units—especially those that burn wood, coal, or oil—are often much less efficient than a well maintained and operated central power plant. Individual combustion units also produce pollutants that are emitted to the atmosphere very near ground level, rather than from tall stacks. Because of the difference in release points, pollutants from individual combustion units have a greater impact on ground-level $PM_{2.5}$ concentrations.

An increase in the coverage of the district heating systems would therefore result in a decrease in measured $PM_{2.5}$ concentrations.

This control measure is technologically feasible.

5.7.3.9. Energy Efficiency and Weatherization

Home Improvement Rebate Program

EPA recognizes the benefits of including energy efficiency programs in SIPs as a low cost means of reducing emissions.

The Alaska Housing Finance Corporation (AHFC) implements several energy programs that are designed to make homes more energy efficient. As homeowners make energy efficiency improvements, they reduce the amount of fuel and electricity needed for power and heat, leading to corresponding air quality benefits due to the reduced fuels being burned for space heating and power generation.

This control measure is technologically feasible and already implemented.

5.7.3.10. Transportation

Listed below are the transportation-related programs currently being implemented in Fairbanks.

- Expanded availability of plug-ins; electrical outlets were installed on 1,500+ parking spaces between 2008 & 2015

- Ordinance mandating—for employers with 275+ parking spaces—electrification of outlets at temps < 21° F between November 1 and March 31

- Public education focused on the benefits of plugging-in and using the transit program called Metropolitan Area Commuter System (MACS)

- Expanded transit service includes improved service frequency on high ridership routes, new routes and better bus stop facilities; ridership increased 61% between 2008 & 2013

- Commuter Van Pool program, includes Van Tran program for elderly and disabled

- Anti-idling program for heavy-duty diesel vehicles started as a ADOT&PF program focused on dump trucks and tractors and has been expanded to a CMAQ-funded pilot program focused on the purchase and installation of auxiliary heaters to reduce idle time

- Federal Motor Vehicle Control Program

With the exception of the anti-idling program, the programs listed above have been in place for well over a decade and are working to reduce motor vehicle emissions under extreme winter operating conditions.

Measures focused on reducing traffic congestion offer limited benefits as the Fairbanks road network has few roads operating at Level of Service (LOS) levels D, E, or F.

Community-wide ridesharing programs offer few potential emission reduction benefits because of the low population and employment density in the nonattainment area (employer programs are operated where sufficient density supports participation).

Travel reduction programs have been found to have limited benefits on a national basis, with principal reductions coming from commute trips, which require high density employment to be successful.

EPA’s motor vehicle emissions model MOVES, including the recently released version MOVES2014, does not provide a PM benefit for either light- or heavy-duty I/M programs. Thus, there is no way to quantify a particulate benefit from I/M, and EPA clearly does not recognize I/M as an appropriate PM control measure.

Given these constraints, no additional TCMs appear viable for Fairbanks. Because TCMs are not expected to provide additional reductions, all TCMs are classified as “not technologically feasible.”

5.7.3.11. Measures Deemed Technologically Infeasible

A summary of the assessment of technological feasibility for candidate control measures is presented below in Table 5.7-6. It shows that a number of candidate control measures are not technologically feasible at this time: two of those—construction of regional kilns and use of stove change outs to generate NSR credits—are not feasible because there is no evidence of demand, so no emission reductions are expected; the remainder are infeasible because they are not practically enforceable in the Borough at this time.

Table 5.7-6. Candidate Control Measures Considered for RACM

Source Category	Control Measure	Technologically Feasible?	
Dry Wood Measures	Education and Outreach	Yes	
	Regional kiln		No
	Ban on green wood sales		No
Hydronic Heaters	Education and Outreach	Yes	
	Voluntary curtailment on air quality advisory days	Yes	
	Mandatory curtailment on air quality advisory days		No
	All new units must be certified	Yes	
	All new units must meet more stringent standards	Yes	
	All units must be certified		No
	Ban new installations		No
	Remove at time of home sale		No
	Subsidize heater change outs	Yes	
	Ban use		No
Wood Stoves	Education and Outreach	Yes	
	Voluntary curtailment on air quality advisory days	Yes	
	Mandatory curtailment on air quality advisory days		No
	All new units must be certified	Yes	
	All new units must meet more stringent standards	Yes	
	All units must be certified		No
	Replace uncertified stoves at time of home sale		No
	Replace uncertified stoves in rental units		No
	Require alternate heat source in rental units		No
	Require alternate heat source in new construction		No
	Ban new installations		No
	Subsidize stove change outs	Yes	
	Ban use		No
	Use stove change outs to generate NSR offsets		No

Source Category	Control Measure	Technologically Feasible?	
Fireplaces/Fireplace Inserts	Education and Outreach	Yes	
	Voluntary curtailment on air quality advisory days	Yes	
	Mandatory curtailment on air quality advisory days		No
	Subsidize fireplace insert change outs	Yes	
Open Burning	Reinstate open burning ban	Yes	
Burn Barrel	Prohibit use of burn barrels (seasonal or year-round)	Yes	
Residential Fuel Oil Combustion	Provide economic incentives to switch to low-sulfur fuel	Yes	
	Increase coverage of District heating systems	Yes	
Energy Efficiency Measures	Subsidize heating upgrades and weatherization	Yes	
Transportation	Improved public transit	Yes	
	HOV lanes		No
	Traffic flow improvement programs		No
	Create non-motorized traffic zones		No
	Restrict truck idling	Yes	
	Reduce cold start emissions	Yes	
	Employer-sponsored flexible work schedules		No
	Retrofit diesel fleet (school buses, transit fleets)		No
	Onroad vehicle I&M program		No
	Heavy-duty vehicle I&M program		No
	State LEV Program		No

5.7.4. Step 3: Evaluate Emission Reductions and Costs for Each Technologically Feasible Control Measure

In this section, technologically feasible control measures are evaluated for emission benefits and cost effectiveness. Measures with negligible potential for emission reductions were screened out in previous steps.

The process used to evaluate the economic feasibility of candidate control measures is outlined below. Some of the control measures determined to be RACM in this analysis are already implemented in the FNSB. Because the economic feasibility of these measures does not need to be established, a qualitative analysis has been performed.

1. **For each technologically feasible emission control technology or measure**, provide best estimates of the following:

a. the control efficiency by pollutant;
b. the possible emission reductions by pollutant;
c. the estimated cost per ton of pollutant reduced; and
d. the date by which the technology or measure could be reasonably implemented.

2. Determine if any technologically feasible control measures are economically infeasible:

    a. Consider the cost of reducing emissions and the difference between the cost of an emissions reduction measure at a particular source and the cost of emissions reduction measures that have been implemented at other similar sources.

    b. Economic feasibility of RACM/RACT is thus largely determined by evidence that other sources in a source category have in fact applied the control technology, process change, or measure in question.

    c. For each technologically feasible control measure or technology, a state must determine the capital costs, annualized costs, and cost effectiveness (i.e., cost per ton of pollutant reduced by that measure or technology).

    d. A state may not reject a technologically feasible control measure or technology as being economically infeasible if such a measure or technology has been implemented at other similar sources, unless the state provides a detailed justification that clearly explains the specific circumstances of the source or sources in the nonattainment area that make such a measure or technology economically infeasible.

Table 5.7-7 presents the list of candidate control measures that were determined to be technologically feasible.

Table 5.7-7. Technologically Feasible Control Measures

Source Category	Control Measure	Economically Feasible?	RACM?	Potential Implementation Date
Dry Wood Measures	Education and Outreach	Yes	RACM	Already in place
Hydronic Heaters	Education and Outreach	Yes	RACM	Already in place
	Voluntary curtailment on air quality advisory	Yes	RACM	1st Qtr 2016

Source Category	Control Measure	Economically Feasible?	RACM?	Potential Implementation Date
	days			
	All new units must be certified to more stringent standards	Yes	RACM	1st Qtr 2016
	Subsidize heater change outs	Yes	RACM	Already in place
Wood Stoves	Education and Outreach	Yes	RACM	Already in place
	Voluntary curtailment on air quality advisory days	Yes	RACM	Already in place
	All new units must be certified	Yes	RACM	1st Qtr 2016
	Subsidize stove change outs	Yes	RACM	Already in place
Fireplaces/Fireplace Inserts	Education and Outreach	Yes	RACM	Already in place
	Voluntary curtailment on air quality advisory days	Yes	RACM	Already in place
	Subsidize fireplace insert change outs	Yes	RACM	Already in place
Open Burning	Reinstate open burning ban	Yes	RACM	1st Qtr 2016
Burn Barrel	Prohibit use of burn barrels (seasonal or year-round)	Yes	RACM	1st Qtr 2016
Residential Fuel Oil Combustion	Provide economic incentives to switch to low-sulfur fuel	No	No	Not cost effective
	Increase coverage of District heating systems	No	No	Not cost effective
Energy Efficiency Measures	Subsidize heating upgrades and weatherization	Yes	RACM	Already in place
Transportation	Improved Public Transit	Yes	RACM	Already in place

Source Category	Control Measure	Economically Feasible?	RACM?	Potential Implementation Date
	Restrict Truck Idling	Yes	RACM	Already in place
	Reduce Cold Start Emissions	Yes	RACM	Already in place

5.7.4.1. Dry Wood Programs

As shown in Table 5.7-2, residential wood combustion in Fairbanks is responsible for 2.72 tons per day, or 60% of total direct $PM_{2.5}$ emissions on episode days. About 60% of the wood burned in residential wood combustion units is green wood, on a volume basis.[55] According to a 2008 NESCAUM report, for every 10 percentage point increase in the moisture content of wood the $PM_{2.5}$ emissions increase by 65% to 167%.[56] If dry wood (20% moisture content) is burned instead of all of the wet wood, a reduction of between 1.2 and 1.8 ton/day of $PM_{2.5}$ could result.

Education and Outreach

The overall effectiveness of voluntary measures depends upon the extent of implementation, as well as the actual steps taken by the public. Actual quantification of emission reduction is difficult to do. However, these programs are considered pivotal to the acceptance of any wood smoke control program.[57]

Costs associated with this measure are small. Costs include the cost to the State and/or Borough to develop educational materials (small, because educational materials for this purpose have already been developed) and the cost to homeowners to store wood for a season. (In order to have dry wood all year, a full year's supply of wood would need to be purchased at least six months before it is to be used, and split and stored in a manner that would allow it to dry. The average amount of wood burned per year in Fairbanks is 3.57 cords/year per household,[58] which would require 460 cubic feet of storage. Although construction of this much storage would not be a trivial expense, the cost would

[55] Based on a 2011 sample of 20 households, 40% of the households sampled had moisture contents at or below 20%.
[56] NESCAUM, *Source Characterization of Outdoor Wood Furnaces,* September 9, 2008, p. 4-1
[57] Hearth, Patio and Barbecue Association, *Clearing the Smoke: The Wood Stove Changeout in Libby, Montana*, January 2008, p. 20; see also Canadian Council of Ministers of the Environment, Code of Practice for Residential Wood Burning Applicances, 2012, p. 28.
[58] A 2011 home heating survey (Sierra Research, June 10, 2011) indicated an average wood fuel use of 3.57 cords/year per installation for stoves and inserts, and 1.80 cords/year for fireplaces.

go down after the first year by as much as 30% because less dry wood is needed for the same useful heat production.[59])

- Control efficiency by pollutant: N/A
- Possible emission reductions by pollutant: Potentially large. However, EPA guidance allows only a small amount of SIP credit for voluntary measures.
- Estimated cost per ton of pollutant reduced: small
- Date by which the measure could be reasonably implemented: already implemented

This measure is economically feasible.

5.7.4.2. Residential Wood Burning: Outdoor Wood-burning Boilers (hydronic heater)

Education and Outreach

Overall effectiveness of voluntary measures depends upon the extent of implementation, as well as the actual steps taken by the public. Costs associated with this measure are small. Costs include the cost to the State and/or Borough to develop educational materials (small, because educational materials for this purpose have already been developed).

- Control efficiency by pollutant: N/A
- Possible emission reductions by pollutant: Potentially large. However, EPA guidance allows only a small amount of SIP credit for voluntary measures.
- Estimated cost per ton of pollutant reduced: small
- Date by which the measure could be reasonably implemented: already implemented

This measure is economically feasible.

Voluntary curtailment on air quality advisory days

Under a voluntary curtailment program, owners of wood burning devices are asked to voluntarily reduce or avoid operation of the devices on days when air quality is poor.

[59] Useful heat energy from a typical wood fuel is 5,000 btu/lb at 20% moisture, and 3,500 btu/lb at 40% moisture (the difference is due to the heat required to evaporate the extra water). The fuel savings due to burning dry wood (20% moisture) is 30% [(5,000-3,500)/5,000].

Such a program relies on agency efforts to predict poor air quality days, agency efforts to make the public aware of predictions, agency efforts to educate the public about reducing emissions, and public cooperation with requests to minimize emissions.

The FNSB Air Quality Division provides daily air quality information on its website and by telephone. Alaska DEC also provides air quality advisories when circumstances call for them

Under this control measure, the agencies will develop and distribute additional educational materials. They will increase efforts to publicize the program, beginning with links on the existing Air Quality Index webpages to the FNSB's existing AQ Advisory program webpages.

- Control efficiency by pollutant: N/A

- Possible emission reductions by pollutant: Potentially large. However, EPA guidance allows only a small amount of SIP credit for voluntary measures.

- Estimated cost per ton of pollutant reduced: not estimated because already implemented

- Date by which the measure could be reasonably implemented: 1st Qtr 2016

This measure is economically feasible.

<u>All new units must meet 2.5 gm/hr</u>

This control measure reduces the rate of growth of emissions due to the increased number of installations by minimizing the emissions from new equipment. In addition, it reduces emissions as old units are retired and replaced by new ones.

Because of the small rate of projected growth, and the low rate of replacement of old units, emission reductions from this measure are small. Cost of control is also small, because there is no incremental cost between a certified unit and a non-certified unit.

Alaska DEC has proposed[60] to adopt a new regulation, 18 AAC 50.077(b)(2), that would require that all new woodstoves meet an emission limit of 2.5 gm/hr and be certified by EPA.

- Control efficiency by pollutant: small
- Possible emission reductions by pollutant: small.
- Estimated cost per ton of pollutant reduced: small

[60] Alaska DEC, *Proposed Regulation changes Pertaining to: Open Burning, Wood-fired Heating Device Visible Emission Standards, Solid Fuel-Fired Heating Device Fuels, Wood Fired Heating Device Standards, & Fine Particulate Matter (PM-2.5) Air Episode and Advisories, Public Review Draft*, September 19, 2013.

- Date by which the measure could be reasonably implemented: 1st Qtr 2016

This measure is economically feasible.

Subsidize hydronic heater change outs

The FNSB's hydronic heater change out program is a voluntary program initiated by FNSB to promote the use of cleaner-burning heating appliances. It uses a cash rebate, combined with public outreach and education, to encourage consumers to replace their old, inefficient, and high-polluting woodstoves with new clean-burning EPA-certified woodstoves, or other heating appliances such as pellet stoves or gas/electric stoves.[61] EPA has provided estimates of control effectiveness and costs for such a program.[62] These are summarized below.

- Control efficiency by pollutant: 60%
- Possible emission reductions by pollutant: small
- Estimated cost per ton of pollutant reduced: $10,000
- Date by which the measure could be reasonably implemented: already implemented

This measure is economically feasible.

5.7.4.3. Residential Wood Burning: Wood Stoves

Education and Outreach

Overall effectiveness of voluntary measures depends upon the extent of implementation, as well as the actual steps taken by the public. Costs associated with this measure are small. Costs include the cost to the State and/or Borough to develop educational materials (small, because educational materials for this purpose have already been developed).

- Control efficiency by pollutant: N/A

- Possible emission reductions by pollutant: Potentially large. However, EPA guidance allows only a small amount of SIP credit for voluntary measures.

- Estimated cost per ton of pollutant reduced: small

- Date by which the measure could be reasonably implemented: already implemented

This measure is economically feasible.

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61 Guidance for Quantifying and Using Emission Reductions from Voluntary Woodstove Changeout Programs in State Implementation Plans.

62 EPA, *Menu of Control Measures* (8/6/2013), p. 52

Voluntary curtailment on air quality advisory or alert days

Under a voluntary curtailment program, owners of wood-burning devices are asked to voluntarily reduce or avoid operation of the devices on days when air quality is poor. Such a program relies on agency efforts to predict poor air quality days, agency efforts to make the public aware of predictions, agency efforts to educate the public about reducing emissions, and public cooperation with requests to minimize emissions.

The FNSB Air Quality Division provides daily air quality information on its website and by telephone. Alaska DEC also provides air quality advisories when circumstances call for them. Advisories are called when $PM_{2.5}$ concentrations above 35 micrograms per cubic meter are predicted.

Under this control measure, the agencies will develop additional educational materials. They will increase efforts to publicize the program, beginning with links on the existing Air Quality Index webpages to the FNSB's existing AQ Advisory program webpages.

- Control efficiency by pollutant: N/A
- Possible emission reductions by pollutant: Potentially large. However, EPA guidance allows only a small amount of SIP credit for voluntary measures.
- Estimated cost per ton of pollutant reduced: small
- Date by which the measure could be reasonably implemented: already implemented

This measure is economically feasible.

Only certified stoves may be sold

This control measure reduces the rate of growth of emissions due to the increased number of installations by minimizing the emissions from new equipment. In addition, it reduces emissions as old units are retired and replaced by new ones.

Because of the small rate of projected growth, and the low rate of replacement of old units, emission reductions from this measure are small. Cost of control is also small, because there is no incremental cost between a certified unit and a non-certified unit.[63]

Alaska DEC has proposed[64] to adopt a new regulation, 18 AAC 50.077(b)(2), that would require that all new woodstoves meet an emission limit of 2.5 gm/hr and be certified by EPA.

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[63] An analysis of the 2012 List of EPA Certified Wood Stoves shows there is essentially no correlation between retail price and the EPA certification emission rate, with a R2 of 0.023. The List was accessed at (www.lrapa.org/downloads/publications/**certifiedwood**.pdf *)*

[64] Alaska DEC, *Proposed Regulation changes Pertaining to: Open Burning, Wood-fired Heating Device Visible Emission Standards, Solid Fuel-Fired Heating Device Fuels,*

- Control efficiency by pollutant: small
- Possible emission reductions by pollutant: small.
- Estimated cost per ton of pollutant reduced: small
- Date by which the measure could be reasonably implemented: 1st Qtr 2016

This measure is economically feasible.

Subsidize stove change outs

The FNSB's woodstove change out program is a voluntary program initiated by FNSB to promote the use of cleaner-burning heating appliances. It uses a cash rebate, combined with public outreach and education, to encourage consumers to replace their old, inefficient, and high-polluting woodstoves with new clean-burning EPA-certified woodstoves, or other heating appliances such as pellet stoves or gas/electric stoves.[65] EPA[66] has provided estimates of control effectiveness and costs for such a program, as summarized below.

- Control efficiency by pollutant: 60%
- Possible emission reductions by pollutant: small
- Estimated cost per ton of pollutant reduced: $9,900 (2010$)
- Date by which the measure could be reasonably implemented: already implemented

This measure is economically feasible.

5.7.4.4. Residential Wood Burning: Fireplaces

Education and Outreach

Overall effectiveness of voluntary measures depends upon the extent of implementation, as well as the actual steps taken by the public. Costs associated with this measure are small. Costs include the cost to the State and/or Borough to develop educational materials (small, because educational materials for this purpose have already been developed).

- Control efficiency by pollutant: N/A

- Possible emission reductions by pollutant: Potentially large. However, EPA guidance allows only a small amount of SIP credit for voluntary measures.

Wood Fired Heating Device Standards, & Fine Particulate Matter (PM-2.5) Air Episode and Advisories, Public Review Draft, September 19, 2013.

[65] Guidance for Quantifying and Using Emission Reductions from Voluntary Woodstove Changeout Programs in State Implementation Plans.

[66] EPA, *Menu of Control Measures* (8/6/2013), p. 52

- Estimated cost per ton of pollutant reduced: small
- Date by which the measure could be reasonably implemented: already implemented

This measure is economically feasible.

Voluntary curtailment on air quality advisory days

Under a voluntary curtailment program, owners of wood burning devices are asked to voluntarily reduce or avoid operation of the devices on days when air quality is poor. Such a program relies on agency efforts to predict poor air quality days, agency efforts to make the public aware of predictions, agency efforts to educate the public about reducing emissions, and public cooperation with requests to minimize emissions.

The FNSB Air Quality Division provides daily air quality information on its website and by telephone. Alaska DEC also provides air quality advisories when circumstances call for them. Advisories are called when $PM_{2.5}$ concentrations above 35 micrograms per cubic meter are predicted.

Under this control measure, the agencies will develop additional educational materials. They will increase efforts to publicize the program, beginning with links on the existing Air Quality Index webpages to the FNSB's existing AQ Advisory program webpages.

- Control efficiency by pollutant: N/A
- Possible emission reductions by pollutant: Potentially large. However, EPA guidance allows only a small amount of SIP credit for voluntary measures.
- Estimated cost per ton of pollutant reduced: small
- Date by which the measure could be reasonably implemented: already implemented

This measure is economically feasible.

Subsidize fireplace insert change outs

The FNSB's fireplace change out program is a voluntary program initiated by FNSB to promote the use of cleaner-burning heating appliances. It uses a cash rebate, combined with public outreach and education, to encourage consumers to retrofit fireplaces with devices that reduce emissions.

EPA[67] has provided estimates of control effectiveness and costs for such a program, as summarized below.

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[67] EPA, *Menu of Control Measures* (8/6/2013), p. 43

- Control efficiency by pollutant: 70%
- Possible emission reductions by pollutant: small
- Estimated cost per ton of pollutant reduced: $9,500 (2012$)
- Date by which the measure could be reasonably implemented: already implemented

This measure is economically feasible.

5.7.4.5. Residential Wood Burning: Burn barrels, open burning

Open burning (including the use of burn barrels) is currently banned between November 1 and March 31 in Wood Smoke Control Areas (18 AAC 50.065(f)). FNSB is not currently a Wood Smoke Control Area. Alaska DEC has proposed adding $PM_{2.5}$ nonattainment areas to the areas covered by this regulation as a proactive measure to prevent additional smoke during winter months.[68]

Alaska DEC's regulation 18 AAC 50.065(e) prohibits open burning (including the use of burn barrels) during an air quality advisory. Advisories are called when $PM_{2.5}$ concentrations above 35 micrograms per cubic meter are predicted.

Open burning ban

Open burning is not considered a large contributor to air pollution episodes. However, a ban on open burning on air quality advisory days could prevent such activities from contributing to unhealthful air, and is relatively inexpensive to implement. Because the expected reductions are small and variable, they are difficult to quantify.

- Control efficiency by pollutant: N/A
- Possible emission reductions by pollutant: small
- Estimated cost per ton of pollutant reduced: small
- Date by which the measure could be reasonably implemented: 1st Qtr 2016

This measure is economically feasible.

Burn barrel prohibition

Burn barrels are not considered a large contributor to air pollution episodes. However, a ban on burn barrels could prevent such activities from contributing to unhealthful air, could avoid nuisance situations, and is relatively inexpensive to implement. Because the expected reductions are small and variable, they are difficult to quantify.

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[68] Alaska DEC, *Proposed Regulation changes Pertaining to: Open Burning, Wood-fired Heating Device Visible Emission Standards, Solid Fuel-Fired Heating Device Fuels, Wood Fired Heating Device Standards, & Fine Particulate Matter (PM-2.5) Air Episode and Advisories, Public Review Draft*, September 19, 2013.

- Control efficiency by pollutant: N/A
- Possible emission reductions by pollutant: small
- Estimated cost per ton of pollutant reduced: small
- Date by which the measure could be reasonably implemented: 1st Qtr 2016

This measure is economically feasible.

5.7.4.6. Residential Fuel Oil

Economic incentives to switch to low sulfur fuel

The sulfur in fuel oil is emitted as SOx when the fuel is burned. SOx emissions contribute to the formation of secondary particulate matter in the form of sulfate aerosols. Ambient sampling and modeling in FNSB indicates that reduction of six tons of SOx emissions result in the same reduction in ambient $PM_{2.5}$ concentration as the reduction of one ton of directly emitted $PM_{2.5}$.[69] Additionally, fuel oil combustion contributes to secondary particulate formation because virtually all (99%) of the sulfur in fuel oil is oxidized to SO_2 when combusted, and a portion of the SO_2 reacts to form sulfate aerosols, a form of $PM_{2.5}$.

Reducing six tons of SOx emissions results in the same ambient PM concentration that would result from about a one ton reduction of directly emitted PM. SOx emissions from fuel oil combustion are estimated to be about 770 tons per year,[70] equivalent to 130 tons per year of direct $PM_{2.5}$ emissions.

Using low-sulfur fuel (500 ppm sulfur) instead of current fuel oil (2,000 ppm sulfur) would reduce SOx emissions from this source category by 1500/2000 = 75%, or 580 tons per year. This is equivalent to 96 tons per year of $PM_{2.5}$ reductions.

The incremental cost of low sulfur fuel oil is assumed to be \$0.10 per gallon;[71] the resulting reduction in SO_2 emissions is 0.011 lb/gal. The cost effectiveness of control is therefore \$0.10/0.011 lb of SO_2, or \$18,000 per ton of SO_2. Because SO_2 reductions are 1/6 as effective as $PM_{2,5}$ reductions as a control measure, this is equivalent to more than \$100,000 per ton of $PM_{2.5}$.

In addition to the increased cost of fuel, there are potentially capital costs involved in switching fuels as well. Because the physical characteristics of low-sulfur fuel oil are different, changes may be needed to storage, pumps, and burners to accommodate the new fuel.

- Control efficiency by pollutant: 75% reduction of SO_2
- Possible emission reductions by pollutant: 580 tons per year of SO_2
- Estimated cost per ton of pollutant reduced: \$18,000

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[69] Appendix III.D.5.7 Precursors
[70] Ibid.
[71] Personal communication, Sourdough Fuel, October 2, 2014

- Date by which the measure could be reasonably implemented: Not cost effective

This control measure is not cost effective, and is therefore not RACM.

5.7.4.7. District Heating System

Increased usage/coverage of district heating systems

The costs and benefits of potential increases in the coverage of the district heating systems are highly variable and depend on the number and types of individual combustion units replaced.

Aurora Energy operates a coal-fired power plant that cogenerates steam for heating use. Aurora Energy also provides district heating (in the form of low-pressure steam or hot water) to approximately 180 customers. Customers range in size from small residential to large commercial/institutional loads. In the last nine years, Aurora Energy has added 35 new district heat customers, with a total load of approximately 45 million btu/hr.

Aurora Energy has prepared a study of the feasibility of increasing the size of the district heat program by 210 MMBtu/hr, to serve an additional 1,989 individual buildings.[72] The increased cost associated with this measure is the capital cost of constructing the steam distribution infrastructure; no additional capital costs are needed for the heating plant. The total cost of the expanded distribution system and building conversions to hot water heat exchanger is estimated to be $238 million. The resulting cost per connection is estimated to be $120,000.

The average amount of wood used for home heating in a home that relies on a wood stove for home heating in Fairbanks is 3.57 cords/year.[73] The emission factor for burning air-dried wood in an uncertified wood stove is 20.3 lb $PM_{2.5}$ per cord. The emissions from each household would therefore average 72.5 lb/year. Over 30 years, the emissions would total 2175 lb, or 1.1 tons.

Even without taking into consideration increased emissions at the power plant, the cost effectiveness of this proposal would be no less than $120,000/1.1 tons, or $109,000/ton of $PM_{2.5}$.

This control measure is not cost effective.

5.7.4.8. Transportation

Improved Public Transit

[72] PDC, Inc. Engineers, *Aurora Energy District Heat Capacity Study, Phase 2,* December 2008

[73] A 2011 home heating survey (Sierra Research, June 10, 2011) indicated an average wood fuel use of 3.57 cords/year per installation for stoves and inserts, and 1.80 cords/year for fireplaces.

While Fairbanks has expanded its transit service in recent years and continues to experience increased ridership, a review of the MOVES-based emission factors for transit buses and motor vehicles operating in Fairbanks conditions shows that PM and NOx emissions from buses are higher than passenger vehicles. Thus, new bus routes need to take enough passenger vehicles off the road to offset the emissions associated with increased bus operations. Information on the transit program operations obtained from the Borough[74] indicates that current average winter ridership over the entire transit system is 1,725 passengers per day at a cost of $16,370 per day (this cost includes the cost of both bus service operation and ADA-required para-transit services).[75] Using an estimated average trip length of 6.9 miles per trip replaced (i.e., for passenger vehicles trips), an average 1,800 miles of transit VMT per day, and 2014 MOVES-based emission factors, it is estimated that 1 lb of $PM_{2.5}$ is eliminated through transit operations each winter day service is provided (i.e., Monday through Saturday, transit service is not provided on Sundays). The cost per ton of this reduction is $32.7 million dollars.

The control measure is not cost effective.

Restrict Truck Idling

Alaska DEC recently received approval for a CMAQ program that is intended to reduce heavy-duty diesel emissions through anti-idling, maintenance, and other emission reduction opportunities. The focus of the program is to expand the use of auxiliary heaters to reduce idle time, thereby reducing emissions and providing an associated cost savings due to less diesel fuel needed. The program has the following elements:

- Provide support for the existing anti-idling pilot project currently underway at DOT in Fairbanks by assisting with Telemetric purchase and installation, installing additional heaters, and assisting with education and training. With assistance from this program, the DOT pilot program will be fully functional and will be able to provide additional information to assist in expanding anti-idling programs to others.

- Expand anti-idling to other heavy-duty vehicles within the FNSB nonattainment area: state fleets, local government fleets, private fleets, and commercial fleets. This includes working with the heavy-duty fleet owners by providing education material and training; contracting for installations of auxiliary heaters; and providing incentives for participation, including purchasing of heaters and auxiliary equipment.

- During installation of program auxiliary heaters, conduct an inspection of the vehicle to identify where implementation of additional emission reductions may be possible, such as maintenance (filter, tune-up), retrofit technologies or

[74] Email communication from Glenn Miller to Bob Dulla, October 7, 2014.
[75] *http://www.ecfr.gov/cgi-bin/text-idx?SID=3387a7533c3134e09c52ac1170a185d7&tpl=/ecfrbrowse/Title49/49tab_02.tp*l

repower, and/or additional emission reduction equipment (particulate matter traps). Partnership and incentive opportunities with vehicle fleet owners will be explored to further emission reduction benefits while the vehicle is in shop.

CMAQ funding in the amount of $750,000 has been approved for the program, which will be implemented by Alaska DEC. While CMAQ funding will not support continued operation of a project, the bulk of the funding cover the cost of procurement and installation of equipment which can continue to operate after the project has ended.

This program is economically feasible.

Reduce Cold Start Emissions

The Borough recently received approval for CMAQ project funding that continues a long-standing practice of expanding the number of parking spaces in both public and private lots equipped with electrical outlets. This program will add a total of 975 outlets to four community facility parking lots.

CMAQ funding in the amount of $2,912,000 has been approved and the Borough will implement the program.

Since the project will cover the cost of the outlet installation and the Borough Plug-In Ordinance[76] requires parking lot owners with 275+ parking spaces to supply electricity to outlets at temperatures below 21° F, the outlets will continue to operate after the CMAQ project has ended.

This program is economically feasible.

5.7.5. Step 4: Determine Whether Control Measures Can Be Implemented Within Four Years of Designation

Five of the technologically feasible and cost effective control measures have not already been implemented.

- Hydronic heaters: voluntary curtailment on air quality advisory days
- Hydronic heaters: All new units must be certified to 2.5 gm/hr
- Wood stoves: All new units must be certified to 2.5 gm/hr
- Open burning: Reinstate open burning ban
- Burn barrels: Prohibit use of burn barrels (seasonal or year-round)

All of these measures may be implemented within four years of designation, with a target implementation date of 1st Qtr 2016.

[76] http://yosemite.epa.gov/r10/airpage.nsf/283d45bd5bb068e68825650f0064cdc2/fa36e96da9630a5588256da20070d1c1/$FILE/Ordinance%20No.%202001-17.pdf

5.7.6. STEP 5: IDENTIFY REASONABLY AVAILABLE CONTROL MEASURES

Table 5.7-8. Reasonably Available Control Measures

Source Category	Control Measure	Potential Implementation Date
Dry Wood Measures	Education and Outreach	Already in place
Hydronic Heaters	Education and Outreach	Already in place
	Voluntary curtailment on air quality advisory days	1st Qtr 2016
	All new units must be certified to 2.5 gm/hr	1st Qtr 2016
	Subsidize heater change outs	Already in place
Wood Stoves	Education and Outreach	Already in place
	Voluntary curtailment on air quality advisory days	Already in place
	All new units must be certified to 2.5 gm/hr	1st Qtr 2016
	Subsidize stove change outs	Already in place
Fireplaces/Fireplace Inserts	Education and Outreach	Already in place
	Voluntary curtailment on air quality advisory days	Already in place
	Subsidize fireplace insert change outs	Already in place
Open Burning	Reinstate open burning ban	1st Qtr 2016
Burn Barrel	Prohibit use of burn barrels (seasonal or year-round)	1st Qtr 2016
Energy Efficiency Measures	Subsidize heating upgrades and weatherization	Already in place
Transportation	Restrict truck idling	Already in place
	Reduce cold start emissions	Already in place

Note:
a. Implementation dates are targets for planning purposes, not commitments.

APPENDIX A

CONTROL MEASURES NOT CONSIDERED

- Stationary Diesel Engine (prime) retrofits (insignificant contribution to ambient concentrations)
- Charbroilers (insignificant contribution to ambient concentrations)
- Reduced solvent usage or solvent substitution (insignificant contribution to ambient concentrations)

ADEC

<u>DRAFT</u> Addressing the precursor gases for Fairbanks $PM_{2.5}$ State Implementation Plan

Deanna Huff
9/25/2014

As part of requirements for subpart 4 Non-Attainment Area (NAA) PM2.5 State Implementation Plan (SIP), all of the precursor gases that contribute to PM2.5 (NOx, SO2,NH3 and VOCs) are addressed for potential controls in addition to the primary PM2.5 components (organic carbon, elemental carbon, ammonium, sulfate, nitrate, other).

Executive Summary

This document explains how the precursor gases (sulfur dioxide, nitrogen oxides, ammonia, and volatile organic compounds) contribute to $PM_{2.5}$ in the Fairbanks, Alaska NAA. The Clean Air Act (Subpart 4 of Part D of Title I, id. 7513-7513b (Subpart 4)) calls upon states to develop an analysis called RACM (Reasonable Available Control Technologies) for all source sectors for $PM_{2.5}$ including all precursor gases. The major source sectors are points, area (home-heating), and road and non-road vehicles. The precursor gases that must be addresses as part of the analysis are nitrogen oxides, sulfur dioxide, ammonia and Volatile Organic Compounds (NO_x, SO_2, NH_3 and VOCs). Fairbanks is designated a non-attainment area for exceeding the $PM_{2.5}$ 24-hour NAAQS of 35 μg/m³. The designation was calculated from the 98%-tile of 3 years of data from 2006-2008 and 2008 is the design year. The baseline design value of 44.7 μg/m³, that the attainment demonstration is based on, was derived from 5 years (2006-2010) of FRM monitor data at the State Office Building, monitored data is found in Appendix III.D.5.4.

Particulate Matter ($PM_{2.5}$) is directly emitted into the atmosphere or formed by secondary chemical reactions from precursor gases. The largest component of $PM_{2.5}$ in the Fairbanks area is organic carbon, primarily from direct emission with less resulting from secondary formation. The major components of atmospheric aerosols formed by secondary chemistry are nitrate (NO^{-3}), sulfate (SO_2^{-4}) and ammonium (NH_4^+). These species are formed mostly from chemical reactions in the atmosphere involving the precursor's nitrogen oxides (NO_x), sulfur dioxide (SO_2) and ammonia (NH_3).

SO_2: ADEC's analysis shows that sulfates comprise approximately 18% of the total mass of Fairbanks $PM_{2.5}$. Direct emissions and atmospheric formation of particulate sulfate contribute to measured sulfate concentrations. Most of the sulfate is in the form of ammonium sulfate and the total mass contribution including particle bound water is 8.69 μg/m³. Comparing SO_2 controls that lead to a reduction in ammonium sulfate would be 3.2 times less effective than wood stove controls.

NO_x: Aerosol processes play a dominant role in the formation of nitrate. Most nitrate is formed in the atmosphere from NO_x emissions that transform into from secondary processes. Assuming that all of the moles of nitrate are balanced by any equivalent molar amount of ammonium the observations show that ammonium nitrate accounts for 4% of the total $PM_{2.5}$. In order to reduce NO_x emissions effectively, it is necessary to understand the formation of nitrate in the atmosphere and how NO_x controls influence nitrate formation in $PM_{2.5}$. The total amount of nitrate that can be removed as ammonium nitrate including particle bound water, according to filter-based measurements is 3.39 μg/m³ $PM_{2.5}$. Comparing NO_x controls to reduce ammonium nitrate, wood stove controls are 13.2 times more effective.

NH_3: The processes that emit ammonia (biomass burning, mobile, home heating) differ in Fairbanks from those in the lower 48, where ammonia from agricultural activities, vehicles, and other industrial activities form ammonium nitrate. In the Fairbanks nonattainment area, there is only a limited about of PM-nitrate formed from on the measurement filters. The maximum reductions of the 2.44 μg/m³ of ammonium in the $PM_{2.5}$ would come from the reductions in nitrate and sulfate in the form of ammonium nitrate and ammonium sulfate that were formed from precursor gases NO_x and SO_2 (some ammonium is associated with primarily emitted sulfate that is not from precursor gases).

VOCs: The VOCs emissions contribute to $PM_{2.5}$ by condensing after being emitted from a high temperature stack and through photochemistry forming secondary organic aerosols (SOA). The VOC emissions are 14.8 TPD, but according to model results on 0.00062 $\mu g/m^3$ are from SOA. The model performance shows good agreement between organic carbon observed and organic carbon + SOA modeled. For this reason we believe the contribution from VOCs to $PM_{2.5}$ is very small.

Fairbanks Chemistry Overview

Addressing the precursor gases and how they are related to $PM_{2.5}$ requires understanding the Fairbanks wintertime characteristics that lead to the formation of $PM_{2.5}$ from both direct and secondary formations. Precursor gases form secondary $PM_{2.5}$ and this component of $PM_{2.5}$ is addressed through reviewing current knowledge of the chemistry involved in the secondary formation in the Fairbanks airshed

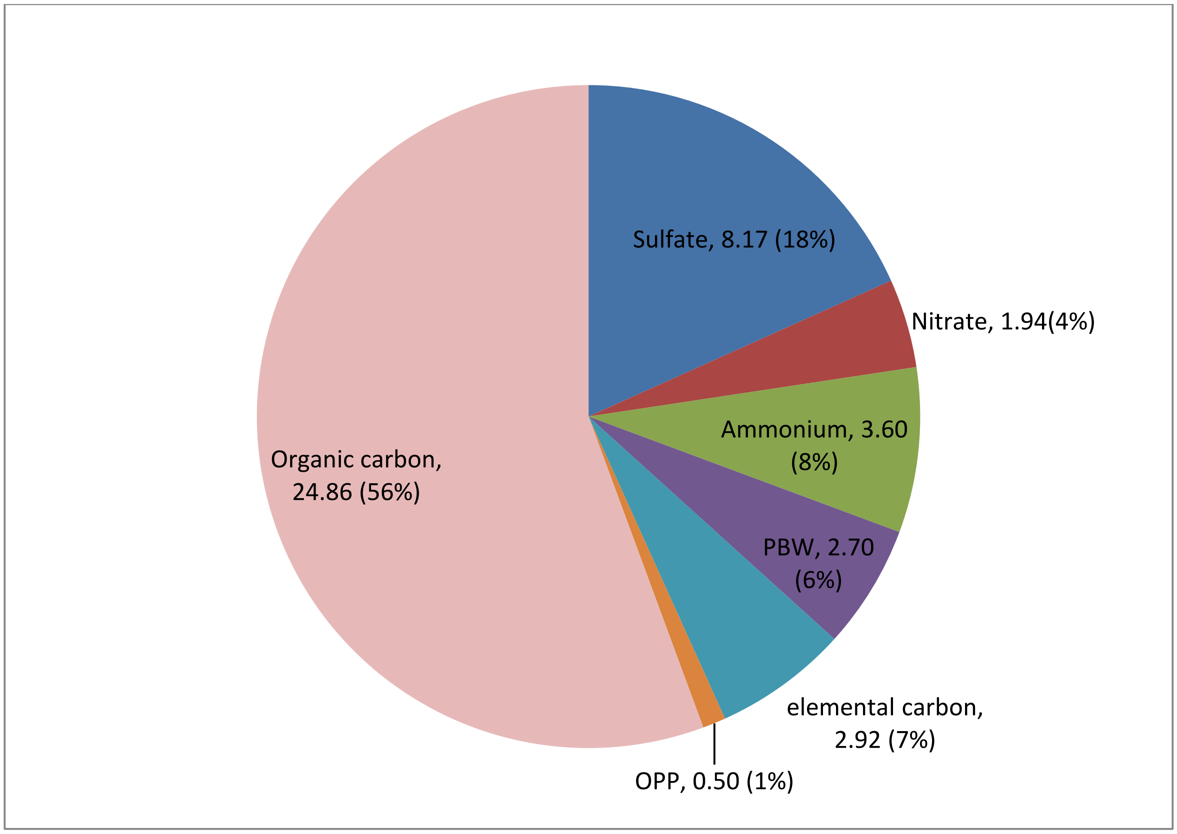

Figure 1: 24-hr average FRM-derived $PM_{2.5}$ speciation concentrations based on the design value (DV) of 44.7 µg/m^3 for the top 25% of wintertime days from the years 2006 -2010 at the Fairbanks State Office Building.

Particulate Matter ($PM_{2.5}$) is directly emitted into the atmosphere or formed by secondary chemical reactions from precursor gases. The major components of atmospheric aerosols formed by secondary chemistry are nitrate (NO^{-3}), sulfate (SO_2^{-4}) and ammonium (NH_4^+). These species are formed primarily from chemical reactions in the atmosphere involving the gas-phase precursors, nitrogen oxides (NO_x), sulfur dioxide (SO_2) and ammonia (NH_3). The major component of Fairbanks $PM_{2.5}$ is organic carbon and is directly emitted as particles, condenses to existing particles, or contributes to the formation of new particles from gaseous molecules.

Speciation of the Fairbanks winter $PM_{2.5}$ components (Figure 1) are derived from the top 25% of wintertime high $PM_{2.5}$ days from the years 2006-2010. The speciation concentrations that represent the

breakdown of the components of $PM_{2.5}$ in the Fairbanks area are measured from the SASS speciation instrument. The two different instruments both measure $PM_{2.5}$ but have different measurement artifacts. The goal is to derive concentrations of chemical species as they would be found on the official Federal Reference Method (FRM) monitor filter, not as they are found through the SASS instrument. To convert the concentrations of each chemical species from the measurement by the SASS to what would have been found on the FRM filter, we use the SANDWICH method (Frank, 2006). A detailed account of the adjustments made to compare speciation measurements to FRM total $PM_{2.5}$ measurements are found in Appendix III.D5.8. The speciation results in Figure 1 are post-SANDWICH and thus represent speciation on the FRM filter that is used to calculate regulatory design values.
Conversion of precursor gas emissions of nitrogen oxides (NO_x) and sulfur dioxides (SO_2) are constrained by atmospheric conditions including photochemical reactions from sunlight, the pH and the ambient temperature.

pH is an important aspect of atmospheric chemistry and has strong baring on the formation of ammonium sulfate and ammonium nitrate in particulate matter. One method to estimate the pH of the particulate matter is to balance the charge of major ions including ammonium (NH4+, Na+, K+, nitrate $(NO_3)^-$, Sulfate $(SO_4)^{2-}$ and Chloride (Cl^-). Figure 2 was completed by an ion mass balance approach using NH_4^+, Na^+, K^+ for the cations and NO_3^- , SO_4^{2-} and Cl^- as the anions for the Fairbanks State Office Building speciation data for 2006-2010. The net equivalent charge of all the speciation days from 2006-2010 are plotted verses the total FRM $PM_{2.5}$. If the net charge is 0, greater than 0 or less than 0; then the particulate matter is neutral, basic or acidic, respectively.

Our analysis finds neutral to basic aerosol pH on high $PM_{2.5}$ days, which is in general agreement with Dr. Peltier's analysis (2011, 2012) of Fairbanks $PM_{2.5}$. His 2011 white paper compares net charge in $\mu eq/m^3$ for observed winter speciation from 2007-2010 from the State Office Building, using only sulfate, nitrate and ammonium. Peltier found basic conditions during the winter, but did not break down the speciation data by high $PM_{2.5}$ days. In his 2012 analysis, he obtained a more time resolved analysis of two months of hourly sampling for aerosols using a PILS (Particle In Liquid Sampler) instrument, which collects airborne particles into a liquid vial for analysis on hourly speciation, and was used for net equivalent charge comparison. Peltier used the ion molar ratio method using the anions, cations and organic acid measurements to calculate a resulting net particle charge. The results showed that the aerosol is slightly acidic to neutral at high organic carbon hours. The hourly data is only representative of 280 hours during the time period from February 11- March 11th, 2011. There were only two $PM_{2.5}$ days greater than $30\mu g/m^3$during the study and no days were at or above the design value of $44.7\mu g/m^3$.

Although the first Peltier analysis concludes Fairbanks $PM_{2.5}$ is basic and the second analysis finds slightly acidic to neutral particles, they agree that particles on less polluted days are neutral. Both data sets have net equivalence charges between -0.1 and 0.1, which is considered to be in the category of neutrally charged (Peltier, 2012). The basic conditions in the first Peltier analysis occurred at high $PM_{2.5}$ loadings not experienced during collection of the second dataset. It is possible that the denuder on the SASS instrument used at the State Office Building could allow for excess ammonia gas penetration and an overrepresentation of ammonium. Another factor to consider is the presence of sulfur in non-sulfate forms, but Peltier (2012) found only 10% non-sulfate sulfur in Fairbanks $PM_{2.5}$. To within the degree we can trust the measurement techniques and compare datasets across time, the three analyses are in reasonably good agreement that $PM_{2.5}$ in Fairbanks is not noticeably acidic.

In addition to the net equivalence charge using observed data, a modeling study was conducted in the Fairbanks area using local NO_x, O_3 and particulate matter data to understand the formation of ammonium (Joyce et. al., 2012). The results indicated that ammonium nitrate would only form downwind of downtown and no secondary formation of nitrate or sulfate occurred in the downtown Fairbanks area. Figure 3 shows the process analysis results from a CMAQ model run for the Jan. 23th- Feb. 10th representative episode for the formation of nitrate. “Aerosol Processes” play a dominant role in the formation of nitrate, which means that nitrate is being formed from NO_x precursors rather than being directly emitted from emission sources. It is not possible to understand control strategies for nitrate without understanding the emissions and fate of NO_x.

Forming nitrate downwind from the Fairbanks area has important implications for whether ammonia controls would reduce $PM_{2.5}$ or not. With neutral to basic pH in the particles, this suggests there may be enough ammonium to neutralize the sulfate and excess ammonium to form ammonium nitrate under the right conditions. For nitrate, the excess ammonium denoted by the neutral particles suggests that we are limited by nitrate formation under the dark and cold conditions and by fresh injection of NO hindering the nitrate production. For the sulfate secondary formation, reductions in SO_2 will yield a proportional reduction in $PM_{2.5}$ rather than simply replace ammonium sulfate with ammonium nitrate. The photochemistry in downtown Fairbanks due to the low to no sunlight and cold conditions during the winter, limits the photochemical production of nitric acid from the daytime processes of OH and NO_2. In addition at night, NO titrates the ozone removing the main oxidant to form nitrate (Joyce et. al, 2012). Joyce showed that ammonium nitrate is formed downwind of downtown, adding to the probability that aerosol nitrate from nitric acid is not being formed in downtown Fairbanks. Heterogeneous nighttime chemistry from N_2O_5 is thought to be responsible for 80% of the nitric acid formation at high latitudes (Crutzen et al, 2000), but in polluted areas the fast reaction of excess NO with the nitrate radical, nitric acid formation is hindered at night (Seinfeld and Pandis, 1999).

The largest component of $PM_{2.5}$ in the Fairbanks area is organic carbon. Organic carbon is primarily due to direct emission with very little resulting from secondary formation. The CMAQ modeling results show the fraction of secondary organic aerosols formed are 6.2 x 10^-4 $\mu g/m^3$ for the State Office Building grid cell. The observed organic carbon mass is in good agreement with modeled organic carbon mass (Table 1) at 17.1 observed and 25.1 $\mu g/m^3$ of organic carbon modeled for the average of the two modeling episodes (details can be found in Appendix III.D.5.8).

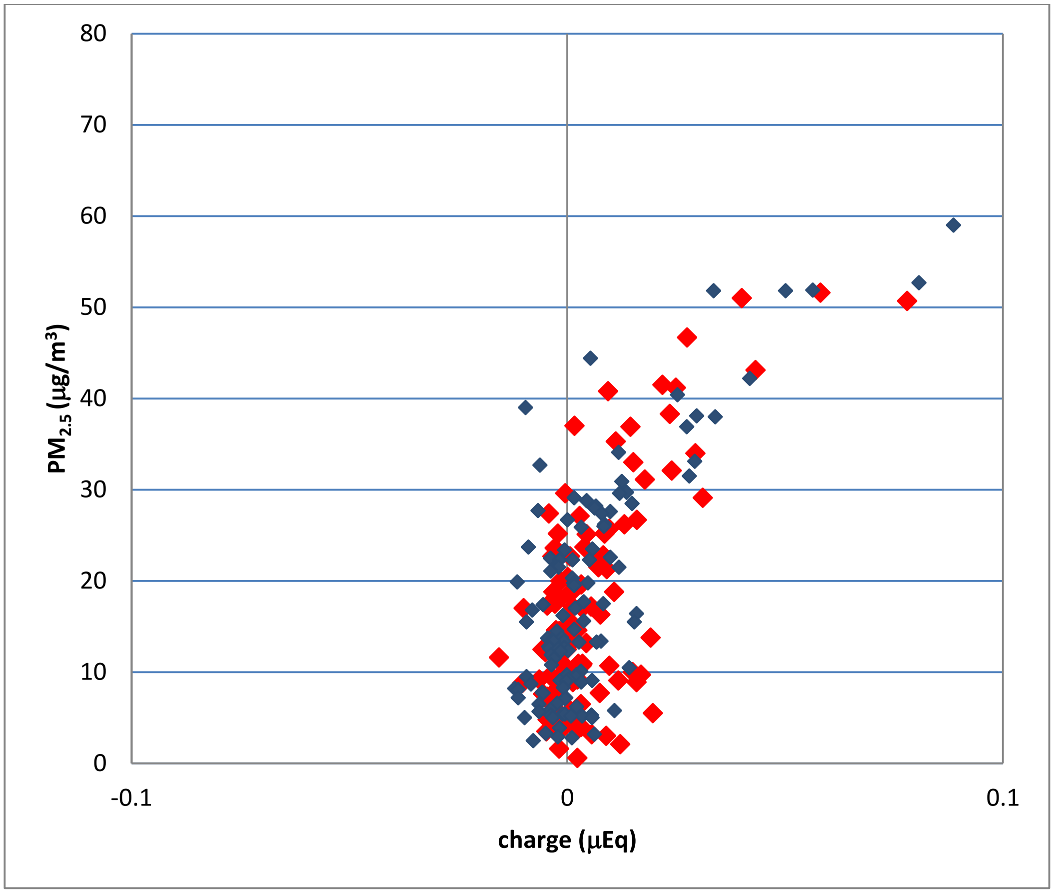

Figure 2: Aerosol charge vs. high $PM_{2.5}$ concentrations measured by FRM from 2006-2010 concentrations. Charge less than zero is acidic and greater than zero is basic.

Table 1. CMAQ and Observed Species Comparison from the State Office Building Monitor-FRM days Averaged for both modeling episodes.

Species	**Observed** ($\mu g/m^3$)	**Modeled** ($\mu g/m^3$)
$PM_{2.5}$ Total	36.1	35.7
OC	17.0	24.5
EC	2.3	4.3
SO_4	6.2	2.1
NO_3	1.6	1.3

NH_4	3.1	1.2
OTH	6.3	2.3

The CMAQ model run for Fairbanks performs well for nitrate and is in agreement with the State Office Building observed concentrations of nitrate and the modeled state office building grid cell concentration. Table 1 represents the observed verses simulated concentrations for the chemical components of $PM_{2.5}$ during two representative design episodes, episode 1 (Jan. 23-Feb 11th) and episode 2 (Nov. 2nd to the 17th) used for simulated control strategy model runs for the impracticability demonstration. The observed and modeled speciation components are 24-hr averages of the FRM days only and when speciation measurements were available.

The model adequately represents the organic carbon, elemental carbon and nitrate components. The CMAQ model runs do not well represent ammonium, sulfate or other primary particulates. Details on the model performance are found in Section 5.8.

Satisfying the EPA guideline for RACM requires the validation of all controls to advance attainment for year. In the case of Fairbanks, an estimate of 2 $\mu g/m^3$ per year is needed to advance attainment by 1 year. The design value of 45 mg/m^3 minus the $PM_{2.5}$ NAAQS of 35.0$\mu g/m^3$ is a 10 $\mu g/m^3$ reduction needed to reach attainment. If we have 5 years to reach attainment then a 10 $\mu g/m^3$ reduction over 5 years is estimated to be 2 $\mu g/m^3$. After each precursor discussion section, RACM applicability follows.

Nitrogen oxide precursors and nitrates

Nitrogen oxides are referred to as the chemical family NO_x (NO_2+NO), NO and NO_2 with primary emissions coming from combustion processes, home heating, vehicles and industry. Typically, during the day, NO_x is oxidized by reacting with ozone and OH radical chemistry and forms nitric acid (HNO_3) and during the night NO_x is oxidized to form $N_2O_{5\ (g)}$, which reacts on aerosol surfaces to form $HNO_{3\ (aq)}$ and deposition to snowpack. Particles containing nitrate are neutralized via reaction with ammonia gas (NH_3) to form ammonium nitrate.

Winter time chemistry is well represented by the model from a comparison of simulated to observed concentrations of nitrates. The modeled 24-hr mean NO_x concentration for both episodes near the surface at the State Office Building is 30ppm or 51$\mu g/m^3$. The State Office Building simulated grid cell mean 24-hr average NO_x of 51 $\mu g/m^3$ and simulated 1.3 $\mu g/m^3$ for the nitrate mass concentrations on FRM days (FRM days are a 1/3 schedule and used to compare observed filters directly to modeled days, not the same concentrations that are used for model performance all modeled days) only and converted to molar concentrations leads to a nitrate/ NO_x molar ratio of 0.031. The production of nitrate compared to NO_x emissions is very low at 3.1%. The molar ratio of 0.031 assumes that the NOx at the State Office Building grid cell has not undergone chemical reactions (some NO has already converted to NO_2), but equivalent observed 24-hr nitrate measurement on FRM days used for performance evaluation of CMAQ is 1.6 μg/m^3, meaning that the simulated nitrate mass concentration of 1.3 μg/m^3 is in good agreement with the observed measurement almost all of the NO_x converting to nitrate is captured by the model (Table 1). This is good model agreement and gives weight to CMAQ's analysis of nitrogen chemistry during polluted wintertime episodes. The aerosol process or secondary formation of nitrate is the driving process (Figure 3) from our modeled analysis and shows that CMAQ is representing nitrate with an acceptable bias and error (section 5.8.4 "Basecase Model Performance"). All of the PM-nitrate is considered secondary and primary emitted nitrate quantity is very small (10^ (-5) μg/m^3).

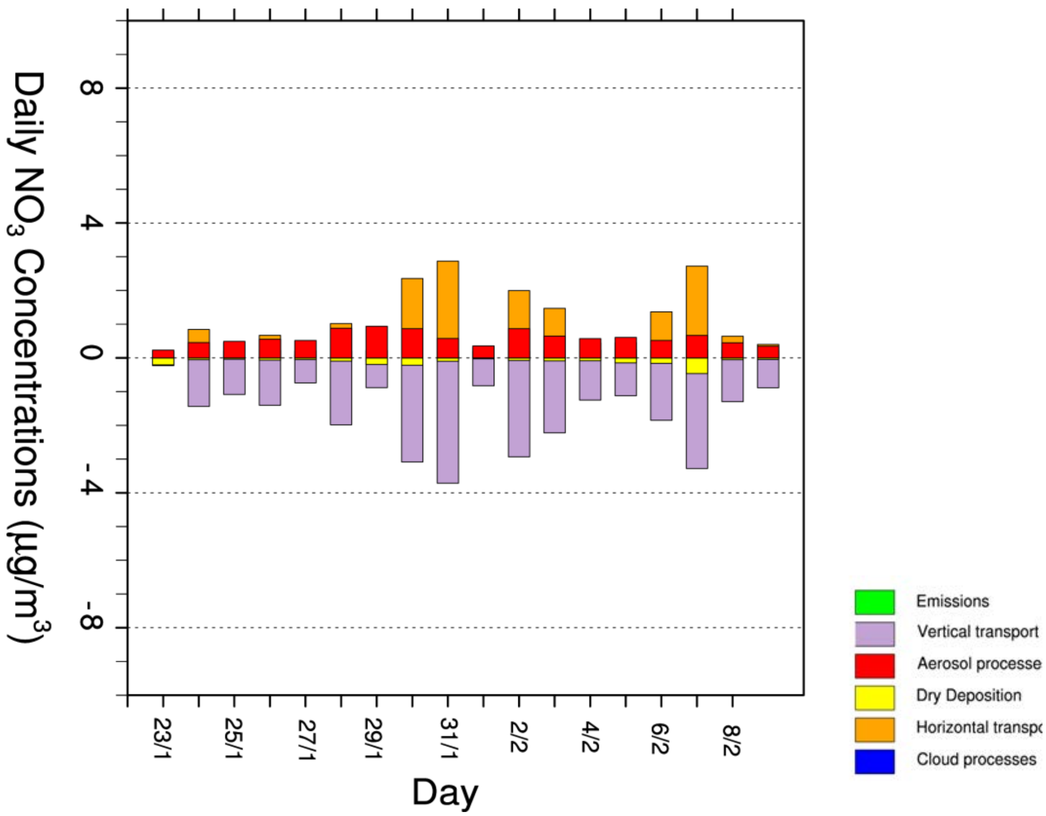

Figure 3. Process analysis results for nitrate from CMAQ for Jan. 23rd to Feb. 10th from the State Office Building grid cell.

The contribution from point sources is an important factor for NO_x emissions, because they contribute to the nitrate component of $PM_{2.5}$. The NO_x emissions by source category are 60% point sources, 20% mobile, 15% area, 4% non-road and less than 1% for all other sources combined. The total NO_x emissions from point sources are 13.45 Tons per Day (TPD).

In the winter, nitrate composes 4.33% (Figure 1) of the total $PM_{2.5}$ at the Fairbanks State Office Building on the top 25% most polluted days. For Fairbanks' baseline design value of 44.7 μg/m^3, this corresponds to 1.93 μg/m^3 of nitrate. In the CMAQ modeling, nitrate is 3.6% whereas the nitrate was 4.33 % of the observed $PM_{2.5}$.

Assuming that all of the moles of nitrate are balanced by any equivalent molar amount of ammonium the observations show that ammonium nitrate accounts for 4% of the total $PM_{2.5}$. This percentage is calculated based on an observed 1.94 μg/m^3 nitrate (Figure 1) and equivalent to 2.5 μg/m^3 ammonium nitrate (1.94 x (80 g/mol NH_3NO_3/ 62 g/mol NO_3). The observed ammonium nitrate originates from 13.45 TPD of NO_x emitted by point sources and we are assuming that all the nitrate is formed from point source emissions alone for this example. In addition to ammonium nitrate, a certain amount of water is associated with the ammonium nitrate, called particle bound water. The amount of water depends the acidity of the aerosol, the components, relative humidity and temperature. These parameters are hard to measure of an individual aerosol and there is an assumption that the water is bound in a 1/3 to 2/3 ratio, 1/3 for ammonium nitrate and 2/3 for ammonium sulfate (Frank, 2006). Taking the particle bound water (PBW) into account as part of the ammonium nitrate, then 0.89 μg/m^3 addition to the 2.5 μg/m^3 ammonium nitrate, for total of 3.39 μg/m^3 of ammonium nitrate + PBW. The 0.89 μg/m^3 (2.70 x 0.33) estimate is from the Frank (2006) paper where the ratio of PBW of 0.12 for ammonium nitrate or 1/3 (0.33) of the 2.70 μg/m^3 that is PBW (Figure 1).

Next, the observed ammonium nitrate and emitted NO_x are translated into a \$/ton NO_x metric to assess the NO_x control reduction. Dividing through the emitted tons by the observed ammonium nitrate (13.45 TPD / 3.39 μg/m^3 ammonium nitrate + PBW) it is determined that 3.97 Tons of NO_x makes 1 μg/m^3 of $PM_{2.5}$. Assuming that the conversion of NO_x to nitrate is linear throughout the range of nitrate concentrations, every ton of NO_x controls would reduce $PM_{2.5}$ nitrate by 1/3.97 μg/m^3, or 0.295 μg/m^3. In comparison, the total emissions for woodstoves are 3.18 TPD and the modeled reduction of $PM_{2.5}$ from woodstoves is 10.62 μg/m^3 (details on the emissions inventory and modeling for wood stoves can be found in Appendix III.D.5.6). Every ton of wood smoke emissions yields, by dividing the through the emitted tons by the modeled wood smoke $PM_{2.5}$ (3.18 Tons/ 10.62 μg/m^3), 0.3 tons of wood smoke $PM_{2.5}$ emissions makes 1 μg/m^3 of $PM_{2.5}$. Recalling that 3.97 tons of emissions makes 1 μg/m^3 of $PM_{2.5}$, wood smoke emissions are 13.2 (3.97/0.3) times more efficient at producing 1 μg/m^3 $PM_{2.5}$ than NO_x emissions are.

When it comes to the economic feasibility of various control strategies, NO_x controls will need to be 13.2 (3.97/0.30) times less expensive to be cost effective relative to controls on wood stove emissions. If wood stove emissions reductions are \$10,000/ton (from pg 41, EPA wood stove change outs), NO_x controls would need to be less than ~\$758/ton (\$10,000/13.2) to be considered cost effective relative to wood stove change outs.

Sulfur Dioxide precursor gas and Sulfate

Sulfates are a major component of the $PM_{2.5}$ mass; estimates show that sulfates comprise approximately 18% (8.17 μg/m^3) of the total mass of Fairbanks $PM_{2.5}$. Direct emissions and atmospheric formation of particulate sulfate contribute to measured sulfate concentrations. The bulk of the primary sulfate results from the combustion of fossil fuels, and to a lesser extent wood combustion also contribute. The speciation profiles used for the different emission categories show that primary sulfate is emitted by point, area (home heating) and mobile sources. Direct emissions of sulfate are not enough to account for the amount of sulfate observed at the State Office Building. It is very likely that SO_2 is converted into sulfate in the atmosphere after being emitted and thus accounts for the remainder of the observed sulfate. The direct emissions of sulfate do not account for all of the sulfate found on the filters and even though the mechanism is not known, secondary sulfate formation is important. As control strategies are adopted, for example to reduce wood stove use by switching to fuel oil, fuel oil has higher SO_2 and primary sulfate emissions. Due to the complex nature of the sulfate chemistry a white paper on sulfur chemistry was written by Rick Peltier of UMass, Division of Environmental Health Science (Peltier, 2011). As discussed in the introduction, the white paper concludes that the lack of oxidants available in the dark and cold conditions would impede production of sulfate by the most common photochemical pathways(Peltier, 2011), and the chemical mechanisms to convert SO_2 to sulfate under the Fairbanks wintertime conditions are unknown. Unlike nitrate, the CMAQ model does not capture the sulfate concentrations found at the State Office Building speciation filters resulting in a need to parameterize the conversion of SO_x to sulfate with a blend of observations and model results.

The CMAQ inventory for point and area sources reveal that point sources are a majority of primary sulfate (Dulla, 2010c, Elleman, 2010) emissions. After further refinements based on source apportionment modeling and locally derived emissions factors (Appendix III.D.5.6), the latest emissions inventory break down shows 65.4 % of SO_2 is linked to point sources and 42.1% of SO_2 is linked to area-space heating fuel oil sources of . Fairbanks total $PM_{2.5}$ speciation at the surface is composed of 18% sulfates by mass or 8.17 μg/m^3 (Figure 1).

Sulfate and sulfur dioxide as precursor gas are significant when addressing sulfate in the attainment demonstration as well as in the RACM analysis. In the case of sulfate, the modeled concentrations of primary and secondary sulfate are 2.03 μg/m^3 from both episodes, 24-hr average concentration at the State Office Building grid cell on modeled FRM days (Table 1). The observed FRM values from the representative modeling episodes are 5.25 μg/m^3, leaving an unexplained secondary sulfate contribution not represented by the model of 3.22 μg/m^3 (Table 2).

Table 2. Sulfate Average (μg/m^3) from FRM days for our two representative modeling episodes

	Episode 1	Episode 2	Weighted Average
Observed	5.38	5.08	5.25
Modeled	2.03	2.03	2.03
Remainder	3.35	3.04	3.22

The modeled concentrations in Table 2 are the sulfate average days from the two representative episodes. Evaluating the reduction in PM-sulfate for RACM, the design value, a 5-yr rolling average of the 98%-tile concentrations from years 2006-2010 of 44.7 μg/m^3 is used instead the modeling episode days which are only 14 day periods. Taking the weighted average column of observed, modeled and remainder concentrations in Table 2, multiplying by the ratio of design value observed sulfate (8.17 μg/m^3) by the observed sulfate during the episodes (5.25 μg/m^3) the sulfate fraction from all sources modeled is 3.16 μg/m^{3}and 5.01μg/m^3 is the unexplained sulfate remainder:

2.03 (modeled sulfate μg/m^3) * (8.17/5.25) = 3.16 μg/m^3
3.22 (remainder sulfate μg/m^3) *(8.17/5.25) = 5.01 μg/m^3

The model runs have very little secondary sulfate (average of 0.2 μg/m^{3}of secondary sulfate formed for both episodes), but the main chemical reactions in the model are photochemical and a function of OH and H_2O_2 (Molders, 2012). There are no observed measurements of OH or H_2O_2 for daytime winter conditions to prove that the mechanism is not favorable, but background OH concentrations at high latitudes in remote areas are measured to be extremely low even in the summertime (Mao et al., 2010). Sulfate is not well represented in the CMAQ model runs (Table 2). The observed average sulfate concentrations at the State Office Building during all days in both episode 1 and episode 2 is 6.2μg/m^3 and the simulated concentration is 2.1 μg/m^3 (Table 1).

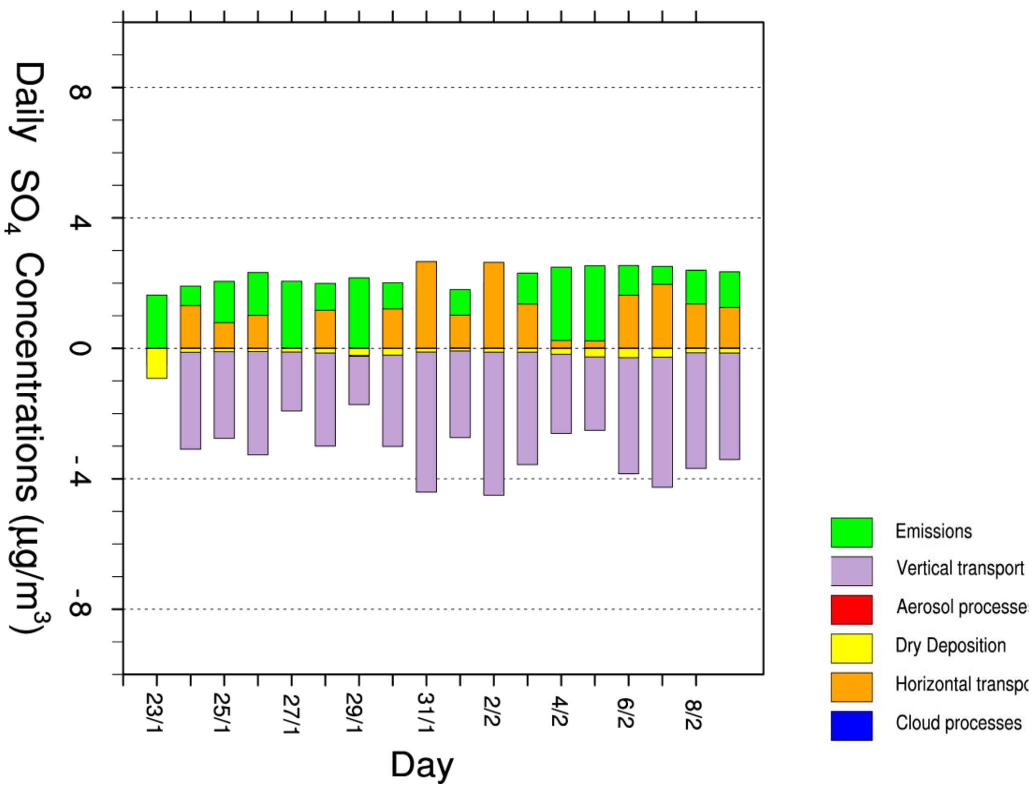

Figure 4. Process analysis for SO_4 concentrations from the CMAQ model for Jan. 23rd to Feb. 10th at the State Office Building grid cell (Molders, 2012).

The CMAQ process analysis results for sulfate show the sulfate emissions are nearly entirely primarily emitted and no aerosol processes are responsible for secondary formation of sulfate (Figure 4) in the model. CMAQ under predicts sulfate formation when compared to the total sulfate of the $PM_{2.5}$ speciation concentrations (Figure 1).

Understanding why CMAQ performs poorly for secondary sulfate in Fairbanks, several changes were made to the CMAQ model to investigate secondary sulfate, from increasing the water available for the Fe/Mn catalyst conversion reaction of SO_2 to SO_4, changing the pH and combining meteorological inputs of ice and water (Molders, 2012). The percentage of sulfate increased from 4.2 to 5.3% and from 3.9 to 5.0% for the November and January episodes. The increase in the percentage of SO4 increased NH4 and the percentage of NO3 and organic compounds decreased. The increase of sulfur dioxide and sulfate affected the thermodynamic equilibrium of the aerosol and allowed further neutralization of the sulfate and nitrate into ammonium sulfate and ammonium nitrate (Seinfeld, 2006). The 1% increase in sulfate in the model results did not account for 34% missing secondary sulfate from the observed sulfate to the modeling sulfate (Table 1) and sulfate model performance is still poor.

In order for the Fe/Mn catalyst reaction to take the place, the pH and the amount of water available are important. One idea for the underrepresentation of sulfate in the model is that the anthropogenic water not represented in the model that comes from the point sources could be enough to initialize the conversion of Fe/Mn catalyst reaction. This chemical mechanism was presented by Grgic et al. (1993) in a laboratory setting and she found that under the right pH and available water that the conversion to sulfate could be accounted for by Fe/Mn. The anthropogenic water that is not represented in the model has not been calculated and an additional box model study is needed to predict if this mechanism is responsible for the under representation in the CMAQ model. Since this study is not conducted, we currently parameterized the upper and lower bound of the sulfate conversion. The CMAQ inventory SO_2 precursor gas and primary sulfate emission estimates are total emissions into the entire modeling domain, not specifically what sources contribute to the high $PM_{2.5}$ surface concentrations.

Another determination for SO_2 precursor gas benefits is the possibility of forming ammonium nitrate and in fact increasing the $PM_{2.5}$. We have evidence from the understanding of wintertime Fairbanks chemistry that this would not occur and the details are in the ammonia precursor gas section. A total of 8.38 TPD of SO_2 are emitted. After source elimination CMAQ model results (Hixson, 2012c), it is estimated that 5% of primary emitted sulfate is from the point sources and up to 15% of secondary sulfate (assuming the entire unexplained sulfate portion is formed from point source emissions). These CMAQ model results were corroborated by running CALPUFF, a dispersion model. The CALPUFF model (Huff, 2012) results showed minimal impact for directly emitted PM2.5, less than 5%. The CALPUFF model was also run for SO_2 emissions from point sources and found 21% of the SO_2 at the State Office Building was from point sources for the November modeling episode. More detailed calculations on the SO_2 forming sulfate predications are discussed below.

CMAQ has been used in a series of source elimination runs to determine the contributions of different source sectors to the primary SO_4 and SO_2 gas at the monitor grid cell. It was found that 22% of the SO_2 originates from points, 78% from central oil and <1% is from mobile source. Using the design value day unexplained sulfate remainder and assuming that each source contributes linearly to the unexplained sulfate remainder of 5.01 $\mu g/m^3$ ((8.17 obs sulfate design value/5.25) *3.22 remainder sulfate on FRM days), then an estimate of the secondary SO_4 attributable to point sources would be calculated to be 1.10 $\mu g/m^3$ as shown below.

> 5.01 $\mu g/m^3$ Unexplained SO_4 Total x 0.22 (fractional SO_2 from point sources) = 1.10 $\mu g/m^3$ Unexplained SO_4 from point sources

The sulfate reduction of 1.10 μg/m^3 is a mid-range estimated benefit of 100% SO_2 controls on all point sources based on the modeled source contributions to SO_2 at the monitor assuming a linear relationship between SO_2 reductions and unexplained, measured sulfate. This sulfate reduction benefit was calculated only for our model episodes, but this secondary sulfate reduction can also be calculated on a design value basis. In the context of the design value of 5.01μg/m^3 of unexplained (secondary) sulfate in question as a portion of the total design concentration of 44.7μg/m^3. There are three scenarios for the unexplained sulfate (Hixson, 2013, sulfate elimination):

1) 61.3% (5.01 μg/m^3) Upper bound - All of the unexplained sulfate is from point sources
2) 13.5% (1.10 μg/m^3) Middle/Estimated - 22% of modeled contribution from points
3) 0% (0 μg/m^3) Lower bound- None of the unexplained sulfate is from the point sources

In addition to CMAQ modeling results, the CALPUFF dispersion model was run for the same November episode when SO_2 measurements were available at the State Office Building and used to corroborate the CMAQ model results. Hourly SO_2 measurements for Nov. 2-17th were averaged to 24-hour measurements and then to an episode average of 46 μg/m^3. The CALPUFF surface layer at the State office Building grid cell for all point sources combined was 9.7 μg/m^{3}of SO_2. Comparing the CMAQ total point source apportionment results for SO_2 above to actual SO_2 measurements for the November episode using CALPUFF:

> 9.7 μg/m^3 SO_2 modeled concentration at SOB / 46 μg/m^3 SO_2 OBS at the SOB = 21 % point source contribution of total SO_2 (Huff, 2012).

Considering the cost effectiveness for SO_2, the most conservative scenario 1) was used or all of the unexplained sulfate remainder of 5.01 μg/m^3 is from the point sources. Adding in the mass of ammonium that provides the charge balance within the particles, the concentration of ammonium sulfate is calculated to be 6.89 μg/m^3 (5.01 + 1.89 μg/m^3 (using the ratio132 g/mol of ammonium sulfate/96 g/mol ammonium). Using the same methodology as for comparing SO_2 emissions to $PM_{2.5}$ sulfate, it takes 1.21 TPD (8.38 SO_2 TPD / 6.89 μg/m^3 sulfate) of SO_2 to form each 1 μg/m^{3}of $PM_{2.5}$. Assuming the SO_2 to sulfate to be linear and a source the total that could be removed by SO_2 controls is 1.22 Tons (8.38 TPD/6.89 ammonium sulfate). Recalling that 0.3 tons of wood smoke $PM_{2.5}$ emissions makes 1 μg/m^3 of $PM_{2.5}$, SO_2 controls would need to be 4.1 times (1.22 / 0.3) cheaper than wood stove controls in order to provide the same air quality benefit as wood stove controls.

If we take particle bound water (PBW) into account as part of the ammonium sulfate, then 1.8 μg/m^3 addition to the 6.89 μg/m^3 for total ammonium sulfate and particle bound water of 8.69 μg/m^3 would be included in the cost effectiveness. The 1.8 μg/m^3 estimate is from the Frank (2006) paper where the ratio of PBW of 0.12 for ammonium nitrate or 1/3 of the PBW and therefore 2/3rds is bound to ammonium sulfate (2.70 x 0.66 = 1.8).Using the above equations there are 0.96 Tons of SO_2 removed (8.38 SO_2 TPD emitted/ (6.89 μg/m^3 ammonium sulfate + 1.8 μg/m^3 PBW)). The SO_2 control cost effectiveness would then be 3.2 (0.96/0.30) or less than $3,125/ton ($10,000/3.2).

In conclusion if the RACT controls for point sources and woodstoves are the same at $10,000/ton and all of the secondary sulfate is from point sources, then SO_2 controls would need to be 3.2 times more efficient (than primary $PM_{2.5}$ in wood stoves) to be cost effective (0.96/0.30). SO_2 controls would need to be less than \$3,125/ton (\$10,000/3.2) to be considered cost effective.

Ammonia precursor gas and ammonium

Ammonia gas (NH_3) reacts with acid aerosols containing nitrate (NO_3^-) and sulfate (SO_4^{2-}) to from ammonium nitrate (NH_4NO_3) and ammonium sulfate ($(NH_4)_2SO_4$). Nitrate is assumed to be all ammonium nitrate. Sulfates are partially neutralized to form ammonium sulfate and are associated with a degree of neutralization. Speciation data shows that 3.6 µg/m³ (8 %) of total $PM_{2.5}$ mass 44.7 µg/m³ on violation days is ammonium (Figure 1). In locations that are ammonium limited, reductions in sulfate make an ammonium available to nitrate. Controls on sulfate have the net effect of decreasing ammonium sulfate but increasing ammonium nitrate. Since nitrate is heavier on a per mole basis than sulfate, sulfate controls in an ammonium-limited environment increase $PM_{2.5}$ mass. There is no indication this would occur in Fairbanks since the observed $PM_{2.5}$ appears to be well-balanced in charge and because we have other evidence that nitrate does not readily form from NO_x in Fairbanks in the winter. With an approximately neutral particle acidity in Fairbanks, there is no indication that particle formation is ammonia limited. If sulfate is reduced in Fairbanks, $PM_{2.5}$ is reduced by the weight of the sulfate reduced and also by the weight of the ammonium.

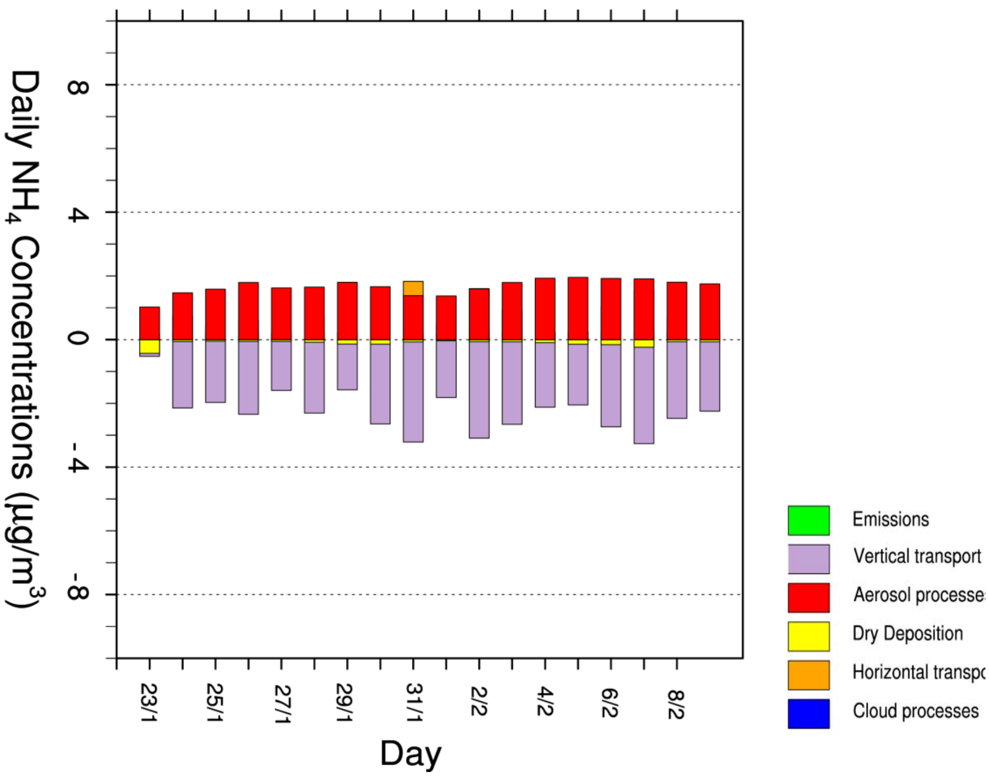

Figure 5. Ammonium concentration process analysis for episode 1 using the CMAQ model (Molders, 2012) at the State Office Building grid cell.

The modeling process analysis Figure 5 shows that the driving process for the production of ammonium is aerosol processes. The model does not accurately represent ammonium and is linked to the under prediction of secondary formation of sulfate and possible missing chemical mechanisms to convert SO_2 to sulfate. In addition, the ammonia emissions are measured and observed poorly due to measurement techniques. Figure 5 shows that there is enough ammonium to neutralize the sulfate, but in the model the amount of secondary ammonium sulfate production is very low, approximately 0.4 $\mu g/m^3$ of 2 $\mu g/m^3$ of sulfate (Molders, 2012).

Ammonia as a precursor gas is emitted from area sources at 60.7% (mostly home heating), mobile is 38.7% and non-road is 0.7%. Because ammonium in the Fairbanks $PM_{2.5}$ is dictated by the availability of sulfate and nitrate, this analysis accounts for ammonium decreases as part of sulfate and nitrate control strategies. If control strategies were to remove all 6.89 $\mu g/m^3$ of ammonium sulfate (1.88 $\mu g/m^3$ is ammonium) and 2.5 $\mu g/m^3$ of ammonium nitrate (0.56 $\mu g/m^3$ is ammonium), 2.45 $\mu g/m^3$ of ammonium (1.89 + 0.56 = 2.45) would be removed. The remainder of ammonium of 1.15 $\mu g/m^3$ (3.6 observed – 2.45 removed = 1.15) is associated with sulfate that is primarily emitted and not formed from the precursor gas emissions of SO_2.

<u>Volatile Organic Compounds</u>

The emissions of Volatile Organic Compounds (VOCs) are precursor gas emissions that contribute to the secondary formation of $PM_{2.5}$ by forming particulate organic carbon through condensing in the cold air after emission and through photochemistry to form secondary organic aerosols (SOA). The VOC emissions for home heating are 14.8 TPD. The condensable fraction of PM from point sources, gases that are emitted and form particles right out of the high temperature stack could be a significant from the condensation due to low temperature. After analyzing the CMAQ modeling results from the VOC emitted tons per day, the VOC fraction of secondary organic aerosols formed are 6.2 x 10^-4 $\mu g/m^3$ for the State Office Building grid cell. Some VOCs are temperature driven by higher temperatures and greater vaporization, but in Fairbanks winter the temperatures are routinely as low -40 with a winter time average temperature of -10° F, this pathway is not expected to add VOC emissions. As mentioned in the introduction, the observed organic carbon mass (particles primarily emitted and those formed from VOCs) is in good agreement with modeled organic carbon mass (Table 1) at 17.1 observed and 25.1 $\mu g/m^3$ of organic carbon modeled for the average of the two modeling episodes. The observed organic carbon mass is mostly accounted by primary particle contribution with no unexplained secondary organic aerosol. The relationship between modeled vs. observed concentrations and the very small modeled SOA leads us to believe that VOCs forming SOA are miniscule in the Fairbanks area and will be not be dealt with in detail in further RACT or RACM analysis.

The largest contributor to $PM_{2.5}$ in Fairbanks is organic carbon mass (OCM) at 21.47 µg/m^3 or 48% (Figure 1). Both organic carbon (OC) and elemental carbon (EC) are from combustion processes. Elemental carbon (EC) is a primary particulate emitted and is 17% of total. Elemental carbon is not involved in precursor chemistry and will not be addressed. Organic carbon is a primary and secondary particulate and calculated as the organic mass fraction of the total using the SANDWICH method (Frank, 2006) for the design value on high days (Figure 1). The major sources for EC/OC components are home heating. This includes wood stoves, fireplaces, inserts and wood boilers as the main component of OC and EC. Primary $PM_{2.5}$ emitted from point sources is 1.38 tons/day, not considering what fraction reaches the surface. The wood home heating primary $PM_{2.5}$ emitted is 3.18 tons/day and is emitted near the surface. Woodsmoke is found to be a major source contributor to $PM_{2.5}$ in Fairbanks and from the receptor model CMB (chemical mass balance), woodsmoke is shown to have 60-80% of total $PM_{2.5}$ (Ward, 2013). Carbon-14 testing can identify the aging of the carbon particles. Newer particles are associated with wood burning and aged carbon with fossil fuels (34-62%) (Ward, 2013).

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Appendix III.D.5.7

Individual Emission Unit RACT Determinations

Introduction

This appendix provides the detailed Reasonably Available Control Technology (RACT) analyses performed to support the RACT determinations contained in the Fairbanks $PM_{2.5}$ SIP. All facilities with emissions exceeding 100 TPY of $PM_{2.5}$, or one of its precursors SO_2 and NOx, were included. An individual RACT determination was made for each emission unit with emissions equal to or exceeding 5 TPY of one of these pollutants, for that pollutant.

The U.S. EPA has defined RACT as "the lowest emission limitation that a particular source is capable of meeting by the application of control technology that is reasonably available considering technological and economic feasibility."[1] EPA has also defined "presumptive RACT" as the norm achievable by the source category.[2] EPA interprets the term "reasonably available" to allow consideration of both the costs and benefits of applying the measure.[3]

> *RACT and RACM are those measures that a State finds are both reasonably available and contribute to attainment as expeditiously as practical in the specific nonattainment area.*[4]

The individual RACT analysis in this document follows the steps outlined below.

1. Identify baseline RACT[5] for the source category. This involves a review of current practice within the category.
2. Determine whether the emission unit meets baseline RACT.
3. If the emission unit does not meet baseline RACT, determine whether site-specific considerations preclude implementation of baseline RACT.

The emission units, and affected pollutants, are shown in Table 1.

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[1] 44 FR 53762 (September 17, 1979)
[2] 72 FR 20610 (April 25, 2007)
[3] 72 FR 20610 (April 25, 2007)
[4] 72 FR 20612 (April 25, 2007)
[5] "Baseline RACT," as used in this analysis, is intended to be conceptually similar to "presumptive RACT"—it is the norm achievable by the source category, and serves as the starting point for the individual RACT evaluation. However, because it has not been established with the rigor utilized by EPA to determine presumptive RACT in the ozone and NO_2 programs, the term "presumptive RACT" is not utilized in this report.

Table 1. Emission units, located at major stationary sources, with actual emissions of $PM_{2.5}$, or a precursor, greater than 5 TPY.

Facility	Source	Source Category	Unit Size[a]	Actual Emissions[b] $PM_{2.5}$	SO_2	NOx	Current Controls	Proposed RACT
Fort Wainwright	Boiler 3	Coal-fired boiler	230 MMBtu/hr	2	**109**	**101**	Baghouse	Baghouse
Fort Wainwright	Boiler 4	Coal-fired boiler	230 MMBtu/hr	2	**101**	**99**	Baghouse	Baghouse
Fort Wainwright	Boiler 5	Coal-fired boiler	230 MMBtu/hr	2	**126**	**117**	Baghouse	Baghouse
Fort Wainwright	Boiler 6	Coal-fired boiler	230 MMBtu/hr	1	**87**	**91**	Baghouse	Baghouse
Fort Wainwright	Boiler 7	Coal-fired boiler	230 MMBtu/hr	3	**171**	**197**	Baghouse	Baghouse
Fort Wainwright	Boiler 8	Coal-fired boiler	230 MMBtu/hr	2	**122**	**168**	Baghouse	Baghouse
Aurora Energy, Chena	Boiler 1, 2, 3, 5[c]	Coal-fired boiler	5 MW each (Boilers 1,2,3); 20 MW (Boiler 5)	**7.81 (total)**	**838.9 (total)**	**792.7 (total)**	Baghouse	Baghouse
North Pole Refinery	H-2001 Crude Heater	Liquid Fuel Fired Process Heater	325.6 MMBtu/hr	5.1	3.3	**62.0**	Ultra low NOx burners	No additional controls
North Pole Refinery	H-241 Crude Heater	Liquid Fuel Fired Process Heater	120 MMBtu/hr	2.0	1.0	**44.6**		Note (d)
North Pole Refinery	H-1001 Crude Heater	Liquid Fuel Fired Process Heater	62.5 MMBtu/hr	0.3	0.8	**20.6**		Note (d)
North Pole Refinery	B-401 Steam Generation	Liquid Fuel Fired Boiler	25 MMBtu/hr	0.3	0.1	**11.8**		Note (d)
North Pole Power Plant	Gas Turbine #1	Gas Turbine	60.5 MW	**15.5**	**42.3**	**50.3**		Continued use of HAGO
	Gas Turbine #2	Gas Turbine	60.5 MW	**131**	**326**	**464**		Continued use of HAGO
	GT #3	Gas Turbine	43 MW	**16.8**	**1.86**	**367**		Continued use of naptha and LSR
Zehnder	GT#1	Gas Turbine		**16.05**	**39.83**	**54.3**		Continued use of HAGO
	GT#2	Gas Turbine		**10.77**	**25.73**	**36.4**		Continued use of HAGO
UofA, Fairbanks	Boiler #1	Coal-fired boiler	84.5 MMBtu/Hr	3.62	**123.8**	**250**	Baghouse	Baghouse
	Boiler #2	Coal-fired boiler	84.5 MMBtu/Hr	3.77	**128.93**	**260**	Baghouse	Baghouse
	Boiler #3	Dual Fuel-fired Boiler	180.9 MMBtu/Hr	2	**17.7**	**5.72**		Continued use of No. 2 Distillate
	Boiler #4	Dual Fuel-fired Boiler	180.9 MMBtu/Hr	1.27	**11.23**	3.63		Continued use of No. 2 Distillate

NOTES:
[a]From each facility's Title V Permit Application.
[b]Actual emissions are based on information submitted in by facility operators 2013 for operations in 2011. The information was requested by Alaska Department of Environmental Conservation to satisfy the requirement to prepare a statewide point-source emission inventory (40 CFR 51.30). The inventory report has not been completed.
[c]Emissions shown for the Chena boilers, which share a common stack, are the combined emissions for all four boilers.
[d]No RACT determined for this source because the only pollutant above the threshold is NOx.

The emission units for which determinations were made fall into three source categories:

- Coal-fired boilers (12; excludes dual fuel-fired boilers), evaluated for $PM_{2.5}$ (1), SO_2 (12)
- Dual Fuel-fired Boilers (2), evaluated for SO_2 (2)
- Gas Turbines (5), evaluated for $PM_{2.5}$ (5), SO_2 (5)

Control of NOx as a $PM_{2.5}$ Precursor

NOx is a precursor for $PM_{2.5}$ in the form of nitrates, especially ammonium nitrate. Atmospheric phenomena involving NOx are very complex. Dispersion and transport of NOx emissions, atmospheric chemistry, and other factors affect the ultimate fate of NOx emissions.

NOx is widely controlled in many parts of the United States as a precursor for ozone. Current and former ozone nonattainment areas have NOx control requirements for many source categories. Some of these regulations reflect RACT, while others go beyond RACT.

The definition of RACT includes consideration of both costs and benefits of candidate controls. A control technique that is widely used for some other purpose because the emission reduction contributes towards attainment or maintenance of the standard (as an ozone precursor, for example) may still not be RACT for PM control, if the costs of control greatly outweigh the benefits of control.

EPA's policy towards control of NOx as a precursor for $PM_{2.5}$ includes a strong presumption in favor of requiring controls; this presumption may be overcome, however, if controls are very expensive, and the local conditions are such that NOx reductions are will not advance attainment by one year. The cost/benefit element of RACT review is commonly expressed as cost effectiveness for a proposed control. Cost effectiveness is expressed in units of dollars per ton of emissions avoided. A lower value for cost effectiveness means that the control technology is more efficient from a cost perspective at reducing emissions.

No threshold has been set for acceptable cost effectiveness for RACT review.[6] Instead, cost effectiveness is used as an indicator of the relative value of the costs and benefits of control. A very high cost effectiveness value may mean that a candidate control technology, even if commonly used and affordable, is not RACT for a specific emission unit because the costs of control outweigh the benefits from control. Whether a particular control technology is cost-effective as RACT for a specific emission unit is a case-by-case determination made by states and EPA.

As part of this analysis, the effectiveness of NOx emission reduction as a strategy to reduce ambient $PM_{2.5}$ concentrations in Fairbanks has been evaluated relative to reductions of directly emitted $PM_{2.5}$. The evaluation was based on the contribution that nitrates make to $PM_{2.5}$ concentrations in the design case for the region's attainment demonstration, and the regional NOx emissions that contribute to them.[7]

Based upon ambient sampling, nitrates comprise about 4% of the measured $PM_{2.5}$ concentrations in Fairbanks.[8] This corresponds to hydrated ammonium nitrate concentration of 3.4 $\mu g/m^3$. This represents the theoretical upper-bound of $PM_{2.5}$ reductions that could be achieved by elimination of NOx emissions.

Regional emissions of NOx from point sources are 13.45 TPD.[9] Assuming that all of the ambient nitrate $PM_{2.5}$ can be attributed to emissions from point sources establishes an upper bound for the effectiveness of NOx reductions as a strategy for reducing $PM_{2.5}$ concentrations.[10] Using this assumption, a reduction of 13.45 TPD of NOx would result in a reduction, at most, of 3.4 $\mu g/m^3$, or 0..25 $\mu g/m^3$ (= 3.4/13.45) per TPD.

For comparison, a wood stove change out program implemented by Fairbanks North Star Borough to reduce directly emitted $PM_{2.5}$—is expected to achieve a reduction in ambient $PM_{2.5}$ of 10.62 $\mu g/m^3$ through a reduction of 3.18 TPD of $PM_{2.5}$ emissions, or 3.34

[6] Some states and local agencies use cost effectiveness thresholds when evaluating the economic feasibility of controls that have been proposed as Best Available Control Technology (BACT). Some states and some local agencies, notably several in California, establish "bright line" thresholds above which controls are considered too costly to apply. Current typical practice at Alaska DEC from reviewing BACT analyses is to deem any control that costs more than $10,000 per ton of reduction it may be too expensive to require for BACT. EPA has not established such cost-effectiveness thresholds. Both states and EPA also may use cost effectiveness in prioritizing post-RACT control measures for plans to attain and maintain National Ambient Air Quality Standards. For this reason, any control technique deemed too expensive for RACT may still be required as part of the attainment demonstration.

[7] This analysis is not as precise as one based, for example, on atmospheric modeling. However, the results are being used here as an indicator of the relative cost/benefit of requiring reduced emissions of a given pollutant. For this limited purpose, the level of approximation provided by the analysis is reasonable.

[8] Appendix III.D.5.7 Precursors

[9] Fairbanks PM 2.5 SIP Chapter III.D.5.8

[10] This is a conservative assumption. Region-wide, 60% of all NOx emissions are from point sources (the other 40% come from mobile, area, non-road, and miscellaneous other sources). It would therefore be reasonable to apportion 60% of the NOx-originated PM2.5 to point sources. This apportionment would still be conservative because the plumes from industrial sources frequently penetrate the inversion layer that is a common feature of local meteorology, and as a result the NOx in those plumes does not contribute as significantly to local $PM_{2.5}$ concentrations as the emission inventory would suggest. However, neither of these adjustments is necessary to demonstrate that NOx control is not an effective strategy for reducing ambient $PM_{2.5}$ concentrations in Fairbanks.

(=10.62/3.18) μg/m^3 per TPD. Based on this measure, control of a ton of directly emitted $PM_{2.5}$ is about 13 times more effective[11] than control of a ton of NOx.

Survey of NOx Controls in $PM_{2.5}$ SIPs

In order to ensure that the RACT determinations in this analysis are consistent with those made by other jurisdictions in similar circumstances, a survey of $PM_{2.5}$ SIPs was performed.

All areas designated nonattainment for the 2006 $PM_{2.5}$ standard[12] were identified. Areas that are currently nonattainment for ozone were eliminated from further review. This was done because control requirements for NOx in current ozone nonattainment areas are already well beyond RACT levels. PM SIPs in such areas cannot provide insight into NOx RACT in ozone attainment areas.

Next, areas that have been redesignated attainment for the 2006 $PM_{2.5}$ standard, or that have Clean Area determinations, were eliminated from further review. The plans for these areas were not expected to include NOx control measures as strategies for attaining the PM standard because the standard has already been attained.

Six jurisdictions, including Fairbanks, were left. SIPS for these other areas were reviewed for information useful in establishing RACT. The results of this review were:

- Klamath Falls, Oregon: Klamath Falls point sources emit a total of 755 lb/day (138 TPY). Point source control measures identified as RACT: 20% opacity limitation (direct PM control). No NOx control measures were identified as RACT.
- Oakridge, Oregon: Nitrates contribute less than 0.4% of the PM mass on exceedance days. As a result, Oakridge did not evaluate RACT for NOx sources in its plan.
- Logan, Utah: Total NOx inventory from point sources = 7.3 TPY. [13] No NOx RACT proposed.
- Provo, Utah: Unlike Fairbanks, secondary particulate is most responsible for Provo's PM exceedances.[14] However, due to previous efforts to attain the federal PM_{10} standard, most point sources were already controlled at RACT/BACT levels. Additional control measures for point sources are listed with Salt Lake City, below.

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[11] 13.2 = 3.97 tons of NOx emissions / 0.3 tons of woodsmoke emissions
[12] EPA, *Area Designations for 2006 24-Hour Fine Particle ($PM_{2.5}$) Standards,* http://www.epa.gov/airquality/particlepollution/designations/2006standards/state.htm
[13] *Utah State Implementation Plan, Control Measures for Area and Point Sources, Fine Particulate Matter, PM2.5 SIP for the Logan, UT-ID Nonattainment Area* (November 6, 2013), p. 24
[14] *Utah State Implementation Plan, Control Measures for Area and Point Sources, Fine Particulate Matter, PM2.5 SIP for the Provo, UT Nonattainment Area* (November 6, 2013), p. 43

- Salt Lake City, Utah: Unlike Fairbanks, secondary particulate is most responsible for Provo's PM exceedances.[15] However, due to previous efforts to attain the federal PM_{10} standard, most point sources were already controlled at RACT/BACT levels. The State identified the following additional point source control measures:[16]
  - Ultra-Low NOx Burners (liquid fuel-fired process heaters), $1,813-$7,200 per ton
  - Low NOx Burners and Flue Gas Recirculation (FGR): $8,340 per ton
  - Combustion Controls, $1,357 per ton

The methodology used by Utah to establish the levels that it characterized as RACT went beyond RACT requirements.[17] Utah identified feasible control methods for each source it reviewed; it then evaluated expected reductions in its air quality model, in an effort to achieve attainment of the NAAQS as expeditiously as practicable. Finally, it determined which control measures would be included in the overall control strategy for the SIP.

The last two steps utilized by Utah are not part of a RACT analysis. They are the steps used in evaluating and prioritizing control measures for attainment. In other words, Utah blended the RACT evaluation process and the attainment planning process. Utah skipped making RACT determinations and efficiently proceeded directly to identification of the controls needed to demonstrate attainment. These control requirements are certainly *at least stringent as* RACT would be for the affected sources. In many cases, however, the controls go beyond RACT, as indicated by the cost effectiveness calculations included in the analysis.

For this reason, Utah's RACT determinations were considered, but in the end not used, in the RACT determinations for Fairbanks.

Methodology

As discussed above, NOx controls are not an efficient method for reducing PM concentrations in Fairbanks. This conclusion is based upon the relatively small contribution that secondary particulate (specifically nitrates) make to ambient PM concentrations on episode days, and the relatively large reductions in NOx emissions needed to have the same benefit (as measured by ambient PM concentrations) as a modest reduction in PM emissions.

Because the purpose of this analysis is to determine whether expenditures are reasonable for reduction of ambient $PM_{2.5}$ concentrations, the cost-effectiveness threshold for this analysis has been selected by taking the relative effectiveness of NOx control for PM reductions into account. This adjustment is necessary in order to ensure that control dollars are spent effectively. As discussed elsewhere in this report, a NOx reduction of 13 tons was determined to have the same effect as reduction of a single ton of directly-

[15] *Utah State Implementation Plan, Control Measures for Area and Point Sources, Fine Particulate Matter, PM2.5 SIP for the Provo, UT Nonattainment Area* (November 6, 2013), p. 43
[16] *PM2.5 Technical Support Documentation For the Salt Lake City and Provo PM2.5 Nonattainment Areas*
[17] *PM2.5 Technical Support Documentation For the Salt Lake City and Provo PM2.5 Nonattainment Areas*, p. 5.c.i-1

emitted PM, for the purposes of reducing ambient concentrations of PM. After reviewing several past ADEC BACT determinations for various pollutants, staff determined that $10,000 per ton was a representative threshold for BACT for all pollutants. For this analysis, the RACT cost-effectiveness threshold for PM was set at the same level as the BACT threshold.

In order to maximize the environmental benefit for the amount of money spent, the cost RACT cost-effectiveness for NOx reductions for the purpose of reducing ambient PM concentrations was derived by taking into account the relative benefits of reducing NOx and direct PM. As discussed above, a reduction of PM emissions is about 13 times more effective than a reduction of the same amount of NOx emissions.

In order to be conservative, a cost effectiveness threshold of $1,000 per ton of NOx has been used in this RACT review. Any technology with a lower bound of more than $1,000 per ton of NOx reduction was eliminated from further consideration.

Control technologies considered

All of the point sources under review emit NOx as a combustion product. There are two approaches to the control of NOx from combustion: combustion controls, and post-combustion controls. Combustion controls include use of water injection, low NOx burners, and other combustion modifications to reduce the formation of NOx during combustion. Post-combustion controls include catalyst systems that convert NOx to nitrogen in the stack.

The control techniques evaluated are presented in Table 1, along with the estimated cost effectiveness.

Table 1 shows that the screening estimate of the cost effectiveness[18] (based on the low end of the dollar-per-ton range, if one was provided) of all identified control technologies except one is higher than (i.e., less cost-effective than) the $1,000 per ton threshold established above. As a result, none of these control technologies are considered cost effective for the control of NOx as a precursor of $PM_{2.5}$ in Fairbanks.

The exception is the use of low NOx burners and flue gas recirculation (FGR) to control NOx emissions from oil-fired process heaters. The only oil-fired process heaters under review are the heaters at the North Pole refinery. The largest of these units, the H-2001 Crude Heater, is already equipped with ultra low-Nox burners. The other three heaters are not currently equipped with low NOx burners. Installation of low NOx burners was considered as a possible RACT measure for these units. However, the cost effectiveness value shown in Table 1 is the low end of the range of estimated costs, and it is just barely below the RACT threshold. Installation costs in Alaska are not expected to be at the low

[18] The values shown in Table 1 are the low values in the range, if a range was given in *EPA Menu of Control Options*. The cost of controls in Fairbanks is expected to be above the middle of the range of costs in the lower 48 states. Additionally, some of the cost effectiveness values do not take equipment size into account. Many of the sources are relatively small, at or below the range for which cost estimates are valid. Smaller units generally cost more per ton than larger units. As a result, the values shown are conservatively low. Actual costs would be expected to be much higher.

end of the range of costs; additionally, the costs of installation on small units are almost never at the low end of the range—economies of scale usually result in the low end of the cost scale being associated with large units. For these reasons, the cost effectiveness of installation of low NOx burners at North Pole Refinery are expected to be sufficiently higher than the value shown in Table 1 to be above the cost effectiveness threshold, and installation of low-NOx burners was determined to not be RACT for these units.

Because none of the identified NOx control measures will result in a cost-effective reduction of ambient PM concentrations, existing controls are deemed to meet RACT requirements for NOx for each of the identified sources.

Table 1. NOx Control Techniques[a]

Source Category	Control Technique	Cost Effectiveness ($/ton of NOx removed)[b]	Additional Information
Coal-Fired Boilers (and Dual Fuel-Fired Boilers)[c]			
Industrial Boilers firing coal (stoker)	Low NOx burner	$1,526	<250 MMBtu/hr
Industrial Boilers firing coal (stoker)	Low NOx burner and overfire air	$1,077	
EGU boiler firing coal	SCR	$1,550	
EGU Boilers firing coal	SNCR	$1,370	
Liquid Fuel-Fired Process Heaters[d]			
Industrial Fuel Oil Combustion	Low NOx Burner	$1,894	
Process Heaters	Low NOx burner and FGR	$915	
Oil combustion in Process Heaters	Low NOx burner retrofit & SNCR	$3,691	
Gas Turbines[e]			
Turbines, oil fired	Water Injection & SCR	$3,691	
Turbines, oil fired	Water Injection	$2,070	

[a]Data from _EPA Menu of Control Options_ (Updated 4/12/2012). The values shown are the bottom of the range, if a range was provided.
[b]2006 dollars
[c]Fort Wainwright Boilers 3-8; Chena Power Plant Boilers 1,2,3,5; UofA Fairbanks Boiler 1-2.
[d]North Pole Refinery Crude Heaters and Steam Generation.
[e]North Pole Power Plant GT1-3; Zehnder GT 1-2.

Conclusion: Reducing NOx emissions is a relatively inefficient strategy for reducing $PM_{2.5}$ in Fairbanks. Using the analysis discussed and cited above, our assessment of the cost and effectiveness of NOx controls concludes that available controls are not cost effective and would not advance attainment of the $PM_{2.5}$ standard by a year. Based on the fact that controlling for direct $PM_{2.5}$ is approximately 13 times more effective, on a per-pound basis, than controlling for NOx emissions, any cost effectiveness analysis for NOx control equipment would need to reflect this factor and still be shown to be cost effective.

Our analysis did not find any NOx controls that are cost effective for reducing $PM_{2.5}$ emissions in the nonattainment area.

For this reason, NOx reductions, for the purposes of $PM_{2.5}$ reductions within the context of RACM and RACT, will not be considered at this time.

Coal-Fired Boilers

The following is considered baseline RACT for coal-fired boilers in Fairbanks:

- $PM_{2.5}$: Fabric Filters
- SO_2: Use of low-sulfur coal

The basis for each baseline RACT determination is described below.

$PM_{2.5}$ (Direct Emissions)

Candidate Control Technologies – The following control technologies were considered for this source category:

- Fabric Filters;
- Electrostatic Precipitators; and
- Wet Scrubbers.

All of the coal-fired boilers under evaluation are currently equipped with fabric filters. If properly designed and maintained, fabric filters generally reflect the best performing control technology available for emissions of PM from coal-fired boilers.

Conclusion: RACT for PM for each of the coal-fired boilers is a properly designed and operated fabric filter system. A design review will be conducted for each boiler to confirm that the existing baghouses are properly designed and operated.

SO_2

Candidate Control Technologies – The following control technologies were considered for this source category:

- Scrubber (Wet, Spray Dry, and Dry); and
- Fuel sulfur content reduction.

Scrubbers[19] – Scrubbers are used extensively to control emissions of inorganic contaminants, including acid gases such as sulfur dioxide (SO_2). Scrubbers are capable of reduction efficiencies in the range of 50% to 90%. In a wet system, the exhaust gas is contacted in a scrubber with a wet solution. Acid components (SO_2 and HCl) are absorbed into the liquid, and a liquid waste must be disposed of. Dry systems involve injection of dry alkali substances (usually some form of lime), which is removed from the exhaust by a fabric filter or ESP. Spray dry systems introduce the absorbent in a slurry that is fully evaporated by the exhaust stream, resulting in particulates that are removed by fabric filter or ESP. Approximately 85% of the Flue Gas Desulfurization (FGD) systems installed in the U.S. are wet systems, 12% are spray dry, and 3% are dry systems.

[19] Information in this section is from: EPA, *Air Pollution Control Technology Fact Sheet: Flue Gas Desulfurization (FGD) - Wet, Spray Dry, and Dry Scrubbers*, EPA-452/F-03-034

SO_2 scrubbers have been applied to combustion units as small as 5 MW (~50 MMBtu/Hr). Dry and spray dry scrubbers are generally applied to units less than 300 MW (~3,000 MMBtu/Hr).[20] However, there are relatively few installations on units smaller than 300 MMBtu/hr. All 14 of the units in Fairbanks are smaller than 300 MMBtu/hr; 6 of them are smaller than 100 MMBtu/hr. See Table 1. The strategy for control of SO_2 emissions under the Acid Rain program provides an incentive to invest in controls for large to very large sources while leaving smaller sources without controls. EPA has characterized the range of "realistic values" for unit size for scrubber installations as between 100 and 2000 MW_e.[21]

Capital costs for all SO_2 scrubbers were reported to be approximately $100/kW in 2001.[22] Retrofit costs vary significantly between sites and depend on space limitations, requirements for duct modifications, and operating conditions (temperature, flow rate); retrofit of scrubbers on existing units can increase the capital costs up to 30%.

The addition of a scrubber to an existing combustion device causes a loss of energy due to evaporation of water and the energy required to drive the reaction.[23] New scrubber designs result in energy penalties of less than 1% of total plant energy.

Wet scrubbers rely primarily on the absorption process to remove these soluble contaminants from the exhaust gas stream. Wet scrubbing devices that are based on absorption principles include packed towers, plate (or tray) columns, venturi scrubbers, and spray chambers. Removal efficiencies for gas absorbers vary for each pollutant-solvent system and with the type of absorber used. Pollutant removal may also be enhanced by manipulating the chemistry of the absorbing solution so that it reacts with the pollutant(s), e.g., caustic solution for acid-gas absorption vs. pure water as a solvent. Chemical absorption may be limited by the rate of reaction, although the rate-limiting step is typically the physical absorption rate, not the chemical reaction rate.

Most absorbers have removal efficiencies in excess of 90%, and packed tower absorbers may achieve efficiencies as high as 99.9% for some pollutant-solvent systems.

EPA considers dry scrubbers to be a promising emerging technology.

> *Dry scrubbers have significantly lower capital and annual costs than wet systems because they are simpler, demand less water and waste disposal is less complex. Dry injection systems install easily and use less space, therefore, they are good candidates for retrofit applications. SO_2 removal efficiencies are significantly*

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[20] For the purposes of this analysis, a nominal plant heat rate of 10,000 Btu/kwhr is assumed for boilers producing steam for electricity where a heat rate is required site specific information is not available.
[21] Srivastava, *Controlling SO_2 Emissions: A Review of Technologies, EPA/600/R-00/093* (November 2000) , p. 44.
[22] Smith, *SO_2 Controls: Cost of SO_2 Scrubbers Down to $100/kW,* Power Engineering (September 2001).
[23] Although there is no evaporation, there is still an energy penalty associated with the use of dry scrubbing. EPA, *Air Pollution Control Technology Fact Sheet: Flue Gas Desulfurization (FGD) - Wet, Spray Dry, and Dry Scrubbers*, EPA-452/F-03-034, p. 2.

lower than wet systems, between 50% and 60% for calcium based sorbents. Sodium based dry sorbent injection into the duct can achieve up to 80% control efficiencies (Srivastava 2001). Dry sorbent injection is viewed as an emerging SO_2 control technology for medium to small industrial boiler applications. Newer applications of dry sorbent injection on small coal-fired industrial boilers have achieved greater than 90% SO_2 control efficiencies.[24]

The available information for cost effectiveness for scrubbers is summarized below.

Table 2. Cost of SO_2 Scrubbers

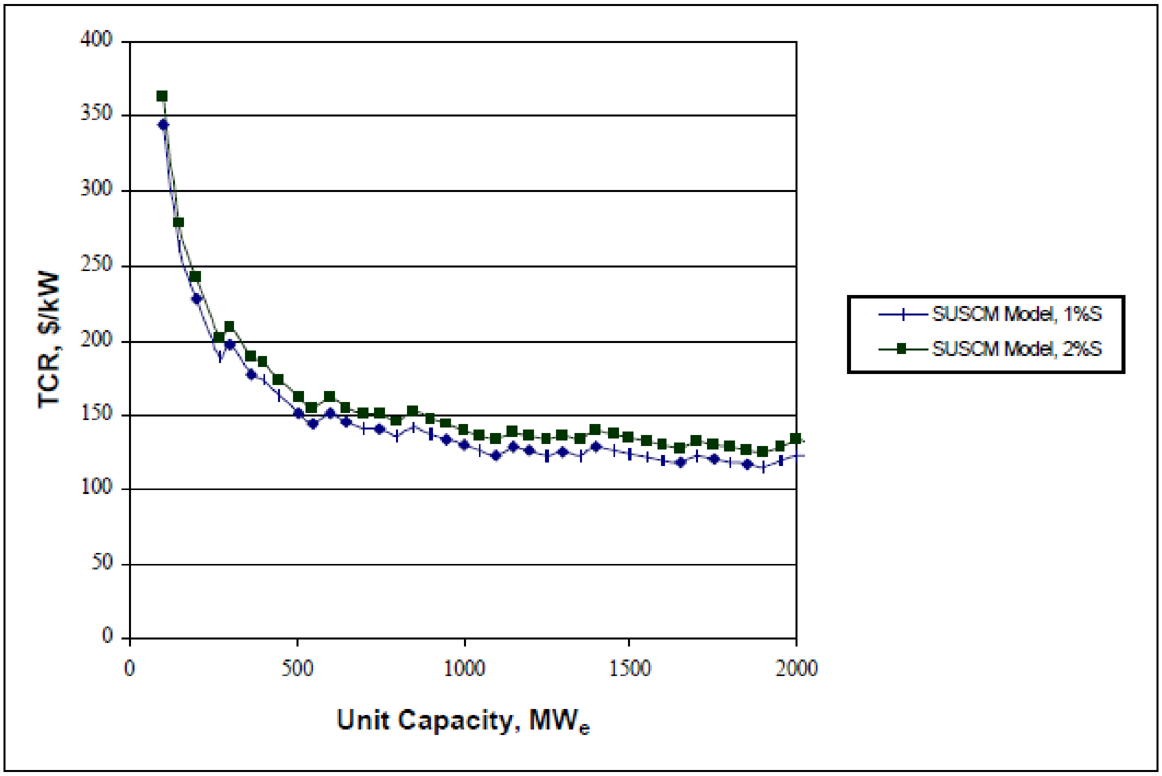
Scrubber Type	Unit Size (MW)	Cost per Ton of Pollutant Removed ($\$_{2001}$/ton)
Wet	>400	200-500
	<400	500-5000
Spray Dry	>200	150-300
	<200	500-4000
Dry Scrubbers	All	Not Available

Source: EPA, *Air Pollution Control Technology Fact Sheet: Flue Gas Desulfurization (FGD) - Wet, Spray Dry, and Dry Scrubbers*, EPA-452/F-03-034. EPA does not provide cost information for dry scrubbers.

By far the most significant factor determining cost effectiveness of controls is the size of the unit. This is illustrated in Figure 1.

[24] EPA, *Air Pollution Control Technology Fact Sheet: Flue Gas Desulfurization (FGD) - Wet, Spray Dry, and Dry Scrubbers*, EPA-452/F-03-034

Figure 1. Total Capital Requirement for Lime Spray Drying System (as calculated by State-of-the-Art Utility Scrubber Cost Model [SUSCM])[25]



NOTE: 100 $MW_e \approx$ 1,000 MMBtu/hr

In order to better refine this cost estimate, EPA's tool for estimating the cost of controls for coal-fired boilers, CUECost,[26] was utilized to estimate the cost of wet scrubbers for coal-fired equipment in Fairbanks. CUECost is the Coal Utility Environmental Cost workbook, an interrelated set of spreadsheets that "produces rough-order-of-magnitude cost estimates (+/- 30% accuracy) of the installed capital and annualized operating costs for air pollution control systems installed on coal-fired power plants."[27] As noted above, EPA has determined realistic values for unit size for scrubber installations as between 100 and 2000 MW_e. Consistent with this determination, the minimum unit size for which CUECost is valid is 100 MW_e whereas the largest example in the nonattainment area are the 40 MWe associated with the combines exhaust from the Chena power plant.

Default values were used for most user-specified inputs. Non-default values, and the basis for their selection, are shown in Table 3. The analysis was performed using values for the largest boiler under review (the combined emissions of the four boilers at Aurora Energy's Chena facility). This exhaust stream was selected because it is expected to have the best cost effectiveness value for capital costs; operating costs for sulfur controls are roughly

[25] Taken from Srivastava, *Controlling SO_2 Emissions: A Review of Technologies, EPA/600/R-00/093* (November 2000) , p. 74.
[26] CUECost Model Version 3.0, downloaded from *http://www.epa.gov/ttn/catc/products.html*. This is the most current version of CUECost available.
[27] Yelverton, *Coal Utility Environmental Cost (CUECost) Workbook User's Manual, Version 1.0,* p. 1. This is the version of the user's manual that accompanies CUECost Version 3.0.

proportional to actual throughput, so unit size does not affect overall operating costs as strongly.

Table 3
CUECost Estimate of Cost of Sulfur Scrubbers for 100 MW Coal-fired Boiler—Input

Description	Units	Range	Default	Case 2
Location - State	Abbrev.	All States	PA	AK
MW Equivalent of Flue Gas to Control System	MW	100-2000	500	100[a]
Net Plant Heat Rate (w/o APC)	Btu/kWhr		10,500	10,500
Plant Capacity Factor	%	40-90%	65%	40%[b]
Percent Excess Air in Boiler	%		120%	120%
Air Heater Inleakage	%		12%	12%
Air Heater Outlet Gas Temperature	°F		300	300
Inlet Air Temperature	°F		80	26.7[c]
Ambient Absolute Pressure	In. of Hg		29.4	29.4
Pressure After Air Heater	In. of H2O		-12	-12
Moisture in Air	lb/lb dry air		0.013	0.0026[d]
Ash Split:				
Fly Ash	%		80%	80%
Bottom Ash	%		20%	20%
Seismic Zone	Integer	1-5	1	4[e]
Retrofit Factor (1.0 = new, 1.3 = medium, 1.6 = difficult)	Dimensionless	1.0-3.0	1.3	1.3 – 3
Coal Cost	$/MMBtu		1.50	3.30[f]
Coal Moisture	wt%		30.24	30.00[g]
Coal Carbon	wt%		48.18	45.00[g]
Coal Sulfur	wt%		0.37	0.13[h]
Ash	wt%		5.32	9.23[h]
Electricity cost	mills/kwh		25	60[i]
2013 Chemical Engineering Price Index			388 (1998)	585.7 (2012)

NOTES:
[a] Largest boiler in the study is 37 MW (combined exhaust of boilers at Aurora Energy's Chena Facility). Used minimum value in the tool's range (i.e., 100 MW).
[b] The analysis was run using the lowest value for capacity factor within the tool's allowed range (i.e., 40%)
[c] U.S. Climate Data *http://usclimatedata.com/climate.php?location=USAK0083*, accessed 9/19/13.
[d] Vapor pressure of water over ice at 32F.
[e] Seismic zone = 4 ("Areas within Zone 3 close to major fault systems"), based on information from this website: *http://seismic.alaska.gov/seismic_hazards_earthquake_risk.html*
[f] Cost of coal ~$50/st
[g] Adjusted from default to compensate for ash content.
[h] From Emission Inventory 2011
[I] Source: Alaska Electric Light and Power Company, Large Commercial Tariff

Information about the estimates is provided in Table 4. Based on the model, the cost effectiveness of wet scrubbers and spray dryer systems to control SO_2 from these boilers is between \$24,000 and \$58,000 per ton of SO_2. This is much higher than the cost effectiveness values provided by the EPA Fact Sheet, shown in Table 2. However, this outcome is expected, given the small size and low sulfur content of the unit being evaluated. Furthermore, it is important to bear in mind that the definition of “small” for coal-fired units is 500 MWe, and that EPA considers installation of scrubbers on units smaller than 100 MW_e to be “unrealistic.”

Table 4
CUECost Estimate of Cost of Sulfur Scrubbers for 100 MW Coal-fired Boiler—Output

Description	Units	Limestone Forced Oxidation[a]	Lime Spray Dryer[b]
Total Capital Requirements	$\$_{2012}$	\$77-176 million	\$57-131 million
Levelized Constant Dollars			
Fixed O&M	$\$_{2012}$/year	\$4.0 million/year	\$3.0 million/year
Variable O&M	$\$_{2012}$/year	\$0.6 million/year	\$0.8 million/year
Fixed Charges	$\$_{2012}$/year	\$9.0-20.6 million/year	\$6.7-15.3 million/year
Total	$\$_{2012}$/year	\$13.6-25.0 million/year	\$10.4-19.1 million/year
Total	$\$_{2012}$/ton SO_2	\$29,600-57,600/ton	\$23,900-46,100/ton

[a]Limestone Forced Oxidation is a type of wet scrubber.
[b]Lime Spray Dryer is a type of spray dryer.

In summary, available cost information for wet scrubbers and spray dry systems indicate that these systems are not cost effective for small units (smaller than 500 MW_e).

As for dry scrubbers, the most recent EPA guidance indicates that EPA considers dry scrubbers to be a promising, but still emerging, technology, with potentially lower capital costs, particularly for medium to small installations. An emerging technology may be a candidate for evaluation in a top-down BACT analysis, but cannot be considered to be the “norm.” Efforts to find cost data for dry scrubbers were largely unsuccessful. After searching various literature sources and vendor websites, one article comparing circulating dry scrubbers with other wet scrubber systems was found.[28] The report compared units designed for 400-500 MW coal-fired power plants. The report concluded that, for that size at least, the cost of a dry scrubber was essentially a tie with the cost of a lime spray-dry system.

The Sargent & Lundy report compares capital and operating costs for power plants of two sizes: 400 MW and 500MW. The report also evaluated the effect of fuel sulfur content on cost. The cost calculations were developed for the purpose of comparing the relative cost effectiveness of the various technologies on power plants of the selected sizes. The report cautions that costs should not be used to plan the cost of a FGD project. Taking these cautions into account, the report still contains information relevant to the RACT analysis. What follows is an attempt to scale the cost data for a 400 MW plant down to the 20-40 MW units in Fairbanks.

[28] Sargent & Lundy, *Flue Gas Desulfurizaiton Technology Evaluation: Dry Lime vs. Wet Limestone FGD,* March 2007.

Effect of fuel sulfur content on cost

Table 5 presents the cost information from the Sargent & Lundy report (Cases 1-6), as well as an extrapolation of the costs to a hypothetical 400 MW power plant burning Alaska coal. The costs shown are retrofit costs.

The defining characteristic of Alaska coal is very low sulfur content. For this reason, uncontrolled sulfur emissions are 4 times lower than occur at a plant burning "low sulfur" coal in the lower 48 states.

Table 5. Cost of Circulating Dry Scrubber for SO_2 Controls (400 and 500 MW Coal-fired Power Plant)

		Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Unit Size	MW	400	500	400	500	400	500
boiler fuel capacity	MMBtu/hr	4000	5000	4000	5000	4000	5000
Coal HHV	btu/lb	8,335	8,335	13,100	13,100	13,100	13,100
Sulfur content	wt%	0.6	0.6	1.3	1.3	2	2
SO2 generation	lb/MMBtu	1.44	1.44	2.0	2.0	3.1	3.1
Annual fuel use	ton/year	1,681,584	2,101,980	1,069,924	1,337,405	1,069,924	1,337,405
Capacity Factor		80%	80%	80%	80%	80%	80%
Control efficiency		97.2%	97.2%	98%	98%	98%	98%
Capital Cost	M$	110.2	139.3	107.9	135.9	111.9	140.6
Annualized Cap Cost	M$/year	10.40	13.15	10.18	12.83	10.56	13.27
Fixed Operating Cost	M$/year	2.08	2.45	2.05	2.40	2.11	2.47
Variable Operating Cost	M$/year	5.13	6.41	7.03	8.79	10.46	13.07
Total Operating Cost	M$/year	7.21	8.86	9.08	11.19	12.57	15.54
Total cost	M$/year	17.61	22.00	19.27	24.02	23.13	28.81
Cost per kwh	₵/kwh	0.63	0.63	0.69	0.69	0.83	0.82
SO2 removed	ton/year	19,614	25,224	27,818	34,773	42,797	53,496
Cost effectiveness	$/ton SO2	898	872	693	691	540	539

Notes:
[a]All data from Sargent & Lundy, *Flue Gas Desulfurizaiton Technology Evaluation: Dry Lime vs. Wet Limestone FGD,* March 2007.
[b]Annual capital cost calculated using a 7% discount rate and a 20-year equipment life.

A direct result of this is that the cost effectiveness of any sulfur emission reduction strategy is much poorer for facilities firing Alaskan coal. The estimated cost effectiveness of retrofitting a 400 MW baseload (80% capacity factor) firing Alaskan coal is $2,800 per ton; this is more than 3 times the cost of retrofitting a similar unit in the lower 48 states. This value is based on an assumption that the control efficiency of the control device will be 95%. It is likely that the control efficiency will be lower, because a lower inlet pollutant loading usually results in a lower overall control efficiency.

Effect of unit size on cost

Extrapolating costs from data at 400-500 MW to units that are 5-40 MW in size is unreliable, at best. Generally, economies of scale result in capital costs (expressed as dollars per unit of capacity) being higher for smaller units.

The Sargent & Lundy capital cost data were evaluated to determine a capital cost factor of $0.276 million per MW for scrubber units applied to boilers in the 400-500 MW range

The linear factor above does not take into account economies of scale. Small units are more expensive (on a dollar per unit capacity basis) than larger units. A scaling equation to account for the non-linearity of construction costs, adjusting equipment cost estimates for size, is provided by the National Energy Technology Library.[29]

$$SC = RC * \left(\frac{SP}{RP}\right)^{Exp}$$

Where

SC = Scaled Cost
RC = Reference Cost
SP = Scaling Parameter
RP = Reference Parameter
Exp = exponent

For the components comprising the desulfurization system (sorbent handling, injection, collection, etc.) the exponents range from 0.5 to 0.72. An exponent value of 0.64 was used to calculate the costs presented in Table 4. Costs were calculated by scaling the estimated cost of a 400 MW unit burning Alaska coal (Case 7 in Table 4) by the ratio of the boiler capacity (in MW) to 400 MW, raised to the power of 0.64.

Operating and maintenance (O&M) costs can be separated into two components: fixed costs (overhead costs that are insensitive to usage; these include labor and maintenance materials) and variable costs (costs that are tied to production, including cost of consumable, by-product management, water and power). Fixed costs were estimated by evaluating the Sargent & Lundy cost data to get a fixed cost factor of $5,036 per MW. Variable costs were based on a variable cost factor of $252 per ton of SO_2 recovered.

[29] US Department of Energy, *Capital Cost Scaling Methodology*, January 2013.

Results of Cost Calculations

Table 6 presents the cost estimates for dry scrubbers using the methodology described above. Estimated site-specific cost effectiveness are $2,200 per ton of SO_2 removed (Chena power plant); $2,200 per ton of SO_2 removed (University of Alaska 1 & 2); and over $5,000 per ton of SO_2 removed (Wainwright, University of Alaska 3 & 4).

Table 6. Cost of Circulating Dry Scrubber for SO_2 Controls (Fairbanks Facilities)

		Case 7 (Alaska coal)	Wainwright 3-8	U of A 1, 2[c]	Chena (combined)[d]
Unit Size	MW	400	23	8.5	42
boiler fuel capacity	MMBtu/hr	4000	230	85	420
Coal HHV	btu/lb	7,545	7,545	7,545	7,545
Sulfur content	wt%	0.14	0.14	0.18	0.14
SO2 generation	lb/MMBtu	0.4	0.4	0.5	0.4
Annual fuel use	ton/year	1,857,654	50,391	36,950	234,251
Capacity Factor		80%	38%	75%	96%
Control efficiency		95%	95%	95%	95%
Capital Cost	M$	110.4	12.0	4.5	22.0
Annualized Cap Cost	M$/year	10.42	1.14	0.42	2.08
Fixed Operating Cost	M$/year	2.01	0.12	0.04	0.21
Variable Operating Cost	M$/year	1.24	0.04	0.03	0.16
Total Operating Cost	M$/year	3.26	0.15	0.08	0.37
Total cost	M$/year	13.68	1.29	0.50	2.45
Cost per kwh	₵/kwh	0.49	1.70	0.89	0.69
SO2 removed	ton/year	4,941	141	133	656
Cost effectiveness	$/ton SO2	2,769	9,140	3,734	3,732

Notes:
[A]All costs are estimates based on cost factors derived from Sargent & Lundy, *Flue Gas Desulfurizaiton Technology Evaluation: Dry Lime vs. Wet Limestone FGD,* March 2007. The values in this table are extrapolated from 400 and 500 MW examples.
[b]Annual capital cost calculated using a 7% discount rate and a 20-year equipment life.
[c]University of Alaska Units 3 & 4 are not included. These dual fuel-fired units did not burn coal in the inventory year.
[d]Chena Units are combined because they share a common stack. Unit 4 capacity was adjusted upward (from 20 MW to 27 MW) to match actual physical capacity as demonstrated by historical firing rate data.

In interpreting these values, it is important to note that they are very likely low estimates. They are based on cost factors for much larger facilities, and do not take economies of scale into account. The Wainwright boilers have relatively low capacity factors, which contributes to poor cost effectiveness. All of them use low-sulfur Alaska coal, which also contributes to poor cost effectiveness. Additionally, the low sulfur loading may result in much lower abatement efficiencies than assumed in this analysis, further increasing the cost per ton of SO_2 controlled, and reducing the effectiveness of the control strategy.

Other observations

The Sargent & Lundy report indicates that the cost of a circulating dry scrubber is very similar to that of a spray dryer.[30]

Information in the Sargent & Lundy report creates concerns about cost estimates using older sources.

> FGD prices have seen a minimum of 25% inflation in the last year [CY2006]. Some recent contracts have been signed at prices over 300% higher than the market of 5 years ago.[31]

The EPA fact sheet used to describe and estimate costs for other SO_2 removal technologies uses cost data from 2000 and 2001.

Sargent & Lundy indicated that, at least in 2007, the scrubber marketplace was a "seller's market."

> [E]ven when the seller's costs agree with the costs that these tables were based on, the seller's price may include a factor of 20% that reflects his diminished desire to capture the contract. This diminished desire may alternatively be exp0ressed as a refusal to offer any price. Many suppliers are declining to bid on contracts they deem too small, too different from their experience base, to short a schedule, too difficult a labor environment, or too commercially risky.[32]

Conclusions

The cost effectiveness of controlling SO_2 from coal-fired units in Fairbanks using dry scrubbing technology has been estimated. The estimated costs exceed $3,700 per ton for all facilities, and range as high as $9,100 per ton. For a number of reasons, these cost estimates are considered to be underestimates of the actual costs.

- The capital cost per unit capacity is extrapolated from 400 MW examples to units smaller than 40 MW.
- A control efficiency of 90% was assumed. However, this level of control may not be achievable due to the much lower inlet sulfur loading.
- Actual vendor costs may be higher, or even unavailable, because the projects are too small or too challenging to be attractive.

These control costs are too high for this technology to be considered RACT for the small units operated in Fairbanks.

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[30] Sargent & Lundy, *Flue Gas Desulfurizaiton Technology Evaluation: Dry Lime vs. Wet Limestone FGD,* March 2007, p. 53.

[31] Sargent & Lundy, *Flue Gas Desulfurizaiton Technology Evaluation: Dry Lime vs. Wet Limestone FGD,* March 2007, p. 33.

[32] Sargent & Lundy, *Flue Gas Desulfurizaiton Technology Evaluation: Dry Lime vs. Wet Limestone FGD,* March 2007, p. 33.

The Sargent & Lundy report indicates that the cost of dry scrubbing is very similar to that of a spray dryer, characterizing them as a "tie" from a cost standpoint. The report also indicates that the costs of controls have increased substantially since the EPA guidance on sulfur control technologies was issued, and the costs in that guidance may underestimate control costs by a factor of 3 or more.

For the reasons presented above, the use of scrubbers (wet, spray-dry, or dry) on boilers smaller than 100 MW_e cannot be considered to be the norm for SO_2 control, and therefore scrubbers are not considered RACT for these units

Reduced Sulfur in Fuels – Perhaps the simplest and, in many cases, the most cost effective SO_2 emission reduction technology that can be employed for fuel combustion sources is to switch to a lower sulfur content fuel. Reducing the sulfur content in the fuel will reduce the sulfur emissions linearly.

For coal-fired boilers, this means either cleaning the coal to remove sulfur, or switching to a coal source with a lower sulfur content.

Alaskan coal has very low sulfur content.[33] As a result, switching to a coal with a lower sulfur content is not an option. The low sulfur content makes fuel cleaning uneconomical as well, because of the higher volume of fuel that must be cleaned to achieve a given reduction in sulfur.

Conclusion: In order to establish baseline RACT for this source category, data collected by EPA during development of the Boiler NESHAPS were reviewed. Very few coal-fired boilers are currently equipped with exhaust gas SO_2 controls—certainly not enough to be able to say that exhaust gas scrubbers are the norm for this source category. EPA guidance states that use of scrubbers on units smaller than 100 MW is unrealistic. Wet scrubbers and spray dry scrubbers are too expensive to be cost effective. Dry scrubbers may be less expensive than other scrubbers, but the available information on control costs is extremely sparse, and extrapolation to estimate the cost of very small units is unreliable. However, costs have been estimated using available information, and the result appears to indicate that dry scrubbers are too costly to be deemed RACT.

Alaskan coal has a very low fuel content, making fuel switching ineffective and fuel cleaning uneconomical. For these reasons, baseline RACT for SO_2 for each of the coal-fired boilers is use of low-sulfur coal, with no additional controls.

[33] "Alaskan coal resources have a lower sulfur content (averaging 0.3 percent) than most coals in the conterminous United States and are within or below the minimum sulfur value mandated by the 1990 Clean Air Act Amendments." USGS, *Alaska Coal Geology, Resources, and Coalbed Methane Potential* ,(2004) p. 1.

Individual RACT: Fort Wainwright Boilers 3-8

Fort Wainwright has a Central Heat and Power Plant (CHPP) that generates steam and electricity to meet the heating and electricity demands of the base. The CHPP has six identical 230 MMBtu/hr coal-fired boilers (identified as boiler 3 through 8). The boilers were built in 1953 and each is controlled with a full stream baghouse.

$PM_{2.5}$ – Actual PM emissions from each of these boilers were less than the 5 TPY threshold used to screen sources for inclusion in this analysis.

Conclusion: RACT for PM for each boiler is properly designed and operated fabric filters. A design review will be conducted to confirm that the existing fabric filter controls are properly designed.

SO_2 – Actual emissions from each of these boilers was between 87 and 171 tons in 2011. The boilers are currently not equipped with SO_2 controls.

Each boiler's capacity of about 23 MW is above the size of the smallest commercial scrubber installations, yet is below the bottom of the size range (i.e., 100-2,000 MW) for cost estimates. The capacity of each boiler is well below the "realistic range" EPA has determined for scrubbers. As explained above, Aurora Energy's Chena Facility was selected for detailed cost calculations because it was expected to be the most economical to control. Based on the CUECost evaluation of the larger boiler exhaust stream at the Chena facility, the cost effectiveness of wet or spray dry sulfur scrubbing is expected to be higher than $24,000/ton. Efforts to find cost data for dry scrubbers were largely unsuccessful. After searching various literature sources and vendor websites, one article comparing circulating dry scrubbers with other wet scrubber systems was found.[34] The report compared units designed for 400-500 MW coal-fired power plants. The report concluded that, for that size at least, the cost of a dry scrubber was essentially a tie with the cost of a lime spray-dry system.

Conclusion: RACT for SO_2 for each boiler is use of low-sulfur coal, with no additional controls. The boilers are already using low-sulfur coal.[35]

Individual RACT: Aurora Energy Chena Boilers 1, 2, 3, 5

The Chena facility has four coal-fired boilers: three overfeed traveling grate stokers and one spreader stoker. The three traveling grate boilers (identified as Chena 1, 2, and 3) were installed in the 1950s and the maximum design power production of each is 5 megawatts (MW); fuel capacity is 76 MMBtu/Hr.[36] The spreader stoker unit (identified as Chena 5) was installed in 1970 and has a maximum power production rating of 20 MW; fuel capacity is 269 MMBtu/hr. The four coal-fired boilers are controlled with a single

[34] Sargent & Lundy, *Flue Gas Desulfurization Technology Evaluation: Dry Lime vs. Wet Limestone FGD,* March 2007.
[35] 0.14 wt% sulfur content (Data submitted to ADEC for 2011 Emission Inventory).
[36] Aurora Energy Company, *Application, Title V Permit No. AQ0315TVPO2 Revision 1* (October 2010) Table 2-1

full stream baghouse (installed in 2007) through which all of the combined exhaust gas flows.

Because the four boilers share a common stack and exhaust control system, the RACT analysis will be based on the combined capacity and exhaust characteristics.

$PM_{2.5}$ – Actual emissions from all four of these boilers combined was 7.81 TPY in 2011.

Conclusion: RACT for PM for each boiler is properly designed and operated fabric filters. A design review will be conducted to confirm that the existing fabric filter controls are properly designed.

SO_2 – Actual emissions from all four of these boilers combined was 838.9 TPY in 2011. The boilers are currently not equipped with SO_2 controls.

The combined capacity of 35 MW (500 MMBtu/hr) is above the size of the smallest commercial scrubber installations, yet is below the bottom of the size range (i.e., 100-2,000 MW) for cost estimates. The capacity of each boiler is well below the "realistic range" EPA has determined for scrubbers. Based on the CUECost evaluation of this facility, described above, the cost effectiveness of wet or spray dry sulfur scrubbing is expected to be higher than $24,000/ton. Efforts to find cost data for dry scrubbers were largely unsuccessful. After searching various literature sources and vendor websites, one article comparing circulating dry scrubbers with other wet scrubber systems was found.[37] The report compared units designed for 400-500 MW coal-fired power plants. The report concluded that, for that size at least, the cost of a dry scrubber was essentially a tie with the cost of a lime spray-dry system.

Fuel sulfur content is very low (0.13 weight%). As discussed above, this makes fuel switching ineffective and fuel cleaning uneconomical.

Conclusion: RACT for SO_2 for each boiler is use of low-sulfur coal, with no additional controls.

Individual RACT: University of Alaska, Fairbanks Campus Power Plant
Boilers 1, 2, 3 and 4

The University of Alaska's Utilities Division operates a combined heat and power plant that provides electric power, steam heat, domestic water, and chilled water to campus. The power plant has two 140 MMBtu/Hr coal-fired boilers (identified as Boilers 1 and 2) that were installed in 1962 and two 181 MMBtu/Hr dual-fired (gas, liquid, or coal slurry) boilers (identified as Boiler 3, installed in 1970, and Boiler 4, installed in 1987) that generate the steam that powers the three turbines. The coal-fired boilers are controlled by a multi-cyclone separator that came as part of the unit followed by an add-on baghouse installed in 1982. The dual-fired boilers both have low NOx burners. The University is

[37] Sargent & Lundy, *Flue Gas Desulfurization Technology Evaluation: Dry Lime vs. Wet Limestone FGD,* March 2007.

planning to construct a new coal-fired boiler and that will be controlled with lime injection and a fabric filter.[38] The new boiler will replace boilers 1 and 2 while greatly reducing the need for boilers 3 and 4. It is scheduled to start operations in 2017.

$PM_{2.5}$ – Actual PM emissions from each of these boilers were less than the 5 TPY threshold used to screen sources for inclusion in this analysis.

Conclusion: RACT for PM for each boiler is properly designed and operated fabric filters. A design review will be conducted to confirm that the existing fabric filter controls are properly designed.

SO_2 – Actual emissions from all four of these boilers combined was 281.7 TPY in 2011. The boilers are currently not equipped with SO_2 controls.

The individual boiler capacity (~14-18 MW) is above the size of the smallest commercial scrubber installations, yet is below the bottom of the size range (i.e., 100-2,000 MW) for cost estimates. The capacity of each boiler is well below the "realistic range" for scrubbers. Based on the CUECost evaluation of the larger boiler exhaust stream at Aurora Energy's Chena facility, the cost effectiveness of wet or spray-dry sulfur scrubbing is expected to be higher than $24,000/ton. Efforts to find cost data for dry scrubbers were largely unsuccessful. After searching various literature sources and vendor websites, one article comparing circulating dry scrubbers with other wet scrubber systems was found.[39] The report compared units designed for 400-500 MW coal-fired power plants. The report concluded that, for that size at least, the cost of a dry scrubber was essentially a tie with the cost of a lime spray-dry system.

Fuel sulfur content is very low (0.18 weight%). As discussed above, this makes fuel switching ineffective and fuel cleaning uneconomical.

Conclusion: RACT for SO_2 for each boiler is use of low-sulfur coal, with no additional controls.

Dual Fuel-fired Boilers

Because only two identical units are included in this category, baseline RACT was not established. Instead, the relevant factors were considered as part of the individual emission unit analysis, presented below.

Individual RACT: U of Alaska, Fairbanks Boilers 3, 4

Boilers 3 and 4 are 181 MMBtu/Hr dual-fired (gas, liquid, or coal slurry) boilers. The dual-fired boilers both have low NOx burners. The University is planning to construct a new coal-fired boiler and that will be controlled with lime injection and a fabric filter.

[38] The University has obtained permits to construct two units; however, only one has been scheduled for construction.
[39] Sargent & Lundy, *Flue Gas Desulfurizaiton Technology Evaluation: Dry Lime vs. Wet Limestone FGD,* March 2007.

The new boiler will replace boilers 1 and 2 while greatly reducing the need for boilers 3 and 4. It is scheduled to start operations in 2017. See the previous section for more details.

$PM_{2.5}$ – Actual PM emissions from each of these boilers were less than the 5 TPY threshold used to screen sources for inclusion in this analysis.

Conclusion: RACT for PM was not determined for these boilers, because emissions are below the threshold for evaluation.

SO_2 – Actual emissions from combustion of fuel oil were 17.7 tons (Boiler 3) and 11.2 tons (Boiler 4) in 2011.[40] Based on the analyses prepared for the coal-fired boilers, use of wet or spray-dry scrubbers to control SO_2 from the dual-fuel fired boilers is not expected to be cost-effective. Since the only available cost information for dry scrubbers indicates that the costs are similar to those for spray dry scrubbers, dry scrubbers are not expected to be cost-effective.

The fuel used in these boilers is #2 Distillate Oil. The fuel sulfur content of this fuel, 0.43 wt%, is considered typical for this fuel. The feasibility of achieving cost-effective SO_2 reductions at this facility by replacing this fuel with a low-sulfur alternative is discussed below.

Table 5 shows fuel characteristics of the fuels included in this analysis. Information in this table was provided by Golden Valley Electric Association in a site specific analysis prepared by CH2MHill to evaluate the costs associated with fuel switching at GVEA North Pole and Zehnder Peaker Units.[41] HAGO is Heavy Atmospheric Gas Oil, a relatively inexpensive heavy fuel oil produced at the North Pole refinery.

Table 5
Fuel Characteristics

Fuel Type		HAGO	No. 2 fuel oil	Naphtha	ULSD
Sulfur[a]	wt%	1	0.5	0.05	0.0015
Density	lb/gal	7.12	7.05	6.43	7.1
Heat value	BTU/gal	141,000	138,000	116,000	138,500
Cost	$/gal	$2.79	$3.28	$2.41	$3.66
$PM_{2.5}$ emissions	lb/MMBtu	0.043	0.012	0.012	0.012
SO2 emissions	lb/MMBtu	1.01	0.51	0.06	0.00
Cost	$/MMBtu	$19.79	$23.77	$20.78	$26.43

Notes:
[a]Fuel sulfur content is based on fuel specifications rather than actual current fuel content.

Tables 6 and 7 show the fuel costs associated with switching fuels. This is just the cost of buying the new fuel instead of the old one. Capital investment will be required for some

[40] Data submitted to ADEC for 2011 Emission Inventory.
[41] CH2MHill, *Evaluation of Fuel Switching for Potential PM2.5 Reduction for GVEA North Pole and Zehnder Peaker Units*, January 2014

units to be able to switch fuels due to fuel physical characteristics such as viscosity. Additionally, some units will require onsite storage in order to meet system reliability requirements.

Table 6
Fuel Cost of Switching Fuels ($/ton $PM_{2.5}$ Reduced)

	To this fuel		
From this fuel	No. 2 fuel oil	Naphtha	ULSD
HAGO	$25,683.11	$6,378.25	$42,830.70
No. 2 fuel oil		no benefit	no benefit
Naphtha			no benefit

Table 7
Fuel Cost of Switching Fuels ($/ton SO_2 Reduced)

	To this fuel		
From this fuel	No. 2 fuel oil	Naphtha	ULSD
HAGO	$15,951.27	$2,071.36	$13,166.10
No. 2 fuel oil		-$13,140.10	$10,436.72
Naphtha			$209,679.08

Table 6 shows that the cost of fuel, by itself, is above ADEC's $10,000/ton BACT cost effectiveness threshold for $PM_{2.5}$ for all fuels except naphtha. Table 7 shows that the cost of fuel, by itself, is above typical ADEC's $10,000/ton BACT cost effectiveness threshold for SO2 for all fuels except naphtha. For this reason, fuel switching to fuels other than naphtha is ruled out as RACT.

Switching from #2 distillate to naphtha would significantly reduce fuel costs for these units. However, naphtha has significantly different combustion characteristics that would require substantial equipment modification. Naphtha is significantly more flammable than heavier fuels, potentially requiring significant construction costs for storage and structures. Fuel systems would need to be modified or replaced. Although the costs of these modifications would be very site-specific, and are not currently available, it is clear that switching to naphtha is a costly effort for a facility not currently equipped to burn this fuel.

Conclusion: Use of low-sulfur naphtha as a fuel would result in PM and SO_2 emission reductions. However, because of the relatively low use/low emissions of these boilers, and the fact that usage is expected to be even lower in 2017 when the new boiler begins operating, the significant capital investment needed to convert Boilers 3 and 4 to naphtha is not justified. RACT is continued use of #2 distillate.

Gas Turbine

Because only five units are included in this category, baseline RACT was not established. Instead, the relevant factors were considered as part of the individual emission unit analysis, presented below.

Individual RACT: North Pole Power Plant GTs 1, 2, and 3

The North Pole Power Plant has three generating units. One unit (GT#3) is a base load unit and operates continuously except for periods of repair or maintenance. This unit was installed in 2006 and is a 455 MMBtu/hr GE Gas Turbine fueled with low sulfur naphtha and LSR fuel and equipped with water injection for NOx control and a CO oxidation catalyst. The other two units at the North Pole Power Plant are 672 MMBtu/hr GE fuel oil-fired regenerative Gas Turbines, installed in 1976 and 1977, and are now operated in peak load periods only. The fuel used in Units 1 and 2 is HAGO. The two units operated a combined total of about 123 days during 2011. This facility also has a permit to install a fourth gas turbine similar to the base unit, but the unit has not yet been installed.

$PM_{2.5}$ – Actual PM emissions from the gas turbines were 16 TPY for GT #1, 131 TPY for GT#2, and 16 TPY for GT#3.[42]
SO_2 – Actual SO_2 emissions from the gas turbines were 42 TPY for GT #1, 326 TPY for GT#2, and 1.9 TPY for GT#3.[43]

Candidate Control Technologies – The following control technologies were considered for this source category:

- Use of gaseous fuels
- Use of low sulfur liquid fuels

Gaseous fuels such as natural gas or propane have much lower sulfur content than liquid distillate fuels. Gas turbines burning gaseous fuels have lower particulate emissions than those burning liquid fuels. However, none of the gas turbines under evaluation are currently capable of burning gaseous fuels. Furthermore, a supply of pipeline natural gas is not available in Fairbanks. The only natural gas currently used in Fairbanks is brought in by truck for supply to a network of 1100 customers. This network does not extend to North Pole. For this reason, use of gaseous fuel is not an option.

Table 5 shows fuel characteristics of the fuels included in this analysis. Information in this table was provided by Golden Valley Electric Association in a site specific analysis prepared by CH2MHill to evaluate the costs associated with fuel switching at GVEA North Pole and Zehnder Peaker Units.

[42] Data submitted to ADEC for 2011 Emission Inventory.
[43] Data submitted to ADEC for 2011 Emission Inventory.

Tables 6 and 7 show the fuel costs associated with switching fuels. This is just the cost of buying the new fuel instead of the old one. Capital investment will be required for some units to be able to switch fuels due to fuel physical characteristics such as viscosity. Additionally, some units will require onsite storage in order to meet system reliability requirements.

Table 6 shows that the cost of fuel, by itself, is above the typical ADEC $10,000/ton BACT cost effectiveness threshold for $PM_{2.5}$ for all fuels except naphtha. Table 7 shows that the cost of fuel, by itself, is above typical ADEC BACT cost effectiveness for SO2 for all fuels except naphtha. For this reason, fuel switching to fuels other than naphtha is ruled out as RACT.

Switching from HAGO to naphtha would significantly reduce fuel costs for Units 1 and 2 (Unit 3 already uses naphtha). However, naphtha has significantly different combustion characteristics that may require substantial modification before it can be used as a fuel. Naphtha is significantly more flammable than heavier fuels, potentially requiring significant construction costs for storage and structures. Fuel systems would need to be modified or replaced. Switching to naphtha is a costly effort for a facility not currently equipped to burn this fuel. GVEA has stated that, due to the age of its turbines, a requirement to retrofit the turbines to use naphtha would likely result in replacement of the turbines. Additionally, GVEA has indicated that it would probably need to demolish and rebuild structures in order to meet safety requirements. Finally, GVEA has indicated that it would need to replace all fuel systems.

Conclusion: Use of low-sulfur naphtha as a fuel would result in PM and SO_2 emission reductions from Units 1 and 2. However, because of the relatively low use/low emissions of these boilers, the significant capital investment needed to Units 1 and 2 to naphtha is not justified. RACT for directly emitted $PM_{2.5}$ and SO_2 control is continued use of current fuels: HAGO in Units 1 and 2, and naphtha and LSR in Unit 3.

Individual RACT: Zehnder, GTs 1 and 2

The Zehnder Power Plant has two GE Frame 5 fuel oil-fired gas turbines, which were installed in 1971 and 1972. The two gas turbines ran a combined total of about 53 days during 2011.

$PM_{2.5}$ – Actual PM emissions from the gas turbines were 16 TPY for GT #1 and 11 TPY for GT#2.[44]

SO_2 – Actual SO_2 emissions from the gas turbines were 40 TPY for GT #1 and 26 TPY for GT#2.[45]

[44] Data submitted to ADEC for 2011 Emission Inventory.
[45] Data submitted to ADEC for 2011 Emission Inventory.

<u>Candidate Control Technologies</u> – The following control technologies were considered for this source category:

- Use of gaseous fuels
- Use of low sulfur liquid fuels

Gaseous fuels such as natural gas or propane have much lower sulfur content than liquid distillate fuels. Gas turbines burning gaseous fuels have lower particulate emissions than those burning liquid fuels. However, none of the gas turbines under evaluation are currently capable of burning gaseous fuels. Furthermore, a supply of pipeline natural gas is not available in Fairbanks. The only natural gas currently used in Fairbanks is brought in by truck for supply to a network of 1100 customers. This network does not extend to Zehnder. For this reason, use of gaseous fuel is not an option.

Table 5 shows fuel characteristics of the fuels included in this analysis. Information in this table was provided by Golden Valley Electric Association in a site specific analysis prepared by CH2MHill to evaluate the costs associated with fuel switching at GVEA North Pole and Zehnder Peaker Units.

Tables 6 and 7 show the fuel costs associated with switching fuels. This is just the cost of buying the new fuel instead of the old one. Capital investment will be required for some units to be able to switch fuels due to fuel physical characteristics such as viscosity. Additionally, some units will require onsite storage in order to meet system reliability requirements.

Table 6 shows that the cost of fuel, by itself, is above the typical ADEC's $10,000/ton BACT cost effectiveness (based on reviewing BACT analyses) threshold for $PM_{2.5}$ for all fuels except naphtha. Table 7 shows that the cost of fuel, by itself, is above ADEC's $10,000/ton BACT cost effectiveness threshold for SO_2 for all fuels except naphtha. For this reason, fuel switching to fuels other than naphtha is ruled out as RACT.

Switching from HAGO to naphtha would significantly reduce fuel costs for Units 1 and 2. However, naphtha has significantly different combustion characteristics that may require substantial modification before it can be used as a fuel. Naphtha is significantly more flammable than heavier fuels, potentially requiring significant construction costs for storage and structures. Fuel systems would need to be modified or replaced. Switching to naphtha is a costly effort for a facility not currently equipped to burn this fuel. GVEA has stated that, due to the age of its turbines, a requirement to retrofit the turbines to use naphtha would likely result in replacement of the turbines. Additionally, GVEA has indicated that it would probably need to demolish and rebuild structures in order to meet safety requirements. Finally, GVEA has indicated that it would need to replace all fuel systems.

Conclusion: Use of low-sulfur naphtha as a fuel would result in PM and SO_2 emission reductions from Units 1 and 2. However, because of the relatively low use/low emissions of these boilers, the significant capital investment needed to Units 1 and 2 to naphtha is not justified. RACT for directly emitted $PM_{2.5}$ and SO_2 control is continued use of current fuels: HAGO in Units 1 and 2.

Process Heater, Oil-fired

The only emission units at the facility with emissions above the screening level are the Crude Heaters at the North Pole Refinery. NOx emissions from these units are already controlled using an Low NOx Burners. As discussed above, NOx controls are not an effective way to reduce $PM_{2.5}$ in Fairbanks.

SO_2 emissions for these units are less than 5 TPY each, and are therefore below the threshold used in this analysis for RACT determinations for SO_2.

At 5.1 TPY $PM_{2.5}$ emissions for one unit (H-2001 Crude Heater) are just above the threshold for evaluation for RACT. This unit burns a very low sulfur distillate fuel and refinery fuel gas. In fact, particulate emissions from oil combustion are below the 5 TPY threshold; emissions from natural gas combustion bring the unit's emissions above 5 TPY. The unit is equipped with ultra low-NOx burners.

Control of PM emissions from units firing gas and/or distillate fuels is accomplished by improving burner servicing and improving oil atomization and combustion aerodynamics (i.e., burner design).[46]

The H-2001 Crude heater is already equipped with ultra low-NOx burners. The burner design incorporates features that improve combustion dynamics, with the result that the uncontrolled PM emissions (as measured by source test) are very low (0.5 lb/thousand gallons,[47] compared with the uncontrolled emission factor of 2.0 lb/thousand gallons in AP-42). It is not expected that further PM reductions can be achieved through design changes.

Based on the low uncontrolled emission factor; the small amount of particulate to be controlled (less that 5 TPY from oil combustion); the type of oil burned (low sulfur distillate fuel); and commonly applied controls as described in AP-42, RACT for $PM_{2.5}$ for H-2001 Crude Heater is best practices for burner maintenance.

[46] AP-42 (May 2010) p. 1.3-6
[47] 2011 Emission Inventory

State of Alaska Department of Environmental Conservation

Evaluation of Reasonably Available Control Technologies (RACT) to Support the Development of the Fairbanks $PM_{2.5}$ SIP

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I. Executive Summary

The purpose of this report is to present an evaluation of emission control technologies that are candidates for selection as reasonably available control technologies (RACT) that could be implemented to advance the timeframe for attaining the annual Fine Particulate Matter ($PM_{2.5}$) National Ambient Air Quality Standard (NAAQS)[1] in the Fairbanks North Star Borough (FNSB). Section I (this section) provides a brief discussion of the results of the evaluation. Section II discusses FNSB's designation by the U.S. Environmental Protection Agency (EPA) as a nonattainment area for $PM_{2.5}$ and refers to the statutory requirements that Alaska must meet in response to this designation. Section III describes the major point source facilities found in the FNSB. Section IV provides additional information on individual emission units at these facilities as well as the control technologies currently in use. Section V describes the control technologies that were considered to be candidates for RACT for each source category, and analysis discussion of the estimated costs and benefits of each candidate technology. Section VI presents the recommended RACT for each emission source type. Detailed individual RACT determinations are provided in Appendix III.D.5.7

Information supplied by the Alaska Department of Environmental Conservation (ADEC) was used to identify individual emission units that comprise the significant sources of $PM_{2.5}$, SO_2, and NO_x emissions at the FNSB major point source facilities. These emission units were grouped by source category types (i.e., coal-fired boilers, gas turbines, process heaters, etc.). For each of the source category types, emission control technologies were identified that could be potential candidates for selection as RACT. A review of available literature, including RACT analyses performed by other States, was performed to gather information on the expected efficiency, capital cost, and cost-effectiveness for each of the candidate technologies. Other site-specific factors, such as the availability of various types of clean fuel in Fairbanks, were also considered in evaluating the candidate technologies.

RACT determinations were made for those emission units at major point source facilities having actual emissions greater than 5 tons per year of any one of the following pollutants: $PM_{2.5}$, NOx, or SO_2. Emission units at area sources were not included in this RACT analysis; such units will be addressed, if necessary, during the development of Reasonably Available Control Measures (RACM). Emission units with actual emissions below 5 TPY were not evaluated, because EPA guidance, described below, indicates that that further control of such sources, individually, is inefficient in reducing area-wide concentrations of PM.

[1] 40 CFR 50.13

The emission units for which RACT determinations were made include boilers, process heaters, and turbines. The $PM_{2.5}$ RACT is a fabric filter system for boilers. Additional $PM_{2.5}$ controls are considered unreasonable for process heaters and turbines. RACT for the SO_2 emissions is the use of low sulfur fuel for all of the fuel combustion sources. RACT controls were not recommended for NOx because control of NOx is not an efficient method for reducing ambient $PM_{2.5}$ in Fairbanks.

All of the emission units that were reviewed are already implementing the emission control techniques identified as RACT. All of the coal-fired units are already equipped with fabric filters, and Alaskan coal has a very low sulfur content. The costs associated with switching from high- to low-sulfur liquid fuels were too high to be deemed to be source specific RACT for those sources currently using liquid fuels.

II. Background

On November 13, 2009 the U.S. Environmental Protection Agency (EPA) designated a portion of the FNSB as a nonattainment area[2] for the 2006 24-hour $PM_{2.5}$ National Ambient Air Quality Standards (NAAQS). This designation obligates the State to develop an approvable State Implementation Plan (SIP) to demonstrate attainment of the NAAQS. Requirements for the preparation, adoption, and submittal of a SIP are outlined under 40 CFR 51, Subpart Z. Paragraph (a) of section 51.1010 states:

> *(a) For each $PM_{2.5}$ nonattainment area, the State shall submit with the attainment demonstration a SIP revision demonstrating that it has adopted all reasonably available control measures (including RACT for stationary sources) necessary to demonstrate attainment as expeditiously as practicable and to meet any RFP requirements. The SIP revision shall contain the list of the potential measures considered by the State, and information and analysis sufficient to support the State's judgment that it has adopted all RACM, including RACT.*

As defined in 40 CFR 51.100(o), RACT "means devices, systems, process modifications, or other apparatus or techniques that are reasonably available taking into account: (1) The necessity of imposing such controls in order to attain and maintain a national ambient air quality standard, and (2) The social, environmental, and economic impact of such controls." The State's SIP for demonstrating attainment with the $PM_{2.5}$ NAAQS must, therefore, include analyses of the emission control technologies currently in use at the applicable stationary sources and whether there are additional emissions reductions that could be achieved by applying other controls that are found to be reasonable. This report presents the results of these analyses.

As described in more detail in Section III, there are six major point source facilities in the FNSB. These six major point source facilities are all operating under Title V permits. A modeling analysis[3] was performed by the State using a dispersion model to evaluate the impact of the point source facilities on the observed $PM_{2.5}$ values at the monitor located at the Fairbanks state office building. Cumulatively, according to information provided by ADEC, these six major point source facilities are estimated to contribute approximately 5 percent of the direct $PM_{2.5}$ on the state office building monitor filter[4] and up to an additional 15 percent of the secondary sulfate.[5] Nitrates account for less than 5

[2] 74 FR 58688 (November 13, 2009); Designations effective December 14, 2009.
[3] Appendix III.D.5.8 Weight of Evidence/ Using the CALPUFF dispersion model to characterize Fairbanks power plant plumes.
[4] Appendix III.D.5.7 Precursors.
[5] Fairbanks PM 2.5 SIP Chapter III.D.5.8 Modeling

percent of the overall mass collected on the filters.[6] Therefore, although NO_x control technologies are discussed in this analysis, the installation of additional NO_x controls on the point source facilities would have little impact on ambient $PM_{2.5}$ concentrations.

Some of the FNSB major point source facilities include numerous small, low emitting sources of $PM_{2.5}$, SO_2, and NO_x.[7] Several other emission units that would have large uncontrolled emissions are already so well controlled that their potential emissions of $PM_{2.5}$ are very low.[8] Additional PM controls for these emission units would not be cost effective because of the very low emission reductions that could be achieved. For example, an annualized capital cost of as low as $30,000 to reduce particulate emissions from a small oil-fired process heater that emits 3 tons of $PM_{2.5}$ per year would have a cost effectiveness of over $10,000 per ton even without considering any operating cost for the controls. Most viable emissions control techniques actually cost at least an order of magnitude more than the $30,000 used in the hypothetical example. In its 2006 Regulatory Impact Analysis for the Particulate Matter National Ambient Air Quality Standards, EPA stated that sources emitting less than 5 tons per year "were likely to have existing controls in place, and further control was typically not cost-effective and inefficient in reducing area-wide concentrations of PM." [9] In light of this statement by EPA, only those emission units having the potential to emit greater than 5 tons per year of $PM_{2.5}$ (or one of its precursors, SO_2 or NOx, for which the same rationale applies) were evaluated individually for RACT.[10]

[6] Appendix III.D.5.7 Precursors.
[7] Title V Permit applications for Fort Wainwright, North Pole Refinery, and University of Alaska. See Section IV below.
[8] Title V Permit applications for Fort Wainwright, Chena Power Plant, Zehnder Power Plant, and University of Alaska. See Section IV below.
[9] EPA, *Regulatory Impact Analysis for 2006 National Ambient Air Quality Standards for Particle Pollution* (October 2006). p. 1-12
[10] This conclusion does not rule out the possibility that the cumulative impact of numerous small sources may be considerable, and worth controlling as a group. For example, reduction of SO_2 emissions from area combustion sources by means of stringent limit on fuel sulfur content may be a cost effective control technique. Evaluation of such measures is beyond the scope of this analysis.

III. Description of Major Point Source Facilities

As mentioned earlier, the FNSB includes six major point source facilities that are estimated to contribute approximately 5 percent of the direct $PM_{2.5}$ and an additional 15 percent of the secondary sulfate measured at the Fairbanks state office building monitoring site. Of the six major point source facilities, five are operating power plants that produce electricity and, in some cases, provide steam and hot water for comfort heating in nearby commercial/residential buildings. The sixth facility is a refinery that has numerous emission points related to its process operations. The following paragraphs present brief descriptions of each of the six major point source facilities. Additional information on the major point source facilities' emissions and emission controls is presented in Section IV of this report.

Discussion and assessment of non-major point source facilities (also known as "area sources") is beyond the scope of this analysis.

A. Aurora Energy, LLC, Chena Power Plant[11]

Aurora Energy, LLC, owns and operates the Chena Power Plant, which provides steam and electrical power to the City of Fairbanks. The facility not only produces electricity for the Fairbanks area but also operates two district heat systems (one steam and the other hot water) to provide heat to nearby commercial/residential buildings. The Chena facility has four coal-fired boilers, with three being overfeed traveling grate stokers and one being a spreader stoker. The three traveling grate boilers (identified as Chena 1, 2, and 3) were installed in the 1950s and the maximum design power production of each is 5 megawatts (MW_e). The spreader stoker unit (identified as Chena 5) was installed in 1970 and has a maximum power production rating of 20 MW_e. The four coal-fired boilers are controlled with a single full stream baghouse (installed in 2007) through which all of the combined exhaust gas flows.[12]

B. Doyon Utilities, LLC, Ft. Wainwright Power Plant

Fort Wainwright has a Central Heat and Power Plant (CHPP) that generates steam and electricity to meet the heating and electricity demands of the base. The CHPP has six identical 230 MMBtu/hr (23 MW_e) coal-fired boilers (identified as Boiler 3 through 8).[13] The boilers were built in 1953 and each is controlled with a full stream baghouse.[14] The

[11] The following information comes from *Title V Statement of Basis, Revision 1* (October 9, 2006) p. 2.
[12] *Renewal Application for Title V Permit* (October 2010). p. 2.
[13] *Revised Title V Renewal Permit Application Package for Fort Wainwright, Alaska* (March 2008), p. 4
[14] *Revised Title V Renewal Permit Application Package for Fort Wainwright, Alaska* (March 2008), p. 8

facility also operated a coal preparation plant that prepares the coal for the boilers.[15] The emission units at the coal preparation plant are controlled by baghouses.[16] Fort Wainwright's CHPP also has a 2 megawatt Black Start generator that meets the EPA Tier II requirements.[17]

Fort Wainwright also has several insignificant sources that emit $PM_{2.5}$, NO_x, and SO_2. The insignificant sources are not controlled and are spread out across the base. The insignificant units include 16 generator sets, 5 lift stations, 4 well pumps, and wind erosion and drop loading at the coal pile.[18]

C. Flint Hills Resources, North Pole Refinery

The North Pole Refinery processes North Slope crude oil and supplies gasoline, jet fuel, heating oil, diesel, gasoil and asphalt to Alaska markets. Most of the current combustion emission units at the facility were installed either in the mid-1980s or during renovations in 1998.[19] There are four combustion devices with actual emissions greater than 5 TPY (three crude heaters and one steam generator), as well as a number of smaller combustion devices..[20] The combustion units burn light straight run (LSR)[21], fuel gas, waste gas, or diesel depending on the unit. In addition, the refinery has numerous VOC sources.

D. Golden Valley Electric Association (GVEA)

Golden Valley Electric Association (GVEA) operates two electric generating facilities within the Fairbanks North Star Borough; the North Pole Power Plant and the Zehnder Power Plant.

D.1. The North Pole Power Plant has three generating units. One unit is a base load unit and operates continuously except for periods of repair or maintenance.[22] This unit was installed in 2005 and is a GE LM6000 Gas Turbine fueled with low sulfur naphtha and LSR fuel and equipped with water injection for NO_x control and a CO oxidation

[15] *Revised Title V Renewal Permit Application Package for Fort Wainwright, Alaska* (March 2008), p. 4
[16] 2011 Emission Inventory
[17] 2011 Emission Inventory
[18] *Revised Title V Renewal Permit Application Package for Fort Wainwright, Alaska* (March 2008), p. 42
[19] *Department of Environmental Conservation Air Quality Operating Permit No. AQ0071TVP02* (April 23, 2010) Section 2, Table A
[20] 2011 Emission Inventory
[21] LSR is a very low sulfur (0.0025 wt. percent sulfur) liquid fuel, with properties similar to gasoline. See 2011 Emission Inventory
[22] *Application for Renewal of Title V Permit AQ0110TVP02, Golden Valley Electric Association North Pole Power Plant* (May 2013), Form A3

catalyst.[23] The other two units at the North Pole Power Plant are GE Frame 7 fuel oil-fired regenerative Gas Turbines, installed in 1976 and 1977, and are now operated in peak load periods only.[24] This facility also has a permit to install a fourth gas turbine similar to the base unit, but the unit has not yet been installed.[25]

D.2. The Zehnder Power Plant has four units. Two of the units are GE Frame 5 fuel oil-fired gas turbines installed in 1971 and 1972.[26] The other two units are GE fuel oil-fired electro-motive diesel engines, installed in 1970, that are used for emergency power and also serve as black start engines for the GVEA generation system.

E. <u>University of Alaska, Fairbanks Campus Power Plant</u>

The University of Alaska's Utilities Division operates a combined heat and power plant that provides electric power, steam heat, domestic water and chilled water to campus. The power plant has two 84.5 MMBtu/hr coal-fired boilers (identified as Boilers 1 and 2) that were installed in 1962 and two 181 MMBtu/hr dual-fired (gas, liquid, or coal slurry) boilers (identified as Boiler 3, installed in 1970, and Boiler 4, installed in 1987) that generate the steam that powers the three turbines.[27] The coal-fired boilers are controlled by a multi cyclone separator that came as part of the unit followed by an add-on baghouse installed in 1982.[28] The dual-fired boilers both have low NO_x burners.[29] The power plant also has one 13,226 hp diesel generator, two backup 125 kW diesel generators, and one backup oil-fired boiler.[30] The generator was originally designed to burn a coal slurry and was installed with an SCR unit.[31] The SCR is still in operation; however, the generator burns diesel fuel instead of the coal slurry.[32]

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[23] *Application for Renewal of Title V Permit AQ0110TVP02, Golden Valley Electric Association North Pole Power Plant* (May 2013), Form A2
[24] *Application for Renewal of Title V Permit AQ0110TVP02, Golden Valley Electric Association North Pole Power Plant* (May 2013), Form A3
[25] *Application for Renewal of Title V Permit AQ0110TVP02, Golden Valley Electric Association North Pole Power Plant* (May 2013), Form A2
[26] *Revision to Application for Renewal of Title V Permit AQ0109TVP02, Golden Valley Electric Association Zehnder Power Plant* (October 2013), Form B
[27] *Application for Renewal of an Air Quality Control Operating Permit, University of Alaska--Fairbanks Campus Power Plant* (June 2012), Section 5, Table A
[28] *Application for Renewal of an Air Quality Control Operating Permit, University of Alaska--Fairbanks Campus Power Plant* (June 2012), Section 1, Table 1-1
[29] *Application for Renewal of an Air Quality Control Operating Permit, University of Alaska--Fairbanks Campus Power Plant* (June 2012), Section 4, Page 21
[30] *Application for Renewal of an Air Quality Control Operating Permit, University of Alaska--Fairbanks Campus Power Plant* (June 2012), Section 4, Table A
[31] *Application for Renewal of an Air Quality Control Operating Permit, University of Alaska--Fairbanks Campus Power Plant,* Section 4, Table A, Note 3
[32] *Application for Renewal of an Air Quality Control Operating Permit, University of Alaska--Fairbanks Campus Power Plant* (June 2012), Section 4, Table A, Note 3

The University is planning to construct two new coal and biomass-fired boilers that will be controlled with lime injection and a fabric filter.[33] The new boilers will replace boilers 1 and 2 while greatly reducing the need for boilers 3 and 4.[34] They are scheduled to start operations in 2017.[35]

The University also operates a diesel fired medical waste incinerator that is mostly used for pathological waste.[36] The University also has several insignificant sources that emit $PM_{2.5}$, NO_x, and SO_2. The insignificant sources are not controlled and are spread out across the campus. The insignificant units include fifteen (15) boilers, two (2) generators, three (3) furnaces, one (1) grain dryer, one (1) hot water heater, one (1) classroom engine.[37] All of the insignificant sources burn diesel fuel. The sulfur content in the fuel is not regulated directly and the facility does not burn low sulfur diesel fuel, but SO_2 emissions from these sources are limited to 500 ppm averaged over three hours.[38]

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[33] *Application for a Prevention of Significant Deterioration Air Quality Construction Permit* (January 2013), p. 1

[34] *Application for a Prevention of Significant Deterioration Air Quality Construction Permit* (January 2013), p. 1.

[35] *Application for a Prevention of Significant Deterioration Air Quality Construction Permit* (January 2013), p. 8.

[36] *Application for Renewal of an Air Quality Control Operating Permit, University of Alaska--Fairbanks Campus Power Plant* (June 2012), Section 4, Table 2-4

[37] *Application for Renewal of an Air Quality Control Operating Permit, University of Alaska--Fairbanks Campus Power Plant* (June 2012), Section 4, Table 2-4

[38] *Application for Renewal of an Air Quality Control Operating Permit, University of Alaska--Fairbanks Campus Power Plant, Section 4* (June 2012), Permit Conditions13 and 24

IV. Emission Units and Current Emission Levels

This section presents information on the significant emission units (defined in this analysis as those that have the potential to emit greater than 5 tons of $PM_{2.5}$, SO_2, or NOx emissions per year) found at each of the FNSB major point source facilities. In the first subsection, each facility is addressed in a separate table that shows the facility's emission units current control technology, control efficiency, and the actual and potential emissions of $PM_{2.5}$, NO_x and SO_2. All of this information except the actual reported emissions was taken from the facilities' Title V permits and applications. The actual emissions are those reported by the facilities in their 2011 annual emissions inventory report. In a few cases, the reported actual emissions are higher than the calculated potential to emit (PTE) in the Title V permit information.

For some emission units, the PTE is the maximum allowable emissions, and reflects enforceable emission limits. For such units, actual emissions cannot exceed the PTE without being out of compliance. However, there are many units for which the PTE is an estimate, not an enforceable limit, calculated for the sole purpose of determining applicability of certain programs, including the Title V permit program. One option recommended by EPA to calculate PTE is to use of average emission rates from agency references such as AP-42, and assume continuous operation at full capacity. See, e.g., EPA Potential to Emit: A Guide for Small Businesses, (October 1998).

If subsequent source tests indicate that the actual emission factor is higher than the one used to calculate PTE, then the actual emissions may exceed the PTE without resulting in noncompliance. This is the situation for all but one of the emission units where actual emissions exceed PTE.

The one exception is Chena Boiler #5, which reported an actual annual average firing rate 20% above the boiler's rated capacity. After investigation, it was determined that this unit has not been modified. The boiler's rated capacity is simply much lower than its actual physical capacity.

The second subsection presents the emission units grouped by source category types. This allows a comparison of the different control technologies for the existing sources in the FNSB.

EMISSION UNITS BY FACILITY

A. Aurora Energy, LLC, Chena Power Plant

Description	Control Device	$PM_{2.5}$			NO_x			SO_2		
		Control Efficiency	2011 Actual (tpy)	Potential (tpy)	Control Efficiency	2011 Actual (tpy)	Potential (tpy)	Control Efficiency	2011 Actual (tpy)	Potential (tpy)
Coal-fired boilers (units 1, 2, 3, & 5, combined)	Baghouse	99.9%[f]	7.81[e]	5.0[d]	None	792.7[e]	744.6[c]	None	838.9[e]	1,294.7[a,c]
Coal preparation plant	Baghouse	99.9%[f]	0.28[e]	0.34[d]	NA[b]	NA	NA	NA	NA	NA
Ash vacuum pump exhaust	Baghouse	99.9%[f]	0.197[e]	0.23[d]	NA	NA	NA	NA	NA	NA

[a] Based on average sulfur content of coal of 0.26 wt. percent (Title V Permit Application Table 2-8); reported sulfur content in 2011 emission inventory was 0.13 wt. percent

[b] NA means that the pollutant is not emitted by the source type

[c] Data from 2010 Title V Permit Application Table 2-2.

[d] Data from 2010 Title V Permit Application Table 2-6d.

[e] Data from 2011 Emission Inventory (2011 EI SS-315_Chena)

[f] $PM_{2.5}$ Control Efficiency is from Chapter 6, OAQPS Control Cost Manual (Sixth Edition), EPA, Office of Air Quality Planning and Standards, Emissions Standards Division, January 2002 (EPA 452/B-02-001).

Note that actual 2011 emissions exceed the reported PTE for the coal-fired boilers. This discrepancy is due to two things. First, the PTE calculations are based on emission factors developed from a 2007 source test, while the actual emissions are based on emission factors developed from a 2011 source test. Second, Unit 5, the largest boiler, reported an annual average firing rate 20% above its rated capacity. After investigation, it was determined that this unit has not been modified. The boiler's rated capacity is simply much lower than its actual physical capacity.

B. Doyon Utilities, LLC, Ft. Wainwright Power Plant

Description	Control Device	$PM_{2.5}$			NO_x			SO_2		
		Control Efficiency	2011 Actual (tpy)	Potential (tpy)	Control Efficiency	2011 Actual (tpy)	Potential (tpy)	Control Efficiency	2011 Actual (tpy)	Potential (tpy)
Coal-fired boiler 3	Baghouse	99.9%[a]	2[d]	5.4[c]	None	101[d]	767.9[c]	None	109[d]	2,352.0[c]
Coal-fired boiler 4	Baghouse	99.9%[a]	2[d]		None	101[d]		None	99[d]	
Coal-fired boiler 5	Baghouse	99.9%[a]	2[d]		None	117[d]		None	126[d]	
Coal-fired boiler 6	Baghouse	99.9%[a]	1[d]		None	91[d]		None	87[d]	
Coal-fired boiler 7	Baghouse	99.9%[a]	3[d]		None	197[d]		None	171[d]	
Coal-fired boiler 8	Baghouse	99.9%[a]	2[d]		None	168[d]		None	122[d]	
Coal Preparation Plant South	Baghouse	99.9%[a]	0.596[d]	14[c]	NA[b]	NA	NA	NA	NA	NA
Ash Handling	Baghouse	99.9%[a]	None reported[d]	11.8[c]	NA	NA	NA	NA	NA	NA

[a] $PM_{2.5}$ Control Efficiency is from Chapter 6, OAQPS Control Cost Manual (Sixth Edition), EPA, Office of Air Quality Planning and Standards, Emissions Standards Division, January 2002 (EPA 452/B-02-001).

[b] NA means that the pollutant is not emitted by the source type

[c] *Revised Title V Renewal Permit Application Package for Fort Wainwright, Alaska* (March 2008), p. 9.

[d] 2011 Emission Inventory

Note that actual 2011 $PM_{2.5}$ emissions exceed the reported PTE for the coal-fired boilers. This discrepancy is because, the PTE calculations are based on emission factors developed from a 2005 source test, while the actual emissions are based on emission factors from EPA's WebFIRE database.

C. Flint Hills Resources, North Pole Refinery

Description	Control Device	$PM_{2.5}$			NO_x			SO_2		
		Control Efficiency	2011 Actual (tpy)	Potential (tpy)	Control Efficiency	2011 Actual (tpy)	Potential (tpy)	Control Efficiency	2011 Actual (tpy)	Potential (tpy)
H-241 Crude Heater (120 MMBtu/hr)		None	2.0[b]	3.0[c]	None	44.6[b]	65.4[c]	None	1.0[b]	1.5[c]
H-1001 Crude Heater (70 MMBtu/hr)		None	0.3[b]	0.5[c]	None	20.6[b]	38.6[c]	None	0.9[b]	1.6[c]
B-401 Steam Generator		None	0.3[b]	0.6[c]	None	11.8[b]	23.5[c]	None	0.1[b]	0.2[c]
H-2001 Crude Heater[a]	ULNB	None	5.1[b]	6.7[c]	None	62.0[b]	81.5[c]	None	3.3[b]	4.3[c]

[a] The crude heater was grouped with H-3700 Asphalt Heater which had an actual NO_x emissions of 0.81 tpy compared to 52.2 tpy from H-2001. In the analysis we assumed that the crude heater was the significant unit and included in the RACT analysis.

[b] 2011 Emission Inventory

[c] PTE Calculations based on rated capacity and emission factors in Emission Inventory, and operation at full capacity for 8760 hours per year.

D.1 Golden Valley Electric Association (GVEA), North Pole Plant

Description	Control Device	$PM_{2.5}$[a]			NO_x			SO_2		
		Control Efficiency	**2011 Actual (tpy)**	**Potential (tpy)**	**Control Efficiency**	**2011 Actual (tpy)**	**Potential (tpy)**	**Control Efficiency**	**2011 Actual (tpy)**	**Potential (tpy)**
GT#2 Gas Turbine	None		131[c]	141[d]	Limited to 7,992 hr/yr	464[c]	3,733[d]	Combined limit of 24,500 lb/day[e]	326[c]	4079[d]
GT#1 Gas Turbine	None		15.5[c]	290[d]	Limited to 1,600 tpy[d]	50.3[c]	1,600[d]		42.3[c]	
GT#3 Gas Turbine	NO_x - Water Injection CO - Oxidation Catalyst[f]		16.8[c]	25.6[d]		367[c]		Limited to naphtha or LSR to .05%S[e]	1.86[c]	192[d]
GT#4 Gas Turbine[b]	NO_x - water injection[f]		--	1.2[d]		--		Limited to Jet A to 0.3%S[e]	--	31[d]

[a] Assume that PM_{10} equals $PM_{2.5}$ since no other data is available in the permit application.
[b] This unit is included in the pending permit application but had not yet been installed in 2011.
[c] 2011 Emission Inventory
[d] *Application for Renewal of Air Quality Operating Permit North Pole Power Plant* (2007), Attachment 1, Table 1.
[e] *Application for Renewal of Air Quality Operating Permit North Pole Power Plant* (2007), Attachment 1, Table 5.
[f] *Application for Renewal of Air Quality Operating Permit North Pole Power Plant* (2007), Attachment 2, Table 1.

D.2 Golden Valley Electric Association (GVEA), Zehnder Power Plant

Description	Control Device	$PM_{2.5}$[a]			NO_x			SO_2		
		Control Efficiency	2011 Actual (tpy)	Potential (tpy)	Control Efficiency	2011 Actual (tpy)	Potenti al (tpy)	Control Efficiency	2011 Actual (tpy)	Potential (tpy)
Diesel Generator #2	None	None	0.007[c]	8.5[b]	None	0.393[c]	392[b]	None	0.012[c]	580 TPY total facility permit limit
Diesel Generator #1	None	None	0.028[c]	8.5[b]	None	1.58[c]	392[b]	None	0.048[c]	
Combustion Gas Turbine #1	None	None	16.05[c]	14.1[b]	None	54.3[c]	1033[b]	None	39.83[c]	
Combustion Gas Turbine #2	None	None	10.77[c]	14.1[b]	None	36.4[c]	1033[b]	None	25.73[c]	

[a] Assume that PM_{10} equals $PM_{2.5}$ since no other data is available in the permit application.
[b] *Application for Renewal of Air Quality Operating Permit Zehnder Power Plant (2007),* Attachment 1, Table 1
[c] 2011 Emission Inventory

E. University of Alaska, Fairbanks Campus Power Plant

Description:	Control Device	$PM_{2.5}$			NO_x			SO_2		
		Control Efficiency [a]	2011 Actual (tpy)	Potential (tpy)	Control Efficiency	2011 Actual (tpy)	Potential (tpy)	Control Efficiency	2011 Actual (tpy)	Potential (tpy)
Coal-fired Boiler #1	Multicyclone with a Baghouse	99.9%	3.62[g]	7.3[c]	None	250[g]	212.9[b]	Limited to 500ppm S[e]	123.8[g]	220.1[d]
Coal-fired Boiler #2	Multicyclone with a Baghouse	99.9%	3.77[g]	7.3[c]	None	260[g]	212.9[b]		128.9[g]	220.1[d]
Dual Fuel-Fired Boiler #3	Low NO_x Burners	None	2[g]	11.6[c]	30-50%[f]	5.72[g]	138.8[b]		17.7[g]	410.6[d]
Dual Fuel-Fired Boiler #4	Low NO_x Burners	None	1.27[g]	11.6[c]	30-50%[f]	3.63[g]			11.23[g]	410.6[d]

[a] $PM_{2.5}$ Control Efficiency is from Chapter 6, OAQPS Control Cost Manual (Sixth Edition), EPA, Office of Air Quality Planning and Standards, Emissions Standards Division, January 2002 (EPA 452/B-02-001).

[b] *Application for Renewal of an Air Quality Control Operating Permit* (June 2012) Table 2-4

[c] *Application for Renewal of an Air Quality Control Operating Permit* (June 2012) Table 2-6c

[d] *Application for Renewal of an Air Quality Control Operating Permit* (June 2012) Table 2-8

[e] *Application for Renewal of an Air Quality Control Operating Permit* (June 2012) Permit Condition 13

[f] EPA, *Technical Bulletin: Nitrogen Oxides (NOx), Why and How They Are Controlled* (November 1999), Table 16

[g] 2011 Emission Inventory

V. Candidates for Reasonably Available Control Technology

This section presents discussions of the various control technologies that were considered as candidates for selection as RACT for the applicable source categories. The first subsection (A) presents those technologies that primarily control emissions of direct $PM_{2.5}$. Subsections B and C present technologies that primarily control emissions of $PM_{2.5}$ and precursors SO_2 and NO_x, respectively.

A. $PM_{2.5}$ Control Technologies

The $PM_{2.5}$ control technologies that were identified as potentially applicable to the sources being evaluated for RACT are presented below in a top down order: the technology with the theoretically highest potential $PM_{2.5}$ reduction being first and the remaining technologies in descending order of reduction effectiveness:

- Fabric Filters
- Electrostatic Precipitators
- Wet Scrubbers
- Controls for Stationary Diesel Engines

Provided below is a general description of each of these technologies, as well as a rough assessment (~+/- 30%) of the associated costs. The technical feasibility of each control device, as it specifically applies to the Fairbanks area will be discussed in Section VI. The cost and cost effectiveness values presented below were taken from EPA publications available on the Clean Air Technology Center at EPA's website: www.epa.gov/ttn/catc/products.[39] The cost information presented here is intended to be representative of the typical costs of the control technologies but does not account for numerous variables that may be encountered by a specific facility. In addition, the cost effectiveness values are typical of those that would be expected when applying the control technologies to an uncontrolled source. For these reasons, a more detailed assessment was made, as appropriate, for each of the emission units being evaluated for RACT. This detailed assessment is provided in Appendix XXX.

[39] *Chemical Engineering*, May 2012, p. 64. Costs were first determined using the methods described in the EPA publications, then adjusted to 2012 dollars using the ratio of the CE Composite Index for 2012 and the reference year for the cost calculations. The index in 2002 (most of the costs in the EPA references were reported in 2002 dollars) was 395.6. The index value used for 2012 was 584.6. Costs in 2002 dollars were adjusted to 2012 dollars using a factor of 584.6/395.6 = 1.48.

A1. Fabric Filters[40]

Fabric filters consist of one or more isolated compartments containing rows of fabric bags in the form of round, flat, or shaped tubes, or pleated cartridges. Particle laden gas passes through the fabric, particles are retained on the upstream face of the bags, and the cleaned gas stream is vented to the atmosphere. Fabric filters collect particles with sizes ranging from submicron to several hundred microns in diameter at efficiencies generally in excess of 99 percent. Fabric filter removal efficiency is relatively level across the particle size range, so that excellent control of PM_{10} and $PM_{2.5}$ can be obtained. The layer of dust, or dust cake, collected on the fabric is primarily responsible for such high efficiency. Gas temperatures up to about 500°F, with surges to about 550°F can be accommodated routinely in some configurations. Most of the energy used to operate the system appears as pressure drop across the bags and associated hardware and ducting. Typical values of system pressure drop range from about 5 to 20 inches of water.

Fabric filters are used where high efficiency particle collection is required. Limitations are imposed by gas characteristics (temperature and corrosivity) and particle characteristics (primarily stickiness) that affect the fabric or its operation and that cannot be economically accommodated. Fabric filter costs vary depending on the type of fabric filter, the air to cloth ratio, and the filter type used. According to cost information presented in EPA publications "EPA-452/F-03-025 and EPA-452/F-03-026," typical capital costs for pulse jet and reverse air fabric filters range from \$9 to \$128 per standard cubic feet per minute (scfm) of air flow. Annualized costs range from \$9 to \$75 per scfm and the cost effectiveness ranges from \$63 to \$508 per ton of PM controlled.

A2. Electrostatic Precipitators[41]

Electrostatic precipitators (ESPs) use electrical fields to remove particulate from flue gas. In an ESP, an electric field is maintained between high-voltage discharge electrodes, typically wires or rigid frames, and grounded collecting electrodes, typically plates. A corona discharge from the discharge electrodes ionizes the gas passing through the precipitator, and gas ions subsequently ionize particles in the gas stream. The electric field then drives the negatively charged particles to the collecting electrodes. Because ESPs act only on the particulate to be removed and only minimally hinder flue gas flow, they have very low pressure drops and low energy requirements and operating costs. While several factors determine ESP removal efficiency, size is of paramount

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[40] Information in this section is from EPA, *Air Pollution Control Technology Fact Sheet: Fabric Filter – Pulse-Jet Cleaned Type (EPA-452/F-03-025)* and *Air Pollution Control Technology Fact Sheet: Fabric Filter – Reverse Air Cleaned Type (EPA-452/F-03-026).*
[41] Information in this section is from EPA, *Air Pollution Control Technology Fact Sheet: Dry Electrostatic Precipitator (ESP) –Wire-Plate Type (EPA-452/F-03-028).*

importance. Size determines treatment time: the longer a particle spends in the ESP, the greater its chance of being collected, other things being equal.

Factors limiting ESP performance are flow non-uniformity and re-entrainment. More uniform flow will ensure that there are no high gas velocities, short treatment time paths through the ESP. Attaining flow uniformity also will minimize gas flows bypassing the electrical fields.

ESP overall (mass) collection efficiencies can exceed 99.9%, and efficiencies in excess of 99.5% are common. ESPs with high overall collection efficiencies will have high collection efficiencies for particles of all sizes, so that excellent control of PM_{10} and $PM_{2.5}$ will be achieved with well-designed and operated ESPs. According to EPA publication "EPA-452/F-03-028," typical ESP capital costs range from $15 to $50 per scfm of exhaust gas. The annualized cost ranges from $6 to $57 per scfm and the cost effectiveness for PM control ranges from $57 to $355 per ton. In general, smaller units controlling a low concentration waste stream will be towards the high end of the cost range.

A3. Wet Scrubbers[42]

Wet scrubbers control particulates by bringing them in contact with a liquid (in the form of droplets, foam, or bubbles) and then collecting the liquid along with the adhering particulates. There are several wet scrubber designs available commercially, including the venturi, spray tower, packed bed, and impingement plate scrubbers. Collection efficiencies for wet scrubbers are highly variable. Most conventional scrubbers can achieve high collection efficiencies for particles greater than 5-10 micrometers in diameter but they are generally much less effective for particles less than 5 micrometers. Properly designed venturi scrubbers, however, are capable of controlling fine particulate matter and typically provide high removal efficiencies of particles between 0.5 and 5.0 micrometers in diameter. In most applications, venturi scrubbers achieve reductions of 80 to 90% of $PM_{2.5}$ emissions. Although the capital cost for venturi scrubbers is much lower than the costs for fabric filters and ESPs, the high pressure drop through venturi scrubber systems typically results in relatively high energy use. In addition, the operation of scrubbers generates large volumes of water that must be properly treated or disposed.

EPA publication "EPA-452/F-03-017" indicates that the capital costs of venturi scrubbers range from $4 to $32 per scfm. Annualized costs range from $9 to $291 per scfm, and the cost effectiveness values range from$105 to $3600 per ton of PM.

[42] Information in this section is from EPA, *Air Pollution Control Technology Fact Sheet: Packed-Bed/Packed Tower Wet Scrubber (EPA-452/F-03-015)* and *Air Pollution Control Technology Fact Sheet: Venturi Scrubber (EPA-452/F-03-017).*

EPA publication "EPA-452/F-03-015" indicates that the capital costs of packed bed scrubbers range from $17 to $83 per scfm. Annualized costs range from $26 to $117 per scfm, and the cost effectiveness values range from $166 to $828 per ton of PM.

B. SO_2 Control Technologies

There are limited SO_2 control technologies options available for consideration for the Fairbanks Area. The control technologies considered are:

- Wet scrubber
- Dry scrubber
- Spray dry scrubber
- Fuel sulfur reduction

Provided below is a general description of each of these options. The technical feasibility of each control device, as it specifically applies to the Fairbanks area will be discussed in Section VI.

B1. Wet Scrubbers[43]

In addition to their use as particulate control devices (discussed above), wet scrubbers are used extensively to control emissions of inorganic contaminants, including acid gases such as sulfur dioxide (SO_2). Wet scrubbers rely primarily on the absorption process to remove these soluble contaminants from the exhaust gas stream. Wet scrubbing devices that are based on absorption principles include packed towers, plate (or tray) columns, venturi scrubbers, and spray chambers. Removal efficiencies for gas absorbers vary for each pollutant-solvent system and with the type of absorber used. Pollutant removal may also be enhanced by manipulating the chemistry of the absorbing solution so that it reacts with the pollutant(s), e.g., caustic solution for acid-gas absorption vs. pure water as a solvent. Chemical absorption may be limited by the rate of reaction, although the rate limiting step is typically the physical absorption rate, not the chemical reaction rate.

Most absorbers have removal efficiencies in excess of 90%, and packed tower absorbers may achieve efficiencies as high as 99.9% for some pollutant-solvent systems. As discussed above, typical capital costs for wet scrubbers average from about $4 to $83 per scfm. Operating costs for wet scrubbers used to control SO_2 are somewhat higher than for scrubbers used strictly for PM control because of the added cost of the caustic

[43] Information in this section is from EPA, *Air Pollution Control Technology Fact Sheet: Packed-Bed/Packed Tower Wet Scrubber (EPA-452/F-03-015)* and *Air Pollution Control Technology Fact Sheet: Venturi Scrubber (EPA-452/F-03-017).*

solution that is typically added and because of the additional treatment that may be required for the wastewater.

B2. Dry Scrubbers[44]

Dry systems involve injection of dry alkali substances (usually some form of lime), which is removed from the exhaust by a fabric filter or ESP. Sorbent may be mixed with the fuel or injected in the exhaust. Dry scrubbing is not commonly used for coal-fired power plants. EPA considers dry scrubbers to be a promising technology, but one that becomes less cost effective as the boiler size decreases.

An even distribution of sorbent across the reactor and adequate residence time at the proper temperature are critical for high SO_2 removal rates.

> "Dry scrubbers have significantly lower capital and annual costs than wet systems because they are simpler, demand less water and waste disposal is less complex. Dry injection systems install easily and use less space, therefore, they are good candidates for retrofit applications. SO_2 removal efficiencies are significantly lower than wet systems, between 50% and 60% for calcium based sorbents.
>
> "Sodium based dry sorbent injection into the duct can achieve up to 80% control efficiencies (Srivastava 2001). Dry sorbent injection is viewed as an emerging SO_2 control technology for medium to small industrial boiler applications.[45] Newer applications of dry sorbent injection on small coal-fired industrial boilers have achieved greater than 90% SO_2 control efficiencies."[46]

Cost information for dry scrubbers is not readily available.

B3. Spray Dry Scrubbers[47]

Spray dry systems introduce the absorbent in a slurry that is fully evaporated by the exhaust stream, resulting in dry particulates that are removed by fabric filter or ESP. They differ from dry systems because the absorbent is introduced in liquid form. They differ

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[44] Information in this section is from EPA, *Air Pollution Control Technology Fact Sheet: Packed-Bed/Packed Tower Wet Scrubber (EPA-452/F-03-015)* and *Air Pollution Control Technology Fact Sheet: Venturi Scrubber (EPA-452/F-03-017).*
[45] Although this statement is based on EPA guidance that is 11 years old, it remains EPA's current guidance.
[46] EPA, *Air Pollution Control Technology Fact Sheet: Flue Gas Desulfurization (FGD) - Wet, Spray Dry, and Dry Scrubbers*, EPA-452/F-03-034
[47] Information in this section is from EPA, *Air Pollution Control Technology Fact Sheet: Packed-Bed/Packed Tower Wet Scrubber (EPA-452/F-03-015)* and *Air Pollution Control Technology Fact Sheet: Venturi Scrubber (EPA-452/F-03-017).*

from wet systems because the water is fully evaporated, so the absorbed sulfur is removed from the exhaust as a sold by a fabric filter or ESP.

The capital and operating cost for spray dry scrubbers are typically lower than the costs for similarly-sized wet scrubbers because equipment for handling wet waste products is not required. However, the operation of a spray dry scrubber is more sensitive than a wet scrubber to operating conditions. Excess moisture causes wet solids to deposit on the absorber and downstream equipment. .

B4. Reduced Sulfur in Fuels

Perhaps the simplest and, in many cases, the most cost effective SO_2 emission reduction technology that can be employed for fuel combustion sources is to switch to a lower sulfur content fuel. Reducing the sulfur content in the fuel will reduce the sulfur emissions linearly.

The emission units subject to this evaluation burn a variety of fuels. The sulfur content of these each fuel is limited either by regulation or by permit condition. Additionally, some of the emission units are subject to mass emission limits; others are subject to limitations on exhaust SO_2 concentration.

Current limits on liquid fuel sulfur content range from 500 ppm (for naphtha/LSR burned in GT#3 at the North Pole power plant) to 10,000 ppm (for other liquid fuels burned in the same gas turbines).[48]

In recent years, EPA has reduced the permissible level of sulfur in highway diesel fuel to 15 ppm.[49] This ultra-low sulfur fuel is becoming increasingly available on a widespread basis. Tables available on the EIA website (www.eia.gov) show that the average price differential (not including taxes) in Alaska between No. 2 heating oil and ultra-low sulfur No. 2 diesel fuel was about 25 cents per gallon in 2010.[50] Reducing the fuel sulfur content from 500 ppm to 15 ppm results in reduction of 0.0067 lb SO_2 emissions per gallon. Thus, switching from heating oil to an ultra-low sulfur fuel oil would cost about $75,000/ton. This is clearly not a cost-effective strategy for reduction of ambient PM concentrations.

[48] North Pole Power Plant Title V Operating Permit, Condition 12.
[49] USEPA, Heavy-Duty Highway Diesel Program, http://www.epa.gov/oms/highway-diesel, accessed October 25, 2013
[50] Annual Average No. 2 Fuel Oil (residential) price in 2010 in Alaska was $2.95/gal (EIA website http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=EMA_EPD2_PRT_SAK_DPG&f=M accessed October 28, 2013).
Annual Average No. 2 Diesel Fuel price in 2010 in Alaska was $3,20/gal (EIA website http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=EMA_EPD2D_PTC_SAK_DPG&f=M accessed October 28, 2013).

Fuel switching to low sulfur liquid fuels was evaluated as a strategy for reducing both direct PM emissions and SO_2. Switching from high sulfur fuel oil to any fuel but naphtha will increase fuel costs well beyond ADEC's threshold for acceptable costs. Switching from high sulfur fuels to naphtha would significantly reduce fuel costs. However, naphtha has significantly different combustion characteristics from currently used fuels Naphtha is significantly more flammable than heavier fuels, potentially requiring significant construction costs for storage and structures. Fuel systems would need to be modified or replaced. The combustion units themselves would require significant modifications or possibly retirement and replacement. Switching to naphtha is a costly effort for a facility not currently equipped to burn this fuel.

As a result, fuel switching was ruled out as RACT for all combustion sources.

C. <u>NOx Control Technologies</u>

Based upon ambient sampling, nitrates comprise about 4% of the measured PM2.5 concentrations in Fairbanks.[51] Atmospheric conditions in Fairbanks do not lead to a high rate of conversion from NOx emissions to ambient $PM_{2.5}$. As a result, the installation of additional NO_x controls on the point source facilities would have little impact on ambient $PM_{2.5}$ concentrations. Controlling for direct PM2.5 is approximately 13 times more effective, on a per-pound basis, than controlling for NOx emissions.[52] Any cost effectiveness analysis for NOx control equipment would need to reflect this factor and still be shown to be cost effective. This is extremely unlikely.

For this reason, NOx controls are not being considered as RACT for $PM_{2.5}$ planning for Fairbanks.

[51] Appendix III.D.5.7 Precursors.
[52] See Appendix III.D.5.7 Precursors, for supporting calculations.

VI. Recommended RACTs for each Source Category Type

The following paragraphs present the recommendations for baseline RACT for the source category types found in the FNSB. RACT is addressed for each of the pollutants of concern ($PM_{2.5}$ and SO_2) for each source category type. NOx controls are not discussed because NOx reduction is not an especially effective method for reducing ambient $PM_{2.5}$ in Fairbanks. As a result, these controls are not considered to be economical or reasonable for the purposes of the RACT analysis.

The baseline RACT determinations below are the starting point for the individual emission unit RACT determinations, details of which are provided in Appendix III.D.5.7.

A. Boilers

$PM_{2.5}$ emissions from coal and dual-fuel fired boilers can be most effectively controlled by the installation and operation of a properly sized fabric filter system. While other types of control devices such as electrostatic precipitators (ESPs) and high pressure drop venturi wet scrubbers may achieve comparable control efficiencies, there are drawbacks to their selection as RACT in the FNSB geographical area. ESPs typically require a larger initial investment than fabric filters and often require more space for installation than a fabric filter system. Venturi scrubbers are less costly than fabric filters but they typically achieve lower control efficiencies unless they are designed to operate at very high pressure drops, which increases the operating costs and, therefore, the total annualized costs to levels exceeding the costs for fabric filters. Also, freezing is a potential disadvantage of any type of wet scrubber in a location where ambient temperatures are well below freezing for many months of the year.[53] Although in-stack temperatures are elevated and would accommodate wet scrubber systems, the auxiliary piping that is required for the operation of a wet system would require heating or greatly increased amounts of insulation, which would further increase the operating cost. Wet scrubbers also typically generate a dense plume of water vapor, which could lead to downstream icing issues. Because fabric filter systems achieve emission reductions comparable to ESPs, and because they tend to be less costly to purchase and install and they typically require less space, they are considered to be RACT for $PM_{2.5}$ control for coal-fired boilers. Fabric filter systems have been used to control PM emissions from large coal-fired boilers in a range of geographical setting, including Alaska, for many years and there is significant precedent for selecting the technology as RACT for the control of $PM_{2.5}$.

While effective control of SO_2 emissions from boilers can be accomplished through the use of wet scrubbers, the cost per pound of sulfur removal rises dramatically as boilers

[53] The Stationary Source Control Techniques Document for Fine Particulate Matter (EPA, 1998), p. 5.4-1

get smaller, and as the sulfur content of the fuel gets lower. Because all of the coal-fired boilers in Fairbanks are relatively small (i.e., below 300 MW capacity) and because they already use very low sulfur coal, the use of scrubbers for SO_2 control unreasonably expensive for the sources being reviewed. See Appendix III.D.5.7 for more details.

The use of low sulfur content fuel is, therefore, recommended as baseline RACT for controlling emissions of SO_2 from combustion devices. For coal-burning units, this means use of low-sulfur Alaskan coal. For the oil-burning units in Fairbanks, the cost of switching to low-sulfur liquid fuels is not cost effective, because of complex physical changes that must be made in order to accommodate a fuel which the equipment cannot currently utilize. Case-by-case evaluations of the effectiveness of SO_2 emission reductions by switching to a lower sulfur fuel are provided in Appendix III.D.5.7.

B. <u>Process Heaters</u>

Process heaters are combustion devices that heat process materials. All of the units included in this analysis are refinery heaters that are fired with diesel fuel or a high grade of fuel oil (such as No. 2 fuel oil or kerosene). One process heater has actual PM emissions slightly above the review threshold (at 5.1 TPY). This process heater burns a very low sulfur distillate fuel.[54] The commonly applied PM control for boilers that burn distillate fuel is best operating practices for boiler maintenance. The combination of best operating practices and the use of very low sulfur distillate fuel constitutes RACT for this source category.

None of the other process heaters included in this evaluation have PM or SO_2 emissions above the review threshold, and NOx control is not effective for reducing ambient PM. For these reasons, no controls are proposed for process heaters.

C. <u>Turbines</u>

Combustion turbines used to generate electricity generally emit relatively low levels of particulate matter and have very high exhaust gas flow rates. AP-42 states: "PM emissions are negligible with natural gas firing and marginally significant with distillate oil firing because of the low ash content."[55] Consequently, direct PM controls are not considered feasible for existing turbines. For the reasons discussed above, the cost of switching to more expensive low-sulfur fuels is not cost-effective; use of current fuels is recommended as RACT for SO_2 controls.

[54] Fuel sulfur content = 0.00146 wt%
[55] EPA, *Compilation of Air Pollutant Emission Factors (AP-42),* p. 3.1-4